SD DOMBO UNIVERSITY OF BUSINESS AND INTEGRATED DEVELOPMENT STUDIES

MOBILITY PATTERNS OF PASTORALISTS UNDER CHANGING CLIMATE IN THE SEMI-ARID ZONE OF GHANA: A CASE STUDY OF THE WA EAST DISTRICT IN THE UPPER WEST REGION

JUSTICE ADUKO

2024

SD DOMBO UNIVERSITY OF BUSINESS AND INTEGRATED DEVELOPMENT STUDIES

DEPARTMENT OF ENVIRONMENT AND RESOURCE STUDIES

MOBILITY PATTERNS OF PASTORALISTS UNDER CHANGING CLIMATE IN THE SEMI-ARID ZONE OF GHANA: A CASE STUDY OF THE WA EAST DISTRICT IN THE UPPER WEST REGION

BY

JUSTICE ADUKO

(PG0084721)

THIS THESIS IS SUBMITTED TO THE SD DOMBO UNIVERSITY OF BUSINESS AND INTEGRATED DEVELOPMENT STUDIES, WA IN PARTIAL FULFILMENT FOR THE AWARD OF PHD IN ENVIRONMENT AND RESOURCE MANAGEMENT

JUNE, 2024

DECLARATION

I, Justice Aduko, declare that this thesis is the outcome of my own studies. I have properly acknowledged and referenced the works of other people that supported the outcome of this thesis. I wish to further confirm that this thesis is original and has never been presented either part or a whole for the award of an academic degree or to any institution. The thesis has been supervised in accordance with the guidelines for supervision of PhD thesis by SDD-UBIDS.

…… ……

Justice Aduko Date

(Candidate)

…… ……

Professor Osumanu I. Kanton Date

(Principal Supervisor)

…… ….. ……

Professor Abdul-Kadri Yahaya Date

(Co-supervisor)

DEDICATION

I dedicate this thesis to God almighty for the abundance of grace and blessings showered on me all these years, and to my wife Doris Fati Daari and my father-in-law, Mr. Erick Mahama Daari.

ABSTRACT

Climate change is increasingly noted as one of the critical challenges to pastoral production systems in arid and semi-arid lands, particularly smallholder farming systems, which are recognized as most vulnerable due to their high dependence on climate conditions and their limited adaptive capacity. For ages, the pastoral system in Wa East District has altered and evolved to adapt to shifting environmental circumstances. This study examined the effects of climate change on mobility patterns of pastoralists in semi-arid northwestern Ghana. The study specifically focused on patterns and trends in climate change and mobile pastoral systems, drivers of change, their effects on land use and cover, and explored the adaptation strategies employed to deal with the effects of climate change and pastoralism on land use and land cover. The study examined resource access and control through the perspective of political ecology and pastoral commons theories, with implications for pastoralism, changes in land use and cover, and climate change. Going by pragmatism as a philosophical underpinning, a mixed research approach, specifically, the concurrent strategy involving household questionnaire survey, focus group discussions and key informant interviews was employed in collecting primary data from 387 sampled smallholder farmers from six communities in the Wa East District. Landsat images, rainfall, and temperature data were sourced using geospatial and meteorological methodologies for analyzing land use and land cover change, as well as climate change trends and patterns. The findings reveal that Wa East District has witnessed severe climate change over the past four decades, which has caused drastic changes in environmental and resource conditions. In response to changes in land use and cover caused by climate change and nomadic pastoralism in the area, smallholder farmers have devised a variety of coping methods. Respondents' adoption of these strategies is heavily influenced by a variety of social, economic, and demographic factors such as

gender, age, household size, length of stay, access to land, livestock ownership, and external support, as well as their perception of climate change using weather parameters such as perceived changes in rainfall, temperature, drought, and seasonal variations.The study has recommended that local adaptation strategies and knowledge of climate change should be integrated and mainstreamed into scientific practice at national, local and sectoral levels such as disaster risk reduction, and livestock and agriculture for sustainable pastoralism practices.

ACKNOWLEDGEMENTS

This work would not have been possible without the help of many individuals, who assisted directly and indirectly. I would like to express my gratitude to God for his mercies and favor throughout my educational career.

My unconditional gratitude goes to my beloved supervisors, Prof. Osumanu I. Kanton and Prof. Abdul-Kadri Yahaya for their direction and assistance in ensuring the successful completion of this assignment. To them, I say, may the Lord's favor be with you always. Special thanks go to Get Fund, Ghana for their financial assistance during this course. I would also like to thank the member of parliament for Wa Central, Hon. Dr. Rasid Pelpo, for the love and generosity shown towards me during this project.

I am also highly indebted to my good friends and brothers, Dr. Philip Aniah and Joseph Nyaaba, for the support during the thesis work. I say a big thank you to all my field data collectors for their support to me during the data collection. Sincerely, I want to thank all friends and family members who contributed to the study in various ways.

Finally, I would like to thank my lovely wife, Doris Fati Daari, for her support and prayers throughout my studies.

TABLE OF CONTENTS

LIST OF TABLE

LIST OF FIGURES

LIST OF ACRONYMS

AfDB/GOG	African Development Bank/Government of Ghana
BC	Before Christ
BRDF	Bidirectional Reflectance Distribution Function
CC	Climate Change
CSM	Cerebro Spinal Meningitis
ESA	European Space Agency
FAO	Food and Agriculture Organization
FGD	Focus Group Discussions
GIS	Geographic Information System
GPS	Geographic Positioning System
GSS	Ghana Statistical Service
IFAD	International Fund for Agricultural Development
IPCC	Intergovernmental Panel on Climate Change
KII	Key Informant Interview
LDP	Livestock Development Project
LULC	Land Use and Land Cover
NGOs	Non-Governmental Organizations
NICFI	Norway's International Climate and Forest Initiative
PHC	Population and Housing Census
QA	Quality Assessment
RF	Random Forest
SEPAL	System for Earth Observation Data Access, Processing, & Analysis for Land Monitoring
SL	Sustainable Livelihood

SPSS	Statistical Package for Social Scientist
SR	Surface Reflectance
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
USAID	United States Agency for International Development
USGS	United States Geological Survey
WEDA	Wa East District Assembly

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

Semi-arid ecosystems across the globe are characterized by erratic rainfall patterns and variability. These ecosystems present great threats and uncertainty for nomadic pastoralism (Samuels et al., 2021). As such, pastoralists and their livestock must adapt to these changing climatic conditions (Napogbong et al., 2021). One of the ways nomadic pastoralists usually adapt is to align their activities with temporal and spatial availability of resources (Samuels et al., 2021). In drylands where pastoralists continually face risks and uncertainty, herd mobility is used to manage climate variability and resource availability (Liao et al., 2020; Napogbonget al., 2021). Mobility is seen as an environmentally rational method to safeguard maximum use of limited resources (Samuels, 2013; Dong, 2016), a risk prevention strategy, and a strategy that maximizes digestible nutrient intake during growing seasons (Samuels et al., 2008; Pas, 2018). Mobility is generally in the form of pastoralists movements in search of better fodder and water (Samuels et al.,2019) or seasonal transhumant patterns between dry and wet season pastures, geomorphological zones, from higher to lower elevation during the cold seasons or between different latitudinal areas (Adriansen, 2008; Samuels et al., 2021).

Although mobile pastoralism is practiced all over the world, it is predominant in environments with extreme weather conditions where crop and animal husbandry are considered risky and commonly susceptible to failure (Samuels et al., 2021). Environmental drivers of mobility among pastoralists include excessive temperature variations, and erratic rainfall regimes. In

mobile pastoral systems, transhumance is also a distinctive feature where livestock are moved along ecological gradients such as hydrology, altitude, soil moisture and rainfall in search of fodder with key functional characteristics to sustain growth and reproduction (Rodriguez-Lopez et al., 2021). These functional characteristics include fodder production, quality, digestibility, phenology, and salinity (Liao et al., 2020). An additional driver is often seasonal cultivation of crops that need to be protected from grazing (Samuels et al., 2021). These conditions have led to the evolution of pastoralists herding practices to comprise the variable availability of fodder and water at various temporal and spatial scales.

Mobility among pastoralists is by far the most crucial strategy adopted by the majority of pastoralists globally to survive and thrive in drylands (Liao et al., 2020). Practicing mobility by pastoralists is an effective way to meet the dietary demands of livestock and guarantees pastoral food security (Pas, 2018). Pastoral mobility also reduces susceptibility of rangelands, reallocates grazing pressure, promotes land sharing with wildlife and increases ecosystem resilience (Samuels, 2013). Due to climate and other environmental conditions, the quantity and quality of fodder resources in a specific patch of dryland can vary immensely, both intra and inter-annually (Rodriguez-Lopez et al., 2021). Instead of fixed control of a piece of land, nomadic pastoralists in drylands normally require flexible access to several grasslands in well distributed and strategic locations (Tacoli, 2011). As a result, pastoralists must continuously collaborate with their neighbouring counterparts, non-migratory communities, and government institutions to maintain access to grasslands at different locations (Samuels, 2013; Liao et al., 2017).

Notwithstanding the vital contributions of pastoralism to the Gross Domestic Product (GDP) of many developing countries, its sustainability is not advocated in government policies (Schrijver, 2019). Pastoral mobility is currently under pressure from environmental change and land scarcity because of increases in human population (Samuels, Allsopp & Timm-Hoffman, 2008); and famine, wars, inadequate supply of infrastructure and breakdown of customary hierarchies have also led to a decrease in pastoral mobility (Liao et al., 2017; Schrijver, 2019).

1.2 Problem Statement

Mobile pastoralism has been practiced since time immemorial in many parts of the world. Pastoral mobility in semi-arid ecosystems is a response to spatial and temporal variability in resources availability. Pastoral mobility allows herds to optimally utilize vegetation, which varies in quantity and quality from place to place (Stojanowski & Knudson, 2014; Liao et al., 2020). It also enables pastoralists to access water and other key resources that are crucial for the survival of livestock during the dry season and helps them to evade disease-stricken areas (Napogbonget al., 2021).

Historically, mobile pastoral systems have shifted in order to adapt to dynamic socio-ecological environments (Dong, 2016). The influencing factors of mobility in pastoral systems are intricate, occur across various scales, and include ecological, social, economic, and political factors (Samuels et al., 2021). A universal trend has been for mobile pastoral systems to become progressively spatially restricted and in many parts of the world pastoralists no longer have the opportunity to move over long distances (Ayantunde et al., 2014; Dong, 2016). For instance, in the pre-colonial era, collective rangelands were managed by traditional institutions, which

allowed for inter-territorial grazing between tribal boundaries so that animals could access fodder and water (Tacoli, 2011; Liao et al., 2020). During colonisation, the British established administrative boundaries that restricted pastoral mobility and, thus, livestock's access to resources. After independence, policies led to the privatisation of some communal lands. As a result, communal rangelands continued to shrink, pastoral mobility became constrained and increased pressure was exerted on the limited resource, which led to overgrazing (Samuels et al., 2019).

Currently, pastoral mobility is under severe pressure due to the breakdown of traditional pastoral resource management systems, impacts of climate change, population growth and expansion of commercial agricultural activities (Basupi, 2018). In the past, pastoralist were able to fulfil the demands of their animals by following rainfall trends or specific pasture supplies across space and time (Oba, 2013; Stringer et al., 2017). Climate change will continue wracking havoc on pastoral mobility due to increased exposure to high temperatures and restricted access to water supplies (Anderson, 2019; Khanal et al., 2018). Climate change has led to a severe decrease in pasture and livestock feed in arid zones through the disruptions in the seasonal cycles (Dupar, 2019).

Livestock production, which includes pastoralism, is regarded as the second-major agricultural activity in the Wa East District, making a considerable contribution to local incomes, food production, and provides employment for about 64.25% rural households (WEDA, 2020; GSS, 2021). Despite the tremendous contribution of pastoralism in the district, it faces a number of threats that reduces its efficiency and sustainability. Pastoralist in the district are already

suffering from the devastating effects of climate change along with shifting land use patterns that reduces grazing areas, which is anticipated to have a greater impact on the production of livestock, particularly cattle due to their feeding habits and susceptibility to heat stress (MLDF, 2015; Kimaro et al., 2018; WEDA, 2020).

Geographical differences in precipitation have a decisive role in determining pasture growth and land use. Rainfall is one of the most important climatic factors for pastoralism since their activities are largely governed by water availability, which is often confined to a relatively short season and irregular in time and space within the district. According to Sulieman and Young (2019), rainfall gradient and variability determines the amount of biomass generated and its nutritional quality, and rainfall less than 300mm per year affects the growth of forage.

Pastoralist adaptation to climate change have been captured in the literature (Liao et al., 2020; Samuels et al., 2021; Napogbonget al., 2021). However, little is known about how mobile pastoralism has changed as a result of socio-ecological constraints imposed on drylands by climate change. In the Upper West Region of Ghana, studies attempting to understand pastoral mobility and the drivers of change in a spatially constrained pastoral system where resources availability still varies in space and time are lacking. This study sought to fill this knowledge gap by improving understanding of mobility patterns and drivers of change among pastoralists in the region. The Upper West Region has witnessed severe climate change over the past decades, which has caused drastic changes in environmental and resource conditions.

This study intends to provide insights into how mobile pastoral systems will be managed in the future to ameliorate the consequences of climate change. Understanding mobile pastoralism and drivers of change thereof is important for policy makers and development practitioners making efforts to support the sustained growth of this dynamic sector by designing targeted programs. As food systems transform across Africa, the importance of livestock products as an affordable animal protein and source of economic livelihood is increasingly justified. Thus, the findings of this study would be relevant to the global food security and climate change discourse.

1.3 Research Questions

The research questions of the study are classified into general and specific research questions**.**

1.3.1 General research question

How is mobility patterns of pastoralist influenced by changing climate in Wa East District?

1.3.2 Specific research questions

i. What are the patterns and trends of climate change and mobile pastoral systems in Wa East District between 1981 and 2021?
ii. How is mobile pastoralism influenced by underlying drivers in Wa East District between 1981 and 2021?
iii. How does climate change and changing mobile pastoralism affect land use and land cover in Wa East District between 1981 and 2021?
iv. How do smallholder farmers adapt to the effects of climate change and changing mobile pastoralism on land use and land cover change in Wa East District between 1981 and 2021?

1.4 Research Objectives

The objectives of the study have been classified into general and specific research objectives.

1.4.1 General Research Objective

To assess the effects of climate change on mobility patterns of pastoralist in Wa East District.

1.4.2 Specific Research Objectives

i. To examine the patterns and trends in climate change and mobile pastoral systems in Wa East District between 1981 and 2021.
ii. To assess the underlying drivers of climate change and changing mobile pastoralism in Wa East District between 1981 and 2021.
iii. To examine the effects of climate change and changing mobile pastoralism on land use and cover in Wa East District between 1981 and 2021.
iv. To explore the adaptation strategies that smallholder farmers use to manage the effects of climate change and changing mobile pastoralism on land use and cover change in Wa East District between 1981 and 2021.

1.6 Significance of the Study

The literature has documented pastoralist adaptation to climate change (Liao et al., 2020; Samuels et al., 2021; Napogbonget al., 2021). However, little is known about how mobile pastoralism has altered as a result of the socio-ecological restrictions of climate change on arid lands. This study will contribute to the existing body of knowledge on the patterns, trends and drivers of mobile pastoralism in the semi-arid agro-ecological zones of Ghana where significant land degradation and depletion of vital environmental services has occurred. In a broader view, this study will elucidate our understanding of the effects of changing mobile pastoralism on land

use that is crucial for household's livelihood needs. It is anticipated that the findings of this study will identify the range of strategies employed by smallholder farmers to manage the effects of changing pastoralism on livelihoods, which could be very useful to government, Non-Governmental Organizations (NGOs), policy makers and other agencies that are concerned about sustainable development issues in the drylands of Ghana and Africa as a whole. Due to the ever-increasing population growth and the demand for food and raw materials to meet the growing population, especially in less developed countries, understanding the effects of mobile pastoralism on livelihoods and the adaptation measures thereof is imperative for developing sustainable landscape governance plans.

As Africa's food systems evolve, the value of livestock products as a cheap animal protein and source of economic livelihood grows. As a result, the study's conclusions would be significant to the global food security and climate change debates. This will also help me improve my research abilities and gain knowledge about climate change and mobile pastoralism challenges, which will allow me to offer measures for consideration when crafting policy on the subject.

Furthermore, it is anticipated that the findings of this study will help address sustainable development goals (SDG) 1, 2 and 15 because pastoralism, as a source of economic livelihood, is a strategy that can improve food security and one that depends largely on land for its survival.

1.7 Scope of the Study

Geographically, the study is focused on Wa East District of the Upper West Region. The district was chosen for the study because the grassy character of the environment is ideal for grazing. Furthermore, the Wa East District is heavily dominated by a good number of water resources, such as Kulkpong River and its tributaries, which provide water throughout the dry season; and there are veterinary offices involved in tsetse fly and other illness control, which makes most Fulani herders visit the area each year to feed their livestock.

Contextually, the study investigates the implications of climate change on pastoralist mobility patterns, patterns, trends, and drivers of mobile pastoralism in Ghana's semi-arid agro-ecological zones, where severe land degradation and depletion of important environmental services has occurred. In a larger sense, this study investigates the consequences of altering nomadic pastoralism on land use, which is critical for household subsistence demands. The study unveils the tactics used by smallholder farmers in the region to deal with the consequences of nomadic pastoralism.

This study covers a 40 year period to identify possible changes in the trends and patterns of mobile pastoralism and climate change as well as the impact these changes have on land use and land cover changes within the same period.

1.8 Organization of the Thesis

The thesis is organized into nine chapters. Figure 1.1 illustrate the general arrangement of the thesis.

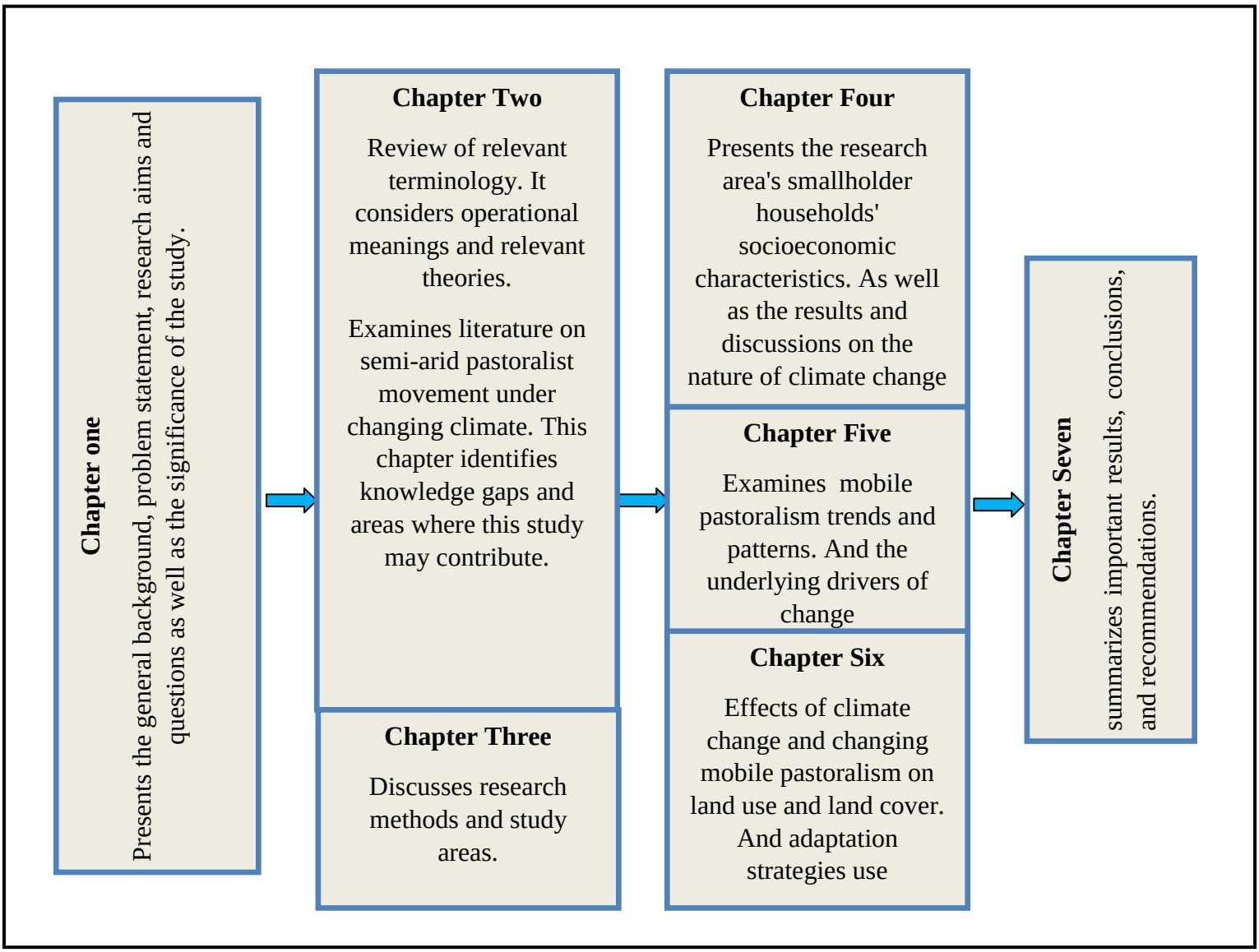

Figure 1.1: Structure of thesis

Source: Authors' Construct, 2020.

CHAPTER TWO

LITERATURE REVIEW AND THEORETICAL PERSPECTIVES

2.1 Introduction

This chapter reviews relevant literature on mobile pastoralism, its implication on livelihoods, land use and household adaptation strategies. Other themes reviewed in the literature include mobility patterns of pastoralists under changing climate in the semi-arid zone of Ghana, global changing patterns of mobile pastoral systems, changing patterns of mobile systems in Africa and its effects on land and livelihood issues and other related themes that gives significant highlights on the different aspects of mobile pastoralism. The literature reviewed under this chapter is with the objective of identifying gaps and defining zones for the contribution of this research to existing knowledge. This chapter maps out clearly what is not fully discussed in existing literature to form the bases for this study. The study takes a critical look at how pastoral systems, as a source of livelihood and as an environmental rational method for many nomadic across the globe, have been affected by climate change.

Important notions on the subject under study, its relationship with climate change in semi-arid zones, the mobility patterns of pastoral systems over time and space, key drivers of change, constrains, spatial scales in relation to resources and human settlement and the effects of pastoral mobility on land use and food security and mobility, which is seen as an environmental rational method to safeguard maximum use of limited resources, are discussed form general views to specific meanings and focus.

The chapter also deals with the review of some key concepts related to topic under study. It takes into account the operational meanings and also considered theories useful to the understanding of the subject matter, and for explaining the study's findings to support the adaption of a conceptual framework, which forms a core part of this chapter. Issues of food security, incomes, vulnerability and violence among young people as an on-going development agenda in most developing nations is relevant to the discourse under consideration. A critical review of key concepts and theories will provide a proper framework for the study.

2.2 Conceptual Overview

2.2.1 Pastoral mobility

Pastoral mobility, livestock mobility, herd mobility, livestock movement are used interchangeably as a term increasingly used across different set of platforms such as pastoral studies, rangeland ecology, social dimensions of climate change as well as conservation (Turner et al., 2019). Pastoral mobility and allied concepts remain increasingly popular not only in scholarly literature but also in broad literature on pastoralism and also dryland development.

Defining mobility is faced with difficulties due to the huge diversity of the systems and the difficulties of explaining the term. For clarity's sake, pastoral mobility refers to the systems in which livestock mobility is a major management approach, particularly linked to the use of common property and private owners (Davies et al., 2010). Pastoral mobility also refers to the movement of people and their livestock from one environment to another environment (Box & Perry, 1971; Mapiye et al., 2009). Pastoral mobility indicates that pastoralists can migrate to

other areas where there is adequate pasture for their livestock. This is regarded as the most effective approach to make use of regularly shifting resources.

Pastoral mobility entails the physical movement of humans and cattle across landscapes in search of water and pasture, as well as crossing boundaries and exchanging knowledge and information about locations (Moss, 2014; Straight et al., 2015). Hundra (2010) defined the phrase as the distance travelled by pastoralists in quest of water and grazing on other territory. Mobility allows pastoralists to use available resources in a rotating fashion. Msuya's (2009) mobility is described as the seasonal and temporal movement of pastoralists in order to obtain livestock needs in an ever-changing environment, and it is a useful instrument that serves numerous elements of livestock demands.

According to Annemick (2019), mobility is a method used by pastoralists to improve spatial utilization of natural resources like as water and pasture under a complicated land tenure structure. Historically, herders have employed mobility to manage uncertainty and risk in arid and semi-arid locations across Africa where rainfall patterns are so unpredictable that it affects pastoralism, particularly in dry seasons owing to limited availability of pasture and water (Msuya, 2009). Pastoralist movement patterns create social network links across landscapes, settlements, and camping places (Turner, 2011). Furthermore, Niamir-Fuller (2000) defines mobility as an opportunistic use of resources that involves the seasonal migration of cattle in arid and semi-arid ecosystems in a spatiotemporal way.

Mobility helps pastoralists to get access to resources, and this access is dependent on social relationships that have developed across geographies. Because arid land resources fluctuate and are uncertain owing to climatic instability, the relationship ensures vital resources for pastoralists. Mobility over larger distances necessitates stronger and wider social network ties for herders to communicate information on pasture and water sites. Mobility over larger distances necessitates stronger and wider social network ties for herders to communicate information on pasture and water sites (Turner, 2011; Galaty, 2013). Mobility is a distinguishing feature in pastoralism. It enables herders to adapt to, and even profit from, environmental fluctuation (Gillin, 2021). Although mobility is a key aspect of pastoralist across the world, it is mostly seasonal in nature. Many various types of movements are performed depending on local conditions and the type of cattle kept. These moves by pastoralist are usually not illogical but rather purposeful, based on local information gathered and risk assessments made by these herders (Gillin, 2021).

Pastoral mobility from its definition can be linked to the mobility of all or a section of some people managing and depending on mobile livestock as well as the cumulative measure of the movements of livestock for a given time period across open rangelands (Turner &Schlect, 2019; Adriansen, 2008). The mobile nature of pastoralists has been argued to be one of the factors why some pastoralists fare quite well during excessive climatic events while others fare poorly, because mobility works by exploiting the spatial and temporal structure of resource failure by shifting from scarcity to abundance (Navchaa et al., 2021).

Pastoralists manage rangelands in a complex common and individual rights where right holders are to comply with the rules governing them. In regions where pastoralists land has been degraded it is mostly the culmination of a weakening of the customary management institutions as well as the loss of important resources that constitute the pastoral system (McGahey et al., 2008).

Globally, pastoralism is practiced differently ranging from a highly technologically improved systems in Europe to near subsistence systems in some parts of Africa. Similarly, the extent of social and political support for pastoralism also differs across geographical boundaries in the sense that while some African governments are strongly opposing pastoralism, European countries have their governments strongly investing in mobile pastoralism to be able to manage and conserve biological diversity (Davies et al., 2010). There are different forms of pastoral mobility, which differ by environmental conditions. Mobility can be seasonal, regular, near random or following erratic rain clouds. This movement can be due to trade, conflict or to engage a new political alliance (Davies et al., 2010).

2.2.2 Nomadic pastoralism

According to the Encyclopedia Britannica, nomadic pastoralism is one of the three general types of nomadism, which is a way of life of people who do not live continuously in the same place but move cyclically or periodically. Hence, pastoral nomads who rely on domesticated livestock, migrate in an established territory to find pasture for their animals. The term nomadic pastoralism is used for instances borrowed from literature, although the definition of nomadic pastoralism differs from country to country (Davies et al., 2010). In literature, nomadic

pastoralism is synonymous to pastoral mobility, hence it somehow replaces the term transhumance, while sometimes it can refer to the absence of permanent home by nomads. Nomads are defined synonymously as mobile pastoralists who compliment their livelihoods primarily through livestock management (Pedersen & Benjaminsen, 2008).

According to FAO (2019), the term nomadic pastoralism is a practice that includes racing animals from one site to another in search of forage. They said that the practice began as a result of the neolithic revolution, often known as the first agricultural revolution. Because man has only just learned to domesticate certain animals and wander about with them in quest of grazing. The term "nomad" comes from the Greek word nemo, which means "to pasture" and is commonly used to characterize both movement and a pastoral subsistence source. Thus, nomadic pastoralism is used to refer to any community that is not established in permanent houses, implying a pastoral subsistence foundation etymologically (Marius, 2013).

Heading communities are often considered nomadic. Where individuals live in moveable tents or temporary shelters and travel long distances from pasture-to-pasture based on ecological conditions and the demand of the beats. Nomadicism is a technical adaptation to sparse and transitory pasturage that has significant ramifications for cultural fundamental traits that are missing when animals are maintained from a constant home base, such as in European dairying or Mexican/Anglo-America ranching. Spatial mobility is one common key survival strategy in nomadic pastoralism. Instead of bringing feed to the cattle, as commonly practiced in the advance countries, traditional non-Western subsistence pastoralist, relocate the animals to where greener fodder can be gotten (Little, 2015).

Studies by Pedersen and Bnejaminsen (2008) in the Northern Sahel revealed that largely rainfall determines whether or not the forage will be good or bad within the year. That not withstanding, even in good years, nomads are on the move to places they can find water and grass at all times. By this, nomads look out for alternative means of spreading risk especially considering the difficulty of carrying both food and animal feed while on the move, as such they move with larger herds of livestock they need in the period of dryness in the year and sometimes sell or trade some of these animals for grain from farmers (Benjaminsen & Berge, 2004).

2.2.3 Pastoral systems

This is an economic activity involving the care of herds of domesticated livestock. In its traditional forms, it is either practiced as the main mode of subsistence combined with agriculture. Pastoralism functions as cultural system with a characteristic ecology. Traditionally pastoral grazing systems across the world are increasingly becoming fragmented, smaller and spatially restricted as a result of environmental, socio-economic and political factors (Turner et al., 2005; Makpe, 2006; Behnke, 2008; Flintan, 2011). Many pastoral systems are focused on the production of several goods and services like milk, hair, meat, blood, manure, and food storage, and hedge against inflation, drought and other associated risks (Davies et al., 2010). The goods and services produced through the pastoral system differ across geographical areas with greater focus on fibre production in the pastoral systems of Central Asia or Southern America while in Sub-Saharan Africa and Southern Asia, the focus of the pastoral system is on dairy products (Davies et al., 2010).

Pastoral production systems are mostly found in climatic zones as different as deserts, dry plains, savannahs, steppes, tundra, and high-altitude mountain ranges, but all have in common the exploitation of ephemeral concentrations of resources (Behnke et al., 2011). In pastoral systems, the herders are mobile with the livestock to target the unreliable availability of resources, while other household members might be sedentary for part or most of the year. Herders target areas of prime pasture with species combinations they know to be beneficial to their animals (Ursula & Flintan, 2019). Normally, mobility is key to pastoral systems, which involves the tracking and use of grazing and water across a given landscape to enhance production by keeping the livestock on a diet that is higher in nutritional value than the average value of the range (African Union, 2010).

Livestock mobility have been established to be vulnerable to notions that it is an ancient cultural characteristic due to the fact that given the current competing land-use concerns, it requires actions of government to secure goods of forage, water and movement corridors (Turner et al., 2019). Thus, this had led to a change of livelihood or decreased mobility of livestock in the pastoral system. Although there is evidence of a decrease in the viability of pastoral livelihood as well as erosion of livestock mobility systems (Fernandez-Gimenez &LeFebre, 2006; Niamir-Fuller 2000; Hobbs et al., 2008), studies have also shown of extensive livestock production systems that have persisted with insignificant growth in modern western systems and on national economies of African nations that are dominated by dryland environments.

2.4.4 Climate change

Climate change is now regarded as one of the world's greatest challenges, with overwhelming compelling data in the literature indicating that it is occurring at an unprecedented rate (IPCC, 2013; Adhikari et al., 2015; Huag et al., 2016). Climate change is predicted to have a greater impact on arid and semi-arid settings, which are home to the world's pastoralists who rely on natural resources for existence (IPCC, 2015; Kimaro et al., 2018).

Climate change refers to the direct or indirect actions of humans resulting in change in global weather conditions in a prolonged period. Climate change vulnerability refers to the to the uncertainties in the average weather conditions occurring annually as well as statistics of extreme weather conditions including storms and rise in temperature particularly during the hot seasons (ISDR, 2008). The little changes in the average weather conditions over a period and which can have great impact on extremes including droughts or floods is referred to as climate extremes (Selvarajn et al., 2006).

According to Asante et al. (2015), when the patterns and timing of occurrences of weather events have altered dramatically over time from how they used to occur, it is said that the climate has changed. The term is frequently used to denote any type of climate change, whether it is caused by human activity or not (IPCC, 2015).

A greater proportion of Ghanaians particularly the rural dwellers livelihoods are tied to agriculture and as such engage in all kinds of agricultural activities including crop farming and animal rearing (ISSER, 2014). Despite the contributions of agriculture to the socio-economic

development of rural dwellers and the nation at large, the sector is greatly challenged with increasing climate change conditions including drought and increase in temperature. Ghana, just like other Saharan African countries, greatly depends on the rains for agricultural activities. Hence, a decrease in precipitation or a substantial delay in the rainfall pattern can result negatively on livelihoods and agricultural activities of peasant farmers (Wringley-Asante et al., 2017).

Concerning the recent phenomenon on climate change, scholars have noted that farmers across gender have either devised means or are devising alternative coping mechanisms to adapt to the negative effects of drought on their source's livelihoods (Arku, 2013; Cudjoe & Owusu, 2011). The Upper West Region is among the five northern regions located within the guinea savanna belt and produces foodstuffs in large quantities and transported to other parts of the country. Notwithstanding the substantial amount of contribution in terms of foodstuffs from this region, the three northern regions are severely exposed to the climate change phenomenon, which invariably would affect food security in general. Studies in the guinea savanna belt have revealed that the belt has one rainy season, which usually commences from April-June to September-October. That notwithstanding, the erratic rainfall pattern as well as the delays in rainfall has dire consequences on crop cultivation in the area (Owusu &Weylen, 2013).

2.2.5 Climate variability

Climate variability refers to the climatic parameter of a region varying from its long-term mean. For every in a particular time period, the climate of a location varies. While some years' experience low rainfall below average, some experience average or above average rainfall

(IPCC, 2001). The change in grasslands globally as a result of climatic variability has made it more complex for pastoralist to cope (Ash & Stafford, 2003; Hunt, 2003). Extreme events are happening coupled with heightened frequency and prolonged duration of dry grasslands worldwide (Galvin, 2019). For instance, events of severe rainfall in East Africa for close to eight months was described as the strongest predictor of East African climate variability (Schreck & Semazii, 2004). The rains took pastoralists unaware and extremely affected those pastoralists who could not move their livestock (Galvin et al., 2001, Little et al., 2001b, Luseno et al., 2003).

Increasing climate variability results in floods and drought to the rangelands such as East Africa leaving pastoralists a very slim chance of relocation most especially under increasing fragmentation (Galvin, 2009). Confirming the impacts of climate variability on pastoralists in Africa, Ojima and Chuluun (2008) revealed that climatic events paradoxically compelled pastoralists to leave their reliance on the state and transform their livelihoods into an extensive market-driven economy. Benefits derived have been altered considerably due to both climatic and socioeconomic changes. Considering the increasing temperature, change in the patterns of precipitation as well as the increasing frequency of droughts, it has resulted in a decrease in water resources (Tugjamba et al., 2021). Consequently, decrease in the availability of water is anticipated to be the major climate change impacts on pastoralists' livelihood.

Pastoralists are in uncertain climatic periods and are experienced at coping with climatic variability and drought (Little et al., 2001b). Nonetheless, the 2007 Intergovernmental Panel on Climate Change (IPCC) have estimated that rainfall pattern in Southern Africa is possible to be

reduced but for East Africa the annual precipitation is projected to increase with unclear rainfall patterns projection for West Africa (Christensen et al., 2007).

2.2.6 Land use

Land use refers to the various purposes for which individuals exploit the land cover. Land use encompasses the ways in which the biophysical characteristics of land are manipulated as well as the intent underlying that manipulation (Lambin&Geist, 2008). Land use also refers to the human alteration of the natural environment into a built environment such as agriculture (crop and pasture lands) and human settlements. Land use is linked to the ascription of new functions of the landscape by humanity (Meyfroidtet al., 2013). Typical land use classes representing land use purposes include parks, forestry, farmlands, settlements, water bodies, grassland, and pastureland (Lambinet al., 2006).

2.2.7 Land use change

Land use change is a dynamic and multifaceted process that links the natural and anthropogenic systems via interactions. The character of the change broadly reflects explicit ecological and socio-economic circumstances (Lambin et al., 2006; Meyfroidt et al., 2013; Frélichová et al., 2014). Land use change refers to changes from one land use form to another. For instance, a shift from forest or agricultural land (pastureland, cropland and biofuel) to another land use form such as built-up and bareland, among others, constitutes land use change (Lambin&Meyfroidt, 2012).

Land use change is described by Davies et al. (2010) to mean the process by which human activities transform the natural landscape. It is one of the major drivers of environmental change and can affect land cover. Recent land use changes are likely to be due to new land users coming

with new production systems. For some pastoralists as in the case of some Massi in Tanzania have taken the opportunity and resorted to crop cultivation as a way of protecting their lands from encroachment (Conroy, 2001). For Kneya and Ethiopia, there is evidence of increased crop cultivation on major dryland areas and this has led to a major resource conflict in pastoralist places. For places where farming has become prevalent, indigenous systems for addressing conflict have been less effective and conflicts are becoming more common in such places (Yirbecho et al., 2004). For some places the interaction between irrigated agriculture and pastoralism in drylands have been complex while in other places it has been complementary (Davies et al., 2010).

Flexible movements as well as pasture tracking are regarded as essential responses to erratic environmental variability as such it should not be impeded. In some instances, these portrayals factor in the building of tenure institutions that depend in part on predictable variability, such as seasonal or spatial (Turner &Schelct, 2019). Some land tenure changes have been observed to be coming directly from the pastoralists themselves with the objective of having full control over their lands to keep agriculturalists, conservation organizations as well as other influential groups from having title to their lands (Silver et al., 2008; Galvin et al., 2008). Similarly, with pastoralists diversifying their livelihood into agriculture, the effect is that pastoralists end up losing access to high-value resources mostly dry season forage areas (Fratkin, 2001).

2.2.8 Land cover change

Land cover refers to the characteristics of the earth's landscape and the immediate subsurface, including the soil, biota, topography, groundwater, and surface via human constructed structures

(Homer et al., 2015). Land-cover change denotes the replacement of the initial land cover type by another and is detected by an alteration from a single land-cover class to another class as is evident in deforestation, agrarian expansion, and urbanization. Land-cover alterations affect the character of the land cover and sometimes may not necessarily affect the general classification of the land cover (Lambin et al., 2006; Ramankutty et al., 2006; Homer et al., 2015). Land cover change therefore encompasses deviations in actual and possible primary productivity, biotic diversity, soil fertility and other qualities of the terrestrial surface of the planet (Lambin et al., 2006). Land cover changes are noticeable in remote sensing data, and secondary data through agricultural census data that require interpretation and ground truthing (Lambin et al., 2006; Lambin & Meyfroidt, 2010). In the context of this study, land cover refers to the biophysical (e.g., soil, and water) land surface while land use is related to any human administration activity affecting land. Land use change hence refers to either a shift into another land use or the intensification of the existing land use (Lambin & Meyfroidt, 2010).

Also, the term land cover change, implies a change in certain continuous characteristics of the land such as loss of natural vegetation especially loss of forests to urban development or the loss of agricultural areas to urban or exurban development (Anthropocene, 2018). Drylands are the most occupied land cover on earth, which support the livelihoods of many people. Notwithstanding the enormous benefits of drylands, it is also extremely vulnerable to risks of environmental degradation, climatic perturbation as well as increasingly the several impacts of global climate change (Boone at al., 2018; Engler et al., 2018; Galvin, 2021). Recent environmental degradation, climate change, growth in human population, resource extraction coupled with other development have had negative impacts on land use and land cover changes,

which have dire consequences in ensuring food security and livelihoods of indigenous populations (Galvin et al., 2008; Reid et al., 2014).

The conditions for pastoral land use are increasingly becoming complex as a result of the progressive fragmentation processes (Greiner et al., 2021). Eventually, forage areas are reducing as a result of either to a change in quality (modification) or by "a direct change in the composition of the elements" attributed by Reid et al. (2004, p.172) to loss or conversion. Pastoral drylands with forage lands are increasingly been decreased and access to forage is changed by other types of land use like farming, conservation or infrastructure development (Galvin, 2009; Reid et al., 2004; Reid et al., 2014). Apart from farming, land cover change can also be as a result of the loss of access due to bush encroachment and this can be invasive, localized, rapid or incremental as well as wide-ranging, which eventually increases land fragmentation (Griener et al., 2021). Both farming and bush encroachment consequently alter mobility patterns particularly the migration of pastoralists out of the area since livestock herds need to escape dense bush land as they urgently require to circumnavigate farmlands (Greiner et al., 2013).

2.2.9 Adaptation

Adaptation refers to the process by which individuals lessen the adverse effects of changing provisioning ecosystem services on their livelihoods or well-being (Aritiet al., 2015). This normally comprises alterations in economic structure, lifestyle and activities intended to lessen the susceptibility of an ecosystem to land use and cover change, and in so doing increasing its sustainability (Ariti et al., 2015).

Adaptations are the features that increases an organism's chance of survival in a given habitat. Involving traditional ecological knowledge to appreciate the extent of the capacity and resilience of systems at the local level that enhance adaptation (Tugjamba et al., 2021). Complimenting indigenous ecological knowledge with Western scientific knowledge results in an opportunity for effective and efficient adaptation strategies at the local level (Makondo & Thomas, 2018). Although evidence points to the use of traditional knowledge and practices for coping with natural hazards as well as adapting to changing environments have long been transformed from one generation to another generation, however such knowledge and practices are mostly abandoned or underutilized in formal adaptation strategies (Leonard et al., 2013; Makondo & Thomas, 2018; Naess, 2013).

Whilst there is a growing concern to the use of traditional and indigenous ecological knowledge in adaptation (Leonard et al., 2013; Pearce et al., 2015) as well as other few studies have focused instead on its role in temperate and climate regions (Reyes-Garcia et al., 2016). Little emphasis has been given to local knowledge as a major component in decision making regarding adaptation in many parts of Africa (Leonard et al., 2013). McNamara and Buggy (2017) are, however, of the opinion that the use of traditional knowledge can be incorporated into adaptation as well as the role ecosystem services might play.

In recent times, pastoralists have adopted the traditional seasonal mobility strategies as a major adaptive approach in order to migrate to better forage and water resources in order to enhance the well-being of their livestock. This adaptation approach by the pastoralists is helping to play

significant role in the maintenance, restoration and conservation of grazeland ecosystem services (Tugjamba et al., 2021). The study confirms that the use of traditional knowledge is significant to developing the right, locally-based policies and adaptation plans.

2.3 Patterns and Trends of Climate Change

According to the IPCC's most recent assessment report, global climate change is progressing more rapidly than it has in the past (Kabo-Bah et al., 2016). Between 1901 and 2010, the world's average temperature is projected to have risen by around 0.07 ^{o}C, with more increases possible in the near future (Morice et al., 2012; Barry et al., 2018). Climate change is becoming more severe in many nations as a result of environmentally damaging activities such as pastoral activities, farming, mining, and timber harvesting, as well as infrastructural growth to suit human requirements (Lobell et al., 2011). Drought, carbon emissions, high temperatures, and natural disasters are becoming more common as the pace of climate change accelerates (Boyd et al., 2013; Fagariba et al., 2018). As a consequence of climate change, sea levels are increasing due to melting glaciers, and the Sahara Desert is fast spreading by 11% to 18%. (Thomas & Nigam, 2018).

Africa is considered most vulnerable continent to the effects of climate change due to its great poverty, harsh weather, and inadequate government assistance (Fagariba et al., 2018). West Africa is hit most by the effects of climate change, such as precipitation decreases that have serious consequences for the freshwater and pasture production (Niasse et al., 2004; Barry et al., 2018). The average annual temperature in West Africa rose by 0.90 degrees Celsius between

1990 and 2010. Furthermore, it is anticipated that by the year 2050, the magnitude would have significantly increased (Sissoko et al., 2011; Fagariba et al., 2018); and that the continent would become drier than before due to intense and prolonged droughts (Lobell et al., 2011; Boyd et al., 2013; UNFCCC, 2007). Temperature, rainfall frequency and volume, and sea level rise have all been significantly influenced by climate change in African. Because of this, agricultural output particularly pastoral mobility is impacted (Di Falco & Veronesi, 2013; Pereira, 2017; Serdeczny et al., 2016). Although natural factors may also influence climate, human actions are ultimately to blame for global warming (Ballew et al., 2019).

Increases in temperature, decreases in rainfall, and more irregular precipitation are just some of the ways climate change is already being felt in Ghana (Bendell, 2018; de la Poterie, Burchfield, & Carrico, 2018). According to Biesbroek et al. (2013), prolonged droughts in Northern Ghana have considerably contributed to high temperatures, soil sterility, and low water retention capacity. Furthermore, deforestation and increase pastoral mobility are considered to have a substantial role in the rising occurrence of climate change in northern Ghana (Dickinson et al., 2017). The rainy season has been shortened to June to September, despite significant reductions in rainfall quantities and variable weather patterns (Ramanathan et al., 2005; Dash et al., 2007; 2009). Ghana is one of the nation's that is most susceptible to climate change (Apuri et al., 2018). The upper regions of Ghana in recent times has experienced weather event such as erratic rainfall, high temperatures, dry spells, and delayed rains, which have affected pastoralist ability to respond properly to the spatial and temporal availability of resource. These areas have also seen out breaks of livestock diseases (Kanlisi & Arkum, 2013).

2.4 Global Changing Patterns of Mobile Pastoral Systems

Pastoralism is an old kind of human activity. Globally, pastoral phenomena range from Asia's steppes to Andean areas in South America, and from the highlands of Western Europe to Africa's savannah plains. In the previous millennium, pastoral systems spanned over 25% of the world's landmass and contributed almost 10% of the world's meat supply. The system also assisted approximately 200 million families (Davies et al., 2010). These systems were largely found in deserts, arid plains, savannahs, steppes, tundra, and high-altitude mountain ranges, but they all shared the exploitation of transient concentrations of resources (Behnke et al., 2011). Herders in pastoral systems employed mobility to target the uncertain supply of resources over the previous millennium, whereas other household members may have been sedentary for part or most of the year. Herders select prime grazing sites with species combinations they know would benefit their animals. The objective of this "strategic mobility", according to African Union (2010), is to allow them to increase productivity by feeding the animals a diet with a higher nutritional content than the range's average.

The Pre-historic man in Africa just like the San hunter-gatherers and Koikoi pastoralists are perceived to have arrived in Southern Africa around 2000BP with domestic livestock although some researchers have pointed to a later arrival (Cutling, 2008; Sadr, 2008). The people who occupied Southern Africa were primarily into rearing of sheep and cattle as evidenced in the study by Webley (2007). Sadr (2008) confirmed this indicating the existence of adequate archaeological evidence to confirm that the inhabitants were highly mobile in their use of the variable graze land.

With the arrival of Europeans into Africa and the introduction of the cultivation of vegetables and wheat to support pastoralism by the missionaries, the idea was to station pastoralist closer to the missionaries (Samuels et al., 2020). Although pastoralists adopted cultivation, they did not settle rather they added the cultivation of crops to their grazing systems as they move their livestock to low altitudes where there is enough forage and water usually for the months of April to September and then they returned to the upland environment during the dry summer after harvesting their crops and the livestock grazing on the stubble (Samuels et al., 2020). Although the adoption of crop cultivation incorporated mobility, it consequently heightened pastoralist vulnerability to frequent dry seasons due to crop failures (Kelso & Vogel, 2015).

In line with the views by researchers on pastoralism is the position by early anthropologists on pastoralism and other mobile livelihoods such as hunting and gathering, which are regarded as ancient livelihoods linked with cultural evolutionary pathways resulting in crop cultivation, economic surplus as well as territorial forms of governance bringing to bear capitalism and the modern native state (Kuper, 2005). Technically, livestock mobility is regarded to act against the spatial fixity of capital investments needed for the intensification of livestock husbandry (Thornton, 2010). Additionally, pastoralism as a source of livelihood and pastoralists as people are noted to have interests such as mobility that act against private property institutions (McCarthy & Di Gregorio, 2007).

Mobile pastoralism is regarded as the movement of people and livestock from one geographical area to another and is largely practiced across the world most especially in environments that

experience severe weather conditions such as severe temperature fluctuations, low precipitation and several months of drought (Mapiye et al., 2009). Transhumance is considered to be a major feature of mobile pastoral system where livestock are moved on ecological gradients like altitude, rainfall, soil, moisture as well as hydrology with the aim of searching for forage in order to sustain and optimize growth and reproduction (Homewood, 2008; Fynn, 2012; Fynn et al., 2015).

Many have been written about pastoral land use systems in the past, however several researchers in recent times have suggested their change in other forms of land use in the face of climate change, growth of human population as well as globalization (Homewood et al., 2001). Pastoral areas across the globe have experienced significant changes in their environment as well as management systems over time. Kelso (2010) in her study revealed that climate change has greatly affected the livelihood of people to the extent that their ability to cope with the intensity and frequency of droughts have decreased in the 19th century. The decline in the 19th century was attributed to factors such as encroachment of settlers on traditional lands, increased dependence on cultivation and decrease in grazing lands at disposal for the practice of transhumance. Kelso (2010) further opined that the encroachment of colonial farmers on traditional grazing land led to decreased land availability for herds particularly during drought periods.

Pastoralism was viewed as an unreasonable devotion to a traditional way of life beginning in the twentieth century. And recent ecological models, on the other hand, are beginning to emphasize how pastoralists not only make optimal use of resources in rangelands and semi-arid lands, but

also how pastoralists exploit their mobility to capitalize on extremely unstable conditions (Shaughnessy, 2018).

Pastoralism refers to a system of livestock rearing, which is centred on extensive land use as well as some types of herd mobility practiced across several parts of the world for over centuries (WISP, 2007). Pastoralism is distinguished by herd mobility in pursuit for grains and water. As a result, it is made of three parts namely, humans, cattle and natural meadows. Pastoralism is a common way of life in less-favourable sittings such as, drylands, mountains and frigid locations where natural pasture as scarce. Pastoralists have long exploited and maintain drylands, which house approximately one-third of the world human population and almost half of the world cattle (Bovel et al., 2016; Tamou, 2017). According to the FAO (2001), pastoralism covers about 25% of the total land area, particularly across the developing nations spanning from the drylands of Africa, the Arabian Peninsula, through the mountainous parts of Asia, the Latin America where cultivation is not much prevalent. Presently, it has been observed that cattle and sheep herders in places such as Western North America, Australia, New Zealand and other parts of the world currently practice a modern type of pastoralism (Dong et al., 2011). It is estimated that pastoralism globally in recent times assist about 200 million households in addition to herds of close to a billion livestock such as camel, cattle as well as few livestock that are estimated to be about 10% of the world's meat production (FAO, 2011).

Notwithstanding the benefits of pastoralism to human survival through the provision of food and ecological services, economic benefits particularly to the poorest regions in the world, the seemingly threats as well as pressures linked to increase human population, economic

development, land use changes, and climate change are challenges confronting pastoralists in sustaining and securing the significant social, cultural, economic and ecological properties globally (Nori & Daves, 2007). Very notable ecosystem services particularly biodiversity and food production being made available through rangeland ecosystems can be exposed to both climate change and large-scale socio-economic pressures (Schroter et al., 2005; Abildtrys et al., 2006).

The semi-arid transition zone, which is found between the Sahara Desert and the sub-humid savanna zone, the significant pastoral production zone in Africa over centuries is the Sahel due to its significant features of physical and climatic conditions and also associated plant locations. For Brooks (2006), pastoral livelihoods within the Sahel regions historically have relied heavily on negotiated, non-exclusive access to availability of water and its resultant land use measures established between pastoralists and agriculturalists. Stemming from the flexibility of the traditional system coupled with its ability to swiftly address the changing environmental conditions, it suffices that the Sahel regions are well placed to the ecological and sociological conditions (Jarvis, 1993; Marshall & Hildebrand, 2002). Nonetheless, climate change, excessive environmental degradation, and the quest improve agricultural production in order to meet the demands of the teeming population, the adaptability of pastoralism that rely on water availability and grazeland production are currently being hampered (Watkinson & Ormerod, 2001).

Ahmend et al. (2000) has corroborated that the Sahel regions have been characterized with unpredictable large amounts of rainfall for the periods 1950 and 1960s at a time most African nations were gaining independence and thus focused on the development of modern, technocrat

remedies to development to ensure economic growth as well as traditional resource management and food security have been challenged. As a result of the effects of climate change across the Sahel regions, social conflicts between agriculturalists and pastoralists as well as its associated challenges can be escalated. Similarly, studies have shown that the frequent incorporation of pastoralists into modern states across Africa has resulted in a progressive, political, economic as well as cultural marginalization of pastoral communities (Azarya, 1996). These have consequently also led to some regions exposed to a "world of insecurity, war, famine and also drought" (Baxter, 1993, p.143).

2.5 Changing Patterns of Mobile Pastoral Systems in Africa

Pastoralism in Africa dates back to the third millennium BC during the period few-cattle herding, fishing as well as hunting occupied most parts of Southern as well as Southern Nilotic-speakers (Spear, 1993). From generation to generation, more pastoral communities occupied mostly the savannah plains in Africa through communal reforms that pave way to the existence of transhumant. For these communities, cattle rearing gained prominence and great value as a major source of their livelihoods (Kayla, 2011). The ecological variability in most parts of Africa posed a hindrance for pastorals.

According to Mwangi and Ostrom (2009), Africa's savannah ecosystems cover about 40% of the total Africa land area that supports about 50% of the entire population of Africa. Parts of Ghana, particularly Northern Ghana, is located in the semi-arid savannah with irregular rainfall and frequent droughts that confront the inhabitants on a daily basis in the pursuant of their livelihoods. There is also the experience of unpredictability in the weather patterns.

Traditionally, most pastoralists are noted to be conservation mindset who live in sustainable relationship with wildlife (Gadd, 2005; Parkipuny, 1989). For pastoralists, their life has been traditionally characterized with negotiated, seasonal herd migration between wet as well as dry season grazing areas across rangeland landscapes. They depends largely on access to key natural resources such as pastures, watering points, movement corridors that linked together seasonal grazing areas, pastoral settlements or encampments, and markets required to sustain mobile livestock production (USAID, 2019; Morris, 2017). In the pastoral communities, council of elders were established and empowered to allocate resource use and access to rangelands (Mwangi & Ostrom, 2009).

By the close of the 19th century, there was dramatic change in the savannah areas with regards to the introduction of restriction of local control over resources, forced promotion of sedentarization and consequently the inception of established protected areas for wildlife conservation (Campbell et al., 2000). For the British who colonized parts of Africa, most of the seasonal herd movements were resettled and the collectively-owned areas were converted to private, individually-owned farms and also commercial ranches (Mwangi & Ostrom, 2009). As part of regulating rangelands, the colonial government modified property rights system and restricted the number of livestock through the creation of "grazing schemes" in the case of Massai in Kneya (Mwangi & Ostrom, 2009).

Activities of the colonial government led to changes in livestock mobility and productivity. There were both social and ecological loss. The colonial government ended up usurping

authority in decision making from local herds thereby hindering herds to applying local knowledge to appreciate environmental relationships in the communities. For parts of Africa where pastoralism is the major source of livelihood in the semi-arid rangelands, pastoralists in these places are equipped with the knowledge to embrace diverse adaptive strategies that promotes mobility (Butt, 2010). Socio-ecological systems like pastoral livelihood techniques therefore require interdisciplinary problem solving with variable and multi-layered institutions emerging from the colonial system.

Considering the fact that pastoralism has been linked conceptually to livestock mobility, it has resulted in diverse opinions leading to negative notions of both within the African conservation and development since the colonial era. Given the fact that the incidence of forced sedentarization of pastoralists are well known, there are other many widespread policy postures succinctly explained as malign neglect (Turner & Schlect, 2019). Since livestock mobility has been regarded as a primitive cultural feature with competing land use pressures, pastoralists have resorted to change livelihoods or decrease the mobility of livestock they reared (Turner & Schlect, 2019).

2.6 Patterns of Mobile Pastoral Systems in West Africa

Mobile pastoral system is considered as the movement of people and livestock from one environment to another environment (Samuels et al., 2021). Mobile pastoralism is practiced across the world however it is prevalent in environments with severe weather conditions in which cultivation of crop is regarded risky and frequently susceptible to failure (Mapiye et al., 2009).

Again, according to the African Union (2010), pastoralism basically is a way of life and production system that basically depends on livestock raring, particularly, small ruminant cattle and camels. These systems of production are mostly practiced by people who inhabits arid and semi-arid areas of Africa's, which is mostly characterized by noticeable rainfall patterns, and coupled with uncertainties in the spatial and temporal distribution of water resource and grazing for animals. Robbins (2019) indicated that pastoralist generally live in isolated, remote and underdeveloped areas. These are as are usually prone to conflicts, characterised with food insecurity and associated with high levels of environmental vulnerabilities. Although mobility is a key feature of pastoralists in different parts of the world and is often seasonal in nature, many diverse forms of movement are practiced according to local environments and types of livestock reared (Rass, 2006; IFAD, 2009). Such movements are mostly not random and or irrational, but highly strategic to draw on local information gathering and risk analysis (FAO, 2020).

Mobile pastoralists across the world are usually limited to marginal lands (Reid et al., 2014). Hence, they usually have to face the variable climates that are persistently linked to the negative effects of global climate change. Additionally, diverse policies and socio-economic factors also considerably affect negatively on pastoralists livelihoods and further heightened their vulnerability (Cutter et al., 2009; Dong et al., 2011; Samuels, 2013). To mitigate the dynamics and challenging nature of the grazing systems, pastoralists have the options of either to migrate from the area or adapt to the severe conditions in order to make available enough food and water for their livestock (Samuels et al., 2018).

One of the major sources of income and food to most rural households in Sub-Sahara Africa include the rearing of livestock (Thorton, 2010). Irrespective of the enormous benefits of livestock rearing, it is confronted with challenges such as prevalence of traditional practices as well as natural rangelands that form the major pasture for herbivorous animals (Babatounde et al., 2011; Assani et al., 2015). Low rainfall in many parts of the rangelands has resulted in herd mobility in West Africa (Barthel et al., 2009). The seasonal transhumance has become a major means of the adaptation strategies to address the temporal and spatial shortages of pasture as well as water across West Africa (Samuel et al., 2013; Turner et al., 2014; Zampaligre et al., 2014; Sakamoto, 2016). Two forms of transhumance have been identified in literature; which is the short distance transhumance that is limited to the boundaries with a particular pastoral area, either within (national transhumance) or far (cross-border transhumance) the national boundaries.

Notable environmental drivers to mobile pastoralism encompasses severe temperature fluctuations, mostly on a seasonal cycle, decreased precipitation, mostly patchy scattered with its associated high variation between seasons or drought for many months to many years (Samuels et al., 2020). Across the world, traditional pastoral grazing system are consistently being fragmented, smaller and spatially restricted as a result of environmental, socio-economic and political factors (Turner et al., 2005; Makepe, 2006; Behnke, 2008; Flintan, 2011). For some regions, there has been lost of pastoral lands as a result of the proclamation of conservation areas (Kipuri & Naikuni, 2008), however other former pastoral lands have been converted for crop cultivation (Turner, 2003). With the restriction of grazing lands in some regions, herd mobility has either been limited to demarcated or privatized grazing lands or mobile pastoralists have

been restricted from accessing significant forage resources for their livestock in critical periods of the year (de Weijer, 2007). This consequently harm pastoral mobility by increasing the vulnerability of mobile pastoralists at a period when the impacts of climate change have increasingly become extreme.

In recent times, livestock activities are confronted with bushfires as one of the major anthropogenic activities that hampers the availability of pasture (Akpo et al., 2002; Arounaa, 2012; Oloukoi, 2013; Dioggo et al., 2017; Salion et al., 2014). The need to meet the demands of the increasing human population in terms of food and other domestic demands have led to grazelands. Similarly, encroachment of agricultural lands to grazelands can hinder traditional transhumance routes (Lesse, 2011; Sulieman & Ahmend, 2013; Zakari et al., 2015) and as such obstruct herd movements. In recent times, violent and deadly conflicts between local and foreign cattle herds have become prevalent (Lesse, 2011; Ange et al., 2014; Lesse et al., 2015).

2.7 Patterns of Mobile Pastoral Systems in Ghana

In Ghana, it is on record that the majority of cattle herds are mostly owned by the Fulanis whose activities are scattered around the regions of Ghana but predominantly in Northern Ghana, Asante and Eastern Regions (Napogbong et al., 2020). The general activities of pastoralist in Ghana have been characterized with unpredictability of annual rainfall and extreme temperature most especially in Northern Ghana, consequently pastoralists in Ghana are currently embracing new adaptation strategies that are locally acceptable and have the tendency to decrease farmer-herder conflicts (Bukari, 2016; Bukari et al., 2018; Kuusaana & Bukari, 2015). Notable among the adaptation strategies employed by the herds include language, indigenous technical

knowledge and culture. For many years, the herds have used the traditional knowledge system as a way of mitigating against the effects of climate change.

The herding system in Ghana, just like many other pastoral communities in Africa, is characterized with both random and planning transhumance movements and responsibilities are apportioned according to gender roles and age (Tonah, 2002). Their movement patterns are fundamentally caused by climate stressors like heat, access to water, green grazing fields, environmental quality as well as influenced by their traditional environmental knowledge of the area (Adebayo, 1991; Bukari, 2016; Tonah, 2002).

Many semi-arid regions in Ghana have along history of herder-farmer conflicts (Bukari, 2016; Bukari et al., 2018). Most of the conflicts are due to the complexities of the land tenure and decreased access to water (Bukari, 2016). The semi-arid regions are usually characterized by grass and frequent drought, drying up of water bodies leading to prolong dry season and inadequate water for livestock (Ahmend et al., 2020). Resulting from the biophysical restrictions, adaptation strategies are usually fought for between herds and farmers and mostly result to serious clashes (Bukari et al., 2018).

2.8 Underlying Drivers of Change in Pastoral Mobility

The sustainability of pastoralism has become a regular topic for discussions as well as the improvement in knowledge based on the survival of pastoralism with regards to global environmental change since the mid-2000s. In the meantime, while some are of the opinion that pastoralism is fading off as a result of internal causes such as recent climate change falling

beyond its adaptive capacity (Steen, 1994; Markakis, 2004; Sandford, 2006). Others also track the foundation of the pastoral weakness in its settings in deprived places coupled with undesirable environmental conditions (Jonsson, 2010). The culmination of these factors may result to "multiple stressors", which discourage pastoralism (Thebaud & Batterbury, 2001; Miller, 2008).

Many researchers are of the opinion that pastoralism is more appropriate when compared to other land uses to excel under the changing environmental conditions (Bradley & Grainger, 2004; Davies & Nori, 2008; Jones & Thornton, 2008). Globally, indigenous pastoral grazing systems are rapidly becoming smaller, fragmented as well as spatially challenged as a result of environmental, socio-economic and also political factors (Turner et al., 2005; Makepe, 2006; Behnke, 2008; Flintan, 2011). For some pastoral communities, there has been a loss of pastoral grazing places stemming from the proclamation of conservation areas (Turner, 1999; Kipuri & Naikumi, 2008). Meanwhile, some others, especially pastoral lands, have been turned into agricultural crops.

Further, pastoralists are obstructed in their activities due to administrative barriers in place at both local and international levels (Fernandez-Gimenez, 1999). The effect is that herd mobility has thus either become confined to assigned or privatised grazing places (Kimani & Pickard, 1998) or that mobile pastoralists are denied to important pasture for their livestock during crucial times of the year (de Weijer, 2007). The restrictions on the pastoral movement have the likelihood to add up to the vulnerability of mobile pastoralists at a period when the effects of climate change are more severe.

With regard to change in pastoral mobility, studies have shown that the socio-economic feature of pastoral households influence cattle management strategies that can adversely affect the productivity of cattle (Houessou et al., 2019). Ethnicity, for example, is noted to play a significant role in the adoption of a particular pastoral mobility strategy. Sedentary herding is mostly practiced by indigenous farmers of different ethnic groups who are into the cultivation of crops as their major occupation compared to the agro-pastoralists from the Fulani ethnic groups for whom their major source of income is livestock (Ayantunde et al., 2011). Although sedentarization as well as livelihood diversification through adoption of crop cultivation isnot a new trend for pastoralist in East and West Africa, the new addition is the expansion of crop cultivation within Fulani pastoralists (McCabe et al., 2010; Thebaud & Batterbury, 2001; La Rovere et al., 2005). Studies have shown that pastoralists, particularly the Fulani herdsmen being it native or migrants, have limited access to land and pastoral resources and this is a major challenge to the development of livestock production (Pierrre, 2015). Some observations have been made in Ghana by Bukari and Schareika (2015).

2.9 Transitions in Mobile Pastoralism

A number of changes have taken place within the pastoral systems. These changes affecting grasslands and also pastoral communities include land tenure, land use, intensification, sedentarization, institutional changes as well as climate change. Others also include increase in human growth, wildlife conflicts and conservation policies. Many of these factors are major drivers of change while some are equally adaptive strategies to face the changes. The outcome of

these results would include changing herd size and structure, cultivating cereals and wage (Kathleen, 2009).

Based on the understanding of new range ecology, some researchers have designed pastoral economic model as an alternative to the traditional risk-aversion type that identifies pastoralism as a great-reliability system (Roe et al., 1998; Kratli, 2008; Roe & Schulman, 2008). Instead of pastoralism regarded as a coping strategy to address insufficient resource base, it is rather identified as an economic strategy unique of uncertain environment as well as develop to take advantage of the variable as well as scattered resource allocation of pasture. Pastoralism is noted to be working not without risk but by embracing the risk as the very core of production, it is asserted that the pastoral economic system is "proactive", methodological as well as focused at value creation and optimum maximization instead of just survival (Kratli & Sharika, 2010).

Many scholars have written on the unending changes that pastoral lands have had to endure over time with some predicting of changes inland use in a time when issues of climate change, human population growth and globalization have become topical (Homewood et al., 2001). Galvin (2009) identified two main factors contributing to the transition in mobile pastoralism. A major contributing factor to the transitions in mobile pastoralism is about the fragmentation of once closely intact grasslands. Fragmentation, as identified in the review of Galvin (2009), is the dissention of natural systems into spatially isolated parts, which is caused largely by socioeconomic changes. Changes in land tenure system from communal to private ownership is noted to mostly contribute to grassland fragmentation. Another cause of fragmentation includes changes in land use that result in a disconnect of once intact grasslands, hence

compartmentalizing significant parts of the environment (Galvin, 2009). An instance can be seen in the case of agriculture that comes with it economic inputs like fence and well-water construction (Western, 2002; Boone et al., 2007; Hobbs et al., 2008). The consequence of land fragmentation is a decrease in the scale of the landscape over which human pastoral management happens (Galvin, 2009). Alternatively, in the face of land fragmentation, the only way out is to assist pastoralists and their livestock to improve economic and policy inputs (Galvin et al., 2008a; Hobbs et al., 2008).

Another major source of change to grasslands resulting in the transitions in mobile pastoralism is climate change. Although climate change can be considered to be a factor to fragmentation, for the purpose of this review, it is regarded separately due to the possible magnitude of change that can be extraordinary in scale and which can be beyond one's experience (Adger et al., 2007; Galvin et al., 2008a). High climatic variability is prevalent in the semiarid and arid grasslands, however with the increasing fragmentation, greater inputs are needed to mitigate the effects of climate perturbations (Galvin, 2009). Several studies have confirmed that the potential source of change in the environment may also result in change in the structure and function of the ecosystem and by extension it consequently will affect the livelihoods of the people who rely on the ecosystem (Holling & Gunderson, 2002; Walker & Abel, 2002; Hobbs et al., 2008).

Sedentarization is another phenomenon that has been identified to affect the pastoral systems (Galvin, 2009). Sedentarization within the pastoral systems is as a result of several factors as opined by Frankin (2004) in places such as Ariaal, Rendille, Borana and Samburu in the northern part of Kenya. Factors necessitating pastoralists to migrate out of the pastoral environment

include population growth, loss of land, droughts and livestock raiding (Galvin, 2009). Sedentarization attracts both the poor and wealthy herders, however the poor herders usually migrate to towns due to loss of livestock and the quest to secure work in towns (McPeak & Little, 2005). Despite factors associated to sedentarization, it does not entirely show a full-time departure from pastoralism or does it also significantly affect pastoral production as opined by McPeak and Little (2005). That notwithstanding, empirical study in parts of northern Kenya have shown that vulnerability to livestock losses during drought give rise to sedentarization. Hence, higher levels of mobility result in less-drought related livestock losses. Studies have confirmed that as human population increase and land is cultivated, sedentarization results in increased human-wildlife conflicts as a result of competition over scarce resources (Chatty & Colester, 2002; Western, 2002).

2.10 Spatial Scales of Pastoral Mobility

An analysis of spatial scales of pastoral mobility identifies four main transhumance modes through the use of a combination of survey as well as GPS mapping (Xiao et al., 2015). The four transhumance modes of pastoral mobility come with its own properties. According to Xiaoet al. (2015), the first and second modes of pastoral mobility represent the form of transhumance movements where pastoralists relocate to a community for along period of time usually more than 20 days and then migrate around the community but without any particular focus within a seasonal grazeland. The third and fourth modes of pastoral mobility by Xiao et al. (2015) is where pastoralists move to a community for a very short time usually less than 20 days when migrating between seasonal grazelands.

Different spatial levels exist to understand pastoral mobility spanning from daily movements to pasture and water (De Boer, 1989; Moritz et al., 2010), rainy and dry season grazelands as well as migrating across country borders for a scale of decades (Stenning, 1987; Boutrais, 1996; Bassett et al., 2007). Empirical studies have revealed that pastoral mobility is very efficient and sustainable approach to cope with spatial variation in grazing lands, which is typical in both arid and semi-arid ecosystems (Coughenour et al., 1985; Ellis, 1988; McCabe, 2004; Brotten, 2014). Although researchers have studied pastoral mobility for a long time (Stenning, 1987; Barth, 1961), the application of global positioning system (GPS) and mapping technology has enabled the study on pastoral mobility to be largely effective (Copolilo, 2000; Butt, 2009).

Due to the challenges associated with following several herds scattered over vast rangelands, many studies follow a few personal households, spanning from one (34) to 24 (31). Several methods developed within the space-time geography and ecology literature are eminent since the traditional space-time geography (Miller, 1991) centred on the analysis of the likely areas usually referred to as "space-time prisms" where an individual can arrive between the origin and destination areas within a given-time budget and speed (Andriansen et al., 2002; Galaty, 2013; Vosloo et al., 2002; Bornsvoort et al., 2004; Hagerstrand, 1970; Miller, 1991; Kwan, 1998). Research has shown that individuals do not visit every possible area at the same time, instead some areas with greater opportunities are visited more often than others (Xiao et al., 2015).

2.11 Effects of Climate Change on Land Use and Land Cover

The IPCC reported that the rate of occurrence of climate change is rather speeding than was expected. This has greatly influenced land use and land cover in many parts of the world (IPCC,

2014; Kabo-Bah et al., 2016). Changes in land use and land cover may have an impact on climate, and be impacted by climate. According to Smith et al. (2020), climate change has a negative effect on land degradation and land usage. It plays a major role in the processes that leads to land degradation, which in turn leads to a shift in land use and cover. Warmer and shorter winters are expected as a result of rising temperatures and precipitation, which alters land use and cover patterns globally. Climate change is already affecting the land, threatening human and animal life, ecosystem and other important services (Sunderland &Rowland, 2019). High winds and dramatic temperature swings are two examples of extreme occurrences becoming more common due to climate change that may have a negative impact on ecosystem biophysical process. There is a growing concern that these occurrences will pose an even greater risk over the coming decades (Fezzi et al., 2015; Daneshi et al., 2021).

Activities that land is put to greatly influence the extent of changes in land cover. Thus, land use changes that have occurred in the last decades are responsible for the main land use and land cover changes that may occur in the future (Tasser et al., 2017). Land is the most abundant yet contested resource with variety of interest thereby making the resource scarce (Froese & Schilling, 2019). These interests may be categorized into two including primary and secondary interferences. The primary interference include such activities induced as a result of population growth including deforestation for agricultural expansion, urbanization, thereby transforming formerly agricultural lands for settlement, among others. These all contribute to transforming the land use and land cover (Detges, 2017; WBGU, 2008). On the other hand, secondary interferences include such activities undertaken to mitigating the impacts of climate change. These may include activities such as development of large-scale renewable energy plants or

resettlement efforts as adaptation to climate change (Barnett & Chamberlain, 2010). These are measures taken to minimize the adverse effect of climate change but end up indirectly increasing pressure on land and thereby transforming the existing land use and land cover (Boncour & Burson, 2009; Froese & Schilling, 2019).

It must be noted that climate change is mainly caused by human activities. The activities of man leads to the changes we experience in the various parts of our ecosystem (IPCC, 2007; Khosravi et al., 2017). Aside from the environmental risk of floods and droughts resulting from climate change, land use can be affected severely by the climate mitigation and adaptation strategies adopt by people (Froese & Schilling, 2019). Therefore, it is clear that land use and land cover change is not only influenced by changing climatic conditions but include human interferences resulting from population growth, urbanization and consequent increasing pressure on ecosystem resources (Revi et al., 2014). Vegetation cover reduction has been recorded everywhere due to events of climate change (Talib & Randhir, 2017). It is expected that by 2100, changes in climate will significantly impact on land use and land cover changes (Talib & Randhir, 2017).

2.12 Effects of Pastoral Mobility on Land Use and Land Cover

Human communities need dryland ecosystems to undertake several services particularly as the pressure on drylands increases as a result to local effects of overgrazing and climate change (Chuan et al., 2020). Traditional rangelands facilitated a small economy that was primarily milk based, but also produced livestock products. Several pastoralist communities are encountering significant change in land use since the pressure over land increases, and as a response to market and some other forces (Davirs et al., 2020). The significance of mobility in several pastoral

systems mostly results to difficulty in securing land in several nations due to the fact that mobility usually depend largely on communal ownership, regulated through customary institutions that are mostly not regarded in statutory protection off common property rights and rather assign priority to land privatization focused on individual title, although statutory recognition of common property arrangements are now identified in diverse places such as Scotland and Uganda (Fuys et al., 2007).

For some years now, there have been several changes that have resulted in the adaptive strategies to be better placed to cope with the changing pastoral production systems (Kirwa et al., 2012). Some notable causative factors include sedentarization of pastoralists as a result of increased influence of central government whose responsibility is to provide social amenities (Chuan et al., 2020). Further, sedentarization has become prevalent lately as a result of the change in land tenure due to the sub-division as well as individualization of ranches. Increased sedentarization has consequently decreased pastoral mobility and organized the people and livestock close to the water points leading to increased land degradation; thus intensified their vulnerability to drought, and affected the viability of the livestock production, which is the bane of pastoral livelihoods.

Higher possible rangelands have been converted for other land uses (IRIN, 2007), which has consequently decreased dry season grazing. This has therefore reduced pasture resource base, the pastoralists who can no longer withstand subsistence livestock production have resorted to adapting other sources of livelihood such as farming and income generating activities. This has also resulted to shifts in pastoral strategies like the use of secondary grazing land rights, which involve providing farm labour by the agro-pastoral communities (Nyangito et al., 2008).

Similarly, pastoral and agro-pastoral communities have led to a reduction in livestock herds as a result of the decrease in grazing areas and hence missing the benefits of maximizing on the number of livestock to support against total losses of drought (Chuan et al., 2020).

Lately, studies have shown that the adoption of certain principles by many developing countries in the form of land tenure reform, decentralization, devolution and democracy has enhanced some mobile population in terms of their security with regards to access to land, resources and services (Davies et al., 2010). For instance, empirical study in Bolivia where natives made up of over half the rural population, a new land law was passed to create the concept of community lands of origin, which led to the restitution of large territories in support of the indigenous people (Kay & Urioste 2005). Conversely, the international covenant on Economic, Social and Cultural Rights disclosed in their study that original inhabitants are mostly threatened by and vulnerable to loss of access to their cherished ancestral lands (FAO, 2005). Consequently, pastoralists continue to be at the disadvantage due to structural challenges as well as the need of several legal systems in terms of strict definitions of boundaries, single systems of rights as against multiple rights and strict codification (Davies et al., 2010).

Pastoralists continue to be confronted with the loss of key rangeland resources that has significant implications for pastoralists systems, as evidenced in Ethiopia where grazing land and water access has been lost, particularly in the Afar Region, hence disturbing the pastoral economy (Motzfeldt, 2005). The loss of major key resource areas mostly results in a significant blow to the pastoralists system due to the fact that these areas mostly provide buffer resources that are only engaged in moments of duress; hence the resources are declared as vacant and title

assigned to some other users (Davies et al., 2010). Additionally, studies have shown that laws that support land to cultivators, have lead to the removal of seasonal resources or obstacles to transhumance path (Toulmin, 2006). Similar studies in Kenya have corroborated the fact that the loss of resource areas not only compromise pastoral risk management technique, but also as an effect, pastoralists are restricted to smaller areas of land that raises their dependence on feed supports (Dutily-Diane et al., 2005).

2.13 Effects of Pastoral Mobility on Livelihoods

Several livelihood changes take place as a result of pastoral mobility, especially in the Sahel regions of Africa. In recent times, the most prevalent livelihood alternatives to pastoral mobility is the diversification into agriculture and the intensification of livestock production (Homewood et al., 2001; Little et al., 2001a; Burn Silver et al., 2008). Pastoral livelihoods in Africa drylands are currently undergoing much pressure as a result of continues encroachment on pastoral lands indicating a persistent negative policy discourse regarding pastoralism (Thebaud & Batterbury, 2001; Hesse & MacGregor, 2006).

In addressing the recurrent droughts in the Sahel regions, Benjamin and Berge (2004) argued that there have been attempts to encourage nomadic pastoralists to diversify their livelihoods. Both national governments and international organizations have encouraged pastoralists not to depend on a single source of income, hence agriculture has increasingly been promoted in places that are dominated by livestock rearing (Pedersen & Benjaminsen, 2008). There has been much emphasis on livelihood diversification in places such as the northern Sahel and this has gained prominence in the development literature. On the basis of the sustainable livelihoods framework, which has

become popular in development studies in recent times, the seminal work of Ellis (2002) postulated that the capabilities of individuals and households in the poorest developing nations to diversify their livelihood sources should be promoted instead of preventing or discouraging them by policy. Ellis (2002) further argues that diversity enhances pastoralists' resilience of hazard-prone livelihoods by way of substitution between diverse livelihood options.

Pastoral mobility is a multidimensional concept that encompasses empirical engagements with pastoral ecology, mobility and livelihood (Turner, 2019). Empirical and theoretical study has confirmed the assertion that unregularized grazing and travel mobility by herders results in the distributions of grazing pressure with regards to grazing resources (Behnke, 2018; Moritz et al., 2014; Turner et al., 2005). Stemming from the unpredictable nature of pasture and water availability overtime and space, researchers have argued that the ideal institutions managing pastoral movements as well as their access to resources are really porous leading to negative trend on pastoralists livelihood (Moritz et al., 2013; Behnke, 2018; Herrera et al., 2014; Davies et al., 2016). Pastoralism scholars have argued that complex rules of exclusion work against the flexibility needed for livestock movements that require to be responsive to changing social and ecological conditions (Fernanadez-Gimenez, 2002; Moritz et al., 2013; Behnke, 2018; Moritz et al., 2014).

In Africa, pastoralists are cultivating crops in places where rain-fed or irrigated agriculture is feasible (Burn Silver, 2007). Babiker (2006) points out that more technical and economic support has always been extended to crop cultivation than livestock production, as such pastoralists in Africa have also taken advantage of it. Increasing human population coupled with relatively

constant livestock population shows that there is the need for people to diversify their income to make ends meet (Galvin et al., 2002).

Notwithstanding the environmental and economic rationale of pastoral mobility, the restrictions on movement and on livelihood are overwhelming (Davies et al., 2010). Apart from the absence of supporting legal frameworks for mobility such as strategies for regulating transhumance, the prevailing conditions are also against mobility. For some policy makers, they argue that pastoralists need to settle in one area in order to benefit from the services since its challenging to render services to mobile pastoralists (UNDP, 2003). Turner (2019) points to the fact that livestock population are best kept through flexible movements that track unpredictable rainfall patterns in a spatially aggregated fashion. From the argument put up by Turner (2019), it thus can be argued that the presumed positive relationship between spatially variability of rainfall, livestock mobility and pastoral livelihood are crucial in adapting to the high spatio-temporal variability of pasture in African drylands (Boone et al., 2008; Turner et al., 2016a).

2.14 Livelihood Adaption Responses to the Effects of Climate Change

A wide range of climate adaptation strategies exist. However, depending on location, knowledge and experience, one chooses to adopt such strategies appropriate for their situation. Globally, climate change adaptation is one of the most pressing issues (Igarashi et al., 2019). Adaptation is one option for mitigating the negative effects of climate change as the frequency, severity, and duration of extreme weather events continue to rise (IPCC, 2014). Climate change adaptation protects the poor's livelihoods by guaranteeing food security for vulnerable populations. Because adaptation is a dynamic social process, the execution of an adaptation strategy is dependent on

social acceptability of the adaptation alternatives and the capacity of families to benefit from important climatic information via their network (Adger, 2003). Adaptation strategies for pastoral communities to changing climatic circumstances have been researched (Mengistu & Haji, 2015; Amare et al., 2019). Pastoralism, according to the research, may play an essential role in decreasing poverty, producing economic growth, and fostering sustainable development provided adaption measures are carefully overseen and executed (Opiyo et al., 2015; Silvestri et al., 2012).

While some farmers switch between crop varieties, others adopt mix-croppingor postpone seeding dates, yet others integrate livestock and tree plant farming (Fosu-Mensah et al., 2012; Soglo & Nonvide, 2019). Seasonal migration is also a common climate change response adopted by many in West Africa where farmers travel outside their localities to engage in other economic activities during periods of droughts (Cissé et al., 2010; Mertz et al., 2010). Hence, climate change is perceived to be the main driver to migration decision, especially among rural folks (De Longueville et al., 2020). However, others view seasonal migration as a failure to adapt to climate change instead of being a response action (Afifi et al., 2016; De Longueville et al., 2020).

Further, adaptation strategies may differ across different populations and seasons. However, the kind of climate response strategy adapted is inspired by government regulations, socio-economic conditions as well as personal motivations (Bendell, 2018; de la Poterie, Burchfield, & Carrico, 2018). Many institutions, including the Ministry of Food and Agriculture, have advocated for crop diversification, drought resistant crops, afforestation as well as integrating livestock rearing

as smart interventions to combat climate change (UNFCCC, 2007). Nzuma et al. (2010) further observed that such practices as rationing amount of food during droughts, reducing consumption levels, collection of wild foods to complement household food, sale of livestock and migration are strategic off-farm measures people adopt to mitigate the impacts of climate change (Yamba et al., 2019).

2.15 Livelihood Adaptation Responses to the Effects of Changing Pastoral Mobility

The concept of adaptation with regards to human systems to global change is largely broad (Galvin, 2009). Smit and Wandel (2006, p. 282) opine that, "Adaptation in the context of human dimensions of global change mostly refers to a process, action or outcome in a system such as household, community, group, sector, region or country in order for the system to better cope with, manage or adjust to some changing condition, stress, hazard, risk or opportunity". In a given environment, Galvin (2009) posits that people are occasionally adapting, often incrementally however sometimes these adaptations are faster to new opportunities for and the challenges on their livelihoods. Adaptation capacity is the set of measures needed by a society to cope with change. Pastoral management regarding natural resource utilization includes the core of pastoral adaptive capacity, which encompasses formal and informal institutions (Nelson et al., 2007).

Pastoralists are regarded to possess a long history of adaptation to environmental change; however some studies have shown that for the past 30 years, they have been confronted with greater climate change impacts compared to some previous years (Tugjamba et al., 2021). Adaptation capacity at the local level is very crucial to sustain their livelihood. Pastoralist

knowledge and practices invariably possess a major role in sustaining their livelihood as is the concern for indigenous communities (Bhata et al., 2015; Kupika et al., 2019; Naess, 2013; Pearce et al., 2015). Adaptation to diverse conditions is essential to pastoralists' livelihoods; periodic movement and management of livestock particularly in the open pasture land.

In the Sahel regions of West Africa as well as the Horn of Africa where drought has been prevalent have drastically affected people's livelihoods as a result of climate change (A-Z Consults, 2010). Pastoral and agro-pastoral people from these regions are most vulnerable and exposed to climate change as their livelihoods greatly rely on resources that are highly sensitive to unpredictability in the rainfall patterns (A-Z Consults, 2010).

Decreased availability to water is noted to be the major means climate change impacts nomadic livelihoods (Tugjamba et al., 2021). Natural resource managers have recommended the need of calculating pasture carrying capacity accurately and reliably by incorporating assessment of water sources and their accessibility instead of only paying attention to the total size of areas not occupied (Dietz et al., 2003). Thus, a concise approach to assist people into alternative livelihood is needed (Tugjamba et al., 2021). In environments, particularly the arid and semi-arid lands where rainfall is low, there is the need for insurance against the impacts of climate change, especially in terms of risk of food insecurity (Davies et al., 2020). There is therefore the need to build on social capital as a safety net for redistribution or social exchange in order to be able to provide support to the pastoralist communities (Putnam, 2000).

To cope with the impact of climate change, pastoralists have employed agriculture diversification as a technique to reduce the shortfalls and improve their well-being (Ellis, 2000; O'Laughlin, 2002; Ellis & Allison, 2004). This has enabled households to establish resilience to the associated risk of climate change. Some of the contributory factors to the diversification include economic in terms of increased integration, political in terms of changes in land use policies and environmental in terms of climatic uncertainty.

Several traditional pastoral households have diversified their livelihood sources and began agricultural cultivation around their houses (A-Z Consult, 2010). Products of this cultivation aregenerally for household consumption. Notwithstanding the alternatives, the delay in rainfall has discouraged pastoral households who have doubts regardingthe importance of cultivation. Some pastoral households have resorted in the collection of firewood for sale while some pastoralists have resorted to labour migration as one of the major strategies in response to climate change.

In the midst of several pastoral communities experiencing change to their livelihoods, a significant adaptive technique adopted as discussed in literature is the routine trade-offs made by pastoralists between livestock and livestock products and between the use value and commercial value of their assets (Davies et al., 2010). As part of the safety nets and adaptive strategy, Davies et al. (2010) posits that pastoralists trade-off the value of selling livestock produce against the cost of buying replacement food.

Herd mobility, as discussed in the study of Samuels et al. (2020), is one of the important adaptation approaches employed by pastoralists in complex pastoral systems to decrease their vulnerability to climate change and variability. For instance, for dryland ecosystems that are characterized by uncertainty and spatio-temporal variability during rainfall (Vetter, 2005), herd mobility is usually used to access less impacted grazeland resources (Coppolillo, 2000). Additionally, in the quest for for pasture and water, pastoral mobility revolves around several socio-economic factors like proximity of human settlement, access to markets as well as other land uses such as crop cultivation (Baker &Hoffman, 2006; Samuels et al., 2008).

2. 16 Theoretical Underpinning

This research utilizes two ideas as its underpinnings, namely the political ecology theory and the pastoral commons theory.

2.16.1 Political ecology and the pastoral commons

Common pool resources are natural resources managed and utilized by communities or groups of people for mutual benefit (Basu et al., 2017). Hardin's (1968) theory assumed that commonly held resource systems are usually over-exploited because everyone is making decisions based on their self-interest due to a lack of incentive to do otherwise. In pastoral areas, where natural resources are normally collectively owned and managed, privatisation policies were implemented to address land degradation, institutional pressure, and population pressure by restricting mobility and turning collective land into private property (Basu et al., 2017). Within this context of depoliticised narratives on the environment, a political ecology perspective on socio-ecological change and nomadic pastoralism in drylands arose to critically engage with

human-environment interactions. Political ecology theory has focused on embedding ecological processes in the context of the broader political economy, placing environmental changes and conflicts as the products of unequal social relations and political processes leading to new understandings of the pastoral commons (Adriansen, 2008; Robbins, 2019).

Political ecology theory focuses on human-environment interactions, making the role of economic, social, and political forces in environmental challenges and their impacts more explicit (Schrijver, 2019). The theory views human-environment connections as political processes, where power relations and political struggles relative to socio-environmental interaction is focal point of investigation. A shift in examining power within the political ecology theory has taken place, which has opened new ways of understanding connections between society, nature, and power (Robbins, 2019). Power was understood as structural and negative. Now, power is considered as constructive (Robbins, 2019). The labelling of pastoralists as destroyers of nature, for example, produced environmental discourses that shaped the understanding of problems and solutions through policy recommendations (Robbins, 2019). This study will therefore employ political ecology as a lens through which analysis of the changes in resource access and control with regards to governmental interventions (Schrijver, 2019). These changes are viewed as political processes that have implications for the livelihoods of mobile pastoralists with regards to access and control of resources.

2.17 Relationship between Climate Change, Changing Pastoralism and Sustainable Livelihoods

Sustainable livelihoods entail the fulfilment of basic requirements of life. These essential requirements needed for the fulfilment of human needs are provided directly or indirectly by the natural ecosystem. The ability or capacity of the environment to continually provide these services is inevitably affected by land use and land cover changes (Figure 2.1). Changes in the biophysical land surface erode, degrade, and deplete all forms of natural resources found on the landscape. The resulting effects are reduced productivity declines, reduced incomes, food shortfalls, and shortage of natural resources.

Land use and land cover change in turn are driven by a mix of anthropogenic and biophysical factors with direct or indirect impacts. The proximate drivers of land use and land cover change, such as pastoralism, agriculture and wood extraction, exert direct impacts on the land surface. Conversely, the underlying drivers, such as demographic dynamics, cultural change, economic and political factors, directly trigger the proximate drivers. Both proximate and underlying drivers are mediated by both national and international policies, reforms, and institutions. Diverse factors can intervene at the national/regional level, community level or individual/household level to influence changes in the mobility patterns (including its drivers) and livelihoods. At the individual/household and community level adaptation has the potential to lessen or even reverse the impacts associated with changes in mobility patterns, land use and cover and, ultimately, improve livelihoods (food and income security etc.) (see Figure 2.1).

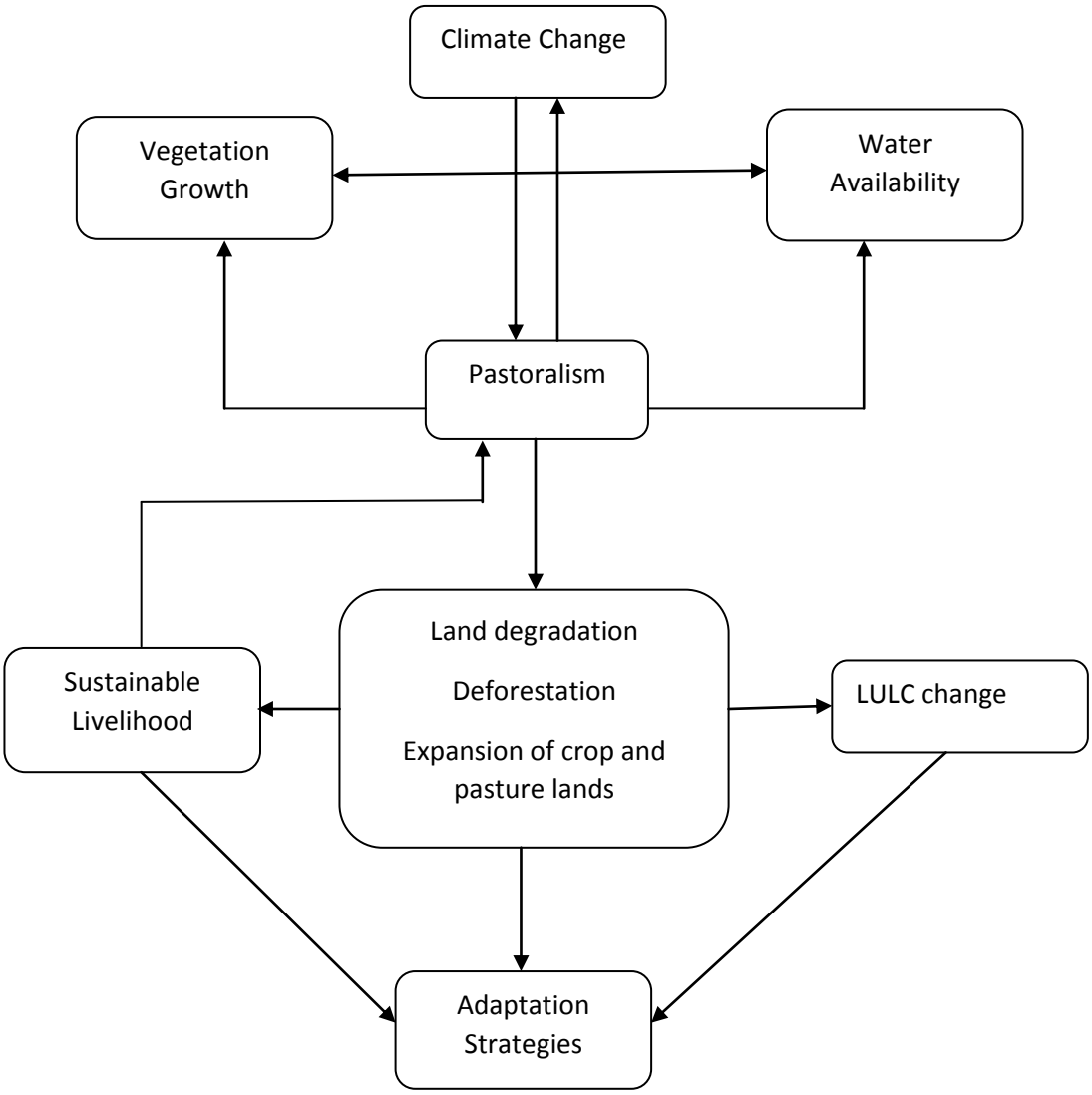

Figure 2.1: Link between climate change, changing pastoralism and livelihoods
Source: Author's construct (2022).

Figure 2.1 clearly demonstrates the important relationship between climate change and pastoralism, as well as changes in land use and cover. Changes in weather patterns, a manifestation of climate change, directly affect the growth of vegetation and the availability of water, essential for pastoralism's survival. Climate change, along with pastoral activities, causes deterioration of the natural environment, resulting in changes in land use and cover. Changes in

land use and land cover, as well as environmental deterioration, have an impact on pastoralists' livelihoods since they rely on land and climate to survive.

Climate change risk for pastoral livestock production is determined by a loss in biomass output and changes in biomass availability of pastureland (Godde et al., 2020). Global projections from 2000 to 2050 reveal that 74% of rangeland may face a drop in biomass output, while 64 and 54% of rangelands may experience inter-annual (year to year) and intra-annual (month to month) changes in biomass availability, respectively. These changes may represent a major danger to around 174 million ruminants, particularly in tropical places such as the Wa East District (Godde et al., 2020). Since the mid-2000s, the sustainability of pastoralism has been a frequent topic of discussion, as has the advancement of knowledge based on pastoralism's survival in the face of global environmental change. The constraints on pastoral movement are likely to increase the vulnerability of nomadic pastoralists at a time when the consequences of climate change are most acute. In light of the scenario, effective measures such as adaptation methods are used to lessen pastoralist vulnerability as show in figure 2.1 above.

2.18 Conceptual Framework

2.18.1 Sustainable livelihood framework

Climate change is now widely acknowledged to have a negative impact on the agricultural sector of developing countries with limited adaptive capacity. Changing climate is a major threat to the security of mobile pastoralists, whose livelihoods are concentrated primarily in rangelands areas, where the most vulnerable rural populations are known to be concentrated, and where persistently high levels of poverty exist in conjunction with inadequate institutional and

governance capacity to manage association risk (IFAD, 2018). The lens of income has traditionally been used to define livelihood. Prior to the change from econometric techniques to people-centered approaches in the twenty-first century, which concentrate on how individuals, particularly disadvantaged groups, acquire various forms of resources for their survival (Osumanu, 2017). In this sense, the framework for sustainable livelihoods becomes crucial when attempting to assess human well-being.

A sustainable livelihood is one that is sufficient to meet up essential needs at the same time bear anticipated shocks and stresses such as climate change. Specifically, the capacity to manage stress, recover from shocks, retain or enhance capacities, and create possibilities for the future generation to live sustainably without endangering its resource base (Chambers &Conway, 1992). Additionally, it entails making a contribution to benefits and safety nets for livelihoods that are both immediate and long-term, local and global (Mettle, 2010). In this study, the idea of sustainable livelihood is crucial since changing mobile pastoralism under a changing climate would have an impact on peoples' livelihoods. The requirement for a sustainable livelihood is therefore highlighted by one's capacity to survive in its midst.

The notion of sustainable livelihood (SL) is an endeavor that goes beyond the traditional definitions and techniques to eradicating poverty, according to Chambers and Conway (1992). According to Soussan et al. (2000), previous efforts to eradicate poverty and improve living conditions were insufficient and constrained because they either concentrated only on a small number of poverty manifestations, such as low income, or neglected to take other crucial factors into account, like vulnerability and social exclusion. It is now crucial to pay greater attention to

the numerous factors and mechanisms that either limit or improve impoverished people's capacity to support themselves in a manner that is sustainable in terms of the economy, society, and the environment (Farrington et al., 1999; Ellis & Mdoe, 2003). As a result of the complexity of sustainable livelihood, several conceptual frameworks have been created to understand the idea. The sustainable livelihood framework proposed by Scoones and Carney (1999) is depicted in Figure 2.2. Their framework is one of the most widely utilized and serves as the foundation for many others.

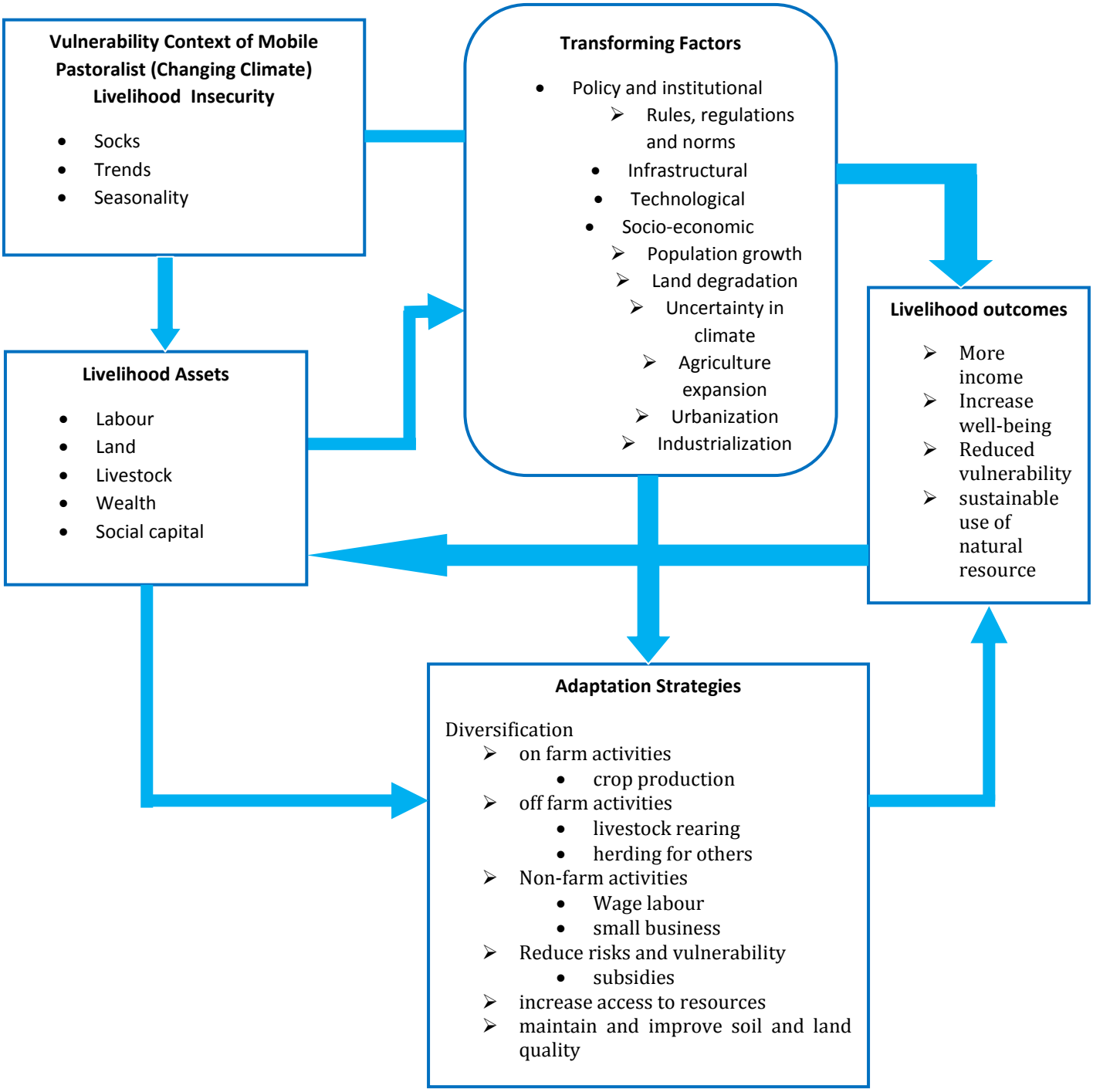

Figure 2.2: The sustainable livelihoods framework

Source: Adapted from Tessema (2008) andScoones (2009)

According to the diagram above (Figure 2.2), sustaining a livelihood necessitates that communities or families be able to resist shocks, trends, and seasonally changes. However, this is according to their assets and depending on how they use them. Furthermore, government and private sector policies, institutions, and procedures impact livelihood vulnerability (hence shocks, trends, and seasonal changes) as such state policies have a direct impact on the resource base accessible to pastoralists, and changes in the resource base drive adjustments in livelihood methods. For peoples' livelihoods to be sustainable, effective structures (effective livelihood adaptation strategies) must be put in place to provide sustainable livelihood outcomes (Carney, 1999). There are three basic sustainable livelihood methods that are mostly adopted by households in times of crisis (shocks, change in trends, and seasonality). They are diversification of livelihoods, agricultural intensification, and mobility (Farringtonet al., 1999; Ellis, 2000).

This indicates that obtaining livelihood security requires a sustained livelihood. In many cases, the two notions are thus equivalent. The two notions, however, are crucial to this investigation. The study therefore intends to explore how changing climate influences pastoralist mobility patterns, as well as how smallholder farmers adjust to the consequences of altering mobile pastoralism on land use and land cover change. Thus, the study's main emphasis is on how climate change impacts the security and sustainability of rural livelihoods. Hence, the sustainable livelihood framework serves as a roadmap for comprehending the many elements of people's means of sustainable livelihood and how shifting climatic trends affect pastoralists' movement patterns.

2.19 Synthesis and Gaps in the Literature

The literature gaps identified include gaps in knowledge, capacity, institutional set-up, governance and policies and finally need for further research evidence in policies. In terms of knowledge gaps, there is the need to focus on pastoralist systems. From the review, it was noted that most of the regions in the Sahel focused on crop farming as coping mechanisms to the detriment of other sub-sectors such as livestock breading at the national, regional and global levels (Mapfumo et al., 2014). Pastoralists have resorted to the use of local knowledge at a cost.

Capacity challenges and technology was another gap that was noted. The reviews identified gaps in the suitability of measures to assist adaptation in the agriculture sector, in addition to the need to address gaps in technology and service delivery. That notwithstanding, empirical studies are required in different agro-ecological zones to test its contribution to the adaptation planning (Limenga et al., 2014).

Regarding institutions and governance, the reviews stressed gaps in institutional structures. Some researchers have argued for the need for national and regional policy shift to focus on facilitating transformative change processes that move agriculture beyond subsistence farming to more dynamic, market-oriented systems that may decrease risks (Mapfumo et al., 2014).

The literature review identified a critical need to bridge gaps existing between regional policy formulation and capacities for action planning as well as implementation at the national and sub-national levels, and thinking around policy engagement should shift from the linear research to policy model (Rhodes et al., 2014).

2.20 Chapter Summary

Globally, semi-arid ecosystems are drying out and also global economic conditions are changing as a result of climate change. Thus, subsistence pastoralism in isolation does not longer exist. The decrease in the practice is due to the increasingly erratic rainfall, dried out and drying grasslands, increased population as well as the limitations on household and pastoral mobility such as sedentarization or privatization of land.

To rear domestic animals such as cattle, sheep as a way of living is expedient to be able to migrate swiftly to where the resources are found. It is thus complex combining both flexible animal husbandry and agriculture successfully. Labour not land is however noted to be the limiting factor in farming in large areas of the Sahel. Pastoralists have adopted for many years to climate, social, political and ecological processes by moving, cooperating with other ethnic groups as well as adapting to agricultural activities as discussed by Galvin (2009). However, their ability to cope with change will depend on how well the system can endure. It is thus established that a social-ecological system that has low levels of social memory and social capital is vulnerable to changes such as floods, change in property rights, resource failures as well as new government regulations.

CHAPTER THREE

STUDY AREA AND RESEARCH METHODOLOGY

3.1 Introduction

This chapter is focused on study area and methodology. The methodology gives important emphasis and clarifications to the philosophical, ontological and epistemological stand points of the research. In addition, the bases and arguments for choosing a particular approach suitable for this study is properly clarified in this chapter. The methodology, which is considered the overall approach in conducting the research, is discussed and clarification is given to the procedures adopted in sampling, data collection and analysis. The chapter also considered measures taken to ensure data validity and reliability. Finally, ethical and integrity issues regarding the study are given attention in this chapter.

3.2 Profile of Study Area

3.2.1 Location and size

Wa East District is one of the 11municipalities and districts in the Upper West Region, which was carved out of the Wa District in 2004 by law (LI 1751) in pursuant to Act 463 of the Local Government, 1993. The District (Figure 3.1) is located between latitudes 9º 55" N and 10º 25" N and longitude 1º 10" W and 2º 5" W (Wa East District Assembly [WEDA], 2022). It is bordered with Mamprugu Morgduri District to the northwest, West Gonja District and Wa Municipality to the Southwest, Daffiama-Bussie-Issa and Nadowli-Kaleo Districts to the north east and Sissala East District to the north. The district occupies approximately 18,478.4km²of total land area

representing about 17.3% of the region's landmass. The district capital is about 115km away from Wa, the regional capital (WEDA, 2022).

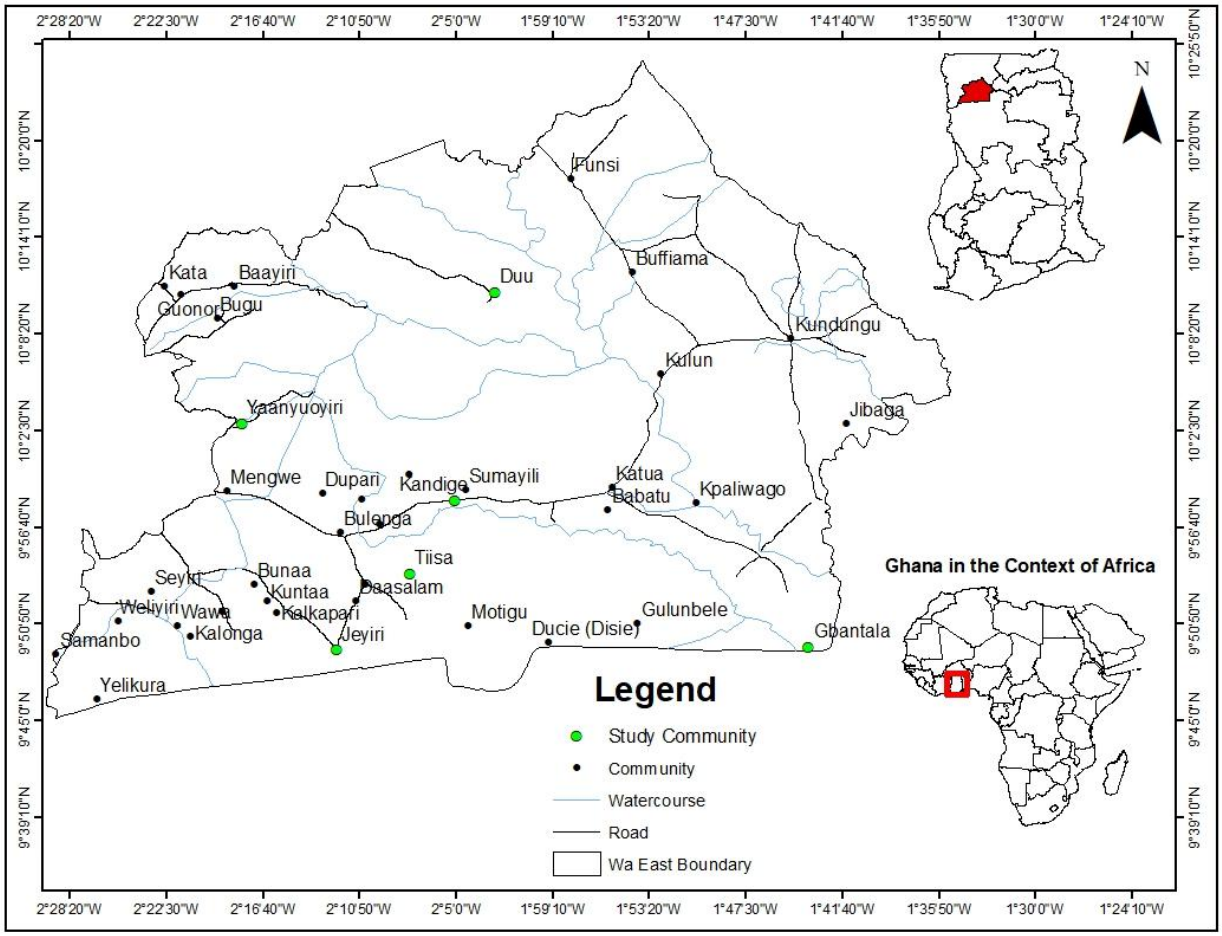

Figure 3.1: Map of Wa East District showing study communities

Source: GSS (2021) and WEDA (2021)

3.2.2 Climate

The climatic condition of the area is that of tropical equatorial, which reflects the general climate of the five northern regions. Two distinctive seasons characterize the district, namely wet and dry. Temperatures are peaked between March and April, which provide the avenue for the outbreak of Cerebro Spinal Meningitis (CSM). During this peaked period, temperatures could

reach as high as 42Cº. Conversely, low temperatures are recorded between December and January with temperatures reaching as low as 22ºC. Very cold, dry dusty wind with occasional haze occurs during this period of low temperatures, which marks the harmattan season (Ghana Statistical Service [GSS], 2021).

The district experiences a single rainfall regime spanning between May and October. The district records a mean annual rainfall of about 1,200mm annually and they are torrential, erratic and stormy. Spatial variation in rainfall is a key factor vegetation growth and land use in the District. The district is mainly agrarian, and the single rainfall regime meant that the majority of the inhabitants are often unemployed as they often out of employment when the farming season is over with limited or no alternative livelihood sources resulting in limited or no alternative livelihood employment avenues during the dry season (GSS, 2021).

3.2.3 Vegetation

The vegetation of the district is one of the guinea savannah grassland types, which conform to the general vegetation of the region. It constitutes trees characterized by stunted growth with little or no cover and shrubs of capricious stature and luxuriance, with grass ground cover in the wet season. The common trees in the district include shea, baobab, kapok, dawadawa, acacia, neem, ebony, mangoes, cashew and achievable. The natural vegetation of the district is however undergoing destructive processes due to anthropogenic factors, which include but is not limited to bush burning, inappropriate farming practices, indiscriminate cutting of trees for wood, charcoal and poor animal husbandry practices, which have destroyed 30% of the natural vegetation. The district is blessed with the Ambalaara forest reserve, which has various species

of animals, namely antelopes, baboons' monkeys and lions, which serves as a tourist attraction site.

Notwithstanding, the grassy nature of the vegetation is excellent for grazing, a potential for livestock production. Thus, alien Fulani herdsmen are attracted to this area annually for grazing their animals. The uncontrolled grazing, burning of forest and other forms of environmental degradation put the district at risk in relation to threats of climate change, and social cohesion. Thus, the few state and community forest reserves as well as sacred grooves are subjected to annual bush burning (GSS, 2021; WEDA, 2022).

3.2.4 Population

The 2021 Population and Housing Census (PHC) conducted by GSS revealed a population size of 91,457 for the district out of which 46,621 (51.0%) were males while 44,836 (49.0%) were females (see Table 3.1). This represents a 2.2% annual population change when compared with the census figures of 2010. The district is basically a rural district with all its population living in rural localities.

Table 3.1: Population of Wa East District

Sex	Population	Percent
Male	46,621	51.0
Female	44,836	49.0
Total	91,457	100

Source: Ghana Statistical Service, 2021.

3.2.5 Agriculture

Agriculture is the mainstay of the people in the district employing about 85% of the population. Food crop production in this sector largely remains subsistence with low output levels. The main activities practiced include food and cash crop production as well as animal rearing. The agriculture sector is also characterized by crop farming and livestock production. The sector is estimated to be growing at 2.1% per annum, which is below the national target of 6% per annum. Even though efforts have been made to boost the sector, production still remains at subsistence, as there are no large plantations holdings in the district (WEDA, 2015).

The major food crops grown in the district are millet, sorghum (guinea corn), maize, cowpea and yam. Cash crops cultivated include groundnuts, cotton, cowpea, soybeans, cassava, tiger nuts and pepper. The cultivation of cash crops has not received much attention as a result of market uncertainties.

The livestock sub-sector is dominated by small scale producers who keep them as a supplementary activity for incomes and /or for food security purposes. It is the second most important agricultural activity in the district. It occurs throughout the length and breadth of the district: 6,530 households representing 64.25% engage in this activity. The major livestock kept are cattle, sheep, goats, pigs and rural poultry (fowls, guinea fowls and turkeys). The production of these animals and birds has seen improvement over the years. They provide alternative livelihood opportunities to the people in the lean season (WEDA, 2015).

3.2.6 Tourism

The district has great tourism potential as it is blessed with natural, cultural and man-made attractions, which can serve as a major source of revenue. Some of these tourist attractions include the Gbantala waterfall, caves at Bulenga, Belekpong, Duccie, as well as Babatu and Samori caves. Popular in the district is the Ambalara Forest Reserve, which have various species of wild life including elephants, antelopes, monkeys, lions, tigers, chimpanzees, and leopards. The Ambalara forest if given the necessary attention by the Ghana Tourism Authority could be developed into an important national park (WEDA, 2015)

Although the district is endowed with these tourists' sites, tourism in the district is however underdeveloped due to long periods of neglect by both the government and the local community. The development of these natural and cultural attractions could lead to the socio-economic transformation of the district as it could serve as a source of livelihood diversification to local people thereby reducing their over reliance on rainfed agriculture (Ghana Statistical Service, 2014).

3.3 Methodology

3.3.1 Philosophical foundations

A research philosophy presents a researcher the opportunity to organize his thoughts around a particular world view or philosophical thinking that supports his way of thinking about the problem of study and its analysis. It is therefore crucial to consider the philosophy that may underpin the world view of the phenomenon under study (Grant and Osanloo, 2014). A philosophical worldview as conceived by Creswell (2013) is a philosophical position that deals

with the world around us and the form and nature of research that a researcher brings forth. In the words of Chilisa and Kawulich (2012),a research philosophy is a collective world of understanding that embodies the beliefs and values in a discipline and guides how problems are resolved.

A variety of philosophies are available for researchers and depending on the phenomenon under study, a suitable philisophy may be selected for a study. These philosophies ranges from positivism to pragmatism as two polar ends of the research worldview (Agubeere, 2014). For this study, pragmatism is used as the philosophical foundation for several reasons. Pragmatism has been conceived by many writers to be borne out of actions, situations and consequences as opposed to positivism and post positivism that premises on conditions (Creswell, 2013; Hall, 2013; Shannon-Baker, 2016). Also, pragmatism as a research philosophy is centered on the research problem rather than the method of approach. Thus, it simply ignores the qualitative and quntitative debates (Barnes, 2019). Pragmatism is therefore about what works for the researcher given the research objectives set by the researcher. For some social researchers (Creswell, 2014; Hall, 2013; Shannon-Baker, 2016), pragmatism is problem centred thus, the best approaches to undertake in solving practical problems at the expense of making assumptions about the nature of what constitutes knowledge. This means that pragmatism leads "action-oriented" research procedures (Cameron, 2011). Pragmatism offers the opportunity to converge the distinctions in mixed method research as Biesta (2010) points out, the pragmatist world view helps draw the strengths of both the positivist and constructivists philosophical views.

In this regard, the philosophy allows for the usage of multiple data collection methods. This is in consonance with the approach proposed by the study which is the mixed method approach. The mixed method approach of data collection involves the integration of both quantitative and qualitative data. The study intends to conduct a convergent parallel data collection. This is to say that, there will be a joint organization of both qualitative and quantitative data in order to realize a comprehensive outcome. Convergent data collection involves the simultaneous collection of both quantitative and qualitative data (Creswell, 2012). The strength of this philosophical view lies in the fact that one approach can be used to assess the efficiency of the database of the other in a like manner.

3.3.2 Research design

Research design is the arrangement of a researcher's ideas about how he intends to carry out his study right from the formulation of research questions or the statement of hypothesis to the final stage of data analysis. It is the schedule of work activities, which dictates the structure in which data will be collected and analysed (Kothari, 2012).

The study employed mixed method approach in collecting both quantitative and qualitative data concurrently. Creswell (2014) and Johnson and Onwuegbuzie (2004) contend that quantitative and qualitative approaches to social research are no longer viewed as two divergent perspectives but two sides of a continuum as a study can either be regarded as more of qualitative than quantitative and vice versa and the mixed method being acknowledged as the middle of that continuum. The term mixed method is used to refer to an approach in research where the researcher mixes both quantitative and qualitative approaches in collecting data either

sequentially (one at a time) or concurrently (both at the same time) (Antwi & Hamza, 2015; Johnson & Christensen, 2012; Ma, 2012; Molina-Azorin, 2016). The underlying strength with such an approach is that it allows for the synchronization of both quantitative and qualitative data in which case the weakness of one is checked by the strength of the other than in the case of one approach (Wisdom & Creswell, 2013).

The adoption of the mixed method is deemed appropriate because the study is made up of both qualitative and quantitative objectives and thus, imperative for the adoption of qualitative and quantitative research techniques. There are a variety of applications of the mixed methods approach, but this study adopted the convergent (concurrent) design, which provides the avenue for synergizing simultaneously, both quantitative and qualitative data in the collection and analysis of data (Creswell, 2012). According to the methodology Creswell and Clark (2017) proposed, researchers can combine a smaller dataset with a larger pool of data to facilitate the analysis of various types of inquiries. The adoption of the concurrent mixed approach was based on the rationale of optimizing the utilization of both qualitative and quantitative data while also establishing significant connections between variables.

3.3.3 Sources of data

The data for the study was generated from two major sources: primary and secondary sources. The combination of the two sources of data is chosen to allow for proper discussions of the phenomena under examination in this study. This method also allowed the study to scrutinize documents and other relevant materials in order to provide a very clear understanding of the patterns and trends in climate change and mobile pastoral system, proximate and underlying

drivers, effects of climate change and changing mobile pastoralism on land use and land cover, and adaptation strategies used to cope with the effects of climate change and mobile pastoralism on land use and land cover. According to Creswell (2019), the use of both primary and secondary data sources enabled the interaction of concepts from theory as established in literature and findings from empirical data analysis collected from the field.

3.3.3.1 Primary data

Primary data was gathered from farmers, Fulani herdsmen as well as some other key informants namely; traditional leaders (chiefs and elders), officials from the Wa East District Assembly, assemble members from the sampled communities, agricultural extension officer(s) etc. The primary data forms the core of this research was obtain through field interviews and observations. According to Kabir (2016), primary sources of data should not be disregarded since they provide useful information and have a greater level of accuracy for addressing a research problem.

Primarily, the data was gathered include, perception on patterns and trends of climate change and changing mobile pastoralism over the past 40 years, thus, 1981 to 2021. Proximate and underlying drivers of change in climate and pastoralism were also gathered. Furthermore, information on land use and cover changes, as well as adaption techniques used by small holders to deal with effects climate change and mobile pastoralism on land use and cover. Some spatial data was collected to assist in tracking the changes and implications of pastoral movement on land use and cover changes.

3.3.3.2 Secondary data

To supplement the primary source data, secondary data was gathered. Secondary sources of information for the study was generated through critical review of official reports from the Wa East District Assembly Agric extension agents. The study made use of landsat datasets for the land use and land cover analysis as well as review journal articles relevant to the study objectives. This source of data allowed for triangulation of the research data collected on pastoralist mobility patterns in the semi-arid zone, as well as adaption techniques to climate-induced shocks and pressures.

3.3.4 Target population

Population is the entire aggregation of cases that meets a designated set of criteria (Burnard, 1996). According to Shao (1999), population refers to the entire range of subjects that can be researched, including people, objects, animals, plants, and organizations, from which a sample can be taken. As a result, a population might be defined as all persons or stuff who share the trait one wishes to comprehend. In this sense, the target population for this study comprised of all individuals in the Wa East District. Specifically, the study targeted the major stakeholders of the topic under investigation, namely farmers, cattle herders, officials from the district assembly, assembly members, and chiefs and elders of sampled communities.

3.3.5 Sampling techniques

This study used of both probability and non-probability sampling techniques. For the purpose of this study, a multi-stage sampling technique was adopted. Under a multi-stage sampling procedure, the researcher chooses a sample in two or more stages with the reason that either the

researcher cannot simply identify the population, or the population is very large (Creswell, 2012). Simple random, proportionate and systematic sampling techniques were relied upon while purposive sampling was employed as the non-probability sampling technique.

First, the Wa East District was purposively selected for this studies because the district has the great potential for livestock production due to the suitable and expansive grassy character of the vegetation, which is dominated by the Kulkpong River and its tributaries. As a result, foreign Fulani herders are drawn to this district every year to let their livestock graze (WEDA, 2022). According to MoFA (2020), livestock production is the second most important agricultural activity under taken by farmers for income generation and home consumption in the district. The major livestock kept by farmers in the district include cattle, sheep, goats, swine, rural poultry, guinea fowls, turkeys, ducks and pigeons.

Livestock development in the district has received special attention through donor support and NGOs. Between 2005 and 2010, the Livestock Development Project (LDP) was implemented with support from AfDB/GOG. The Project aimed at building the capacity of livestock keepers, vaccinations, creating credit in cash/kind, engaged in water source constructions and the creation of fodder banks for herders in the district (MoFA, 2020).

The Wa East District is made up of numerous communities with varying characteristics. A consultative interviews with the district assembly and a veterinary officer from the Tsetse Unit of the Agriculture Department of the district revealed that herdsmen travel along five movement tracks in the district to find good feed and water sources for their livestock. These tracts are also used by Fulani herders to keep their livestock, especially cattle, safe from contracting sleeping

sickness, trypanosomiasis and blindness. The informant asserted that veterinary officials from the tsetse unit made those routes safe by setting traps that capture flies and by spraying the grounds making these routes healthy for cattle and safe for utilization. The study relied on these fivetracts (Table 3.2) for data.

Table 3.2: Movement Tracks Established by the Tsetse Unit of the District Agriculture Department

Tracts	**Description**
Zone A	Funsi Area starts from Sombisi through to Jabaga, to Chawuli Manpieyiri to Holumuni and passes through the game reserve to the areas to the territories of the Savana Region.
Zone B	Begins at Victor, travels through Duu, and then to Kulung, Yaanyuoyiri, Katua, and Kpalworgu before connecting to Holumuni, where the zone A tract finishes.
Zone C	This tract starts at Grumbele and goes through Ducie, Motiga, Sagla, Kilanjong, and Chassie before connecting to Kong in the Savana Region.
Zone D	The pastoralist travels from Danyoukura to Nansaratanga, then to Bananhi, Jonfien, Conjialayiri, Talaworna, and ends at Kulung River.
Zone E	This route extends from the boundary of Ambalara to the Game

	Reserve, then to Kende, Tiisa, Jayiri, Kojokura, Bulee, Wawa, Kandige, Kalanhi, and terminates at the boundary of Tuna in Ghana's Savannah area.

Source: Author's own construct based on consultative interviews.

As a result, simple random sampling was used to select two tracks out of the five track routes that are been used by herders in their search for pastoral resources. Communities within the two tracks where further classified into beginning, middle and end. The simple random sampling technique was then repeated in selecting one community from each of the classifications within the two track routes that have been sampled for the study (Table 3.3).

Purposive sampling technique was adopted in choosing key informants for the study. The appropriateness of this techniques lies in the fact that it offers the researcher the opportunity of selecting individuals who have in-depth knowledge on issues pertaining to patterns and trends of climate change and pastoral mobility, their effects on land use and land cover changes as well as farmers livelihood adaptation strategies. Specifically, Purposive sampling technique was employed in selecting Fulani herder men, farmers, assembly members, chiefs/elders, agricultural extension officers and veterinary officers.

Table 3.3: Communities Classified under Sampled Movement Tracks

Tracks	Classifications	Communities
B	Beginning	Victor Duu Kulung
	Middle	Yaanyuoyiri Katua Kpalworgu
	End	Gbantala Holumuni
E	Beginning	Ambalara Kende Tiisa
	Middle	Jeyiri Kojokura Bulee
	End	Wawa Kalanhi Kandige

Source: Author's own construct based on consultative interview.

3.3.6 Sample Size Determination

According to Kaur (2017), a sample is a set of elements chosen for a study to obtain better knowledge of the nature of the entire population; and that determination of sample size, in an important stage in any research since it helps to increase the quality of data. The target population for this study comprised all residents of the Wa East District. The study however, relied on the sampled communities within the two tracks that have been chosen. From the 2021 Population and Housing Census results obtained from the Ghana Statistical Service, the total population for the sample communities stands at 6,510 (Table 3.4).

The Miller and Brewer (2003) formula was employed in calculating the sample size for the respondents at 95% confidence level allowing for a 5% margin of error as shown below:

The Miller and Brewer formula of (2003) is given by: $n=\frac{N}{1+N(\alpha)^2}$

Where n=sample size, 1 is constant, N= sample frame and α= margin of error.

Table 3.4: Sample Frame

Track/ Routes	**Sampled Community**	**Total Population**
Track B	Duu	778
	Yaanyuoyiri	1186
	Gbantala	896
Track E	Tiisa	861

	Jeyiri Kandige	1705 1084
Total		**6510**

Source: GSS, 2021

$$\mathbf{n = \frac{6{,}510}{1+6510(0.05)^2} = \frac{6{,}510}{16.84} = 386.5 \text{ approximately } 387}$$

Therefore, the sample size (n) is 387 respondents.

Proportionate sampling technique was then used to appropriate the sample size of 387 respondents that was determined using the Miller and Brewer (2003) formula to form the actual sample. This was determined by dividing the total population of each selected community by the total combined population of the six communities selected from the various tract routes and the result multiplied by the total sample size of 387. In this computation, it is expected that communities with larger population will draw larger sample size as compared to their counterparts with relatively fewer population. The result of the proportionate sampling procedure is displayed in Table 3.5.

3.3.7 Sample size distribution

The sample size for the six selected communities within the two tracks sampled, is determined using the proportionate sampling technique explained above.

$$\text{Thus, community sample size} = \frac{\text{Community Population}}{\text{Total Population of selected communities}} \times \text{Total Sample Size}$$

Duu = 778 ÷ 6510 x 387 = 46

Yaanyuoyiri = 1186 ÷ 6510 x 387 = 71

Gbantala = 896 ÷ 6510 x 387 = 53

Tiisa = 861 ÷ 6510 x 387 = 51

Jeyiri = 1705 ÷ 6510 x 387 = 101

Kandige = 1084 ÷ 6510 x 387 = 65

Table 3.5: Sampled Communities in Sampled Track, Population and Sample Size

Track/ Routes	**Sampled Community**	**Total Population**	**Sample Size**
Track B	Duu	778	46
	Yaanyuoyiri	1186	71
	Gbantala	896	53
Track E	Tiisa	861	51
	Jeyiri	1705	101
	Kandige	1084	65
Total		**6510**	**387**

Source: GSS, 2021 and Author's own construct, 2022

This was again followed by the adoption of a systematic sampling technique, which was used to select respondents (units of analysis) from the apportioned sample size from each of the selected communities. Units of analysis in any investigation refer to the actual empirical units, objects

and occurrences that must be observed or measured in order to study a particular phenomenon (Kumekpor, 2002).

3.3.8 Data collection methods and instruments

3.3.8.1 Questionnaire administration

This study employed household questionnaire in soliciting information from different households concerning climate change and changing mobile pastoralism and their effects on land use and cover as well as livelihood adaptation strategies that are used by farmers to deal with these effects in the District. Specifically, it covered the patterns and trends of climate change and mobile pastoral systems in Wa East District between the periods of 1981 to 2021, the underlying drivers of changing mobile pastoralism in Wa East District, the effects of climate change and changing mobile pastoralism on land use and cover in the district as well as the adaptation strategies that smallholder farmers use to manage the effects.

A questionnaire comprises a detailed outline of questions that are either open-ended or closed-ended, which requires responses from respondents based on their knowledge and experience with the issue concerned (Bradley & Harrell, 2009). The questionnaire of the study comprised of both open ended and close ended questions, which was personally administered by the researcher with the help of trained university students in the form of structured interviews.

3.3.8.2 Focus group discussions

Focus group discussions were utilized to gather people's knowledge, opinions, and attitudes on topics facing mobile pastoralism, as well as to seek information that would be more difficult to

reach in replies to direct questions, such as one-on-one interviews (Krueger, 2014). For the purpose of this study, farmers and Fulani herder men who are major stakeholders in mobile pastoralism and might have experienced climate change issues for a long time and therefore have extensive knowledge on the issue under investigation were contacted for the Focus Group Discussions (FGDs), and those who demonstrates interest in participating in the discussion process were chosen.

FGDs sessions were held in three of the sampled communities along the various tract routes used by herder. According to Varkevisser et al. (2003), FGDs deliver immediate results in a short amount of time at a reasonable cost. Araoye (2003) added that this approach allows for a deeper knowledge of issues affecting a particular community in terms of its belief system, experiences, and behaviours; and Krueger (2014) points out that focus groups are more than just gathering a group of individuals to chat, they are a specific form of group in terms of purpose, makeup, size, and process. The focus group thus afforded the researcher the opportunity to collate multiple views from different respondents at the same time.

Overall six (6) sessions of FGDs, four male and two female sessions were held in the three selected communities. The groups were made up of seven (7) to twelve (12) members comprising of farmers, herders, assembly member and representatives of the chief and or tendaana. The respondents within this groups were between the ages of 36 and 70 years.

3.3.8.3 Key informant interviews

Interviews involve the creation of well-considered questions with the goal of exploring and eliciting responses from respondents (Twumasi, 2001; Karma, 1999; Panneerselvam, 2008). Open-ended questions are utilized in semi-structured and in-depth interviews, according to Karma (1999) and Twumasi (2001), and respondents are free to give any replies or responses. Semi structured interviews were conducted by the researcher with the help of an interview guide. The interview guide was made up of open-ended and closed-ended questions. The interview guide was appropriate for the study because it allowed the researcher to collect qualitative data in an organized, easy, and cost-effective manner in a reasonable amount of time.

The study made use of various key informants with requisite knowledge and expertise on climate change and pastoral mobility patterns and there implications for land use and livelihood adaptation strategies. Key informant interviews provided this study with qualitative data to support findings generated by quantitative information generated with survey questionnaire. Qualitative data just like quantitative data is based on empirical research and evidence. Qualitative data however, examine data from the perspective of groups and individuals, producing case studies and summaries rather than lists of numerical facts (Agubeere, 2014). The study conducted in-depth interviews with key informants who had sufficient knowledge and experience regarding the topic under investigation with the help of an interview guide. Information regarding the patterns and trends of climate change and mobile pastoral systems in the district between 1981 and 2021 was considered;and the effects of climate change and changing mobile pastoralism on land use and cover in the district as well as the adaptation strategies that smallholder farmers use to manage these effects was looked at. The key

informants interviewed using this method included the youth group leaders, traditional chiefs/elders, one from each community, assembly members from each electoral areas within sample tracts, an official from the Wa East District Assembly (1), an agricultural extension officer (1), Veterinary officer (1), (2) Leaders of the Fulani herder groups as well as owners (2) of livestock managed by Fulani herder men. This strategy, according to Flick (2002), produces the best results in circumstances where more probing is required to obtain in-depth information.

3.3.9 GIS methodology

In the past decades, remote sensing and geographic information system (GIS) have been widely applied in several studies to understand pastoral mobility in arid and semi-arid zones (Adriansen &Nielsen, 2005; Mulianga, 2009; Sulieman &Young, 2019; Samuels et al., 2021). The techniques, according to Martinuzzi et al. (2007), can effectively identify changes in land cover cause by climate change and mobile pastoralism during a specific time period because of the spatial-temporal features.

3.3.9.1 Land use and land cover (LULC) analysis

Landsat satellite images between 1986 and 2023 was acquired from the United States Geological Survey (USGS) to aid in land use and cover change detection. This is to examine the effects of climate change and mobile pastoralism on land use and cover of the study area.

3.3.9.2 Acquisition of satellite image and ground-truth data

Cloud free Landsat satellite image tiles of the study area were acquired for the years 1986, 1995, 2005, 2014 and 2023 from http://earthexplorer.usgs.gov (see Table 3.6) for satellite image

description) through the System for Earth Observation Data Access, Processing, & Analysis for Land Monitoring (SEPAL), a web-based cloud computing platform. SEPAL is a platform created by the European Space Agency (ESA) for accessing a diverse array of Earth observation data. SEPAL is useful for land monitoring initiatives and applications by providing tools for accessing, processing, and analyzing satellite image data. All images were acquired within the period between peak of the rainy and dry season to curb the effect of seasonal variation in the different tiles. Ground truth data is necessary in order to relate remotely sensed data to the ground for a robust classification (Congalton et al., 1999; Lillesand, et al., 2008). The study relied on Norway's International Climate and Forest Initiative (NICFI) planet satellite base map, which offers 3-5 meter spatial and near-daily temporal resolution for a synoptic view of the study area to aid in validation and accuracy assessment.

Table 3.6: Satellite Image Characteristics and their Date of Acquisition

Satellite	**Sensor**	**Processing Level**	**Paths/Rows**	**Spatial Resolution**	**Cloud Cover**	**Image Date**
Landsat 4-5	TM	L1TP	194/ 053	30m*30m	0%	1986/11/18
Landsat 4-5	TM	L1TP	194/053	30m*30m	0%	1995/06/04
Landsat 7	ETM+	L1TP	195/053	30m*30m	2%	2005/11/14
Landsat 8	OLI	L1TP	195/053	30m*30m	0.03%	2014/06/08
Landsat 8	OLI	L1TP	195/053	30m*30m	2.8%	2023/05/16

Source: Landsat, 2024

3.3.9.3 Satellite image pre-processing

Satellite imagery poses several challenges, including cloud-covered pixels, image noise, systematic errors, terrain-induced distortions, and the complexity of multispectral images, making them less suitable for direct use with map-based products(Dave et al., 2015). To mitigate these distortions, it is essential to employ image pre-processing procedures (Sommervold et al., 2023). Prior to digital image classification, the acquired satellite images underwent pre-processing to rectify errors caused by atmospheric and radiometric effects. SEPAL was utilized to correct variations in sun angles and surface reflectance changes. Radiometric corrections were performed using the "use scenes atmospherically corrected surface reflectance (SR)" and "correct for bidirectional reflectance distribution function (BRDF) effects" options in SEPAL. Additionally, the study relied on Quality Assessment (QA) bands in SEPAL to detect and mask out cloudy pixels.

3.3.9.4 Digital image classification

Supervised classification using the Random Forest (RF) classifier in SEPAL was employed for image classification. This technique involved generating training samples based on spectral reflectance from Landsat satellite imagery and the NICFI planet satellite basemap. These training points were then used to train the RF algorithm within SEPAL, allowing for the classification of pixels based on their likelihood of belonging to specific land cover classes. Random Forest (RF) is a machine learning technique increasingly utilized for image classification, known for its robustness in handling outliers and noisy datasets, as well as its higher accuracy compared to other popular classifiers (Mahdianpari et al., 2017; Xia et al., 2017). Seven land cover classes

were considered: bare land, built up, close woodland, farmland, grassland, open woodland and water bodies following the classification scheme outlined by IPCC, 2022 (see Table 3.7).

Table 3.7:Land Cover Types and Descriptions

ID	Land cover	Description
1.	Bareland	These are the exposed land surface.
2.	Built Up	Built Up include all developed land including residential, transportation, and commercial infrastructure.
3.	Close Woodland	Natural woody vegetation with canopy cover ranging between 35% to 75% and canopy height exceeding 2.5 metres.
4.	Farmland	This includes arable and tillable land and agroforestry systems.
5.	Grassland	Grassland was classified as vegetation dominated by perennial grasses and shrub including rangelands and pastureland.
6.	Open woodland	Natural woody vegetation with canopy cover ranging between 10% to 35% and canopy height exceeding 2.5 metres.
7.	Water Bodies	Areas holding surface water such as; rivers, dugouts and dams.

Source: IPCC, 2022

The area for the various land cover classes were calculated in hectares by multiplying the pixel count in the classified thematic with known Landsat image pixel size 30m*30m ($900m^2$) representing 0.09 hectares using the field calculator in ArcMap 10.8 environment.

3.3.9.5 Accuracy assessment

The final step in digital image classification is accuracy assessment, which serves as a tool for evaluating the classification approach to determine the extent to which the classified map aligns

with reality based on corresponding reference data from ground truth points (Zahraa &Jaber, 2020). Accuracy assessments were conducted on the different classified thematic maps using the confusion matrix. A total of 350 ground truth points were utilized to determine the accuracy of each of the classified thematic maps, taking into account variables such as producer accuracy, user accuracy, overall accuracy, and kappa statistics.

Table 3.8: Accuracy Assessment

	1986		**1995**		**2005**		**2014**		**2023**	
	UA	PA	UA	PA	UA	PA	UA	PA	UA	PA
Bareland	87	98	88	91	89	94	95	93	84	85
Built Up	93	88	95	84	85	90	92	91	89	87
Close Woodland	86	89	89	88	83	87	96	94	81	83
Farmland	90	91	89	89	90	89	95	95	89	90
Grassland	87	85	87	85	87	86	89	88	85	81
Open Woodland	86	86	82	83	91	95	85	83	87	88
Water Bodies	92	91	94	88	86	86	89	88	90	89
Overall Accuracy	89.9		90.9		88.7		90.0		89.0	
Kappa Coefficient	0.89		0.90		0.87		0.89		0.88	

Source: Landsat, 2024

3.3.9.6 Post classification change detection

Finally, a two-date post classification change detection was carried out to assess the landscape transition over-time. Change detection analysis helps to reveal the inter-class changes between the various years and the land cover transitions. This assessment was done using the change

detection algorithm in the Semi-Automatic Classification in QGIS. Final land cover maps and change maps were produced in the ArcMap version 10.8 environment.

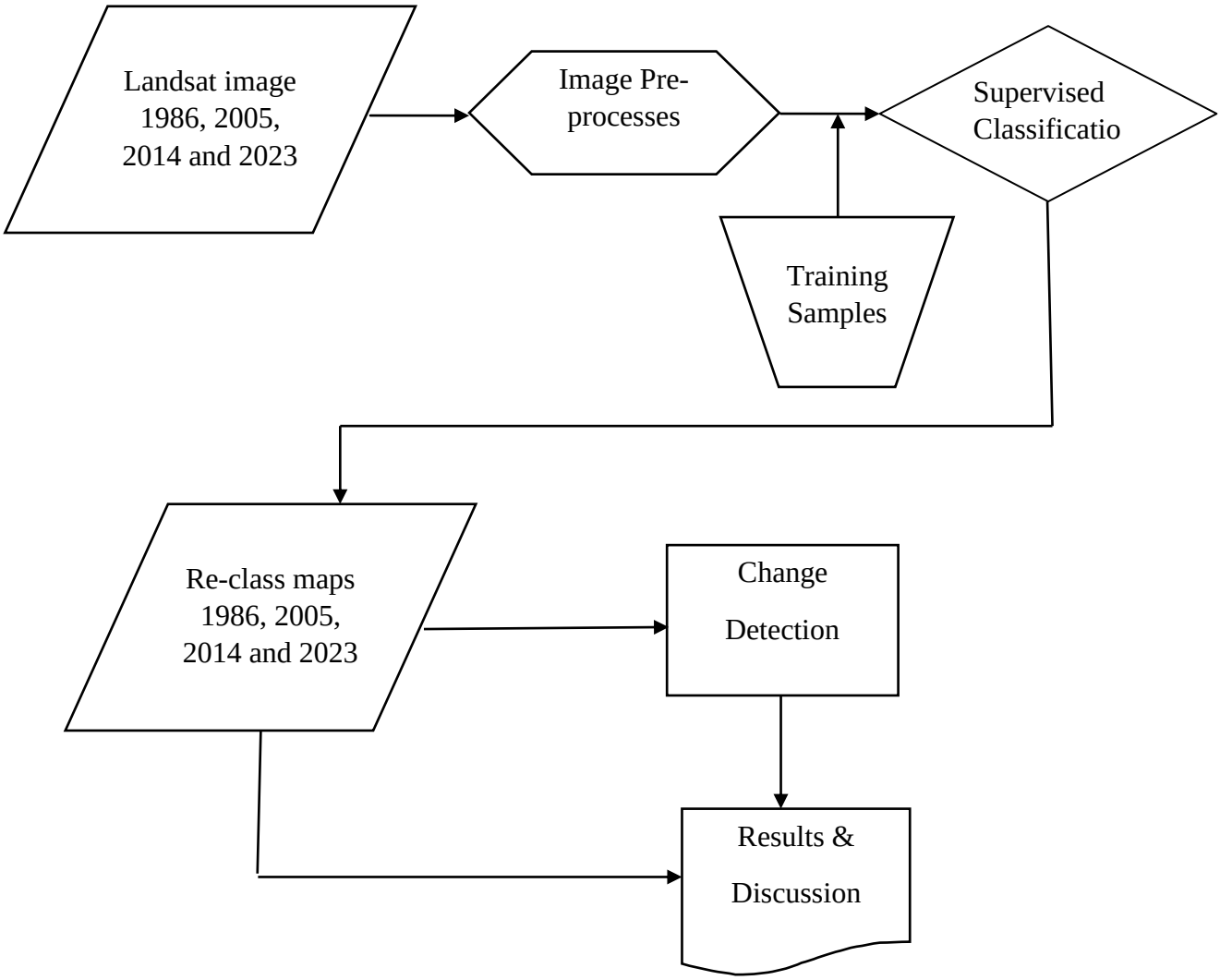

Figure 3.2: Flow Chart of Image Classification Process

Source: Author's own construct (2022)

3.3.10 Data analysis

Data for this study were analyzed by employing both quantitative and qualitative methods of data analysis. Qualitative were gathered via interviews, verbal narratives and focus group discussions. The information were documented in notes books in English language and audio recordings were in the native language. A field assistant who understood the native language translated the audio recordings in to English language before manually categorizing in to themes, interpreted and presented in text, and direct quotes to represent the viewpoints of the respondents in accordance to the objectives set by the study.

Quantitative Data from the household questionnaire survey were coded and analyzed using Microsoft excel and SPSS version 21 (Descriptive statistics, Cross tabulations, Chi-square, binary regression model) after carefully editing the data. A correlation matrix was conducted to examine the relationship between the dominant livestock species in the study area, aiming to ascertain whether households possessed multiple distinct types of livestock concurrently, either for complementary and or supplementary purposes. Cross-tabulations were performed to determine relationships between respondents socio-demographic and their agricultural production characteristics, their perception of climate change and the patterns of change the observed over the years. The quantitative data were summarised into tables, graphs and figures for easy presentation and understanding. In additional a person chi-square test was carried out using SPSS version 21 in order to determine the statistical significance among some categorical variables in the study. It was determined as shown below.

$$X^2 = \sum_{t=1}^{n} \frac{\left(o_{i-E_i}\right)^2}{E_i}$$

Where X^2 is person chi-square test, O_i and $E_{i,}$ are the observed and expected frequencies accordingly. X^2 critical value is at X degree of freedom of (r-1) (c-1), where r and c, respectively, are rows and columns.

A binary logistic regression model was used to satisfy objective four in order to determine relationships between smallholder farmers' background variables and the kinds of adaptations strategies used to manage the effects of climate change and mobile pastoral systems on land use and cover, which directly impacts on their livelihoods. Each of the adaptation techniques accessible to respondents were binary choice; hence, the use of a Binary Logistic Regression model to uncover the key factors that influence respondents adaptation practices to the effects climate change and changing mobile pastoralism on land use and cover. The model was used independently for each of the seven adaption techniques found in the research district. The model is useful because it allows for the analysis of dichotomous decisions, such as whether a respondent adapts his or her practice to offset the effects of climate change and pastoralism on land use and cover, allowing for the determination of choice probabilities for the various categories (Atube et al., 2021). The binary logistic regression model is one of the most often and appropriate used tool in adaption decision studies involving binary choices as well as mathematically convenient and simpler (Kgosikoma et al., 2018; Idrissou et al., 2020).

The binary logistic regression model takes the form of a log-linear model, which is described as

$$Y_i = \beta 0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_{7.....}\beta_n X_n + \alpha_i$$

Where:

The variable Y_i represent respondents decision to adapted a given strategy, βX1 be the vector independent explanatory variable that influences a given adaptation strategy that respondents uses to deal with the effects of climate change and changing pastrolism on land use and cover and α_i be the error associated with the estimation of the regression model.

$Y_i = 1$ if a respondent adopts a given strategy, otherwise 0, if not adopted.

Empirically, the model is formulated as follows:

$$Y_i = \beta 0 + \beta_1 \text{ Gen} + \beta_2 \text{ Age} + \beta_3 \text{ Edu} + \beta_4 \text{ HH Size} + \beta_5 \text{ STP} + \beta_6 \text{ LA} + \beta_7 \text{ LOSP} + \beta_8 \text{ ExtSup} + \beta_8 \text{ PerRF} + \beta_9 \text{ PerTP} + \beta_{10} \text{ PerDRT} + \beta_{11} \text{ PerCHS} + \alpha_i$$

The study dependent variables are the strategies adopted by the respondents to mitigate the effects of climate change and pastoralism on land use and cover (1 if adapted and 0 others). The independent explanatory variables that influences respondents choice of a given adaptation strategy were considered based on review of literature (Bawakyillenuo et al., 2016; Antwi-Agyei et al., 2018). While the adaptation strategies considered were those identified in this study as used by respondents in the study district they manage the effects of climate change and pastoralism on land use and cover. See Table 4.9 below.

Table 3.9: Description, Definition, Unit of Measurement and Values Used in Binary Logistics Regression

Variable	Definition	Unit of measurement and values
Dependent Variables: Adaptation Strategy	The strategies adopted by respondents in this study included: prayers and other rituals, buying of fodder grass, division of livestock, diversifying livelihoods, livestock controlling management pattern, rotational use of pasture and raising different types of livestock.	Dummy, 0 = not using the adaptation strategy 1= using the adaptation strategy
Independent Variable		
Gender	Sex of respondent	Dummy, Male =1 and Female = 0
Age	Number of years of the respondent	Categorical, 1= 20-44, 2= 45-70, 3=71+
Education	Educational level attained by respondent	Dummy, 1=No formal, 2= primary, 3=JHS, 4=SHS, 5=Tertiary
Household Size	Number of family members	Categorical, 1= 1-5, 2= 6-11, 3=12+ Categorical, 1=1-15, 2=16-31,

Stay period	Number of years respondent have lived in community	3=32-46, 4=47+
Land access	Having land for agricultural use	Dummy, 1= Yes, 2= No
Livestock ownership	Respondent having livestock	Dummy, 1=Yes, 2=No
External support	Respondent receiving external support of any kind	Dummy, 1=Yes, 2=No
Perceive rainfall	Respondent perception of rainfall	Dummy, 1=Yes, 2=No
Perceive temperature	Respondent perception temperature	Dummy, 1=Yes, 2=No
Perceive drought	Respondent perception drought	Dummy, 1=Yes, 2=No
Perceive changes in seasons	Respondent perception seasonal changes	

Source: Author's own construct, 2022

3.5 Ethical Issues

The researcher will in the course of data collection uphold certain standards (ethics). The researcher first of all seek the consent of respondents and relevant authorities before commencing data collection. Only respondents who willingly show interest of participation were relied upon for data. Participants in the study were given assurances about their anonymity in the study as well as the confidentiality of all information that were divulged in the course of interactions with respondents. The researcher analysed data objectively without any manipulations and falsification of data; and all relevant documents in the study were appropriately cited and referenced.

3.6 Chapter Summary

The philosophy guiding this study and the methodology employed in conducting this research was presented in this chapter. The chapter categorically argued out the suitability of the various approaches adopted for the study. Mixed method approach was adopted by this study for the purpose of addressing the research objectives. The other issues captured in this chapter are sampling techniques, data collection methods adopted, validity and reliability, ethical issues as well as how the data from the field was analyzed and presented.

CHAPTER FOUR

TRENDS AND PATTERNS OF CLIMATE CHANGE

4.1 Introduction

This chapter presents results and discussions on nature and drivers of climate change and changing mobile pastoralism between 1981 and 2021. The chapter first looked at the respondents'socio-economic and demographic factors such as educational level, period of stay, source of income, gender, age, etc.Thesis followed by their perceived patterns and trends of climate change supported with metrological data as well as projections made up to 2062.

4.2 Socio-Demographic, Economic and Agriculture Characteristics of Respondents

Several researchers (e.g., Belay et al., 2017; Dang et al., 2019; Thinda et al., 2020; Ojo & Baiyegunhi, 2020) have demonstrated that various socio-demographic characteristics, such as household size, age, educational attainment and gender have an influence on knowledge and understanding of climate change, adaptation and pastoral mobility. The socio-demographic profile of the respondents included in this study revealed that the majority of them, 299 (77.3%), were males, while females were 88 (22.7%). The results of the study clearly suggests that there is a higher participation rate of males in pastoral activities compared to females. This is because males are physically strong and are mostly exposed to pastoralism compared to females. Although female involvement in pastoralism is important, it was observed that women in the study area have restricted authority in decision-making and limited access to means of production. This gender disparity can be attributed to cultural norms prevalent in the study area. According to IFAD (2018), the influence of gender on roles and practices in pastoral mobility and climate change, particularly in labour practices, is significant. This results corroborates

Molefi and Nbajiorgu (2017), who attested that the practice of livestock keeping is predominantly associated with men and is considered their responsibility.

Age is considered a prominent demographic variable that exerts a substantial impact on behavioral modifications, encompassing not only human beings but also organisms inhabiting the planet (Talebi & Tajeddin, 2011). Both age and level of experience are considered important factors in determining pastoral mobility and its relationship to climate change. The notion that older individuals possess considerable amounts of knowledge and wisdom, which they have acquired through extensive observation and prolonged exposure to diverse circumstances, is widely recognized. Consequently, these individuals frequently demonstrate an enhanced understanding of the intricate dynamics pertaining to the patterns of mobility observed within pastoralist societies in light of alterations in climatic circumstances (Zanmassou, 2017; Anum et al., 2022). The results showed that the age groups of respondents between 20 and 44 was 106 (27.4%), 45-70 was 234 (60.5%) and 70 and above was 47 (12.1%), with a mean age of 49.9 (approximately 50 years) (see Table 4.1).

Education plays a pivotal and indispensable role in the advancement and growth of every society. It is critical to assert that there exists a positive correlation between an individual's level of education and their capacity to comprehend and analyze issues pertaining to climate change and changing mobile pastoralism (Wafula et al., 2022). Khan (2010) noted that education is a crucial demographic variable and highly influential factor in sociological processes, making significant contributions across various domains. The role of education in shaping social networks, facilitating understanding, access to information, and creating various employment

prospects is of ultimate importance (Ochieng & Waiswa, 2019). The data (Table 4.1) indicated that a significant majority (87.3%) of participants had no formal education, while 6.7% possessed primary education, 3.1% had received Junior High/Middle School Education, 1.6% had attained Senior High/Secondary School Education and 1.3% of the respondents had pursued tertiary education. This observation reveals a significantly higher illiteracy levels among the respondents in the study area. This might cause challenges for agricultural growth, especially pastoralism in the face of climate change. Higher levels of education have been found to enhance an individual's analytical capacity in their pursuit of problem solving. It should be highlighted, however, that higher educational attainment does not always imply greater analytical ability. It is a required, but not sufficient condition (Anum et al., 2022).

The date revealed that crop farming (69%) is the major occupation of the respondents, followed by livestock keeping (28.7%) and Business (2.3%). This finding confirms WEDA (2022), which indicated that crop farming followed by livestock keeping are the major occupations among the people of Wa East District. In terms of livestock ownership, the study result revealed that about 90.7% of the participants in the study owned livestock while 9.3% of them had no livestock as indicated in Table 4.1.

Access to agricultural land is of critical importance to agricultural development as it possesses the potential to enhance household income and alleviate rural poverty. Largely, the study data revealed that the majority (93.5%) of the respondent have access to agricultural lands for farming and rearing purposes. However, 6.5% of the respondents reported having no access to land for agricultural purposes.

Table 4.1: Respondents'Socio-demographic and Agricultural Production Characteristics

Variable	Sex		Totals	Percentage (%)
	Male	Female		
Age				
20-44	84	22	106	27.4
45-70	180	54	234	60.5
71 and above	35	12	47	12.1
Totals	**299**	**88**	**387**	**100**
Education				
No education	263	75	338	87.3
Primary/Basic	15	11	26	6.7
JHS	10	2	12	3.1
SHS	6	0	6	1.6
Tertiary	5	0	5	1.3
Totals	**299**	**88**	**387**	**100**
Occupation				
Livestock keeping	95	16	111	28.7
Crop farming	197	70	267	69
Trade/employment	7	2	9	2.3
Totals	**299**	**88**	**387**	**100**
Livestock ownership				
Yes	270	81	351	90.7
No	29	7	36	9.3
Totals	**299**	**88**	**387**	**100**
Access to agricultural land				
Yes	278	84	362	93.5
No	21	4	25	6.5
Totals	**299**	**88**	**387**	**100**

Source: Field Data, 2023

From Table 4.2, 75% of the respondents in the study indicated that their lands were acquired through inheritance, 0.8% had access to land in the area through purchase, 0.3% have access to agricultural land through rent arrangements and 23.9% had access to agricultural lands through other arrangements like gift. According to the study's results, the majority of household heads obtained their agricultural lands through family transfers. In Ghana, and many parts of the northern Ghana particularly Wa East District, land ownership through inheritance is common and has long been a prominent type of property ownership. This is consistent with the results of Duada et al. (2021), who observed that land inheritance was the most prevalent ownership structure in many parts of Africa.

Table 4.2:Landownership, Livestock Rearing Practices, Income and Ethnicity

Variable	**Response**	**Percentage**	**Average**
By what arrangement do you have the land for farming	Land Purchased	0.8%	
	Land Inherited	75.0%	
	Land rented	0.3%	
	Gift	23.9%	
Total		**100**	
Livestock categories	Sheep	22.0%	
	Goat	31.0%	
	Cattle	20.3%	
	Pig	0.6%	
	Poultry	25.8%	
	Others	0.2%	
Total		**100**	
Household Size			10.98
Number of years			

household head lived in the area		34.93
Source of income	Charcoal Burning Business	3.1%
	Rearing and sell Livestock	34.6%
	Crop Farming	60.5%
	Mining	1.3%
	Gridding Mill	0.5%
Total		**100**
Who look after your Live stock	Family Member	37.7%
	Myself	54.5%
	Employee	4.3%
	There move on their own	3.5%
Total		**100**
Ethnic group of herders	Brefo	5.9%
	Chakale	4.9%
	Dagaati	10.3%
	Fulani	47.3%
	Gonja	1.1%
	Sisala	14.2%
	Waala	16.3%
Total		**100**

Source: Field data, 2023

Livestock play a vital role in the sustenance of rural households. This assertion is supported by Pica-Ciamarra et al. (2011) and Kaur et al. (2017), who emphasize the numerous direct and indirect advantages associated with livestock ownership. They indicated that it augment household income, ensuring a steady supply of essential food items such as milk, meat and eggs, facilitating the utilization of manure for agricultural purposes, providing draft power for various tasks, and enabling transportation services. The various livestock categories owned by respondents in this study were cattle (20.3%), goats (31%), sheep (22%), pigs (0.6%), poultry

(25.8%) and others (0.2%). According the respondents, goats, sheep and poultry are easy to keep because of their less grazing and/or feed demand, and care in terms of labour unlike cattle, pigs and other livestock, hence, their dominance. They also indicated that poultry, goats and sheep were much easy to own particularly among women because they are cheaper to buy compared to cattle and that it was also more of a culturally accepted practice that women can own those categories of livestock and openly declare same unlike cattle ownership, which are mostly seen as a cultural heritage for men in society. The findings of this study are consistent with Mubamba et al. (2018) and Akinola and Essien (2011), who indicate that poultry, goats, sheep, and pigs are classified as small livestock. These animals are relatively low-maintenance and can be easily sold, thereby contributing significantly to household income. They further indicated that poultry, goats, sheep and pigs are regarded as crucial rural livelihood assets that practically everyone owns.

Household size is expected to have direct implications on mobility patterns of pastoralists because large household size means readily available labour and are likely to be more mobile than their counterparts with no or less herding labour. The average family size was determined to be 10.98, which is approximately 11 persons in a household. Akinyemi and Mushunje (2019) confirmed that household size is an important factor in determining family labour availability in agricultural activities and can assure timely completion of task.

From the data, crop farming and selling of the produce (60.5%), rearing and selling of livestock (34.6%), charcoal production (3.1%), mining (1.3%) and grinding mill operation (0.5%) were the sources of household income of respondents included in the study. The field data further

revealed that livestock herding, more especially cattle and sheep were done by family members (37.7%) and/or owners themselves (54.5%). A few (4.3%) of the respondents indicated that they employ people to take care of their livestock while 3.5% said they allow their animals to roam on their own. Apart from cattle and sheep, which respondents indicated are being herded, goats were tethered in the raining season when cropping starts and are allowed to roam on their own for grazing during the dry season when crops are harvested. Poultry and other livestock categories were, however, allowed to roam in all seasons in search for feed.

There were various ethnic groups in the study area who herd livestock but the Fulani ethnic group were dominating in livestock herding with 47.3%, followed by Waala (16.3%), Sissala (14.2%), Dagaaba (10.3%), Brefo (5.7%), Chakale (4.9%) and Gonja (1.1%). According to the respondents, herding is regarded as the main occupation of the Fulani ethnic group and are mostly employed by other ethnic groups to care for their livestock, the reason for their dominance in herding compared to the other ethnic groups found in the study area.

4.2.1 Correlation matrix of different types of livestock owned by respondents

A correlation matrix was conducted to examine the relationship between the dominant livestock species in the study area aiming to ascertain whether households possessed multiple distinct types of livestock concurrently, either for complementary and or supplementary purposes. There was some correlation observed among some of the livestock rared in the study area (Table 4.3). Out of the five dominant livestock species, a positive correlation was observed between goats, sheep, cattle, and poultry. The observation signifies a moderate correlation between the various types of livestock such as goat and sheep (0.606), cattle and goat (0.294), goat and poultry

(0.473), cattle and sheep (0.310), cattle and poultry (0.305), and sheep and poultry (0.388). This implies that a farmer can keep at least two or more of these livestock at the same time.

Table 4.3: Correlation Matrix for Different Type of Livestock Owned by Households

		Sheep	Goat	Cattle	Pig	Poultry
Sheep	Pearson Correlation	1				
	Sig. (2-tailed)					
Goat	Pearson Correlation	0.606**	1			
	Sig. (2-tailed)	(0.000)				
Cattle	Pearson Correlation	0.310**	0.294**	1		
	Sig. (2-tailed)	(0.001)	(0.000)			
Pig	Pearson Correlation	0.026	0.002	0.014	1	
	Sig. (2-tailed)	(0.630)	(0.964)	(0.560)		
Poultry	Pearson Correlation	0.388**	0.473**	0.305**	0.646	1
	Sig. (2-tailed)	(0.000)	(0.000)	(0.000)	(0.553)	

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

Source: Field data, 2023

From the study, there was no correlation between ownership of pigs and the other species of livestock. This could be attributed to religion,which agrees with the results previous research that has shown the influence of religion and ethnicity on the cultural contexts of households, specifically in determining the choice of livestock species they rear (Adams & Ohene-Yankyera, 2014; Kim et al., 2019). The findings also suggest a significant interdependence

among the five leading livestock categories that are possessed by rural households within the study area.

4.3 Respondents' Experiences about Trends and Patterns of Climate Change

This section of the results contains data from a survey that assesses the respondents perceived knowledge regarding patterns and trends of climate change, specifically in relation to the intensity, quantity, timing and frequency of changes experienced in the past 10, 20, 30, or 40 years. According to Bobadoye (2016), respondents' local knowledge of climate change is based on long term experience and familiarity of the area.

In Table 6.1, regarding respondents knowledge of trends and patterns of climate change, reveals that 99% (383) of the respondents have perceived climate change within a forty year period, while only 1% (4) had no knowledge whether the climate had changed or not. The difference in responses between those who perceived climate change and those who did not was statistically significant ($p = 0.000$). This finding suggests a clear disparity in the understanding of climate change variability among the respondents in the study district. Among those who perceived changes in climate, the majority who said "Yes", and had knowledge of climate change and variability, about 379 (99.2%) out of 382 individuals recognised changes in the trends and patterns in terms of the intensity, quantity and timing over the last 10, 20, 30 and 40 year period. Only 0.8% of respondents had not experienced changes in the trends and patterns over the period. The difference between these responses was statistically significant ($p = 0.034$), indicating a noticeable association in the perception of climate change trends and patterns over

time between those who acknowledged their knowledge of climate change and variability and those who did not.

Table 4.4: Climate Change Pattern

Climate Change Pattern	Response Categories	Respondents perception of climate change			p-value
		Total (N=387)	No (n=5)	Yes (n=382)	
Perceived changes in the climate patterns (the intensity, quantity and time) in the last 10/20/30/40 years	No	4(1%)	1(20%)	3(0.8%)	0.034
	Yes	383(99%)	4(80%)	379(99.2%)	
Frequency changed over time	No	14(3.6%)	1(20%)	13(3.4%)	0.159
	Yes	373(96.4%)	4(80%)	369(96.6%)	

Source: Field survey (2023)

For the question related to frequency of change over time, a large majority, 373 (96.4%), of the respondents believed that they have experienced and agree that there are changes in climate frequency over time. However, 3.6% of the respondents did not experience changes in climate frequency over time. Among those who claimed 'No' change in climate frequency over time, 1 out of 5 individuals who initially denied changes, recognised the change in climate in terms of intensity, quantity, timing over the past years compared to 369 (96.6%) out of 382 individuals who acknowledged changes in frequency over time. Statistically, the difference between these responses suggests that respondents' knowledge in climate change is not significantly associated with the frequency of changes observed over time ($p = 0.159$) to draw a definite conclusion.

These finding simply that understanding climate change trends and patterns significantly affects how individuals perceive and recognise changes in climate patterns over time.

Similar expressions of local communities' perceptions of climate change trends and patterns, changes in timing, quantity, intensity and frequency have been reported in various studies (Debela, 2017; Bendell, 2018; Carrico, 2018). A KII participant admitted to observing and experiencing major changes in climate in terms of weather parameters such as changes in quantity, timing, intensity and frequency of rainfall and temperature over time:

> *"As a young boy growing up (60 years back), I can see a big change in the weather. We use to have enough rains and the weather was not hot like this, there were a lot of trees and forest all over the area. What we are experiencing these days is something unusual in this area, the duration of the wet season has decrease and sometimes varies each year"* (KII, Tiisa, 2023).

> *"Sometimes during the raining season, we experience extreme sun shine with normally cause crops and vegetation covers always to wilt"* (FDG, Yaanyuoyiri, 2023).

4.4 Respondents' Experiences on the Direction of Climate Change

Changing climatic conditions such as rainfall variability, temperature fluctuations and drought are often recognised as important variables that affect availability of pasture and water for pastoral activities (Godde et al., 2020). Beyond respondents' overall view of climate change, the study sought to unveil the existence and direction of change taking into consideration the following climatic elements- temperature, rainfall, drought, natural disasters such as storms and

floods, and changes in seasons over the period of study. The respondents indicated varying views towards the various climate elements as presented in Table 4.5.

Table 4.5: Respondents' Views on the Direction of Climate Change

Determinants of Climate Change	Scale of Changes Witnessed over the Years	Respondents perception of climate change			p-value
		Total (N=387)	No (n=5)	Yes (n=382)	
Temperature	Same/Unchanged	67(17.3%)	2(40%)	65(17%)	0.576
	Decreasing	12(3.1%)	0(0%)	12(3.1%)	
	Various continuously	15(3.9%)	0(0%)	15(3.9%)	
	Increasing	293(75.7%)	3(60%)	290(75.9%)	
Rainfall	Same/Unchanged	60(15.5%)	2(40%)	58(15.2%)	0.248
	Decreasing	292(75.5%)	2(40%)	290(75.9%)	
	Various continuously	16(4.1%)	0(0o%)	16(4.2%)	
	Increasing	19(4.9%)	1(20%)	18(4.7%)	
Drought	Same/Unchanged	76(19.6%)	2(40%)	74(19.4%)	0.548
	Decreasing	17(4.4%)	0(0%)	17(4.5%)	
	Various continuously	31(8%)	0(0%)	31(8.1%)	
	Increasing	263(68%)	3(60%)	260(68.1%)	
Natural Calamities (Storm, Flooding, Etc.)	Same/Unchanged	159(41.1%)	2(40%)	157(41.1%)	0.724
	Decreasing	39(10.1%)	1(20%)	38(9.9%)	
	Various continuously	36(9.3%)	0(0%)	36(9.4%)	
	Increasing	153(39.5%)	2(40%)	151(39.5%)	
Seasonal Changes	Same/Unchanged	190(49.1%)	3(60%)	187(49%)	0.577
	Decreasing	18(4.7%)	0(0%)	18(4.7%)	
	Various continuously	51(13.2%)	0(0%)	51(13.4%)	
	Increasing	128(33.1%)	2(40%)	126(33%)	

Source: Field survey (2023)

Regarding temperature, the survey results indicate that the majority (75.7%) of respondents felt an increase in temperature while 3.1% indicated that temperature is decreasing, 17.3% thinks that it is the same over the period or unchanged and 3.9% reported that it varies continuously. Across the categories of same/unchanged, decreasing, varying continuously, and increasing temperatures, the survey did not reveal any significant differences in responses between those views. The study participants who perceived climate change were concerned about the magnitude and direction of change indicating a worsening climate situation as revealed in their perceived knowledge and direction of temperature. This observation by the study respondents agrees with Barry et al. (2018), who reported that the world's temperature is projected to rise and possibly more in the near future.

Rainfall is one of the most important climatic factors for pastoralism since their activities are largely governed by water availability, which is often confined to a relatively short season and irregular in time and space within Wa East District. According to Sulieman and Young (2019), rainfall gradient and variability determines the amount of biomass generated and its nutritional quality, and rainfall less than 300mm per year affects the growth of forage. Understanding the perceptions of respondents on rainfall patterns and trends in the study area for the last 40 years, the majority (75.5%) of respondents indicated that they perceive a decreasing rainfall based on their experience whereas 4.9% of the respondents were of the view that rainfall is increasing, 15.5% also indicated that it is the same or unchanged over the period; and 4.1% reported that it varies continuously. The survey results also showed that there were no significant differences in

responses between those responses. The results concurs with Ayal et al. (2018) who reported that respondents in rural area, mostly perceived decreasing trends in annual rainfall in their localities. While nearly all the respondents included in the study perceived climate change to some extent, including 68.1% perceiving an increase in drought, and 4.5% being of the view that drought is decreasing. Again, 19.4% thought it is same or unchanged over the 40 year period while 8.1% indicated that it varies continuously over the period of study. This, many of the respondents in the study area linked to the decrease in rainfall leading to the occurrences of drought in the study area. Again, the survey results did not reveal any significant differences in responses between those claiming knowledge and those not claiming knowledge of climate change variability across various categories. This result on drought corroborates with Ayal et al. (2018), who indicated that in rural localities generally, respondents mostly perceive that both seasonal and annual rainfall amounts have been decreasing while drought frequency and severity is increasing over time.

Data from the survey revealed that responses on natural calamities, such as storms and flooding, were more evenly distributed, although a substantial proportion (39.5%) of respondents who knew about climate change still perceived an increase in natural calamities while 41.1% perceived no change or same over the period, whereas 10.1% noted a decrease and 9.3% concluded that it varies continuously. Again, the results did not reveal any statistical significant differences between respondents' perceived knowledge of climate change and the direction of the change across the different response categories. In light of shifts in seasonal changes, approximately 49% of the respondents who were familiar with climate change, reported no discernible alterations in seasonal trends and patterns of climate change phenomena in the area

and 4.7%, 13.2%, 33.1% perceived a decreasing, varying continuously and increasing trends in the seasons, respectively. Here again, there were no noteworthy discrepancies (statistically) in responses between those who acknowledged the variability of climate change and those who did not, with regard to the categories of unchanged/same, decreasing, varying continuously, and increasing seasonal variations.

Similarly, many respondents in interviews reported their perceptions and experiences of climate change. This was explained in terms of increasing temperature, decreasing, continuous variations and changes in unset and off set in rainfall, seasonal changes and natural calamities as well as occurrences of frequent drought in the study area for a long period of time. Some of the attested responses are presented in Box 4.1.

Box 4.1: Participants' Responses on Climate Change Trends and Patterns

A 66 year old Tendana at Jeyiri community expressed that:

"Yes, there have been a lot of changes in climate. When I was a kid, I used to follow my father's cattle and there were a lot of grassland and vegetation all over but nowadays, before the rains will even stop, the grasses are gone. In the past, we used to have lots of rainfall amounts. The start date of rainfall has change compared to 40 years ago. The rains used to stop around November and we used to have long raining seasons and the place was not hot like these days."

A header who have been in the study area at Duu community for about 50 years had this to say:

"During the 80s, though I did not pay much attention to the weather at that time,I was young, but I can see that things have changed now. Those days we used to experience more frequent rains than today. The dry season is now longer than what we used to experience. Hmmm, temperature today is very high because the rains have reduce."

In a focus group at Gbantala community:

"When we were growing up, in December, we used to experience rain and it was called Mokohi Saa, and in January we had one called Vonvoglum Saa, this was followed by Vogugiehi Saa and BindakogloSaa in February then the Douhi Saa (Dawadawa rain), which comes in March when dawadawa trees were always fruiting. And in April we had Saajawu, which is the normal rains for everyone to start planting. All this have changed and we no longer experience this rains."

"What I have observed personally is changes in different months.Sometimes, the rains come early and delays other times. This changes affect the seasons. These days, we experience drought more sometimes even in raining season."

" These days, the weather is very hot compared to the days when we were young even in raining seasons.The weather is always very hot and you will see grasses drying up. Those days we had lots of water bodies around but they have all dried up because of the change in climate."

A 80 year old farmer at Kandige community attested that:

"Hmmm, my brother, if it was those days, people would have finished farming in this April but we are still waiting for the rains to start farming. We are in the fourth month of the year and we have not experienced any significant rains for farming. The rains used to end in December.Even we used to get rains on 25th December but now we do not experience that again."

Source: Field Interviews (2023)

Previous studies (e.g., Boyd et al., 2013; Fagariba et al., 2018) have reported similar results as found in this study, in that increasing incidents of drought, decreasing rainfall, increasing temperatures, seasonal changes and natural disasters are becoming more common as the pace of climate change accelerates. As a consequence of climate change, sea levels are increasing due to melting glaciers, and the Sahara Desert is fast spreading by 11% to 18% (Thomas & Nigam, 2018). The IPCC (2019), attested that climate change has led to increase in temperature, decreasing rainfall frequency and intensity, drought and other natural calamities. Again, the study results further agreed with the rainfall and temperature data obtained from the Ghana Meteorological Agency in the District between 1981-2021 as indicated in Figures 4.2 and 4.3. The data clearly depicts annual variations as well as decreasing trends and patterns in precipitation and increasing temperature over the study period.

4.5 Respondents' Views on the Causes of Observed Changes in Climate

In order to fully appreciate the respondents' understanding of the climate change phenomena as per their experience over the period. They were ask to indicate possible reasons for the observed changes in climate as explained in the climate parameters such as increase in temperature,

decreasing rainfall, occurrences of drought, incidents of natural calamities and variations in seasonal changes they have experience over the period. The study results (Figure 4.1) show that the majority (63.8%) of the respondents concluded that environmental destruction, such as increase tree cutting for charcoal and firewood, in recent times as a major cause while 4.1%, 11.9% and 8.8% thought it was as a result of pastoral activities, lack of sacrifices and God's will as a result of increase immorality and disobedience, respectively. Others (11.9%) freely acknowledged that they have no idea as to the reasons for the changes in climate they experienced over the study period. Teka et al. (2013), in a similar study, reported that respondents partly attribute observed variations in climate to lack of sacrifices and disobedience and unfaithfulness to God's rules and that this spiritual perspectives is widespread in Africa. Moreover, climate change is becoming more severe in many nations as a result of environmentally-damaging activities such as pastoral activities, farming, mining, and timber harvesting, as well as infrastructural growth to suit human requirements (Lobell et al., 2011).

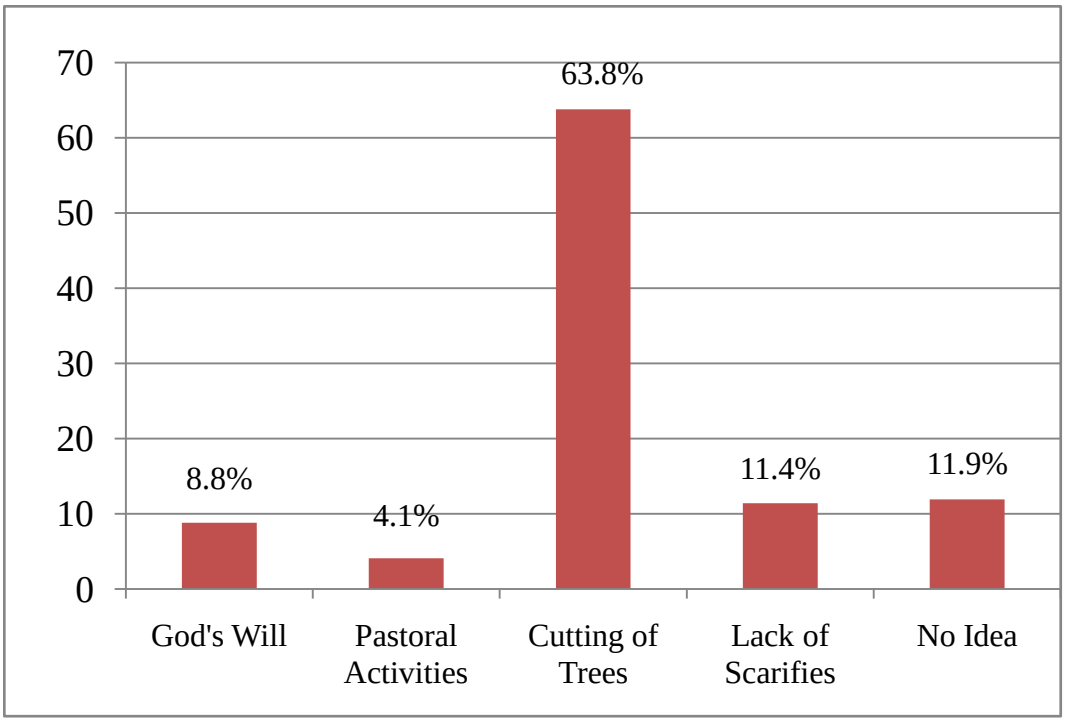

Figure 4.1: Reasons for observed changes in climate

Source: Field survey, 2023.

Some participants commented as follows:

"Ah hmmm ....., if you go down to our dam area, you will see women carrying cooking pots, preparing food there and busily cutting trees for charcoal. The painful thing is that even the men are now competing with the women in charcoal burning. Those days, women use to harvest tree leafs like, the baowba leafs, pumpkin leafs and fruits to sell. But now, they are cutting the trees to burn charcoal" (KII, Duu, 2023).

"My brother, even Shea trees with fruits are cut for fire wood and charcoal these days. What is worrying these days is that men and women all are now into charcoal burning. Sometimes, you

hear some people saying they have burned about 300-400 bags of charcoal and complaining it is not enough" (KII, Kandige, 2023).

"This area was a tick forest when we were kids.But now, they have finished cutting all trees for charcoal and fire wood. Go round and you will see heaps of fire wood packed everywhere. During the dry season, we have no jobs so people go about cutting the trees for charcoal and fire wood to sell in order to meet their monetary needs" (FDG, Yaanyuoyiri, 2023).

4.6 Annual Rainfall Variability

Rainfall is a principal driver that has a direct correlation on plant life and biomass productivity. Figure 4.2 presents the monthly rainfall variability for the study area over a 40 year period. The data clearly depicts that monthly average rainfall is constantly declining and varies substantially between years. The highest rainfall amount (1581.7 mm) was recorded in 1981, which drastically fell to 720 mm in 1983 and to 687.6mm in 1995. It, however, rised to 1353.36mm in 1999 at a decreasing rate compared to 1981(1581.7mm) and continued on a long-term declining trend over the past 40 years. The meteorological data confirms the observation of respondents as the data has shown that rainfall has since displayed a downward trend being erratic in sporadic surges over the 40 year period. Broadly, the forgoing analysis reveals that there is an observed tendency of long-term decline in average annual rainfall with and increasing sign of unpredictability both spatially and temporally in the area. Oba (2013) and Stringer et al. (2017) concluded that pastoralists are able to fulfil the pasture needs of their animals by following rainfall trends or specific pasture supplies across space and time.

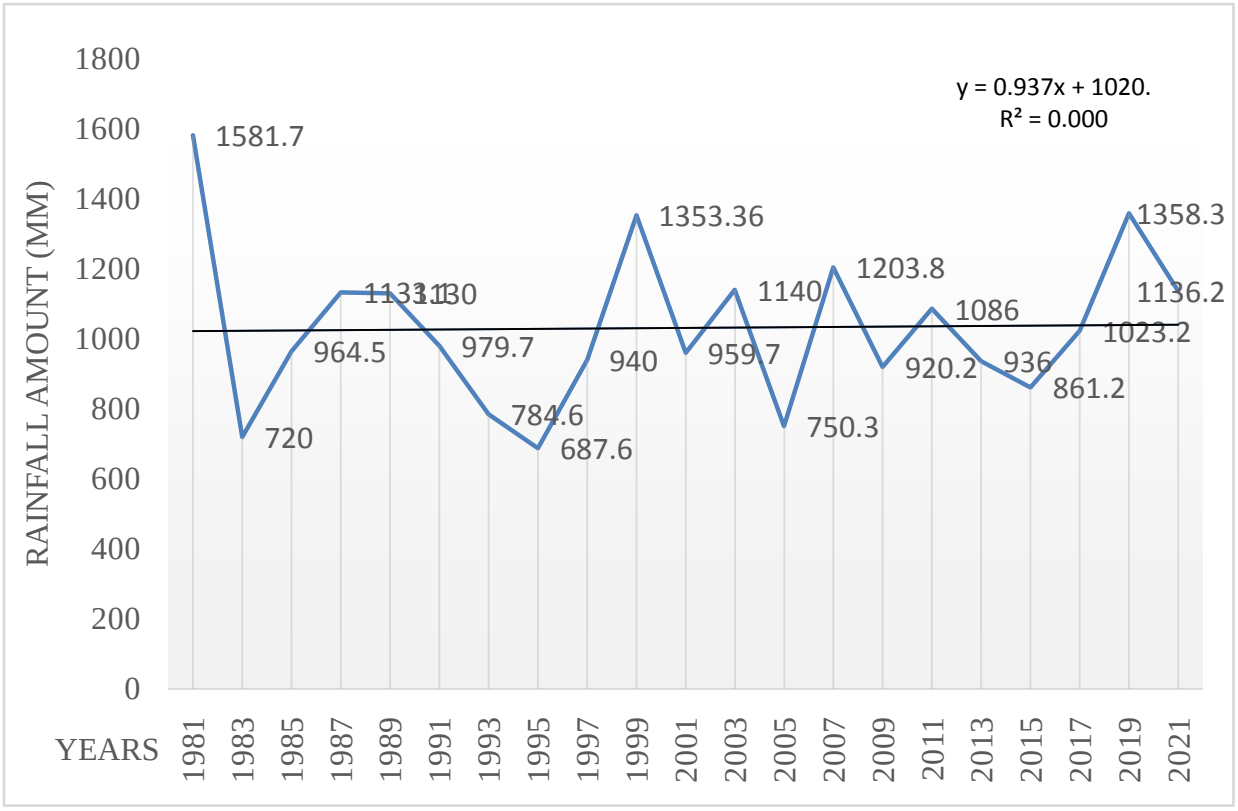

Figure 4.2: Annual rainfall trends and patterns for Wa East District

Source: Ghana Meteorological Agency, Wa East District (2023).

Smallholders, including mobile pastoralists, are able to better plan activities taking into consideration the number of rainy days per year and the onset and cessation of rain. The length and number of rainy days have serious implications on water and forage availability as well as mobility patterns over a certain period. Table 4.6 clearly illustrate inconsistencies in the trend and patterns of rainfall in the district over the past 40 years. The results of the rainfall data shows a continuous fluctuation in the number of raining days, onset and offset of rains while showing an inverse trend in number of rainy days and duration of rainfall. In some years, more rainy days

were recorded with less raining duration and other years had more duration than number of rainy days.

Table 4.6: Number of Rainy Days and Duration of Rain

Years	Number of Rainy Days	Onset	Offset	Duration
1981	75	April	October	7 months
1983	95	April	September	6 months
1985	69	May	October	6 months
1987	85	March	October	8 months
1989	101	March	October	8 months
1991	88	March	October	8 months
1993	81	April	October	7 months
1995	101	March	October	8 months
1997	90	March	October	8 months
1999	101	February	October	9 months
2001	79	April	November	8 months
2003	134	April	November	8 months
2005	89	February	October	9 months
2007	88	April	October	7 months
2009	99	February	October	9 months
2011	78	March	October	8 months
2013	98	March	October	8 months
2015	75	April	October	7 months
2017	64	March	October	8 months
2019	88	March	October	8 months
2021	91	April	October	7 months

Source: Ghana Meteorological Agency, Wa East District (2023).

These occurrences have the tendency to inflict severe harm on the activities of mobile pastoralists who plans and carry out their activities base on temperature and rainfall trends. These variations show the presence of climate change in the area and affirms the findings of Dumont et al. (2015), who reported that continuous seasonal changes in rainfall have the potential of affecting water and forage availability and can impact negatively on livestock production.

4.7 Annual Temperature Variability

The time series plot in Figure 4.3 shows the Ghana Meteorological Agency's data on the yearly mean maximum temperatures from 1981 to 2021 in Wa East District. The series indicates a general increasing trend of yearly mean maximum temperature, which is an indication of the presence of climate change in the area. The equation for the increase of the yearly mean maximum temperature was found to be:

$$\text{Mean Maximum Temperature} = 0.0214\,(\text{Year}) + 34.86$$

Where; 0.0214 is the unit increase of yearly mean maximum temperature per unit increase in years, and 34.86 is the average yearly mean maximum temperature holding any variable constant. This increase in yearly mean maximum temperatures has affected mobile pastoral systems in the area. About 92% of the household heads were of the view that their livestock now have to travel longer distances for feed and drink.

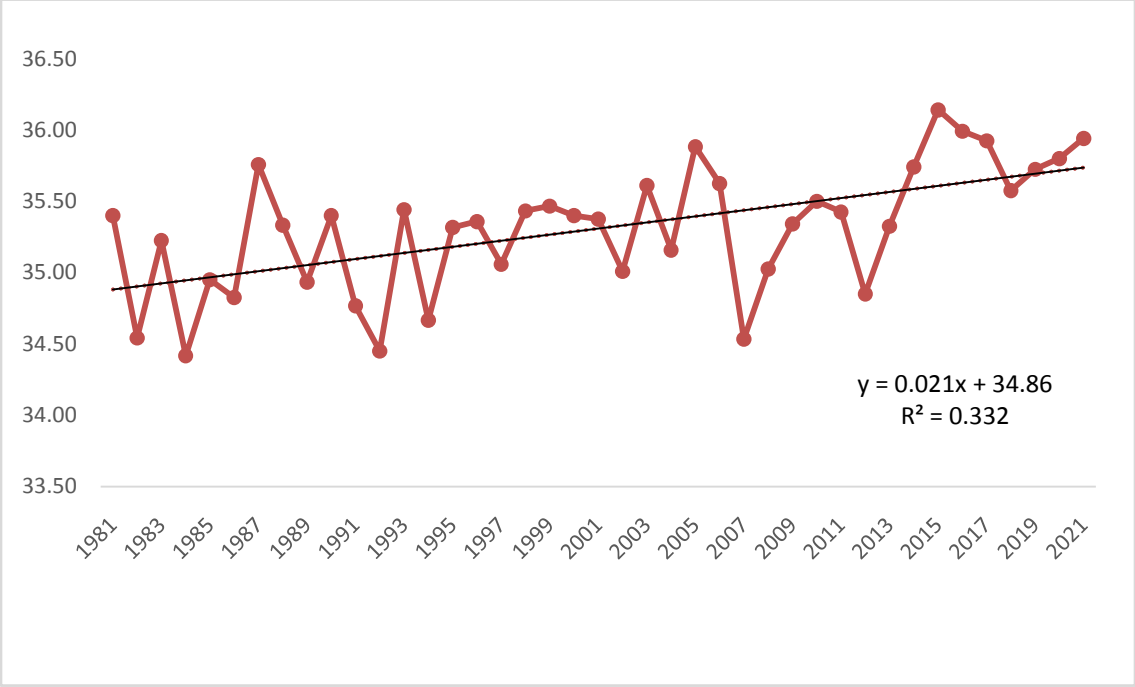

Figure 4.3: Annual mean maximum temperature

Source: Ghana Meteorological Agency, Wa East District (2023).

Data on yearly mean minimum temperature from 1981 to 2021 was obtained from Ghana Meteorological Agency to attain the trend in the area. The time series in Figure 4.4 displays the yearly mean minimum temperature in Wa East District. Generally, the yearly mean minimum temperature was found to be increasing. The equation for the increase in the yearly mean minimum was found to be:

Yearly Mean Minimum Temperature = 0.0083 (Year) + 22.8.

Where; 0.0083 is the unit increase in yearly mean minimum temperature per unit increase in a year, and 22.8 is the average yearly mean minimum temperature holding any other variable constant.

This increase in the yearly mean minimum temperature indicates the presence of climate change in Wa East District. This finding is in line with the majority (about 90%) of household heads who agreed that increasing temperature (maximum and minimum) affects mobile herding in the Wa East District.

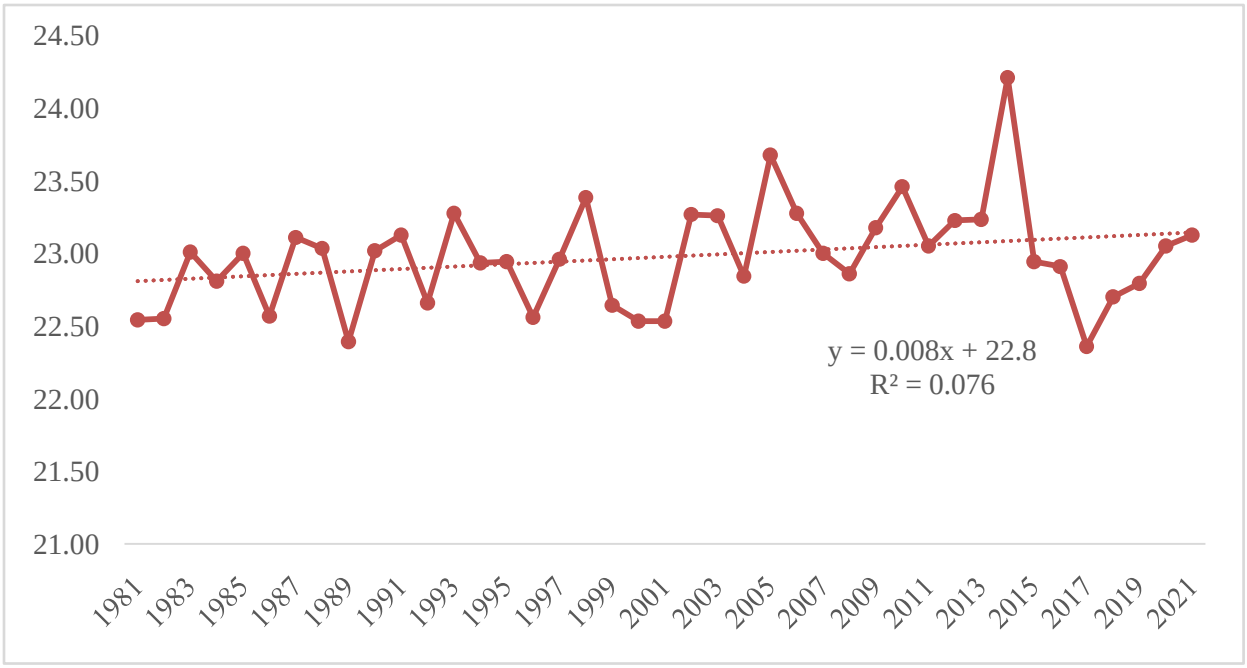

Figure 4.4: Annual mean minimum temperature

Source: Ghana Meteorological Agency, Wa East District (2023).

4.8 Monthly Seasonal Trend Analysis of Climate Change (Actual vs Predicted)

Based on the established decreasing rainfall and increasing temperature trends, a seasonal trend analysis was done to determine variations over the period of study and to predict a future trend and pattern of changes in climate. This was done using the rainfall and temperature data generated from the Ghana Meteorological Agency, Wa East District, Upper West Region. From Figure 4.5, it is observed that low rainfall is more pronounced and mostly recorded in the months

of January, February, March, November, and December, when PCP approaches minimum levels.

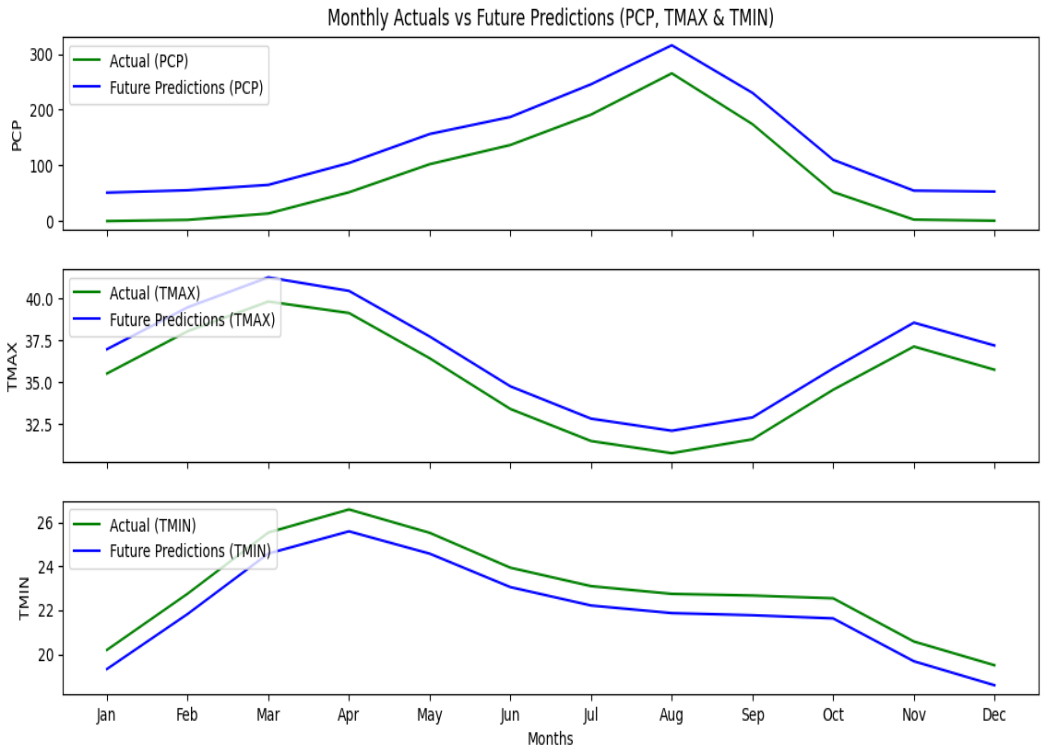

Figure 4.5: Comparison of seasonal trends and patterns monthly actuals vs. predicted estimates (PCP, TMAX, & TMIN)

Source: Ghana Meteorological Agency, Wa East District (2023).

The district has a unimodal rainfall pattern which ranges from April to October with the pick rainfall being in August. The results (see Table 4.7) shows an average monthly precipitation of 82.78 mm over the period and varies substantially between the months with a standard deviation of 90.33 mm. Comparing the predicted estimates (PCP) of both the monthly and yearly rainfall patterns between 2022 and 2060, the results demonstrate a similar pattern. The future predicted

mean monthly rainfall is higher at 135.75mm compared to the actual (82.78mm). It also exhibits variations (standard deviation of 90.47 mm) in comparison to the actual data (90.33 mm). The predicted increase in average rainfall suggests possible improvements in water and feed availability in certain months, such as April, peaking in August, and subsequently decreasing in October. According to Dumont et al. (2015), seasonal changes in rainfall has the potential to affect forage availability, livestock production and the livelihoods of pastoralists.

Table 4.7: Monthly Descriptive Statistics of Comparison of Climate Data (Actual and Predicted)

Descriptions	**Actual Estimates (PCP)**	**Predicted Estimates (PCP)**	**Actual Estimates (TMAX)**	**Predicted Estimates (TMAX)**	**Actual Estimates (TMIN)**	**Predicted Estimates (TMIN)**
Count (Months)	12		12		12	
Mean	82.78366	135.7541	35.30833	36.6752	22.9748	22.06206
Std	90.32695	90.46811	3.019101	3.049586	2.195003	2.168528
Min	0.126829	51.23722	30.77561	32.11265	19.5	18.59008
25%	2.660366	55.29162	32.96037	34.29895	22.05488	21.1445
50%	52.05927	107.2207	35.6378	37.08464	22.75244	21.85321
75%	146.0421	197.7876	37.36402	38.78839	24.33598	23.43679
Max	265.2512	315.6349	39.81951	41.26145	26.59024	25.59473

Source: Ghana Meteorological Agency, Wa East District (2023).

Regarding temperature, the mean monthly maximum temperature (TMAX) for actual estimates was 35.31°C, which represents the average temperature over the 12 months and varied significantly (standard deviation of 3.02°C) with the actual data. These results suggest that months such as January, February, March, November, and December, which recorded higher

maximum temperatures, may present challenges to animal health and pasture conditions and influence the timing of mobile pastoral movements. Temperature is expected to have a continuous increasing trend between 2022 to 2060. This is depicted in the predicted mean monthly maximum temperature for the future period being slightly higher at 36.68°C and would vary with a standard deviation of 3.05°C as in the actual data.

The projected increase in mean maximum temperature suggests that adjustments in mobile herding practices may be needed to mitigate heat-related challenges in certain months, and the minimum actual estimate (TMIN) of the mean monthly minimum temperature (22.97°C), with variability (standard deviation of 2.20°C) for the months of April, August, and October can also affect livestock welfare and influence decisions of mobile herders. According to the predicted estimates (TMIN) (mean = 22.06°C, standard deviation = 2.17 °C) as compared to the actual data, the results suggest that adjustments in mobile herding practices may be needed to ensure livestock health and resilience during months of high temperatures and low temperatures attributed to rainfall patterns.

4.8.1 Annual seasonal trend analysis of climate change (actual vs predicted)

The results of actual estimates (Figure 4.6 and Table 4.8) indicate that the annual precipitation (PCP) over the 40-year period has a mean of approximately 82.78 mm, with a notable degree of variability, evidenced by a standard deviation of 99.47 mm. The minimum recorded rainfall, which was 0 mm in certain years, suggests that some years experienced very little or no rainfall when compared to the maximum recorded rainfall of 455.5 mm, which indicates years with relatively higher rainfall. The median value of 38.1 mm indicates that half of the years had

precipitation below this threshold, and 142.33 mm indicates that 25% of the years had higher precipitation. Similar to the predicted estimates (PCP), the mean predicted precipitation for the future period (2022–2062) is higher, at approximately 135.75 mm, with a standard deviation of 89.86 mm. The predicted range had similar variability to the actual data, with a minimum of 6.89 mm and a maximum of 353.20 mm.

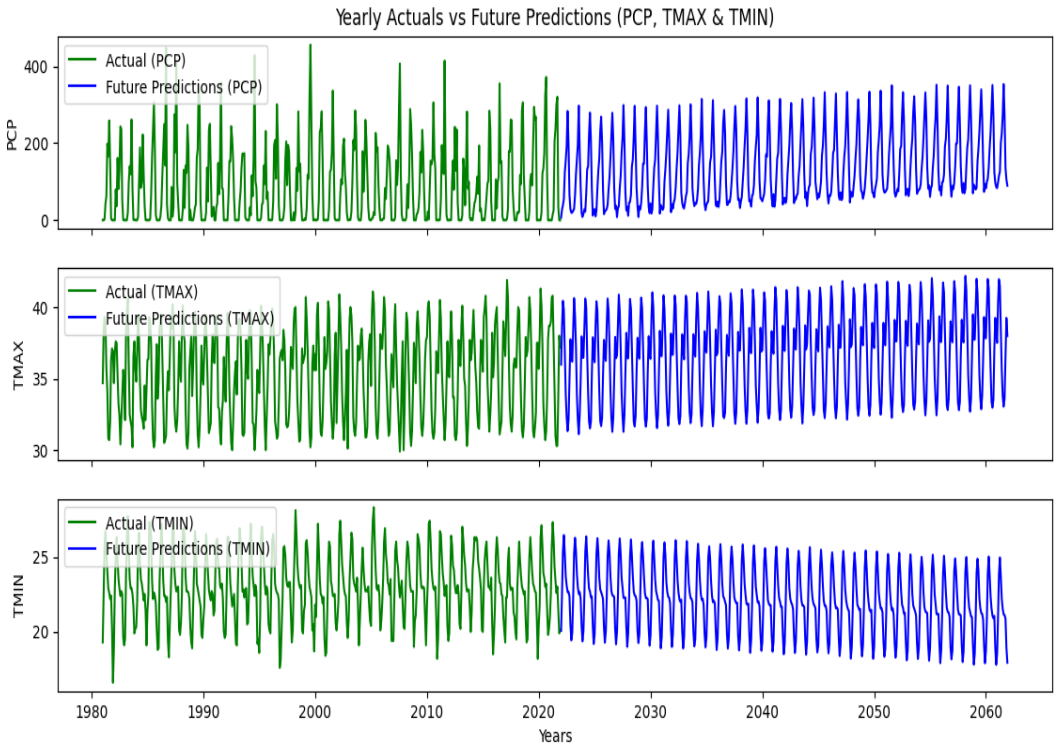

Figure 4.6: Comparison of annual seasonal trends actual vs. predicted estimates (PCP, TMAX, & TMIN)
Source: Ghana Meteorological Agency, Wa East District (2023).

Table 4.8: Yearly Descriptive Statistics of Comparison of Climate Data between Actual and Predicted Estimates

Descriptions	Actual Estimates (PCP)	Predicted Estimates (PCP)	Actual Estimates (TMAX)	Predicted Estimates (TMAX)	Actual Estimates (TMIN)	Predicted Estimates (TMIN)
Count(years)	40		40		40	
Mean	82.78366	135.7541	35.30833	36.6752	22.9748	22.06206
Std	99.46763	89.85538	3.086188	2.965409	2.239475	2.128333
Min	0	6.887076	29.9	31.12078	16.6	17.80415
25%	0	63.26815	32.3	33.8479	21.7	20.72566
50%	38.1	106.9557	35.6	37.00315	22.9	22.01076
75%	142.325	206.1467	37.8	39.04505	24.5	23.76872
Max	455.5	353.2038	41.9	42.18564	28.3	26.43817

Source: Ghana Meteorological Agency, Wa East District (2023).

Furthermore, the mean maximum annual temperature over the 40-year period, as indicated by the maximum temperature (TMAX) for actual estimates, is approximately 35.31°C, with a standard deviation of 3.09°C. The minimum temperature was 29.9°C, and the maximum was 41.9°C. For the years 2022 to 2060, predictions are similar to the actual trends. The predicted mean estimates (TMAX) were slightly higher at approximately 36.68°C, with a standard deviation of 2.97°C. This varied with the actual data, with a minimum of 31.12°C and a maximum of 42.19°C.

With the actual minimum temperature, the estimates (TMIN) showed that the mean annual minimum temperature over the 40-year period was approximately 22.97°C, with a standard deviation of 2.24°C. Additionally, the minimum temperature was 16.6°C, compared to the maximum temperature of 28.3°C. Comparing to the predicted estimates (TMIN), the mean

predicted minimum temperature for the future period was approximately 22.06°C with a standard deviation of 2.13°C. The predicted range has similar variability to the actual data, with a minimum of 17.80°C and a maximum of 26.44°C.

Both actual data show decreasing and fluctuation trends in precipitation, indicating the possibility of water shortages in certain years, affecting pastures and water availability for livestock; and maximum and minimum temperatures show inconsistency in increasing trend for both actual and predicted data. These patterns and trends in climate change over the years have an impact on water and feed availability, animal health, and overall resilience to mobile pastoralism. This requires the development of adaptation strategies and infrastructure planning based on both historical patterns and predicted changes in climatic conditions.

4.8.2 Model Prediction of Climate Change Patterns between Variables from 1981 to 2062

The findings presented in Table 4.9 provide information about the relationships between climate variables, enabling pastoralists to discern annual climatic patterns and make well-informed choices for the pursuit of sustainable mobile pastoralism. Employing both the Pearson correlation matrix and neural prophet regression model analyses, the present analysis was executed with a confidence interval of 95% to discern and verify the correlations and associations between actual and predicted estimates.

Table 4.9: Model Metrics of Prediction Showing Connections between Climate Variables from 1981 to 2062

Monthly			
Actual Estimates	**PCP**	**TMAX**	**TMIN**
PCP	1		
TMAX	-0.82882	1	
TMIN	0.226464	0.292491	1
Predicted Estimates			
PCP	1		
TMAX	-0.83742	1	
TMIN	0.236564	0.269634	1
Yearly			
Actual Estimates	**PCP**	**TMAX**	**TMIN**
PCP	1		
TMAX	-0.72077	1	
TMIN	0.162906	0.293782	1
Predicted Estimates			
PCP	1		
TMAX	-0.76038	1	
TMIN	0.16941	0.226861	1
Reliability of Predicted Climate Patterns From 1981 to 2062			
Statistics	**PCP**	**TMAX**	**TMIN**
MAE	37.75710877	1.100821441	0.660053681
RMSE	56.09767444	1.493079256	0.885916964
Loss (p-value)	0.013186793	0.006152871	0.002587638

Source: Ghana Meteorological Agency, Wa East (2023).

With respect to the actual climate data, the results for PCP and TMAX exhibited a strong negative correlation (coefficient = -0.83; -0.72) between rainfall (PCP) and maximum temperature (TMAX) in both months and yearly estimates, respectively. The negative correlation between rainfall and maximum temperature indicates that in years with higher rainfall, temperatures tend to be lower. This dynamics may impact the suitability of climate conditions for mobile pastoralism. Regarding PCP and TMIN, the correlation between rainfall and minimum temperature (TMIN) showed a positive but relatively weak relationship (coefficient = 0.23; 0.16) in both months and yearly estimates, respectively. This suggests a slight tendency for higher rainfall to be associated with higher minimum temperature. Furthermore, with TMAX and TMIN, the correlation between maximum and minimum temperatures was positive (coefficient = 0.29), indicating a moderate tendency for months and years with higher maximum temperatures to also have higher minimum temperatures.

In comparison of the actual estimates and predicted estimates, the relationship between predicted climate data and actual data was examined, revealing a strong negative correlation (-0.84; -0.76) between predicted precipitation (PCP) and predicted maximum temperature (TMAX) in both months and yearly estimates, respectively. Conversely, PCP and minimum temperature (TMIN) showed a positive but relatively weak correlation (coefficient = 0.24; 0.17), which is similar to the correlation between TMAX and TMIN (coefficient = 0.27; 0.29) for both monthly and yearly estimates, respectively. The consistency in the direction of correlation between the actual and predicted data for both pair of variables (PCP-TMAX and PCP-TMIN) indicates a reliable degree of forecast accuracy for future climate patterns ($p < 0.05$) according to the MAE and RMSE values.

Based on these research findings, understanding the associations between climatic factors enables pastoralists to anticipate potential connections between rainfall and temperature. For instance, in years with increased rainfall, they may expect more favourable conditions for mobile pastoralism. The positive relationship between TMAX and TMIN indicated that higher maximum temperatures were associated with higher minimum temperatures, which may present challenges related to heat stress in livestock. Therefore, by anticipating these climate dynamics, the findings postulate that pastoralists engage in proactive planning for mobile pastoralism, such as adjusting migration schedules, managing water resources, and ensuring animal health during periods of high temperatures.

4.9 Chapter Summary

Smallholders' socio-demographic variables, such as family size, age, education level, and gender, have influenced knowledge and comprehension of climate change, adaptation, and pastoral migration. The study respondents had varying social, economic and agricultural production situations, which could have different impacts on their perception of the phenomena under study, the drivers and adaptation option choices. For instance, respondents' age, gender and educational level have substantial impact on behavioural modifications and that how older persons will perceive climate change will be far different from young ones, likewise gender and educational differences.

Findings from the analysis of rainfall, temperature and drought issues have been detailed in this chapter. Raising temperature with decreasing rainfall trends were reported by respondents, which

is consistent with the meteorological data that was obtained from the Wa East Meteorological Agency. The finding have major implications for pastorlism and other agricultural activities, since pastoral livelihoods depends solely on climatic factors such as rainfall and temperature. The agreement between respondents' perceptions and the meteorological data clearly suggest personal experience and views are crucial and can help them adjust even in the absence of scientific data.

CHAPTER FIVE

PATTERNS AND TRENDS OF CHANGING MOBILE PASTORALISM IN WA EAST DISTRICT FROM 1981-2021

5.1Introduction

Key results based on the objectives of the study are discussed and presented in this chapter. It discusses respondents' perceived trends and patterns of changing mobile pastoralism in the Wa East District between 1981 and 2021. It also took into account how climate change have affected mobile pastoralism and the livelihoods of pastoralist in the study district. Subsequently, the chapter presents analysis of drivers of climate change and changing mobile pastoralism.

5.2 Respondents' Experiences Patterns and Trends of Mobile Pastoralism

Some studies (Ayantunde et al., 2014; Dong, 2016; Samuels et al., 2021) have established that mobile pastoralism is becoming spatially restricted and have shifted in order to adapt to dynamic socio-ecological environments.

To shed light on the pattern and trends of mobile pastoralism in Wa East District, Table 5.1 provides a detailed analysis based on various factors such as previous place of residence, access to grazing, duration of stay in an area, freedom of livestock movement, and any changes in grazing access.The findings reveal that a large majority (64.6%) of respondents interviewed had lived no where prior to moving to the district and were permanent emigrants compared to 35.4% who lived in other places before moving to the district in search for pastoral resources. A significant number (90.2%) of the study participants confirmed the arrival of other pastoralists from further locations to access grazing areas. This shows pastoralists collaborations with other

neighbouring counterparts and non-migratory communities in order to access quality pastoral resources. These results are consistent with Liao et al. (2017), who confirmed pastoralists constantly engage with their neighbours, non-migratory populations, and government agencies to provide access to grasslands in various areas. The study also agrees with Ursula and Flintan (2019), who indicated that herders target areas of prime pasture with species combinations they know to be beneficial to their animals, hence will always keep constant contacts with neighbouring partners.

Table 5.1: Patterns of Mobile Pastoralism

Pattern of Mobile Pastoralism	Response Categories	Frequency (N=387)	Percentage (%)
Have you lived in another place before moving to the current location?	No	250	64.6
	Yes	137	35.4
Do pastoralists from further areas arrive here to access grazing?	No	38	9.8
	Yes	349	90.2
Are you able to move your livestock freely to grazing areas in this district?	No	177	45.7
	Yes	210	54.3
Are there any changes in access to grazing areas in the last 10/20/30/40 years?	Unchanged/same	68	17.6
	Decreasing	221	57.1
	Increasing	98	25.3

Source: Field survey (2023).

There was almost a split concern when respondents were asked whether they are able to move freely in any part of the district. A slim majority, 210 (54.3%), indicated free mobility while 177 (45.7%) attested otherwise. This implies that pastoralists would not be able to spatially utilize natural resources like water and pasture, which can pose serious challenges for smallholders and

livestock production. This study finding is similar to and agrees with Navchaa et al. (2021) who reported that the mobile patterns of pastoralists is one of the reasons why some pastoralists fare quite well during excessive climatic events while others fare poorly, because mobility works by exploiting the spatial and temporal structures of resource failure by shifting from scarcity to abundance.

In light of changes to grazing area for the past 40 years, the majority, 221 (51.1%), of respondents reported that pasture lands have decreased over the period while 98 (25.3%) indicated an increase in grazing areas and 68 (17.6%) of the respondents felt it has been the same or unchanged in the past 40 years. This will be a serious constrain to mobile pastoralism in the area. According to MoFA (2016), reducing grazing land is one of the major threats to mobile pastoralism in arid and semi arid zones in Ghana. The findings are congruent with Tamou et al.'s (2018) research findings in Benin Republic, which found that respondents believed that grazing areas had decreased over the past 20 years.

5.3 Experiences of Climate Change and Mobility Patterns

The data was cross-tabulated and a chi-square test done to fully establish mobility patterns in relation to respondents' perceptions of climate change over the last 40 years. The results (Table 5.2) show that a vast majority, 371 (98.7%), of respondents move their livestock both in the wet and dry seasons, indicating consistent movement throughout the year. However, there was no significant difference in respondents' perceptions of climate change and their seasonal mobility as shown in p=0.929. In line with the frequency of mobility, the chi-square test showed (0.927) no significant difference between respondents' perceptions of climate change and their mobility

frequency. A substantial proportion, 241 (63.1%), of respondents moved their livestock frequently, whereas a significant segment 117 (30.7%) moves theirs very frequently. Conversely, only a small percentage, 18 (4.7%), of respondents moved their livestock barely and 6 (1.6%) of them do not move their animals at all.

Table 5.2: Climate Change and Patterns of Mobility

Variables	**Perception of Climate Change**		**P-value**
	Yes	**No**	0.929
Time of Mobility			
Wet season	1 (0.3%)	0	
Dry Season	10 (2.6%)	0	
Both season	371 (98.7%)	5 (1.3%)	
Total	**382**	**5**	
Mobility Frequency			0.927
Not at all moved	6 (1.6%)	0	
Barely move	18 (4.7%)	0	
Frequently Move	241 (63.1%)	3 (60%)	
Very frequently Move	117 (30.6%)	2 (40%)	
Total	**382**	**5**	
Length of stay during mobility			0.351
Depends	358 (93.7%)	4 (80%)	
< A month	4 (1%)	0	
1-5 month	12 (3.1%)	1 (20%)	
6month and above	8 (2%)	0	
Total	**382**	**5**	

Source: Field survey (2023).

It emerged from the results that a significant proportion, 358 (93.7%), of respondents indicated that the duration of their stay varies and depends on so many factors, suggesting variability in the length of their stay at a particular location during mobility. A smaller percentage of respondents reported staying in an area for specific periods, ranging from less than a month to several

months. Again, there was no statistical significant difference between respondents' mobility patterns and their perceptions of climate change as seen in p= 0.351.

The results agrees with the discussions with respondents during the interviews indicated that their travels and stay times differ throughout time and place. In a key informant interview, a respondent stated that:

"Our movements and stay periods depend; for example, during the dry season, we try to move closer to water points because water is the most important need for our animals, particularly cattle." They are found even if they have ample water but not enough food. Again, during the rainy seasons, we occasionally relocate according to agricultural needs. We travel far, such as into the forest, and stay there until the crops are grown or harvested before returning to prevent disagreements that can often ruin our social relationships with the people in the village" (KII, Jeyire, 2023).

5.4 Respondents' Experiences on Changes in Mobile Pastoral System

During the interviews, many of the respondents conveyed that there have been a continuous shift in mobile pastoral system in the area over the study period (see Figure 5.1). This is reflected in their perception that in the 80s, mobile pastoral system in the study area was characterized with short-range movements, that is movement within ones community with some portions of lands reserved mainly for animal grazing. The study results show that animal herding, at the time, was the preserved occupation of male children of households. The mobile pastoral system that was practiced in the 1980s changed to long distance movements, indicating movement outside ones community to other communities including going far into the forest areas with the use of Fulani

herders and tethering of livestock in 2001 due to the increasing fragile nature of the pastoral grazing system, which is becoming smaller and spatially restricted. This observed shift in the pastoral system between 1981 and 2001, respondents said, is as a result of environmental, socio-economic and political factors. This view is in agreement with Napogbong et al. (2020) who recorded that the majority of cattle herds are mostly the Fulanis whose activities are scattered around the regions of Ghana, predominantly in northern Ghana, Ashanti and Eastern Regions.

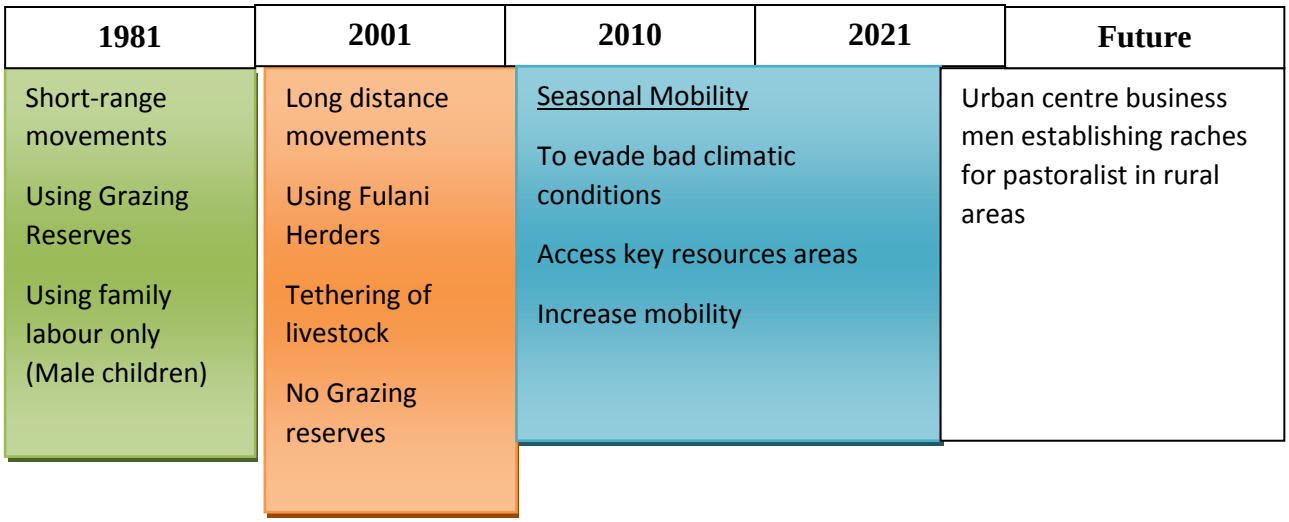

Figure 5.1: Changes in mobile pastoral system

Source: Field survey (2023).

From the perspective of the respondents, great changes were observed between the periods of 2001, 2010 and 2021.The pastoral system in the study area experienced another shift to more of seasonal mobility and increase mobility due to pasture degradation and loss of forage species as well as insufficient watering points, evasion of conflicts, bad climate conditions and access to key pastoral resource. The situation is reflected in the declaration of a 60-year old respondent that,

"In the past years, we had more than enough space for our livestock to move about and freely graze but due to frequent conversion of pasture lands to crop and other land uses, coupled with climate change conditions, the spaces are now limited making us to move far (KII, Kandige, 2023)."

Similarly, the respondents reported that the mobile pastoral system is expected to continue to experience shifts because pasture security is greatly becoming a major concerning issue as never before. The respondents indicated that in the past, there was plenty pastures for livestock and now they see no longer quality grass, and the grassland vanishes quite early forcing many to move away for better pasture. According to the respondents, the mobile pastoral system of the area, which was characterised by traditional patterns of transhumance, will continue to see a constant shift because of climate change and instead of mobile pastoralists passing through or staying temporarily at an area, they will now reside permanently with urban businessmen sponsoring them by creating cattle ranches for headers in the rural areas.

The above findings corroborate with Zampaligre et al. (2013), who attested to the shrinking of grazing areas and decline in forage resources in the past 20 years in different zones of Burikina Faso. The findings are in line with Motta et al. (2018) and Sakamoto (2016), who have reported that herd mobility, which is known within the context of seasonal mobility as a regular movement between relatively fixed locations, have become one major strategy used by pastoralists to overcome temporal and spatial shortages of forage and water resources throughout Africa. Again, other proponents of seasonal mobility (e.g., Jullien, 2006; Corniaux et al., 2012;

Yacouba, 2013; Zakaria, 2014) reported that it is the best strategy for valorizing grazing areas and guaranteeing the survival of animals.

5.5 Respondents' Experiences on Climatic Conditions that Affect Mobile Herding

This section delineates the impact of climate change on changing mobile pastoralim in Wa East District over a 40-year period. Climatic conditions such as temperature, rainfall, drought, natural calamities and seasonal changes are predicted to have a greater impact on arid and semi-arid settings, which are home to the world's pastoralists who rely on natural resources for existence (IPCC, 2015; Kimaro et al., 2018). The assessed climate parameters included temperature, rainfall, drought, natural disasters, and seasonal fluctuations. The study employed cross-tabulations along with chi-square analyses at a 95% confidence interval level to evaluate the relationship between these variables.

From Table 5.3, regarding pastoralists arriving from further areas to access grazing due to climate change conditions, the results indicate that the majority (91.4 %) of mobile pastoralists believe that there have been changes in temperature due to climate change, which has influenced their mobility. This belief was significantly higher ($p = 0.009$) among pastoralists who arrived from elsewhere (76.3%) than among those who had been in the area (23.7%). Similarly, a large proportion (83.7 %) of mobile pastoralists perceived changes in rainfall due to climate change as a factor that influenced their mobility ($p = 0.253$), with a similar perception between those who arrived and those who had been there. Furthermore, the majority (88%) of mobile pastoralists observed changes in drought conditions due to climate change and believe it has influenced their

mobility, with a significantly higher ($p = 0.004$) perception among those who arrived compared to those who were there.

With regard to natural calamities, most (68.5 %) pastoralists who arrived from further areas to access grazing believed there were changes in natural calamities due to climate change that influenced their mobility ($p = 0.000$). On seasonal changes, over half (57.9%) of mobile pastoralists, who arrived from further areas to access grazing noticed changes in seasonal patterns due to climate change as a factor that influenced their mobility, with a significantly higher ($p = 0.000$) perception among those who arrived compared to those who did not. Based on the findings of the study on the influence of climate change on the movement of pastoralists seeking grazing areas, the data indicate that mobile pastoralists who migrated from remote regions to access pasture believed that climate change has a profound impact across a range of parameters, including temperature, drought, natural disasters, and seasonal fluctuations. These perceptions were significantly higher among mobile pastoralists than those who did not migrate for grazing purposes. This suggests a heightened recognition and acceptance of the effects of climate change among those who moved to obtain grazing resources.

With regard to pastoralists who lived in another location prior to their current location, the study revealed that a significantly higher percentage ($p = 0.001$) of pastoralists who had lived elsewhere (83.2%) attributed changes in temperature as a factor that influenced their mobility compared to those who had not (16.8%). Similarly, for rainfall, the results showed a significant difference ($p = 0.015$) in the perception of changes in rainfall due to climate change affecting the mobility of pastoralists who lived elsewhere (76.6%) compared with those who did not (23.4%).

For drought, the study found no significant difference (p = 0.941) in the perception of changes in drought due to climate change, affecting the mobility of pastoralists between those who had lived elsewhere and those who had not. The study found that changes in natural calamities due to climate change did not significantly (p = 0.567) influence the mobility of pastoralists, and did not differ between those who had lived elsewhere and those who had not.

Similarly, regarding seasonal changes, the study found no significant difference (p = 0.969) in the perception of changes in seasonal patterns due to climate change affecting the mobility of pastoralists between those who had lived elsewhere and those who had not. The results indicate that pastoralists who previously resided in a different location prior to their current one had a considerably stronger conviction regarding the effects of climate change, particularly in relation to temperature and rainfall fluctuations, than those who did not have such experiences. This suggests that previous exposure to diverse environments may influence the mobility of pastoralists in times of climate change. However, there was little variation in perceptions regarding drought, natural disasters, and seasonal changes based on past residency influencing pastoralists' mobility.

About 89.9%, 82.9%, 86.3% 65.4% and 56.1% of the respondents identified temperature, rainfall, drought, natural calamities and seasonal changes, respectively, to have a devastating impact on mobile herding in the area over the period. The results indicate that the majority of mobile herders believe that there have been significant changes in climatic conditions of the area, which has influenced their mobility patterns over the period. This belief was significantly higher (P = 0.009, 0.253, 0.004, 0.000 and 0.030) for temperature, rainfall, drought, natural calamities

and seasonal changes, respectively, and was the reason why other pastoralists arrived from other places to access grazing and others relocating.These results are congruent with Kiema et al. (2013) who attested that mobile heads are affected by decreasing rainfall trends, which negatively impact on biomass quality and can lead to the disappearance of most palatable pasture species in grazing lands. Similarly, Gentle and Thwaites (2016) concluded that climate change conditions affects mobile herding through decreases in pasture and water availability.

Table 5.3: Climatic Conditions That Affect Mobile Herding

Climate Change Conditions that Affect Mobile Pastoralists	Response Categories	Pastoralists arrive from further areas to access grazing			p-value	Pastoralists lived in another place before moving to the current location			p-value
		Total (N=387)	No (n=38)	Yes (n=349)		Total (N=387)	No (n=250)	Yes (n=137)	
Temperature	No	39(10.1%)	9(23.7%)	30(8.6%)	0.009	39(10.1%)	16(6.4%)	23(16.8%)	0.001
	Yes	348(89.9%)	29(76.3%)	319(91.4%)		348(89.9%)	234(93.6%)	114(83.2%)	
Rainfall	No	66(17.1%)	9(23.7%)	57(16.3%)	0.253	66(17.1%)	34(13.6%)	32(23.4%)	0.015
	Yes	321(82.9%)	29(76.3%)	292(83.7%)		321(82.9%)	216(86.4%)	105(76.6%)	
Drought	No	53(13.7%)	11(28.9%)	42(12%)	0.004	53(13.7%)	34(13.6%	19(13.9%)	0.941
	Yes	334(86.3%)	27(71.1%)	307(88%)		334(86.3%)	216(86.4%)	118(86.1%)	
Natural Calamities	No	134(34.6%)	24(63.2%)	110(31.5%)	0.000	134(34.6%)	84(33.6%)	50(36.5%)	0.567
	Yes	253(65.4%)	14(36.8%)	239(68.5%)		253(65.4%)	166(66.4%)	87(63.5%)	
Seasonal Changes	No	170(43.9%)	23(60.5%)	147(42.1%)	0.030	170(43.9%)	110(44%)	60(43.8%)	0.969
	Yes	217(56.1%)	15(39.5%)	202(57.9%)		217(56.1%)	140(56%)	77(56.2%)	

Source: Field survey (2023).

5.6 Respondents' Experiences of Climate Change Effects on Mobile Pastoralism

Over the years, extreme climate events have been seen as a major concern for many across the globe including the people of Wa East District. These events, especially rainfall and temperature, have severely affected mobile herding and herders' livelihoods. The study used a six point scale to demand respondents to indicate the level of climate change effects on mobile herding in the study area over a 40-year period.

Firstly, the study finding, as revealed in Table 5.4, shows that about 75.2% and 19.6% of the respondents stated that climate change has very high effects and high effects on herder mobility and, that it makes their animals travel long distances for feed and water. Furthermore, 1.6%, 2.1%, 0.8% and 0.8%, respectively, reported a moderate, low effects, very low effects and on effects on herder mobility. This implies that mobility as a key strategy in pastoralism is severely affected by climate change in the study area.

Table 5.4: Effects of Climate Change on Mobile Pastoralism (%)

Climate effects	No effect	Very low effect	Low effect	Moderate	High effects	Very high effect
Animals travel long distance for feed and water	0.8	0.8	2.1	1.6	19.6	75.2
Decrease in birth rate	1.8	2.8	2.6	3.4	30.5	58.9

Drop in milk production	2.6	2.1	2.6	2.3	22.5	68.0
Death of livestock	2.6	4.1	1.3	3.6	28.9	59.4
Excessive weight lost	1.6	1.8	2.8	3.4	24.5	65.9
Increase in infectious and parasitic diseases	1.8	3.6	2.3	5.2	24.8	62.3
Abortions of livestock	4.1	2.3	2.8	3.4	20.2	67.2
Appearance of new animal disease	6.2	2.3	2.6	3.4	25.8	59.7

Source: Field survey (2023).

Secondly, the respondents indicated that climate change has led to a decrease in the birth rates of livestock as 58.9% and 30.5% concluded that climate change has very high and high effects, respectively, on the birth rate of their livestock. However, 3.4%, 2.6%, 2.8% and 1.8% of the respondents noticed a moderate, low, very low and no effects of climate change on therate of birth of livestock.

Thirdly, concerning climate change effects on drop in milk production, 68% and 22.5% of the study respondents noted very high and high effects, respectively, whereas, 2.3%, 2.6%, 2.1% and 2.6% reported a moderate, low, very low and no effects of climate change on drop in milk production. Indeed, 59.4% and 28.9% of the respondents reported that climate change has very

high and high effects on death of livestock. Accordingly, 3.6%, 1.3%, 4.1% and 2.6% on the other hand, opined a moderate, low, very low and no effects of climate change on death of livestock.

Fourthly, alarge majority (65.9% and 24.5%) of the respondents said climate change has very high and high impacts on weight loss of their livestock. From the data, 62.3% and 24.8% reported that climate change extreme events have led to very high and high increase in infectious and parasitic diseases in livestock.

Finally, the data revealed that 67.2% and 20.2% of the respondents feels that climate extreme events causes abortion among their livestock, and that this has very high and high effects among. Appearance of new animal diseases was also reported to be very high and high, respectively, among mobile herders in the area as large proportions (59.7% and 25.8%) of the respondents noted that. Apparently, the results implies that climate change extreme events have seriously impacted on mobile pastorlism in the study area. Particularly, mobile herding, which is a major surviving and resource management strategy practiced commonly among pastoralists to meet their livestock forage and water needs, has been severely affected. This is congruent with many studies (Samuels et al., 2021; Liao et al., 2020; Dong, 2016) in Africa, which have established similar findings. Cowley et al. (2015) and Summer et al. (2019) concluded in their studies that climatic conditions such as increased temperature can reduce up to 25% of daily milk yield and have the potential of causing high mortality rates among livestock. Liu et al. (2019), on the other hand, reported that climate change adversely affects the development of follicle, which reduces cattle pregnancy rate. The IPCC (2019) stressed that climate change has caused variations in

precipitation, frequency and intensity of extreme weather events such as floods, storms, wildfires and emergence of new diseases for crops, livestock and humans, which goes a long way to affect food insecurity and incomes.

Interactions among respondents During a focus group discussion, it was found that climate change is becoming a reality in the study district, affecting pastoral activities in a variety of ways, including limits on pastoral mobility, causing their animals to lose weight, and high temperatures, causing animals to abort. A member of the Gbantala community group stated, "*This year, I lost about 21 cattle because all of the water sources for the animals had dried up, the temperatures were high with little rain, and the animals had to travel long distances, like 10 kilometers, to get water to drink"* (FGD, Yaanyuoyiri, 2023).

5.7 Effects of Climate Change on Livelihood of Mobile Headers

The frequency and severity of extreme climate events are increasing and significantly affecting the livelihoods of mobile herders in the study area in diverse ways. According to the study results (Table 5.5), 69.3% and 19.9% of the respondents indicated that climate change hasvery high and high affects their livelihoods, respectively, by making them travel long distances to fetch water for domestic use. Contrary to this, a small proportion (3.6%, 2.6%, 2.3% and 2.3%) of the respondents opined that climate change has moderate, low, very low and no effects on their water demands.

Table 5.5: Effects of Climate Change on Livelihoods of Mobile Headers (%)

Climate effects	No effect	Very low effect	Low effect	Moderate	High effects	Very high effect
Long distance to fetch water for domestic use	2.3	2.3	2.6	3.6	19.9	69.3
Increase in physical efforts in heading	1.3	2.3	2.3	2.8	27.4	63.8
Food insecurity	0.5	6.7	6.5	10.9	28.2	43.7
Regression in animal heritage	5.7	2.8	2.1	7.2	25.1	57.1
Decrease income	1.3	2.3	3.6	4.1	23.5	65.1
Loss of prestige	5.4	2.8	1.6	5.7	22.2	62.3

Source: Field survey (2023).

As many as 63.8% and 27.4% of the study respondents also noted that climate change has very high and high effects on their livelihood by increasing the physical efforts in herding while 2.8%, 2.3%, 2.3% and 1.3% thought climate change effects are moderate, low, very low, and zeroon their physical efforts in livestock herding. The respondents (43.7% and 28.2%) further reported that climate change has increased food insecurity among mobile pastoralists in the area and this effect is very high and high, respectively; and 10.9%, 6.5%, 6.7% and 0.5 of the respondents reported moderate, low, very low and no effects of climate change on food insecurity.

Concerning regression on animal heritage, 57.1% and 25.1% concluded very high and high effects of climate change whereas 7.2%, 2.1%, 2.8% and 5.7% of the respondents said climate change had moderate, low, very low and no effects on regression on animal heritage. In addition, the study revealed that 65.1% of respondents indicated that climate change has very high decreasing effect on their incomes and 23.5% of them reported that climate change has led to a decrease incomes of mobile pastoralists and this effect was high. Furthermore, 62.3% and 22.2% of the respondents said climate change has led to very high and high effects on loss of prestige among mobile pastoralists over the period. Judging from the study results, as clearly illustrated in Table 5.5, the respondents considered long distance to fetch water for domestic use and increase in physical efforts to be the most severe effects of climate change on their livelihoods. This can be attributed to increase in temperature levels, drought prevalence and variations in rainfall. A KII also indicated in an interview that:

"Water is our major problem. Because the rains do not come like before and the temperatures are getting high these days, all the water bodies around get dried up early, which makes our women and children to travel far to look for water for domestic use. You see, sometimes, the community don't allow us use their boreholes, we are always fighting because some community members say our animals destroy their things" (FGD, Tiisa, 2023).

The finding of this study supports the finding of Yilma et al. (2009), who reported that mobile pastoralists considered water as a critical need for both humans and animals. It is also consistent with Sanou et al. (2018), who indicated that mobile pastoralists blame climate change for the increase in physical efforts in herding. According to Bati (2013), climate change is a major treat

to food security among mobile herders across Africa. The above has further confirmed the findings of Ayal et al. (2018), who concluded that climate change reduces mobile headers' income and worsens food insecurity because climate change brings about livestock diseases and loss of weight among livestock, which affects their market prices.

5.8 Effects of Pastoral Activities on Climate Change

Logically, pastoral activities exerts a lot of effects on climate change because agriculture and livestock production contributes about 14.5% to the total anthropogenic GHG emissions (Gerber et al., 2013; Rojas-Downing et al., 2017; IPCC, 2019). However, during the survey, it was noticed that respondents did not associate pastoral activities as a cause of climate change. This view of the respondents is demonstrated by their ratings on the effects of pastoral activities on climate change as show in the 5-point ordinal scale with a mean range and verbal interpretation, which was used to determine the effects of pastoral activities on climate change in the study area (see Table 5.6). The 5-point ordinal scale was graded as; 1=strongly disagree (1.00-1.50), 2=disagree (1.51-2.50), 3=neutral (2.51-3.50), 4=agree (3.51-4.50) and 5= strongly agree (4.51-5.00).

Table 5.6: Respondents' Experiences on the Effects of Pastoral Activities on Climate Change

Effects of Pastoralism on CC	N	V.I	Mean	Std. Deviation
Source of greenhouse gas	387	Disagree	2.17	1.661
Reduce water quantity and quality	387	Neutral	3.18	1.175
Causes soil erosion	387	Neutral	3.24	1.148
Causes deforestation	387	Neutral	3.36	1.027

Source: Field survey (2023).

The findings revealed that respondents either disagreed or stayed neutral to the effects of pastoral activities on climate change. The study participants disagreed that pastoral activities is a source of green house gas emission by assigning a mean score of 2.17 and remain neutral on reducing water quantity and quality, causes soil erosion and deforestation with mean scores of 3.18, 3.42 and 3.36, respectively. Though respondents denied that pastoral activities contribute to greenhouse gas emissions, studies by Gerber et al. (2013) found that livestock accounts for around 14.5% of total anthropogenic greenhouse gas emissions. Grossi et al. (2019) also show that animals emit methane and nitrous oxide as a result of manure storage and the usage of organic fertilizers.

5.9 Drivers of Climate Change and Changing Mobile Pastoralism

5.9.1 Drivers of climate change

In order to fully confirm respondents understanding of climate change, they were ask to indicate the drivers causing changes in climate of the area over the past 40 years. The findings indicated that the respondents perceives human activities such as removal of tree cover, bush burning, charcoal burning, animal grazing and fertilizer applications as the underlying drivers of climate change in the study area over the period (Figure 5.2).

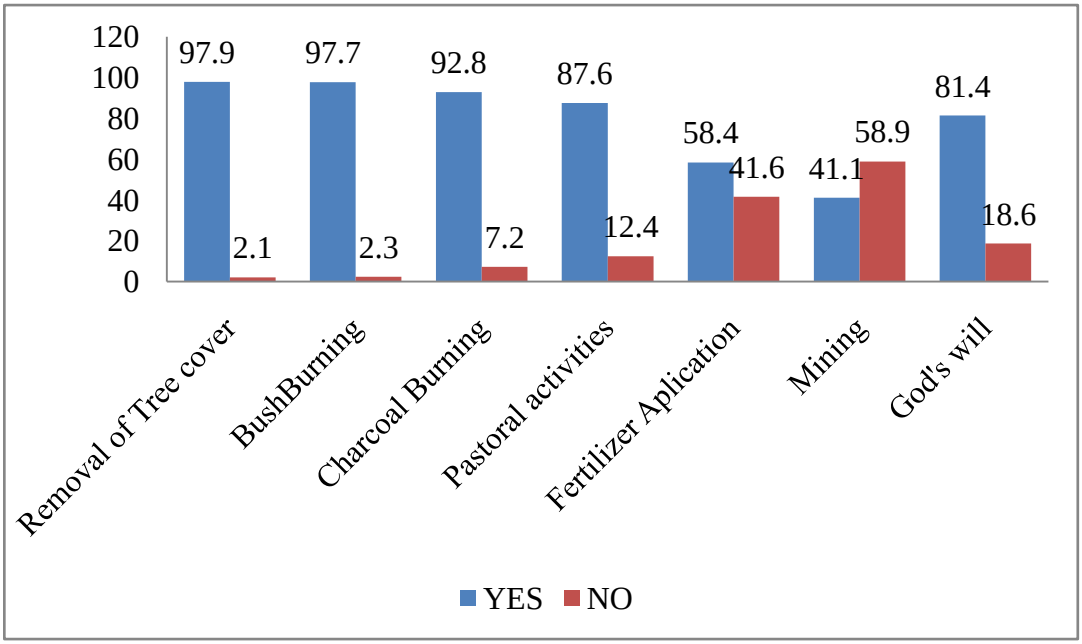

Figure 5.2: Drivers of climate change

Source: Field survey (2023).

Figure 5.2 clearly shows that a large majority, 97.9%, 97.7%, 92.8%, 87.6% and 58.4%, of the respondents asserted that removal of tree cover, bush burning, charcoal burning, pastoral activities and fertilizer application, respectively, are the major drivers of climate change

identified by respondents in the study area over the past 40 years. These, respondents acknowledged to be contributing to low rains, seasonal changes, high temperature, floods and many others.

As envisaged, most (81.4%) of the respondents noted supernatural powers as being the driving force of climate change and that all things are from God and the changes they see in the manifestation of low rains, high temperatures, natural calamities and all other weather variations experienced over the period are punishments for going astray. This view was not surprising because respondents from the study area belonged to various religions, such as Muslims, Christians and African Traditional Religion, which believes in supernatural powers. However, the respondents, through their responses, did not consider greenhouse gases and mining activities to be drivers of changing climate in the study area.

5.9.2 Respondents' Ranking of Drivers of Climate Change

The ranking of the drivers of climate change, clearly demonstrate the relative importance of one driver over the others. By ranking, respondents were able to indicate the severity of each driver of climate change over the period of study. The lower the rank, the higher the importance of the driver and, the higher, the rank, the less importance the driver.

FromTable 5.7, among all the drivers, a good number (37.5%) of respondents ranked removal of tree cover as the highest driver of climate change, followed by bush burning (21.5%). Judging from their rankings, it is clear that the participants understand that environmental destruction leads to emission of greenhouse gases. This suggest a good match of the respondents' scientific

knowledge about climate change. Furthermore, 11.1% of the study participants ranked increase pastoral activities as the third driver of climate change in the study area.

Table 5.7: Respondents' Rankings of Drivers of Climate Change

Variable	Frequency	Percentage (%)	Rank
Removal of tree cover	145	37.5	1
Bush burning	83	21.5	2
Charcoal burning	19	4.9	7
Pastoral activities	43	11.1	3
Fertilizer application	25	6.5	6
Mining	32	8.2	5
God's Will	40	10.3	4

Source: Field survey (2023).

Like in many traditional societies, 10.3% of the sampled respondents freely acknowledged and ranked "God's will" as the fourth most important driver of climate change in the area. This view is widespread in Africa as similar results were obtained by Teka et al. (2013), who reported that farmers in Benin partly attributed disobedience of traditional customs as a causes of climate change. Respectively, mining, fertilizer application and charcoal burning where considered the fifth, sixth and seventh drivers contributing to changes in climate of the area over the 40-year period.

Ultimately the results of the study reveals a possible interaction among the various drivers, which were perceived by respondents. It is clear from the results that one driver can lead to another. For instance, removal of tree cover, which respondents indicated as a very important

driver of climate change, is as a result of bad agricultural practices such as bush burning, land clearing for farming, the need for fuel wood and charcoal which is the major source of energy for rural households. Also, bush burning results in removal of tree cover, which, in turn, drives climate change.

5.9.3 Respondents' indication of proximate drivers of changing mobile pastoralism

Since the mid-2000s, sustainability of pastoralism has become a major concern as well as improvement in knowledge for its survival under changing environmental conditions. While some (e.g., Steen, 1994; Markakis, 2004; Sandford, 2006) are of the view that pastoralism is fading off as a result of internal causes such as recent climate change falling beyond its adaptive capacity, others, such as Jonsson (2010), track the foundation of pastoral weaknesses in its settings in deprived places coupled with undesirable environmental conditions. The culmination of these factors may result in "multiple stressors" that discourage pastoralism (Thebaud & Batterbury, 2001; Miller, 2008).

Changing mobile pastoralism is driven by many complex environmental factors. Eyasu (2014), indicated that changing mobile pastoralism have causations and environmental conditions are the underlying causes of change. Respondents were asked to rate the perceived drivers of changing mobile pastoralsim in the study area based on their level of importance. The study findings as revealed in Table 5.8 clearly shows that 45.2% and 32.6% of the respondents regarded extreme temperature fluctuations as very important and important drivers of changing mobile pastoralism in the study district, while 4.1% perceived it not important. On the other hand, 48.6% and 36.4% of the respondents, respectively, reported that rainfall variations serve as a very important and

important driver of changing mobile pastorlism in the study area. Extreme temperature fluctuations and variations in rainfall could affect growth of forage species and water availability, which are key resources for mobile pastoralism. The results corroborates with the findings of Tugjamba et al. (2021), who asserted that respondents perceive environmental events such as temperature and rainfall as key drivers of pastoralism because they determine the availability of important resources for pastoralism and can impact of pastoralists' livelihood.

Moreover, from the respondents perspective, drought and high variations between seasons are considered very important (47.3%, 47%) and important (33.9%, 35.1%) drivers that determine changes in mobile pastoralism in the district. Indeed, 42.9% and 38.5% of respondents asserted that seasonal cultivation of crops that needs to be protected from animal destruction are very important and important drivers of mobile pastoralism.

Table 5.8: Proximate Drivers of Changing Mobile Pastoralism (%)

	Very Important	Important	Moderately Important	Slightly Important	Not Important
Extreme temperature	45.2	32.6	13.2	4.9	4.1
Rainfall variations	48.6	36.4	7.8	2.6	4.7
Drought	47.3	33.9	10.6	3.4	4.9
High variation between Seasons	47	35.1	8.8	3.4	5.7
Wind intensity	38.5	39.8	12.9	3.6	5.2
Soil moisture and hydrology	37.5	42.9	12.1	2.8	4.7
Forage productivity, quality,	42.4	37.7	10.9	3.6	5.4

phonology, digestibility and salinity					
Seasonal cultivation of crops that need to be protected from grazing	42.9	38.5	8.5	4.9	5.2
Bushfire	51.7	29.7	8.5	4.4	5.7

Source: Field survey (2023).

This findings are similar to Cavanagh and Benjaminsen (2015) and Egeru et al. (2015) who established relations between rainfall, temperature and vegetation patterns and concluded that environmental conditions are key drivers of mobile pastoralism in many pastoral communities in African. Godde et al. (2020) noted that changing climatic conditions, such as rainfall variability, temperature fluctuations and drought, are often recognised as important drivers that affect availability of pasture and water for pastoral actives. The study findings further agrees with IPCC (2015) and Kimaro et al. (2018), which admitted that environmental conditions are great predictors of changing mobile pastoralism in arid and semi-arid settings.

5.9.4 Respondents' Understanding of Underlying Drivers of Changing Mobile Pastoralism

Largely, social, economic and political dynamics can have significant influences on pastoral activities. The influencing factors of mobility in pastoral systems are complicated, occur across various scales, and include ecological, social, economic, and political factors (Samuels et al., 2021). From the data (Table 5.9), the majority (50.1%) of the sampled respondents freely acknowledged that demographic dynamics are very important drivers of changing mobile pastoralism in Wa East District over the past 40 years where as 28.9%, 9.3% and 7.8% of the

respondents indicated that it is important, moderately important and slightly important, respectively. Only a small proportion (3.9%) of the survey respondents indicated that in itis not an important driver of changing mobile pastoralism.

Attitude and migration was considered respectively by 25.6% and 33.9% of the respondents to be very important drivers of change in mobile pastoralim over the past period; and39.8% and 35.4% of the respondents reported that they were important drivers that determines changes in pastoralism. Moreover, 23% and 15.2% of the survey respondents thought they are moderately important drivers of pastoral mobility changes, whereas 7% and 8.3% felt they are slightly important. However,4.7% and 7.2% of the respondents indicated that they are not important drivers of changing mobile pastoralism in the area.

Table 5.9: Underlying Drivers of Changing Mobile Pastoralism (%)

	Very Important	Important	Moderately Important	Slightly Important	Not Important
Demographic dynamics	50.1	28.9	9.3	7.8	3.9
Attitude	25.6	39.8	23	7	4.7
Migration	33.9	35.4	15.2	8.3	7.2
Customary land tenure system	46.8	32	9.8	5.7	5.7
Economic factors: Rising living standards	37	35.1	14.7	7.5	5.7
Political: Governmental laws Institutional factors	18.6	33.1	12.1	21.2	15
Access to pastoral resources	47.3	24.5	7.8	8.0	12.4
Avoiding Conflicts	24.8	33.6	10.3	18.1	13.2

Source: Field survey (2023).

Changes in customary land tenure systems are noted to mostly contribute to grassland fragmentation, which leads to changes in mobile pastoralism. The analysis of the survey data reveals that 46.8% and 32% of the respondents agreed that customary land tenure systems in Wa East District is a very important and important driver of mobile pastoral system. A small proportion (9.8% and 5.7%) of the respondents admitted it was moderately and slightly important while 5.7% of the respondents reported that it is not an important driver that determines changes in mobile pastroalism.

Respectively, 37% and 35.1% of the respondents expressed that economic factors, such as rising living standards, are very important and important drivers that determine changes in mobile pastroalism, 14.7% of the respondents acknowledged that they are moderately important and 7.5% indicated that economic factors are slightly important drivers of mobile pastoralism. A smaller section (5.7%) thought that economic factors are not important drivers of mobile pastoralism.

Furthermore, 18.6% and 33.1% of respondents noted political factors, i.e.,government laws and institutional factors, as very important and important determinants of changes in mobile pastoralism in Wa East Districtover the past 40 years whereas 12.1% and 21.2% of the respondents reported that moderately and slightly important, respectively. However, 15% of respondents opined that political factors have no influence on mobile pastoralism. Most (47.3%, 24.5%, 24.8% and 33.6%) of the respondents mentioned access to pastoral resources and avoiding conflictsas very important and important drivers of changes in mobile pastoral system

over the period,7.8%, 8%, 10.3% and 18.1% of the respondents were of the view that access to pastoral resources and avoiding of conflicts are moderately and slightly important drivers that determine changes in mobile pastoralism. In contrast, 12.4% and 13.2% of the study respondents thought they have no influence on pastoralism and that they are not important drivers of change.

The findings of this study on socio-economic and political drivers of changing mobile pastoralism in Wa East District concord with Bukari (2016), who indicated that mobile pastoralism is fundamentally driven by climate stressors, access to pastoral resources, political and institutional arrangements as well as pastoralists' traditional knowledge of an area. Flintan (2011) noted that mobile pastoral grazing systems are fast becoming smaller, fragmented as well as spatially challenged as a result of socio-economic and political factors.The study results further agrees with Houessou et al. (2019) that with regard to changes in mobile pastoralism, socio-economic features of pastoral households have an influence on their management strategies, which can adversely affect productivity.

5.10 Chapter Summary

The study findings clearly revealed a great shift in mobile pastoralism from 1981-2021. Respondents perceived the changes to be influenced by climate change as one of the most important factor of mobile pastoralism. Since pastoral activities are largely governed by water availability, which is often confined to a relatively short season and irregular in time and space within the district.Addition, the study analysis shows that changes in pastoralism is also fundamentally driven by access to pastoral resources, political and institutional arrangements as well as pastoralists' traditional knowledge of an area.

The findings of the study have major implications for pastorlism, their mobility patterns as well as other agricultural activities, since pastoral livelihoods depends solely on climatic factors such as rainfall and temperature. Respondents perception on the drivers of change in climate and mobile pastoralism were explored. Their views on the drivers gave a clear judgement of their understanding of climate change and mobile pastoralism in the area over the past 40 years.

CHAPTER SIX

EFFECTS OF CLIMATE CHANGE AND CHANGING MOBILE PASTORALISM ON LAND USE/LAND COVER AND SMALLHOLDER ADAPTATION STRATEGIES

6.1 Introduction

The effects of climate change and mobile pastoralism on land use/cover are explored in this chapter. It takes into account the views of respondents regarding the effects of climate change and pastoralism on the various land use and cover types that exist in the study area over the period of the study. The study goes further to complement these views of respondents using satellite images to determine the change rate and percentages of the effects of climate change and mobile pastoralism on the various land use and cover categories in the area. Respondents' adaptation strategies were identify and discussed as well as the factors that influence their choice of adaptation.

6.2 Observed Effects of Climate Change and Changing Mobile Pastoralism on Land Use/Land cover (LULC)

According to Bobadoye (2016), local knowledge of climate change and changing mobile pastoralism is based on long term experience and familiarity of the area and this helps in planning pastoral activities as well as strategies to adapt to the effects of climate change and changing mobile pastoralism. Concerning respondents' observed effects of climate change and changing mobile pastoralism on land use/land cover, the study (Figure 6.1) reveal that 91% of the respondents stressed that they have observed the effects of climate change and changing mobile pastoralism on land use/cover in the study area while a smaller proportion (9%) of the

respondents reported that they have not seen any effects of climate change and changing mobile pastoralism on land use/cover in the area.

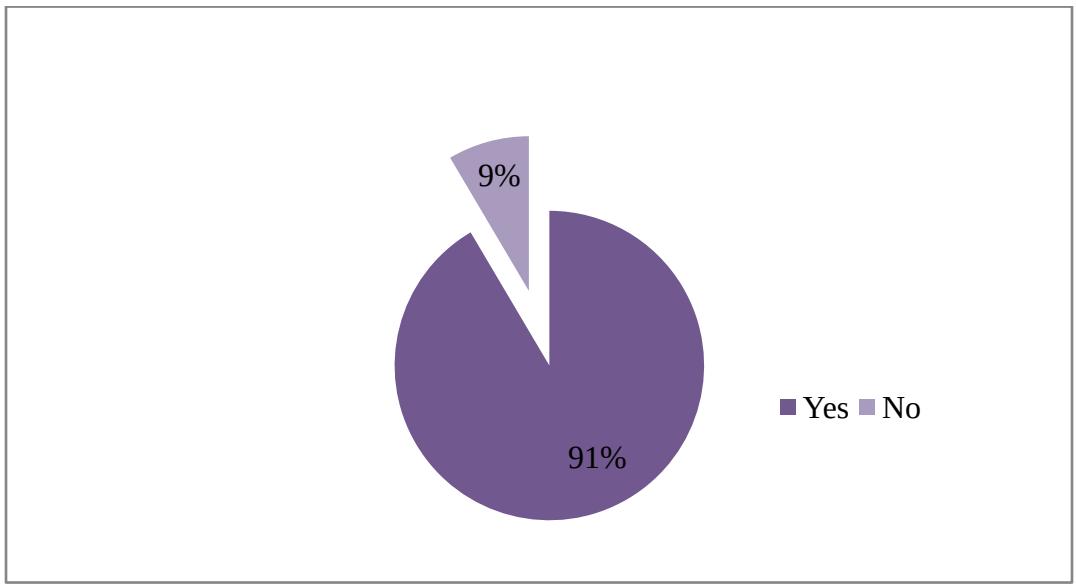

Figure6.1: Observed effects of climate change and mobile pastoralism on land use/land cover

Source: Field survey (2023).

Most of the respondents agreed that climate change and changing mobile pastoralism have negative effects on land use/land cover in the study area over the past decades. Although there are many effects, respondents mentioned and ranked the following as the most important effects: destruction of agriculture lands; decreasing vegetation cover; reduction of water quality and quantity with 45.7%, 33.1%, and 15.5%, respectively, as clearly shown in the ranking from 1st 2nd and 3rd in Table 6.1. In addition, soil erosion and other effects were noted by 3.6% and 2.1% of the study respondents to be the 4th and 5th most important.

Table 6.1: Respondents' Ranking of the Most Important Effects of Climate Change and Pastoralism on LULC

Variable	Frequency	Percent	Rank
Soil erosion	14	3.6	**4**
Decreasing vegetation cover	101	33.1	**2**
Reduction in water quality and quantity	60	15.5	**3**
Destruction of agricultural lands	177	45.7	**1**
Other specify	8	2.1	**5**
Total	387	100.0	

Source: Field survey (2023).

It must be noted that the activities of humans lead to the changes we experience in the various parts of the ecosystem (IPCC, 2007; Khosravi et al., 2017). The study sought to understand the changes in land use/land cover in terms of size or proportion over the past 40 years owing to climate change and pastoral activities. It was revealed that 61% of the study respondents perceived that grassland have decreased over the 40 year period, while 35.5% noted an increase and a small proportion (3.6%) of the respondents thought there have not been any changes in glass land over the same period (Table 6.2).

According the survey results, 60% of the respondents indicated that Savannah woodland has seen a decrease in proportion/size in the past decades whereas 37.2% noted that ithas increased and 2.8% thought there has not been any changes Savannah woodland. A substantial proportion (80%) of the respondents reported that agricultural land has seen an increase over the past 40 years in terms of size while few (18.8% and 1.2%) of the respondents opined a decrease and no change, respectively.

Table 6.2: Respondents Assessment of Changes in LU/LC Dynamics Owing to Climate Change and Mobile Pastoralism (%)

	Grass land	Savannah Woodland	Farm Land	Pasture land	Built-up	Water Bodies	Bare Land
Increase	35.4	37.2	80	35.1	55.7	34.8	20.8
Decrease	61	60	18.8	57.9	19.2	58.2	72.6
Unchanged	3.6	2.8	1.2	7.0	25.1	7.0	6.7

Source: Field survey (2023).

Pasture land, according to the study result, has decreased over the period of study as shown in the responses of 57.9% of the respondents, while 35.1% of themindicated an increase and 7.0% perceived no changes in pasture land. This implies that pastoralists in the district are already suffering from the devastating effects of climate change along with shifting land use patterns that reduces grazing areas, which is anticipated to have a greater impact on the production of

livestock, particularly cattle due to their feeding habits and susceptibility to heat stress. This finding is consistent with MLDF (2015), Kimaro et al. (2018) and WEDA (2020).

The study revealed different trends with regard to perceived changes in water bodies in the study area. According to the findings, 58.2% of the respondents perceived that most water bodies in the area have reduced whereas 34.8% said there is an increase in water bodies and 7.0% of them felt water bodies within the area have been the same for the last 40 years. The research further indicated that 55.7% of respondents concluded that settlements in the study area have increased because there is population growth and people are putting up more houses, 19.2% of them indicated a decrease in settlements and noted further that climate change and increasing pastoral activities, coupled with other socio-economic reasons, have forced many to move out of the district to other places. However, 25.1% of the sampled respondents thought settlements have remained the same over the period.

In an interview with a key informant, he emphasized that:

"When we were children, this place was full of forest and there were lots of water bodies all over.But now, because of this Fulani people and their animals, they have destroyed the forest.Most of the water bodies have dried up because the rains do not come like before. Hmmm, my brother, our own people are part of the problem, they cut the trees for charcoal" (KII, Tiisa, 2024).

Finally, relating to perceived changes in bare lands, it was discovered that a large majority of the respondents, representing 72.6%, opined a decrease in the available of bare lands in the study

area. The study also revealed that 20.8% of the respondents perceived an increase in bare land while 6.7% believed bare land has been the same over the last 40 year period.

The above findings are consistent with the study of Sunderland and Rowland (2019), which noted that climate change and pastoral activities are already affecting land use/land cover, threatening ecosystem and other important services. The results further confirms Smith et al. (2020) that climate change and pastoral activities play major roles in the processes that lead to changes in land use/land cover.

6.2.1 Rate of change in land use and landcover owing to climate change and pastoral activities

To assess the changes in land use/landcover due to climate change and pastoral activities, respondents were requested to provide insights into the major changes observed in the past 40 years in the following land use/land cover categories: forest-grazing land, forest-grazing land and cropland, cropland-settlement, forest-grazing land and bare land soil, forest-grazing land cropland fallow, and bare land soil regenerated land. Responses were recorded on a scale of 'no change, decrease, or 'increase', as shown in Table 6.3.

Table 6.3: Rate of Change in Land Use/Cover Owing to Climate Change and Pastoral Activities

Major shifts in land use and cover occurred owing to climate change and pastoral activities	Response Categories	Respondent Perception of climate change			p-value
		Total (N=387)	No (n=5)	Yes (n=382)	
Forest-Grazing land	No change	18(4.7%)	1(20%)	17(4.5%)	0.411
	Decrease	58(15%)	1(20%)	57(14.9%)	
	Increase	311(80.4%)	3(60%)	308(80.6%)	
Forest-grazing land and Cropland	No change	23(5.9%)	0(0.0%)	23(6.0%)	0.686
	Decrease	51(13.2%)	1(20.0%)	50(13.1%)	
	Increase	313(80.9%)	4(80%)	309(80.9%)	
Cropland-Settlement	No change	53(13.7%)	1(20.0%)	52(13.6%)	0.325
	Decrease	61(15.8%)	2(40.0%)	59(15.4%)	
	Increase	273(70.5%)	2(40.0%)	271(70.9%)	
Forest-grazing land and bare land soil	No change	37(9.6%)	2(40.0%)	35(9.2%)	0.067
	Decrease	256(66.1%)	1(20%)	255(66.8%)	
	Increase	94(24.3%)	2(40%)	92(24.1%)	
Forest-Grazing land cropland fallow	No change	43(11.1%)	1(20%)	42(11%)	0.335
	Decrease	276(71.3%)	2(40%)	274(71.7%)	
	Increase	68(17.6%)	2(40%)	66(17.3%)	
Bare land soil Regenerated land	No change	33(8.5%)	1(20%)	32(8.4%)	0.701
	Decrease	70(18.1%)	1(20%)	69(18.1%)	
	Increase	284(73.4%)	3(60%)	281(73.6%)	

Source: Field survey (2023).

According to the respondents, they have observed major changes in land use/land cover over the past 40 years in the study area. The changes, as reported by the respondents, are due to changes in climate as a result, pastoralists extend their activities into forest land use and cover. This was revealed by 80.4% of the respondents who noted that they observed an increase in grazing land as a result of a shift from forest land use and cover to grazing land. Comparing the respondents' observation to their perceived knowledge of climate change, the results show no significant association between respondents' knowledgeable of climate change and their awareness of major shifts in forest-grazing land use/land cover due to climate change and pastoral activities ($p > 0.05$).

Similarly, from the forest-grazing and cropland land use/land cover category, the majority (80.9%) of respondents opined that they have observed an increasing tread from forest-grazing land use/land cover being turned into croplands over the past 40 years. Again, the observation did not show any statistical significance association between respondents' observed changes in the land use/land cover and the perception of climate change in the area ($p > 0.05$).

In this study, 70.5% of the respondents revealed that over the past decades, many crop lands have been converted to settlement areas leading to an increase from crop land-settlement land use categorywhile 66.1% reported a decreasing trend in the proportion and size of forest-grazing and bare land use/land coverand 71.3% noted thatthey have observed that over the years, there has been a major decrease in fallow lands due to climate change and pastoral activities. These findings also showno significant relationship ($p > 0.05$) between perceived knowledge of climate

change and observed shifts from crop land-settlement land use/land cover due to climate change and mobile pastoral activities.

Furthermore, on bare land soil regenerated land, the majority (73.6%)of respondents who were knowledgeable about climate change indicated an increase in this land use category, compared to 60% of those who had no knowledge of climate change. The study results showed no significant association in responses between those who claimed knowledge of climate change and those who did not regarding the major shift in cropland fallow land use/land cover owing to climate change and pastoral activities ($p > 0.05$).

Overall, the foregoing findings imply that the trends in land use/land cover change, as respondentsrelated to their perceived changesin climate, demonstrate that the majority of themhave observed an increase in several land use/land cover categories over the period of study, particularly those pertaining to forest-grazing land, cropland-settlement, and bare land soil-regenerated land. Although there were some variations in the responses, the findings suggest that perceived changes in land use/land cover attributed to climate change and pastoral activities were generally similar, regardless of respondents'claimed knowledge and experience of climate change.

6.3 Land Use/Land Cover Change from Satellite Image Analysis for Wa East District(1986-2023)

Activities land is put to greatly influence the extent of changes in land cover. Thus, land use changes that have occurred in the last decades are responsible for the main land use and land cover changes that may occur in the future (Tasser et al., 2017). The results obtained from Landsat images of 1986, 1995, 2005, 2014 and 2023 (Table 6.4 and Figure 6.2) revealed substantial changes among the various land cover classes. For instance, both close woodland and open woodland showed significant decreasesin land area from 1986 to 2023 (from 15.54% to 1.71% and 66.26% to 24.74%, respectively). This indicate potential deforestation or land conversion fromwoodland to other land uses. It appears the degradation of that land cover unit was more visible in 2023 than the other years. The significant changes experienced in close and open woodland over the period could be attributed to increase in human activities on land over the past years.

Grassland that occupied one of the smallest portions in 1986 (14.83%) have increased continuously over the years to become the dominant LULC by 2023 with 61.22%. This increase in grassland could be attributed to environmental destruction such as removal of tree cover for charcoal and fuel wood. Similarly, farmland has experienced an increase over the period (3.27% to 10.56%), indicating potential agricultural expansion or conversion of other land uses to farmlands. There are minor fluctuations in bare lands and built-up classes, with a slight increase observed in bare land (from 0.01% in 1986 to 1.13% in 2023%) and built-up areas (0.01% in 1986 to 0.45% in 2023), possibly due to urbanization or infrastructure development. Water

bodies maintained a relative stability over the years, with a slight increase from 0.09% in 1986 to 0.18% of land area in 2023. These results agree with the findings of Davirs et al. (2020), who observed significant changes in land use/land cover in some pastoral communities in Africa as a result of increase pressure on land from mobile pastoralism and climate change. Again, Smith et al. (2020) indicated that climate change and changing mobile pastoralism have a negative effect on land degradation and land usage,and that they play a major role in the processes that leads to land degradation, which in turn leads to a shift in land use/land cover.

Table 6.4: Dynamics of LULC of Wa East Districtfrom 1986 to 2023 (%)

LULC	1986	1995	2005	2014	2023
Close wood land	15.54	16.52	6.34	7.88	1.71
Open wood land	66.26	52.18	63.13	47.57	24.74
Grass land	14.83	26.24	24.38	38.18	61.22
Farm land	3.27	4.89	5.92	6.23	10.56
Bare land	0.01	0.06	0.13	0.02	1.13
Built-up	0.01	0.01	0.06	0.07	0.45
Water bodies	0.09	0.10	0.05	0.04	0.18

Source: Author (2024) based on landsat data.

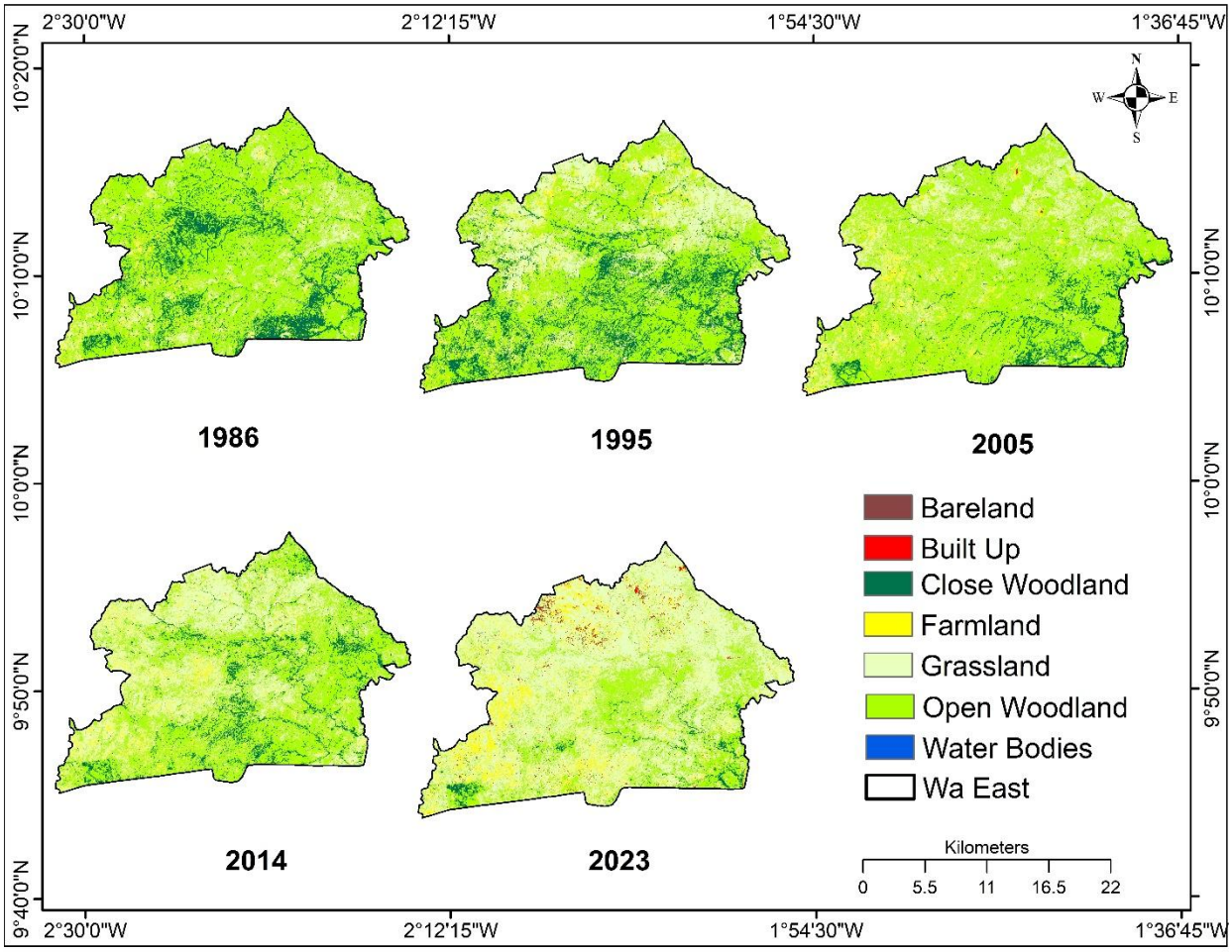

Figure 6.2: Spatial distribution of land cover classes of Wa East District, 1986 – 2023

Source: Author (2024) based on landsat data.

6.3.1 Rate of land use/land cover change in Wa East District between 1986 and 2023

Table 6.5 shows the percentage change in LULC for difference periods. Close woodland experienced a substantial increase of 10.18% from 1986-1995, followed by a decrease of 1.54% from 2005-2014 and a further decrease of 6.17% from 2014-2023. This indicates a fluctuation in close woodland cover over the years. Open woodland experienced a decrease of 14.08% from 1986-1995, followed by another decrease of 15.56% from 2005-2014. This suggests a continued

decline in open woodland cover, which could be due to factors such as deforestation resulting from climate change and mobile pastoralist activities.

Table 6.5: LULC Change Rate from 1986 to 2023 (%)

LULC	1986-1995	1995-2005	2005-2014	2014-2023
Close wood land	0.98	-10.18	1.54	-6.17
Open wood land	-14.08	10.95	-15.56	-22.83
Grass land	11.41	-1.86	13.80	23.04
Farm land	1.62	1.03	0.31	4.33
Bare land	0.05	0.07	-0.11	1.11
Built-up	0.00	0.04	0.01	0.38
Water bodies	0.01	-0.05	-0.01	0.14

Source: Author (2024) based on Landsat data.

Conversely, grassland cover increased consistently over the years, with notable increases of 11.41% from 1986-1995 and 13.80% from 2005-2014 and a further increase to 23.04% from 2014-2023. This could be attributed to land management practices resulting from pastoral activities or natural reclamation of previously unused land. Furthermore, farmland cover showed relatively modest changes compared to other categories, with slight increases over each time

interval. The highest increase was observed from 2014-2023 (4.33%), indicating a trend of gradual expansion of farmlands.

Bare land cover experienced minor fluctuations across the different time intervals. The largest increase in bare land areas was observed from 2014-2023 (1.11%). This may be attributed to overgrazing caused by mobile pastoralism and climate change. Built-up areas showed consistent increases over each time interval, although the percentage changes were relatively small (from 0.00% in 1986 to 0.38% in 2023). This reflect on-going urbanization and infrastructure development. Water bodies experienced minor fluctuations, with slight decreases observed in some time intervals (1995-2005 and 2005-2014). However, these changes are relatively small compared to other land cover types.

Overall, the analysis indicate dynamic changes in land use/land cover over the studied time periods, with some LULC classes experiencing significant fluctuations or trends. Factors driving these changes could include climate change, mobile pastoralism, urbanization, agricultural practices, natural processes, and land management decisions. The results obtained from the analysis of Landsat images do not entirely agree with the perceptions of the study respondents regarding the changes in land use/land cover experienced over the past 40 years. Forinstance,whereas grassland has seen an increase from the observation of the satellite image, 61% of respondents reported a decreasing trend experienced in grassland over the study period. However, the perception of respondents on open and close woodland (wooden Savannah) is in agreement with the generated results from the land use/land cover classifications. For instance,

60%, 80% and 55.7% of the respondents opined a decrease in wooden Savannah, increase in farm land and increase in built-up areas,which is confirmedbythe image analysis.

6.3.2 Land use/land cover transitions in Wa East District(1986 to 2023)

This section shows the major land use/land cover transitions in the Wa East District. The initial land cover types, which did not contribute to changes in land to other land cover classes (i.e., unchanged land cover), were all put together as "stable"class. All minor land cover transitions were put together as "other changes"class. Finally, the major land cover transitions from their respective years are highlighted in Table 6.6.

Table 6.6: Land Use/Land Cover Transitions in the Wa East District(1986 to 2023)

1986-1995		
Land Cover	**Area_ha**	**Area_%**
Stable	205210.0	47.8
Other Changes	32915.8	7.7
Open Woodland to Close Woodland	40729.7	9.5
Close Woodland to Open Woodland	36067.9	8.4
Grassland to Open Woodland	27115.7	6.3
Open Woodland to Grassland	72967.7	17.0
Open Woodland to Farmland	14553.7	3.4
1995-2005		
Land Cover	**Area_ha**	**Area_%**

Stable	216031.0	50.3
Other Changes	30288.6	7.1
Open Woodland to Close Woodland	12704.9	3.0
Close Woodland to Open Woodland	46823.4	10.9
Grassland to Open Woodland	57607.2	13.4
Open Woodland to Grassland	45276.0	10.5
Farmland to Open Woodland	10158.6	2.4
Grassland to Farmland	10670.8	2.5
2005-2014		
Land Cover	**Area_ha**	**Area_%**
Stable	210888.0	49.1
Other Changes	22405.5	5.2
Open Woodland to Close Woodland	22627.2	5.3
Close Woodland to Open Woodland	15675.3	3.6
Grassland to Open Woodland	38229.9	8.9
Open Woodland to Grassland	90970.2	21.2
Open Woodland to Farmland	14581.5	3.4
Farmland to Grassland	14182.9	3.3
2014-2023		
Land Cover	**Area_ha**	**Area_%**
Stable	183272.0	42.7
Other Changes	24525.7	5.7
Close Woodland to Open Woodland	19457.8	4.5

Grassland to Open Woodland	21792.3	5.1
Open Woodland to Grassland	124828.0	29.1
Open Woodland to Farmland	11604.4	2.7
Farmland to Grassland	17163.0	4.0
Grassland to Farmland	26917.3	6.3

Source: Author (2024) based on landsat data.

The table reveal the changes that took place among the various land use/land cover classes in the study area between 1986 and 2023. The results indicate that 205210.0ha (47.8%) of land area remained stable between 1986 and 1995. There is also an observed transition among the different land cover classes. The major changes observed for the period were:40729.7ha (9.5%) of land area changed from open woodland to close woodland; 36067.9ha (8.4%) changed from close woodland to open woodland; 27115.7ha (6.3%) of land area changed from grassland to open woodland; 72967.7ha (17%) from open woodland to grassland; and 14553.7ha (3.4%) from open woodland to grassland.

The stable land area experienced an increase in land area between the period of 1995 and 2005 representing 216031.0 ha (50.3%).Meanwhile, other major changes observed for the period include: 12704.9ha (3.0%) of land area changed from open woodland to close woodland; changes from close woodland to open woodland represented 46823.4ha (10.9%); 57607.2ha (13.4%) changed from grassland to open woodland; changes from open woodland to grassland represented 45276.0ha (10.5%); 10158.6ha (2.4%) changed from farmland to open woodland; and 10670.8ha (2.5%) changed from grassland to farmland.

The period between 2005 and 2014 saw stable land cover area decrease to 183272.0 (42.7%) from the previous time period. The major land cover transition for this period was changes from open woodland to grassland 90970.2ha (21.2%), followed by grassland to open woodland 38229.9ha (8.9%), with the least form of land cover transition beingfrom farmland to grassland representing 14182.9ha (3.3%). There was a further decline in the stable land cover in the period between 2014 and 2023 representing 183272.0ha (42.7%). The major transition between land covers was observed to be from open woodland to grassland representing 124828.0ha (29.1%), 26917.3ha (6.3%) changed from grassland to farmland, with the least form of transition being from open woodland to farmland representing 11604.4ha (2.7%). Overall, it is observed that changes from woodland areas to grasslands are more dominant compared to other land cover transitions indicating the effects of climate change. This is illustrated in Figure 3.

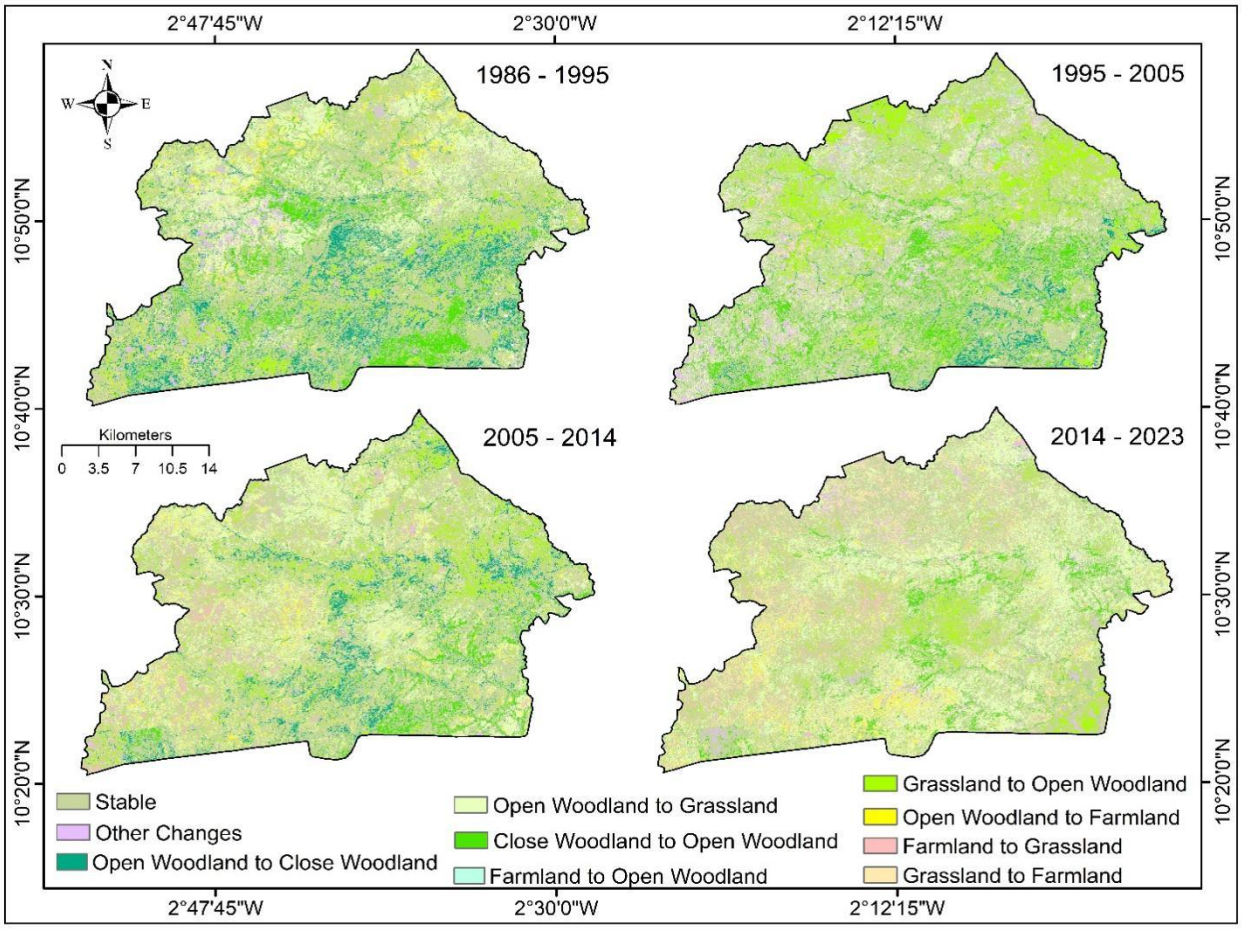

Figure 6.3: Land use and land cover transitions (1986 to 2023)

Source: Author (2024) based on landsat data.

6.4 Adaptation Strategies Used to Manage the Effects of Climate Change and Changing Mobile Pastoralism on Land Use/Cover Change

6.4.1 Respondents' adaptation strategies

Although there are several strategies for managing the effects of climate change and changing mobile pastoralism, the respondents of this study mentioned the following (Figure 6.4) as the most used strategies. Indeed, 96.1%, 89.1%, 74.7% and 67.2% of the study respondents, respectively, reported that they employ prayers and other rituals, buying of fodder grass, division

of livestock and diversifying livelihoods as strategies to mitigate the devastating effects of climate change and pastoralism.

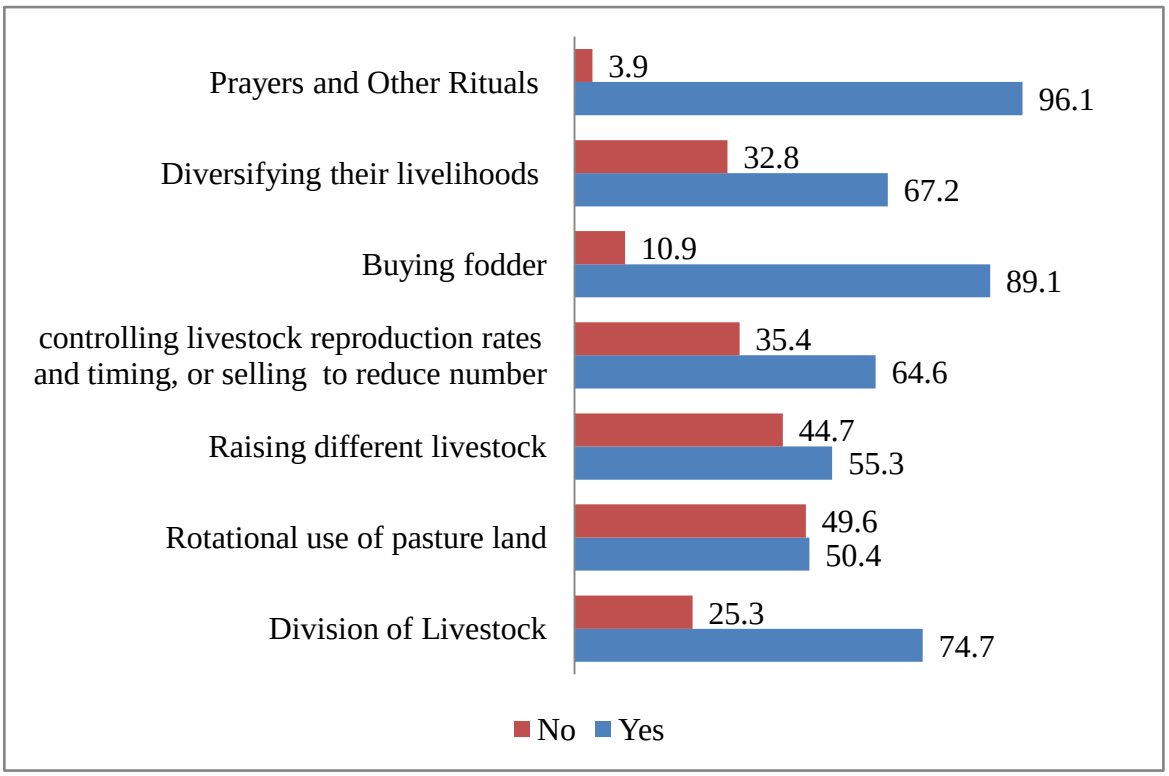

Figure 6.4: Respondents' adaptation strategies

Source: Field survey (2023).

On the other hand, 64.6% of the participants were using livestock controlling management patterns while a smaller proportion of 35.4% did not. Interestingly, about 50.4% of the pastoralists interviewed were practicing rotational use of pasture land as an adaptation strategy to deal with the effects of climate change and mobile pastoralism and 49.6% of the respondents were not practicing that strategy. A slight majority of 55.3% of the interviewed respondents mentioned raising different types of livestock as the adaptation strategy they practiced, whereas 44.7% did not.

Regarding respondents' use of prayers and other rituals as an adaptation strategy, findings from some previous research (Sanou et al., 2018; Makuo, 2017; Teka et al., 2013) show that in many parts of Africa, they believe that all the extreme weather changes that are experienced are the making of God and, as such, they in turn pray or perform other rituals in times of extreme weather conditions that affects their livelihood. Similar findings have been reported by Limoso (2020) and Sanou et al. (2018), which revealed the buying forage or supplementary feeding as one of the main adaptation strategy practiced by smallholders in Hawasa zuria and Hula Districts. According to Turunem et al. (2016), rotational grazing is one of the most common adaptation strategies use by mobile pastoralist across the globe.On raising different types of livestock as an adaptation strategy, Martin et al. (2014) and Karimi et al. (2018), demonstrated same findings in their works. This study is consistent with Nyangena (2018) in that mobile pastoralists mostly divide their livestock and/or diversify livelihoods as strategies adopted by to reduce the effects of climate change and changingpastoralism on land use/land cover change.

6.4.2 Factors influencing respondents' adaptation strategies to the effects of climate change and changing mobile pastoralism

6.4.2.1 Gender

Research (e.g., Jin et al. 2015; Brussow et al., 2019) suggests that vulnerability to climate change is gender-biased. However, several research have shown inconsistent results regarding gender differences in adaptation techniques. Some research (Lasco et al., 2016) find no direct effect of gender while others (Soglo & Nonvide 2019; Aryal et al., 2020) suggest that men and women employ different adaptation methods.

As acknowledged by 74.7% of the respondents, division of livestock as an adaptation strategy minimize the effects of climate change and mobile pastoralism on land use/land cover, gender of respondents was found to be a significant determining factor. From Table 6.7, the binary logistic regression model was significant at 5% indicating that male respondents in the study had 0.538 odd times with (p=0.031) of applying division of livestock as an adaptation strategy to combat the effects of climate change and mobile pastoralism on land use/land cover of the area compared to their female counterparts. This finding is not surprising because males are physically stronger and have more access to knowledge about climate change and weather predictions, leading to increased adaptive ability and can afford to divide their livestock into week and strong ones for grazing. Similarly, it was determined that males had 0.474 odd times with a p=0.005 of raising different types of livestock and 0.359 odd times of controlling livestock reproduction or selling as adaptation strategy (p=0.001). Normally, men have access to several production assets, and authority in decision-making and can afford to rear different types of livestock and or control livestock production or selling some any time they wish (Atube et al., 2021). The result concords with IFAD (2018), Molefi and Nbajiorgu (2017), and Zhang et al. (2020), who found that male farmers are more likely than female farmers to use division of livestock, raising different type of livestock and controlling productivity or selling as adaptation strategies.

6.4.2.2 Age

Age is often considered as an important factor in determining the availability of labour for agricultural activities and also influences peoples' capacity in adaptation strategy in relation to

pastoral mobility and climate change effects on land use/land cover. It is considered a prominent demographic variable that exerts a substantial impact on behavioural modifications, encompassing not only human beings but also organisms inhabiting the planet (Talebi & Tajeddin, 2011). The study revealed through the regression model that age of respondents was significant at 5% and 1%. It indicated that respondentsof the age category 20-45 had, respectively, 0.562, 0.626, 0.400 and 0.587 odd times less likely to adopting division of livestock, raising different livestock species, controlling livestock reproduction or selling and diversification of livelihoods as compared to the older age categories, which are more likely to adapt these strategies. This is because older farmers have the ability to acknowledge climate change and pastoralism risks more clearly and are more likely to adopt measures to mitigate them than the younger ones. This confirms the finding of Alotaibi et al. (2020) and Abbas et al. (2019) that elderly farmers had stronger views about climate change and are more likely to apply adaptation strategies than younger farmers. Similarly, Comoe and Siegrist (2015) found that increasing age greatly influences adaption strategies; and Belay et al. (2017) found a favorable link between increasing age and the capacity to utilize adaptive techniques.

6.4.2.3 Household size

Household size is expected to have direct implications on mobility patterns of pastoralists because large household size means readily available labour. Akinyemi and Mushunje (2019) stated that household size is an important factor in determining family labour availability in agricultural activities and can assure timely completion of task. From the logistic regression result, household size was significant at 10% and 1% confidence level of division of livestock and rotational use of pasture lands as adaptation strategies employed by respondents in the study.

This implies that families with higher members had 1.371 (p=0.099) and 1.658 (p=0.001) odd times of adapting the two strategies than those with smaller family sizes. Indeed, a higher number of household members might supply information on the availability of family labour that could be utilized to carry out these labour-intensive adaptation techniques. Previous studies (Ndamani & Watanbe, 2017; Atinkut & Mebrat, 2016) have shown that household size improves farmers' capacity to implement climate change adaptation techniques.

6.4.2.4 Stay period

Extensive ecological knowledge and climate change experience is linked with the period of stay of an individual in a specific community. The results show that respondents' period of stay is significant at 5%, indicating that they employed livelihood diversification and prayers as adaptation strategies to manage the effects of climate change and changing mobile pastoralism on land use/land cover. The binary regression model results revealed that respondents who lived in any of the study communities from 1-15 years had 0.795 (p=0.42) lower odd times of applying livelihood diversification compared to those who lived there from 16 and above years; and respondents who stayed in any of the communities from 16+years had 1.379 (p=0.049) higher odd times of adopting prayers as adaptation strategy as against those who lived from 1-15years. This finding is consistent with Amare et al. (2018), which recognized long period of stay in a particular community to be a probability of employing adaptation strategies.

6.4.2.5 Land access

Access to land is crucial for agricultural development since it has the ability to increase family income and reduce rural poverty. The results of the study indicated that land access was a

significant influencing factor regarding respondents' choice of adaptation strategies. The results from the regression models show that respondents who did not have access to land for agricultural purposes had 0.385 (p=0.078) odd times of adopting livestock reproduction control or selling as an adaptation strategy over those who have access to land; and respondents without access to land had 0.354 (p=0.047) odd times of diversifying their livelihoods than their other counterparts with access to land for agricultural purposes.

6.4.2.6 Livestock ownership

The findings from the binary logistic model revealed that respondents' livestock ownership status was significantin influencing theirpractice of raising different livestock, controlling livestock reproduction or selling, livelihood diversification and prayers and other rituals as adaptation strategies to the effects of climate change and changing mobile pastoralism on land use/land cover. For raising different livestock, households who did not have livestock had 0.0467 (p=0.062) odd times applying it as a strategy over households that have livestock; and the probability of respondents without livestock adopting controlling livestock reproduction or selling is less likely to occur. This is demonstrated by the odd ratio of 0.0341 (p=0.010) in the binary logistic results. Similarly, families without livestock had 0.0384 (p=0.019) odds times adopting livelihood diversification as an adaptation strategy over those who own livestock. Conversely, households who own livestock had 6.220 (0.083) odd times adopting prayers and other rituals as adaptation strategy to deal with the effects of climate change and mobile pastoralism on land use/land cover than their counterparts who owned no livestock.

6.4.2.7 Received external support

External support such as aides, training, and information sharing, among others, plays critical roles in improving pastoralist capacity and choice of adaptation strategies. From the binary regression model, the study witnessed that respondents who had external support had 0.244 (p=0.029) odds times of dividing their livestock as an adaptation strategy over those who did not receive any external support. Moreover, buying of fodder was significant at 1% with p=0.002, implying that participants who received external support had 7.621 odds times applying buying of fodder as an adaptation measure over those who did not receive any external support. Additional, receives of external support, according to the regression model, had 10.041 odds times engaging in prayers and other rituals as a measure against the effects of climate change and mobile pastoralism on land use and cover than those respondents who did not receive external support in any form. Some studies have identify many variables including external support as influencing factors of pastoralist choices of adaptation measures (Ayal & Filho, 2017; Mequannt et al., 2020).

Table 6.7: Factors Influencing Adaptation Strategies to the Effects of Climate Change and Changing Mobile Pastoralism

Explanatory Variables	Division of Livestock		Rotational use of pasture		Raising different Livestock		Controlling Livestock Reproduction or sell		Buying fodder		Livelihood diversification		Prayers and other rituals	
	Odds ratio (SE)	p>z	Odds ratio (SE)	p>z	Odds ratio (SE)	p>z	Odds ratio (SE)	p>z	Odds ratio (SE)	p>z	Odds ratio (SE)	p>z	Odds ratio (SE)	p>z
Sex Female (Ref category	.538 (.287)	**.031***	1.082 (.253)	.756	.474 (.266)	**.005***	.359 (.302)	**.001*****	.865 (.334)	.664	.693 (.274)	.181	1.482 (.348)	.259
Age 20-44 (Ref category)	.562 (.237)	**.015***	1.365 (.194)	.108	.626 (.198)	**.018****	.400 (.219)	**.000*****	1.139 (.250)	.603	.587 (.207)	**.010*****	1.299 (.277)	.344
Education No school	1.116 (.218)	.613	1.076 (.159)	.647	1.043 (.158)	.789	1.062 (.171)	.724	1.095 (.187)	.627	1.086 (.167)	.621	1.338 (.211)	.167

(Ref category)														
Household size 1-5 (Ref Category	1.371 (.192)	**.099***	1.658 (.157)	**.001***	.854 (.158)	.318	1.045 (.168)	.792	1.069 (.202)	.742	.924 (.163)	.630	.888 (.217)	.584
Period of stay 1-15 (Ref category)	.882 (.131)	.338	1.145 (.107)	.205	.971 (.108)	.786	.849 (.116)	.158	1.224 (.141)	.154	.795 (.113)	**.042****	1.379 (.160)	**.049****
Access to Land Yes (Ref category)	.494 (.811)	.384	1.790 (.498)	.243	.480 (.525)	.163	.385 (.542)	**.078***	.724 (.565)	.567	.354 (.524)	**.047****	1.379 (.831)	.699
Livestock Ownership	.873 (.540)	.802	.962 (.389)	.920	.467 (.408)	**.062****	.341 (420)	**.010***	.501 (.442)	.118	.384 (.408)	**.019****	6.220 (1.054)	**.083***

Yes (Ref Category														
Received external support Yes (Ref Category)	.244 (.646)	**.029***	2.422 (.698)	.205	1.192 (.641)	.784	1.043 (.654)	.949	7.621 (.660)	**.002***	1.032 (.654)	.962	10.041 (.663)	**.001****

*, **, and *** are signs of significant values at 10%, 5% and 1%

Source: Field Survey (2023)

6.5 Climate Change Influence on Adaptation Strategies

6.5.1 Rainfall

The findings show that local perceptions of climate change have a substantial impact on adaptation to this climatic event. This is consistent with those reported in prior research (e.g., Debalke, 2011; Balew et al., 2014; Ndamani & Watanabe, 2017). Indeed, changes in rainfall were shown to have significant influence on adaptation of strategies to combat the effects of climate change and mobile pastoralism on land use/land cover. Based on the regression model (Table 6.8), the findings demonstrate that the impression of decreasing rainfall considerably increases the probability of adapting rotational use of pasture land and prayers with other rituals. As a result, respondents who perceived a shift in the rainfall pattern either decreasing, being the same or varying continuously, had 0.610 (p= 0.023) odd times of employing rotational use of pasture and 1.548 (p=0.087) odd times of adapting prayers and other rituals as strategies to addressing the effects of climate change and mobile pastoralism on land use/land cover. Berhanu and Beyene (2015) found that pastoral respondents' perception of changes in rainfall patterns influenced their willingness to adapt strategies to address them. Similarly, Balew et al. (2014) noted that farmers' perception of rainfall variations influence their judgement regarding adaptation techniques to use. Furthermore, farmers' perception of long-term changes in rainfall influence their choices of adaptation technique (see Debalke, 2011; Piya et al., 2013; Mabe et al., 2014).

6.5.2 Temperature

In line with the results of the binary logistic regression model, temperature influence was significant at 1% for buying of fodder as an adaptation strategy for addressing the effects of

climate change and mobile pastoralism on land use/land cover in Wa East District. This implies that respondents were less likely to adapt buying fodder as an adaptation option when temperature is decreasing. This is expressed in the value of 0.0535 odd times and p=0.001 of adapting buying fodder as an adaptation option. This is similar to the findings of Ndamani and Watanabe (2017); and Anderson (2019) and Khanal et al. (2018) reported that climate change will continue towreck havoc on pastoral mobility due to increased exposure to high temperatures, which will lead to restricted access to water supplies, hence making temperature a great determinant of pastoralists' adaptation strategies. Climate change has led to a severe decrease in pasture and livestock feed in arid zones through the disruptions in the seasonal cycles (Dupar, 2019).

6.5.3 Drought

Droughts are becoming increasingly common in all dryland pastures, posing a significant challenge to the lifestyles of many farmers across the globe. Drought reduces pasture biomass during the growing season, which is crucial for pastoralism. Drought also causes lack of drinking water for livestock (Hauck et al., 2023), suggesting that drought is a great determinant of pastoralists' adaption strategies. From the results of the regression, it indicates that with increasing drought, respondents had 1.246 (p=0.001) odd times of adopting livelihood diversification and 1.148 odd times of adopting prayers and other rituals as adaptation strategies to manage the effects of climate change and mobile pastoralism on land use/land cover.

6.5.4 Seasonal changes

As show in the regression table, it was found out that seasonal changes observed by the surveyed respondents were a significant factor influencing their adoption of buying of fodder and prayers and other rituals as adaptation measures used to combat the effects of changing climate and mobile pastoralism on land use/land cover. The model revealed thatrespondents had odd times of 1.547 (p=0.006) of buying fodder and 1.665 (0.003) of engaging in prayers and other rituals as adaptation strategies in the event of changes in seasons varying continuously over a long period of time. According to Dupar (2019), climate change has led to severe decrease in pasture and livestock feed in arid zones through changes in seasons. This makes mobile pastoralists adapt strategies to cope with the changes that keeps occurring.

Table 6.8: Influence of Climatic Variables on Small Holders' Choice of Adaptation Strategies

Explanatory Variables	Division of Livestock		Rotational use of pasture		Raising different Livestock		Controlling Livestock Reproduction		Buying fodder		Livelihood diversification		Prayers and other Rituals	
	Odds ratio (SE)	p>z	Odds ratio (SE)	p>z	Odds ratio (SE)	p>z	Odds ratio (SE)	p>z	Odds ratio (SE)	p>z	Odds ratio (SE)	p>z	Odds ratio (SE)	p>z
Rainfall Decreasing (Ref category)	1.114 (.266)	.684	.610 (.218)	**.023****	.790 (.213)	.268	.874 (.228)	.554	1.269 (.246)	.334	.848 (.221)	.456	1.548 (.255)	**.087*****
Temperature Decreasing (Ref category)	1.012 (.183)	.950	.918 (.142)	.546	1.112 (.147)	.468	1.146 (.155)	.381	.535 (.183)	**.001***	1.650 (.134)	.101	.556 (.206)	.503
Drought	1.099	.562	.861	.239	.975	.842	1.139	.332	.948	.763	1.246	**.001***	1.148	**.005***

Increasing (Ref Category)	(.164)		(.127)		(.128)		(.134)		(.176)		(.156)		(.207)	
Seasonal Changes Varies con. (Ref Category	1.079 (.128)	.553	1.054 (.107)	.625	.987 (.017)	.907	.938 (.127)	.614	1.547 (.158)	**.006****	1.037 (.124)	.769	1.665 (.169)	**.003***

*, **, and *** are signs of significant values at 10%, 5% and 1%

Source: Field Survey (2023)

6.6 Chapter Summary

Generally, the changes observed in land use/land cover in the district by respondents, through their assessment and perceptions, were confirmed by the satellite data and assessment. It was noted that close and open woodlands lost drastically with agriculture, settlement and grassland increasing. Water bodies also saw an increase but this was not significant because no new water bodies were created but the forest cover was lost exposing the bare land to the satellite visibility, making other water bodies that were hiding to now be visible. The adaptation measures used by smallholders to combat the effects of climate change and changing mobile pastoralism were also discussed.

CHAPTER SEVEN

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

7.1 Introduction

Summaries of major findings, conclusions, recommendations and contributions of the study are presented in this chapter. Pastoralism continues to be a contributor of GDP as well as play a major role in food supply in Ghana and many African nations. Pastoralism, however, work in a multi-dimensional risk environment influenced by many factors including climate change. The study's main objective was to assess the effects of climate change on mobility patterns of pastoralists in Wa East District. The major findings begin with the socio-demographic, economic and agricultural production characteristics of respondents, which is followed by the patterns, trends and drivers of climate change and changing mobile pastoralism as well as the effects and adaptations strategies employed by the respondents to manage the effects of climate change and pastoralism on land use and cover in the area.

7.2 Summary of Major Findings

7.2.1 Socio-demographic, economic and agricultural production characteristics of respondents

The study found that males were more engaged in pastoralism than females and most of the respondents had access to land as well as reared livestock. The commonest means of land acquisition was through inheritance, while major livestock kept by households were cattle, goat, sheep, pigs and poultry. The study revealed that the social and economic characteristics of the respondents had great influence on their understanding and perceptions of climate change and changing mobile pastoralism. The study also found that socio-demographic, economic and

agriculture production factors influenced respondents' decision on adaptation strategies to deal with the effects of climate change and mobile pastoralism. Animal herding is considered as the main occupation of the Fulani ethnic group and other ethnic groups employ Fulanis to care for their livestock.

7.2.2 Patterns, trends and drivers of climate change and mobile pastoralism between 1981 and 2021

Based on the long term experiences and observations of respondents, a greater majority perceived climate change and their understanding climate change trends and patterns significantly affect how individuals perceive and recognise changes in climate patterns over time. The few differences in perceptions between those who claim knowledge and those who do not highlights the impact of awareness and education on understanding environmental changes in the study district. The findings revealed a growing realization among respondents that climate change is happening in their local area. They acknowledged critical changes in climate conditions over the past four decades. Similarly, the discussions from key informants and focus groups indicated a continuous change in climate and that the situation is getting worse.

Respondents associated the term climate change to weather parameters and the greatest concern was decreasing rainfall, increasing drought frequency, decreasing rainy seasons and increasing temperature. Their long term experience of the climate change phenomena agrees with scientific description of the concept. The results clearly do not simply signify awareness but there is a deeper anxiety about the impact of climate change on mobile herding as well as herders' livelihoods. In corroborating the meteorological data with respondents' perceptions of change in

climate, the findings revealed that respondents correctly perceived the climate change phenomena in the area.

The finding have major implications for pastoralism and other agricultural activities, since pastoral livelihoods depend solely on climatic factors such as rainfall and temperature. The agreement between respondents' perceptions and the meteorological data clearly suggest personal experience and views are crucial and can help them adjust even in the absence of scientific data.

Respondents perceived that mobile pastoralism in the study area is becoming spatially restricted and have shifted continuously in order to adapt to dynamic socio-ecological environments. This has led to constant and frequent movement of livestock in the area. Respondents confirmed collaborations with other neighbouring counterparts and non-migratory communities in order to access quality pastoral resources. From the respondents' views, great changes were observed in mobile pastoralism between the period of 2001, 2010 and 2021. The system shifted more to seasonal mobility and increased mobility due to pasture degradation and loss of forage species as well as insufficient watering points and evasion of conflicts, bad climate conditions and access to key pastoral resource.

The findings of the study revealed that the mobile pastoral system of the area, which was characterised by traditional patterns of transhumance, will continue to see a constant shift because of climate change and instead of mobile pastoralists passing through or staying temporarily at an area, they will now reside permanently. Respondents were pessimistic about

mobile pastoralism in the area because of climate change extreme events that have seriously impacted mobile pastoralism in the study area. Particularly, mobile herding is a major surviving and resource management strategy practice among pastoralists to meet their livestock forage and water needs.

Respondents perceived human activities, such as removal of tree cover, bush burning, charcoal burning, animal grazing and fertilizer application, as the underlying drivers of climate change in the study area over the period. God's will, as proximate driver of changes in climate, was also mentioned. Other proximate drivers of changing mobile pastoralism, such as extreme temperature, rainfall variations, drought, high variations between seasons, seasonal cultivation of crops, bushfires and soil moisture and hydrology, exerted direct effects on mobility patterns of pastoralists. However, the indirect drivers, as perceived by respondents are largely triggered by socio-demographics, economic and political dynamics and can have a significant influence on pastoral activities. Their views on the drivers gave a clear judgement of their understanding of climate change and mobile pastoralism in the area over the past 40 years.

7.2.3 Effects of climate change and changing mobile pastoralism on land use and land cover and smallholder adaptation strategies

The study found that climate change and changing mobile pastoralism have several devastating effects on land use and cover in the area over the past decades. Respondents reported destruction of agricultural lands, decreasing vegetation cover and reduction in water quality and quantity as the most important effects exerted by climate change and mobile pastoralism on land use/land

cover. These effects have led to significant changes in land use/land cover in terms of size or proportion.

In corroborating the satellite data with respondents' views and observations of changes in land use/land cover, the results indicate that respondents correctly perceived that open and close wood lands suffered continuous decline in size or proportion while farm land, built-up and water bodies experienced increases in size or proportion. The perception of respondents regarding bare land and grass land did not sync with the satellite data. Whereas, respondents perceived a decrease in grassland and bare land, the satellite data revealed an increase in both bare land and grass land, respectively. The observation from the satellite data is in sharp contradiction with respondents' perceptions. A substantial proportion (72.6% and 61%) of the respondents reported, respectively, a decrease in bare land and grass land. This view of respondents who observed a decrease in these land cover types may not be entirely wrong becausethe respondents may be limited in view compared to the satellite, which can view large portions of the land. Also, respondents'perceptions could be influenced by other factors and/or increases experienced by other land cover types over the period.

Regarding adaptation strategies, the study found that respondents implemented diverse strategies, such as prayers and other rituals, buying of fodder grass, division of livestock, diversifying livelihoods, livestock control management, rotational use of pasture land and raising different types of livestock to offset the damaging effects of climate change and pastoralism on land use/land cover, which inturn impacts on livelihoods of smallholders. A respondent's decision to adapt any of the strategies stated above, were largely influenced by various social, economic and

demographic factors, such as sex, age, household size, length of stay, access to land, livestock ownership, and external support as well as their perceptions of climate change using weather parameters such as perceived changes in rainfall, temperature, drought and seasonal changes.

7.3 Conclusions

This study has clearly established the pattern and trends of climate change and mobile pastoralism, their underlying drivers as well as their effects on land use/land cover. The significant effects of climate change and mobile pastoralism on land use/land cover has led to serious shifts and severe degrading of the ecosystems that smallholders rely on for their livelihood needs. The combination of meteorological, remote sensing and field-based participatory rural appraisal approaches in this study has given a holistic assessment and understanding of the patterns, trends, drivers and effects of climate change and mobile pastoralism on land use/land land cover as well as livelihood adaptation strategies to deal with the identify effects.

The respondents perceived patterns and trends of climate change were verified using meteorological data and the perceived changes observed in land use/land cover was confirmed by satellite data that depicted that respondents in the study correctly perceived these changes. The effects of climate change and mobile pastoralism on land use/land cover reduced the strength of the ecosystem in supporting sustainable pastoralism, which many smallholders highly depend on as a source of livelihood. The declining supply and availability of vital pastoral resources have increased livelihood insecurity and deteriorated well-being of respondents.

The effects of climate change and mobile pastoralism on land use/land cover compelled respondents to implement adaptation strategies to reduce the effects and improve their well-being. The implementation of adaptation strategies were influenced by various socio-economic and environmental factors as well as perceived changes in climate parameters such as rainfall, drought, temperature and changes in seasons.

7.4 Development Implications

Although mobile pastoralism contributes a lot to the economy and food security, it is mostly devalued, unacknowledged and exposed to policies and conditions that do not enable its smooth operations. Pastoral livelihoods are undergoing a slew of concurrent changes as a consequence of combined pressure from climate change and changes in land use/land cover. Climate change is set to become more unpredictable and highly variable over time and anticipated changes in temperature, shifts in seasons, drought occurrences and decrease in rainfall will have significant impacts on land use/land cover, hence, affecting the sustainability of mobile pastoralism in most arid and semi-arid zones across Africa.

For several years, mobile pastoralists have continued to adapt to changes in climate and have seemingly transformed arid and semi-arid zones to productive assets. The low input nature of mobile pastoralism along with existing traditional management systems, makes it a cost effective land use alternative for drylands. Supporting sustainable mobile pastoralism may help governments capitalize on uncertain climate conditions to mitigate the risk of other land uses that will improve livelihoods and allow governments to benefit from the increasing global demand for meat and other livestock products as well as alleviate the stress of conflict and poverty.

Enhancing access to land and allowing proper political representations of mobile pastoralists will empower them to address many of the challenges faced in drylands,which will be less costly to the state and will enhance the positive contribution to the economy, ensure food security while at the same time reducing conflicts and poverty among competing land uses.

7.5 Contributions to Knowledge

This research has contributed to academic knowledge by shedding light on how mobile pastoralism has altered as a result of the socio-ecological restrictions of climate change on arid lands. It has also contributed to the existing body of knowledge on the patterns, trends and drivers of mobile pastoralism and climate change in semi-arid agro-ecological zones of Ghana where significant land degradation and depletion of vital environmental resources has occurred. The study's theoretical and conceptual frameworks allowed for adequate identification and description of the effects of changing mobile pastoralism and climate change on land use/land land cover that is crucial for households' livelihood needs.

This study revealed local actors' opinions and live experiences about the consequences of changing climate on their livelihoods as well as on land use/land cover changes. These local actors can only provide a realistic and holistic evaluation of the consequences of changing climate on mobile pastoralism and land use/land cover since their livelihoods are entirely dependent on the landscape.

The study identified the range of strategies employed by smallholder farmers to manage the effects of changing mobile pastoralism and climate change on their livelihoods, which could be very useful to government, NGOs, policymakers and other agencies that are concerned about sustainable development issues in the drylands of Ghana and Africa as a whole. Due to the ever-increasing population and the demand for food and raw materials to meet the growing population, especially in less developed countries, understanding the effects of climate change and mobile pastoralism on land use/land cover buttresses the policy recommendations of integrating and mainstreaming livelihoods and local adaptation measures into scientific knowledge.

Another distinguishing feature of this study is the use of proper methodological links to compare qualitative, remote sensing, quantitative data from the natural and social sciences. This study's contribution cleared the ground for the establishment of location-specific livelihood assistance.

Though acknowledged by the findings and consistent with GSS (2021) and WEDA (2022), that 30% of the degradation is caused by anthropogenic factors, which include but are not limited to bush burning, inappropriate farming practices, indiscriminate cutting of trees for wood, charcoal, and poor animal husbandry practices, which agrees with the views of the pastoral commons theory, this study considers this viewpoint as outsiders who failed to understand the dynamics of mobile pastoralism. The study concludes that, the pastoral commons theory by Hardin at the time failed to account for the rapid changes in climate characterized by droughts, fewer rainfall, and higher temperatures, which have a direct impact on vegetation growth and land usage.

Furthermore, Hardin's argument ignores how population growth raises the demand for infrastructure development and technical breakthroughs that allow humans to exploit the environment more efficiently. And concludes that present environmental deterioration, which has led to conflicts, is the result of unequal power relations among diverse users, demonstrating the significance of political ecology theory.

7.6 Recommendations

The results of this study has policy and development implications that policymakers can carefully evaluate in order to enhance livelihood of smallholders in Wa East District and the country at large. The findings has shown that conditions of mobile pastoralsim has worsened as a result of continuous changes in climate and changes in land use/land cover, which are the two main resources for sustaining mobile pastoralism. Therefore, the study suggest the following key policy interventions:

- In order to overcome the exacerbation of constraints related to mobile pastoralism, the local government, Ministry of Food and Agriculture (MoFA), National Commission for Civic Education (NCCA) and NGOs should provide appropriate education, skills training and awareness creation to open up opportunities for smallholders, which will reduce further degradation of the natural resource base. This will help smallholders understand and respond to climate change challenges confronting them at various scales.

- Creation of fodder banks and construction of water resources. Climate change constraints on pastoral activities have resulted in reduction in rainfall, increasing temperature and frequent occurrences of drought, which are the main determinants of forage and water availability.

Moreover, it was revealed in the study that grazing areas and water bodies are perceived to be declining over the past decades. Local government, NGOs and other development partners can engaged in water source constructions and the creation of fodder banks for herders in the district. This will ensure herds are fully protected and allow for easy access of pastoral resources. It will also reduce conflicts among farmers and pastoralists.

- Local adaptation strategies and knowledge of climate change should be integrated and mainstreamed into scientific practice at national, local and sectoral levels, such as disaster risk reduction,and livestock and agriculturedevelopment. Sustainable development discourses have recognized local adaptation techniques as important traditional ecological knowledge and mainstreaming them into scientific knowledge systems is critical for increasing ecological resilience in the face of changing climate, changing land use/land cover and changing mobile pastoralism. This integration may lead to the discoveries of innovations and desired future trajectories. The government, through MoFA and NGOs, must encourage information sharing on modifications of innovative adaptations between local farmers and formal institutions and knowledge systems. The policy approaches should deal with ecosystem friendly and sustainable methods that directly promote livelihoods.

- Considering the changes in land use and cover of the area, the District Assembly should undertake a spatial planning in order to provide a guide for crop farmers and settlement so that this developments are not a threat to pastoral mobility but rather co exist with pastoralism and other new livelihood activities.

7.7 Research Limitations

The research procedure was not without hurdles. However, with careful consideration and respect for methodological and scientific rigor, the problems were overcame. The challenges included:

i. During the focus group talks, several people were hesitant to participate. This caused complications since a few people dominated the debates. After understanding this, the researcher supervised the discussions to ensure that each discussant had time and a chance to express themselves. Gender specific focus group discussions were undertaken at various times.

ii. There were issues of potential biases arising from the responses of the respondents due to memory lost and misconceptions regarding previous patterns and trends of climate change and pastoral system and their effects on land use/land cover for the period of study. In addressing this challenge, responses from the household survey and narratives from oral interviews and focus group discussions were cross-checked and confirmed with the metrological data and satellite images.

References

Abbas, Q., Han, J., Adeel, A., &Ullah, R. (2019). Dairy production underclimatic risks: perception, perceived impacts and adaptationsin Punjab, Pakistan. *Int J Environ Res Public Health, 16,* 4036.https:// doi. org/ 10. 3390/ ijerp h1620 4036

Adams, F., & Ohene-Yankyera, K.(2014). Determinants of factors that influencesmall ruminant livestock production decisions in northern Ghana: Applicationof discrete regressionmodel. *Journal of Biology, Agriculture and Healthcare, 4*(27), 310–321. https://search.ebscohost.com/login.aspx?direct=true&db=lah&AN=20153026417&site=ehost-live%5Cn, http://www.iiste.org/Journals/index.php/JBAH/article/view/18662/18938%5Cnemail: fazztop@yahoo.com.

Adhikari, Umesh A., Pouyan Nejadhashemi, &Woznicki, S. A. (2015). Climate change and eastern Africa: A review of impact on major crops. *Food and Energy Security*, *4*(2), 110–132. https://doi.org/10.1002/fes3.61

Adriansen, H. K. (2008). Understanding pastoral mobility: the case of Senegalese Fulani. *Geographical Journal*, *174*(3), 207-222.

Adriansen, H. K., &Nielsen, T. T. (2002). Going where the grass is greener: on the study of pastoral mobility in Ferlo, Senegal.*Human Ecology*, *30*, 215–227. doi: 10.1023/A:1015692730088

Agubeere, R.A. (2014). Rural Tourism as a means of Enhancing Rural Livelihoods at Paaga, *Ghana. A Submitted to the University of Ghana, Legon in Partial Fulfillment of the Requirement for the Award of Mphil Geography and Resource Development Degree.* [Online] Available: http://197.255.68.203/handle/123456789/8410.pdf.DA:

Akinola, L.A.F., &Essien,A. (2011). Relevance of rural poultry production indeveloping countries with special reference to Africa. *World's Poultry Science Journal*, *67*(4), 697–705. https://www.tandfonline.com/doi/abs/10.1017/S0043 933911000778.

Akinyemi, B.E., &Mushunje,A. (2019). Land ownership and usage for agriculture:Empirical evidence from South African Living Conditions Survey. *Cogent Social Sciences, 5*(1),1663691. https://doi.org/10.1080/23311886.2019.1663691.

Ahmed, M. M., Sanders,J. H.,&NellW. T.(2000). New sorghum and millet cultivar introduction in Sub-Saharan Africa: impacts and research agenda. *Agricultural Systems, 64*, 55-65.

Alotaibi, B. A., Kassem, H. S., Nayak, R. K., &Muddassir, M. (2020). Farmers'beliefs and concerns about climate change: an assessment fromSouthern Saudi Arabia. *Agriculture, 10*, 253. https:// doi. org/ 10. 3390/ agric ultur e1007 0253

Amare, A., (2019). Index-based livestock insurance to manage climate risks in Borena zone of southern Oromia, Ethiopia. *Climate Risk Management, 25*, 1–16.

Anderson, S. E. (2019). The critical role of markets in climate change adaptation. *Climate Change Economics*, *10*(1), 1–17.

Antwi-Agyei, P., Dougill, A. J., Stringer, L. C., & Codjoe, S. N. A. (2018). Adaptation opportunities and maladaptive outcomes in climate vulnerability hotspots of northern Ghana. *Climate Risk Management*, *19*, 83-93.

Antwi, S.K., & Hamza, K. (2015). Qualitative and quantitative research paradigms in business research: A philosophical reflection. *European Journal of Business and Management*, *7*(3), 217-225. Retrieved from https://www.iiste.org/Journals/index.php/EJBM/article/view/19543

Anum, R., Ankrah, D. A., & Anaglo, J. N. (2022). Influence of demographic characteristics and social network on peri-urban smallholder farmers adaptation strategies-evidence from southern Ghana. *Cogent Food & Agriculture*, *8*(1), 2130969. https://doi.org/10.1080/23311932.2022.2130969

Araoye, M. O. (2003). *Research methodology with statistics for health and social sciences*. Ilorin: NA THADEX Publishers

Aryal, J. P., Sapkota, T. B., Rahut, D. B., Krupnik, T. J., Shahrin, S., (2020). Major climate risks and adaptation strategies of smallholderfarmers in Coastal Bangladesh. Environ Manage 66:105–120. https:// doi. org/ 10. 1007/ s00267- 020- 01291-8

Asante, F. A., &Amuakwa-Mensah,F. (2015). Climate Change and Variability in Ghana: Stocktaking, *Climate*, 3(1), 78-99. https://doi.org/10.3390/cli3010078

Atinkut, B., & Mebrat, A. (2016). Determinants of farmers choice of adaptation to climate variability in Dera woreda, south Gondar zone, Ethiopia. *Environmental Systems Research*, 5(1), 1–8. https://doi.org/10.1186/s40068-015-0046-x

Atube, F., Malinga, G. M., Nyeko, M., Okello, D. M., Alarakol, S. P., & Okello-Uma, I. (2021). Determinants of smallholder farmers' adaptation strategies to the effects of climate change: Evidence from northern Uganda. *Agriculture & Food Security, 10*(1), 1-14.

Ayal, D.Y., Radeny, M., Desta, S., &Gebru, G., (2018). Climate variability, perceptions ofpastoralists and their adaptation strategies: implications for livestock system anddiseases in Borana zone. Int. J. Clim. Change Strateg. Manag. 10 (4), 596–615.

Ayal, D.Y., &Leal, F.W., (2017). Farmers' perceptions of climate variability and its adverseimpactson crop and livestock production in Ethiopia. J. Arid Environ. 140, 20–28.

Ayantunde, A. A., Asse, R., Said, M. Y., & Fall, A. (2014). Transhumant pastoralism, sustainable management of natural resources and endemic ruminant livestock in the sub-humid zone of West Africa. *Environment, development and sustainability*, *16*(5), 1097-1117.

Bai, W. Q., Zhang,Y. L., Xie,G. D.,&Shi,Z. X. (2002). Analysis of formation causes of grassland degradation in Maduo county, in the source of the Yellow River. *Chinese Journal of Applied Ecology, 13*, 823-826.

Baker, B. B., &Moseley,R. K. (2007). Advancing treeline and retreating glaciers: implications for conservation in Yunnan, P.R. China. *Arctic, Antarctic and Alpine Research, 39*(2), 200-209.

Balew, S., Agwata, J.,&Anyango, S. (2014). Determinants of Adoption Choices of ClimateChange Adaptation Strategies in Crop Production by Small Scale Farmers in SomeRegions of Central Ethiopia. *Journal of Natural Sciences Research,4*(4), 78-93. www.iiste.org.

Barry, A. A., Caesar, J., Klein Tank, A. M. G., Aguilar, E., McSweeney, C., Cyrille, A. M., ... & Laogbessi, E. T. (2018). West Africa climate extremes and climate change indices. *International Journal of Climatology*, *38*, e921-e938.

Bassett, T. J., &Turner, M. D. (2007). Sudden shift or migratory drift? Fulbe herd movements to the Sudano-Guinean region of West Africa. *Human Ecology, 35*, 33–49. doi: 10.1007/s10745-006-9067-4

Basu, S., Jongerden, J., &Ruivenkamp, G. (2017). Development of the drought tolerant variety SahbhagiDhan: exploring the concepts commons and community building. *International Journal of the Commons*, *11*(1).

Bawakyillenuo, S., Yaro, J. A., & Teye, J. (2016). Exploring the autonomous adaptation strategies toclimate change and climate variability in selected villages in the rural northern

savannah zone of Ghana. *Local Environment*, *21*(3), 361-382.

Belay, A., Recha, J. W., Woldeamanuel, T., &Morton, J. F. (2017). Smallholderfarmers' adaptation to climate change and determinants of theiradaptation decisions in the Central Rift Valley of Ethiopia. *AgricFood Security, 6,* 24. https:// doi. org/ 10. 1186/ s40066- 017- 0100-1

Benjaminsen, T. A. (2008). Does Supply-induced Scarcity Drive Violent Conflicts in the African Sahel? The Case of the Tuareg Rebellion in Northern Mali. *Journal of Peace Research, 45*(6).

Berhanu, W., & Beyene, F. (2015). Climate variability and household adaptation strategies in Southern Ethiopia.*Sustainability*, *7*(6), 6353-6375.

Biesta, G. (2010). Pragmatism and the philosophical foundations of mixed methods research. In A.Tashakkori & C. Teddlie (Eds.), *Sage handbook of mixed methods in social & behavioral research* (2nd ed., pp. 95-118). Thousand Oaks, CA: Sage

Blench, R. (2001). '*You can't go home again': pastoralism in the new millennium*. Overseas Development Institute. Citeseer, London

Bobadoye, A. O. (2016). Vulnerability assessment of maasai pastoralists under changing climatic condition and their adaptation strategies in Kajiado County, Kenya. Doctoral dissertation, University of Nairobi.

Boutrais, J. (1996). *Hautes terresd'élevage au Cameroun*. Paris: ORSTOM Éditions; 1996.

Bradley, M. A., & Harrell, M. C. (2009). Data Collection Methods. National Defence Research Risk factors for herdsmanreported foot-and-mouth disease in the Adamawa Province of Cameroon. *Preventive Veterinary Medicine*, 2004; *66*(1), 127–139. doi: 10.1016/j.prevetmed.2004.09.010 PMID: 15579340

Brottem, L., Turner, M. D., Butt, B., &Singh, A. (2014). Biophysical Variability and Pastoral Rights to Resources: West African Transhumance Revisited. *Human Ecology*, *42*(3), 351–365. doi: 10.1007/s10745-014- 9640-1

Brussow, K., Gornott, C., Fabe, A., &Grote, U. (2019). The link betweensmallholders' perception of climatic changes and adaptation inTanzania. *Climate Change, 157*, 545–563. https:// doi. org/ 10. 1007/ s10584- 019- 02581-9

Bhatta, L. D., van Oort,B. E. H., Stork, N. E.,&Baral,H.(2015). Ecosystem Services and Livelihoods in a Changing Climate: Understanding Local Adaptations in the Upper Koshi, Nepal. *International Journal of Biodiversity Science, Ecosystem Services & Management, 11*(2), 145–155.

Boone, R. B., Conant,R. T., Sircely,J., Thornton,P. K.,&Herrero,M.(2018). Climate change impacts on selected global rangeland ecosystem services. *Glob Chang Biol*, *24*(3), 1382-1393. https://doi. org/10.1111/gcb.13995

Boyd, E., Cornforth, R. J., Lamb, P. J., Tarhule, A., Lele, M. I., &Brouder, A.(2013). Building resilience to face recurring environmentalcrises in African Sahel. *Nat Clim Chang 3*(7), 631–637

BurnSilver, S. B., Boone,R. B.,&Galvin,K. A.(2003). Linking pastoralists to heterogeneous landscape: the case of four Maasai ranches in Kahiado District, Kenya. In *People and the environment: approaches for linking household and community surveys to remote sensing and GIS*. Jefferson Fox, Ronald R. Rindfuss, Stephen J. Walsh, and Vinod Mishra, eds. Pp. 173– 199. Boston: Springer.

Burnard, P. (1996). Teaching the analysis of textual data: an experiential approach. *Nurse education today*, *16*(4), 278-281.

Cameron, R. (2011). Mixed methods research: The five P's framework. *The Electronic Journal of Business Research Methods,9,* 96-108. Retrieved from http://www.ejbrm.com/volume9/issue2/p96

Cherryholmes, C. C. (1992). Notes on pragmatism and scientific realism. *Educational Researcher, 21*, 13–17

Chilisa, B., & Kawulich, B. B. (2012). *Selecting a research approach: paradigm, methodology and methods. Doing Social Research, A Global Context*. London: McGraw Hill.

Clemens Greiner, Hauke-Peter Vehrs, & Bolli, M. (2021). Land-use and Land-cover Changes in Pastoral Drylands: Long-term Dynamics, Economic Change, and Shifting Socioecological Frontiers in Baringo, Kenya. *Human Ecology, 49*, 565–577 https://doi.org/10.1007/s10745-021-00263-8

Coughenour, M. B., Ellis, J. E., Swift, D. M., Coppock, D. L., Galvin, K., McCabe, J. T., (1985). Energy extraction and use in a nomadic pastoral ecosystem. *Science, 230*(4726). 619–625. doi: 10.1126/science.230. 4726.619 PMID: 17797276

Comoe, H., &Siegrist, M. (2015). Relevant drivers of farmers' decisionbehavior regarding their adaptation to climate change:a case study of two regions in Cote d'Ivoire. *Mitig Adapt Strateg Glob Change, 20,* 179–199. https:// doi. org/ 10. 1007/ s11027- 013- 9486-7

Creswell, J. W. (2012). *Educational Research; Planning, conducting and evaluating quantitative and qualitative research* (4th ed). Pearson Education, Inc., 501 Boylston Street, Boston

Crewell, J.W. (2013). *Qualitative Inquiry and Research Design. Choosing among Five Approaches*. Los Angeles, CA: Sage

Creswell, J. W. (2014). *Research design: Qualitative, quantitative, and mixed methods approaches*(4th ed.). Thousand Oaks, CA: Sage publications.

Creswell, J. W., & Clark, V. L. P. (2017). *Designing and conducting mixed methods research*. Thousand Oaks, CA: Sage publications.

Daneshi, A., Brouwer, R., Najafinejad, A., Panahi, M., &Maghsood, F. F. (2021). Modelling the impacts of climate and land use change on water security in a semi-arid forested watershed using InVEST. *J. Hydrol.*, 593, 125621. doi: 10. 1016/j.jhydrol.2020.125621

De Boer, W., &Prins, H. (1989). Decisions of cattle herdsmen in Burkina Faso and optimal foraging models. *Human ecology*, *17*(4), 445–464. doi: 10.1007/BF00889500

Debela, B.L. (2017). Factors affecting differences in livestock asset ownershipbetween male-and female-headed households in Northern Ethiopia.*The European Journal of Development Research*, *29*(2), 328–347. https:// doi.org/10.1057/ejdr.2016.9https://link.springer.com/article/10.1057%2 Fejdr.2016.9.

de Weijer, F. (2007). Afghanistan's Kuchi pastoralists: change and adaptation. *Nomadic Peoples*, *11*, 9–37.

Dong, S. (2016). Overview: Pastoralism in the world. Building Resilience of Human-Natural Systems of Pastoralism in the Developing World, 1-37.

Dumont, B., Andueza, D., Niderkorn, V., Lüscher, A., Porqueddu, C., &Picon-Cochard, C. (2015). A meta-analysis of climate change effects on foragequality in grasslands:

specificities of mountain andMediterranean areas. *J. Brit.Grassland Soc., 70*, 239–254. doi: 10.1111/gfs.12169

Dunn, C. E. (2007). Participatory GIS - a people's GIS? *Progress in Human Geography, 31***,** 616 - 637.

Dupar, M. (2019). *IPCC's special report on climate change and land: What's in it for Africa?* Cape Town: Climate and Development Knowledge Network, Overseas Development Institute and SouthSouthNorth.

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

Fagariba, C. J., Song, S., & Soule Baoro, S. K. G. (2018). Climate change adaptation strategies and constraints in northern Ghana: Evidence of farmers in Sissala West District. *Sustainability*, *10*(5), 1484. https://doi.org/10.3390/su10051484

Fezzi, C., Harwood, A. R., Lovett, A. A., &Bateman, I. J. (2015). Erratum: the environmental impact of climate change adaptation on land use and water quality. *Nat. Climate Change, 5*, 255–260. doi: 10.1038/nclimate2585

Flick, U. (2002). *Introduction to Qualitative Research*. London: Sage

Fratkin, E., &Mearns, R. (2003). Sustainability and Pastoral Livelihoods: Lessons from East African Maasai and Mongolia. *Human Organization, 62*(2), 112-122.

Galaty, J. G. (2013). The indigenisation of pastoral modernity: territoriality, mobility, and poverty in Dryland Africa. In: Bollig M, Schnegg M, Wotzka HP, editors. *Pastoralism in Africa: past, present, and future.* New York: Berghahn; 2013. p. 473–510.

Galvin, K. A. (2009). Transitions: pastoralists living with change. *Annual Review of Anthropology*, *38*, 185–198

Godde, C. M., Boone, R. B., Ash, A. J., Waha, K., Sloat, L. L., Thornton, P. K., (2020). Global rangeland production systems and livelihoods atthreat under climate change and variability. *Environ. Res. Lett., 15*, 044021.doi: 10.1088/1748-9326/ab7395

Ghana Statistical Service. (2014). 2010 population and housing census. Regional Analytical report. Upper West Region. Accra, Ghana: Ghana Statistical Service.

Ghana Statistical Service. (2021). 2021 population and housing census. Regional Analytical report. Upper West Region. Accra, Ghana: Ghana Statistical Service.

Golafshani, N. (2003). Understanding reliability and validity in qualitative research. *The qualitative report*, *8*(4), 597-607.

Grant, C.,& Osanloo,A. (2014). Understanding, selecting, and integrating a theoretical framework in dissertation research: Creating the blue print for your house.

Hägerstrand, T. (1970). What about people in regional science? *Papers of the Regional Science Association*, *24*, 7–21.

Hall, R. F. (2013). Mixed methods: In search of a paradigm. In T. Le, & Q. Le (Eds.), *Conducting research in a changing and challenging world*(pp. 71-78). New York: Nova Science Publishers Inc.

Huang, Jianping, Mingxia Ji, Yongkun Xie, Shanshan Wang, Yongli He, and Jinjiang Ran. (2016). Global semi-arid climate change over last 60 years. *Climate Dynamics*, *46*(3), 1131–1150. https://doi.org/10.1007/s00382-015-2636-8.

Idrissou, Y. I., Assani, A. S., Baco, M. N., Yabi, A. J., &Traoré, I. A. (2020). Adaptationstrategies of cattle farmers in the dry and sub-humid tropicalzones of Benin in the context of climate change. *Heliyon, 6*,e04373. https:// doi. org/ 10. 1016/j. heliy on. 2020. e04373

IFAD (2018). Engaging with pastoralists a holistic development approach. Teaser prepared in collaboration with Saverio Krätli, Pastoraldevelopment expert, Michele Nori, Agro-pastorallivelihoods expert, AlbanBellinguez, Livestock development expert, Marco Bassi, Anthropologist, andOliver Mundy, IFAD Environment and Climate Analyst under the supervision ofAntonio Rota.

Intergovernmental Panel on Climate Change (IPCC) (2001). Climate change 2001: the scientific basis. J. T. Houghton, Y. Ding, D. J. Griggs, M. Noguer, P. J. van der Linden, X. Dai, K. Maskell, and C. A. Johnson, editors. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change.

Intergovernmental Panel on Climate Change (IPCC) (2007). Climate Change 2007: impacts, adaptation and vulnerability.Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change(M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden& C.E. Hanson, eds). Summary for policy makers. CambridgeUniversity Press, Cambridge, UK, 7–22. Available at: www. ipcc.ch/pdf/assessment-report/ar4/wg2/ar4_wg2_full_report.pdf

IPCC.(2013). Working group I contribution to the IPCC fifth assessment report climate change 2013: The physical science basis summary for policymakers. http://www.ipcc.ch/report/ar5/wg1/.

IPCC. (2014). Climate Change 2014 Impacts, Adaptation, and Vulnerability. Full Report Part A: 'Global and Sectoral aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Retrieved from Cambridge University Press. Cambridge, United Kingdom and New York, NY, USA, pp688.

IPCC. (2015). Climate Change 2014 Synthesis Report. Intergovernmental Panel on Climate Change. https://www.ipcc.ch/pdf/assessment-report/ar5/syr/SYR_ AR5_FINAL_full.pdf.

IPCC. (2019). “Summary for Policymakers” in Climate Change and Land: An IPCC Special Report on Climate Change, Desertification, Land Degradation, Sustainable Land Management, Food Security, and Greenhouse Gas Fluxes in Terrestrial Ecosystems; Available online at: https://www.ipcc.ch/site/assets/uploads/2019/11/02_Summary-for-Policymakers_SPM.pdf.

IPCC. (2022). Climate change 2022: impacts, adaptation, and vulnerability. Contribution of Working Group II to the Sixth AssessmentReport of the Intergovernmental Panel on Climate Change. In:Pörtner H-O, Roberts DC, Tignor M, Poloczanska ES, Mintenbeck K, Alegría A, Craig M, Langsdorf S, Löschke S, Möller V,Okem A, Rama B (eds) Cambridge University Press. CambridgeUniversity Press, Cambridge, UK and New York, NY, USA, p3056. https:// doi. org/ 10. 1017/ 97810 09325 844

ILRI (International Livestock Research Institute). (2006). Pastoralism: The surest way out of poverty in East African drylands. Fact sheet. Nairobi: International Livestock Research Institute.

Jagchid, S., &Hyer, P. (2019). *Mongolia’s Culture and Society*. Routledge.

Jin, J., Wang, X., &Gao, Y. (2015). Gender differences in farmer’ responsesto climate change adaptation in Yongqiao district, China. *Sci Total Environ, 538*, 942–948. https:// doi. org/ 10. 1016/j. scito tenv. 2015. 07. 027

Johnson, R. B., & Onwuegbuzie, A. J. (2004). Mixed methods research: A research paradigm whose time has come. *Educational researcher*, *33*(7), 14-26.

Johnson, B., & Christensen, L. (2012). *Educational research: quantitative, qualitative, and mixed approaches* (4th ed.). Thousand Oaks, CA: Sage publications.

Jonathan D., Maryam N., Carol K., and Kenneth B., (2010). Extensive Livestock Production in Transition. The Future of Sustainable Pastoralism. https://www.researchgate.net/publication/285360020.

Jon Pedersen and Tor A. Benjaminsen(Feb., 2008). One Leg or Two? Food Security and Pastoralism in the Northern Sahel. http://www.jstor.org/stable/27654255.*Human Ecology*, *36*(1), 43-57. Accessed: 22/06/2014 00:05

Kabir, S.M.S. (2016). *Basic Guidelines for Research: An Introductory Approach for All Disciplines.* Book Zone Publication, ISBN: 978-984-33-9565-8, Chittagong-4203, Bangladesh.

Karimi, V., Karami, E., &Keshavarz, M. (2018). Vulnerability andadaptation of livestock producers to climate variability andchange. *Rangeland Ecology and Management,71*, 175–184.https://doi.org/10.1016/j.rama.2017.09.006.

Karma, R.(1999). *Research Methods.* SAGE Publications. New Delhi, India

Kathleen A. Galvin (2009). Transitions: Pastoralist Living with Change. The Annual Review of Anthropology.

Kaur, M., Graham,J.P.,& Eisenberg,J.N.S. (2017). Livestock ownership amongrural households and child morbidity and mortality: An analysis ofdemographic health survey data from 30 Sub-Saharan African Countries(2005-2015). *American Journal of Tropical Medicine and Hygiene, 96*(3), 741–748. https://doi.org/10.4269/ajtmh.16-0664.

Keenan, R.J. (2015). Climate change impacts and adaptation in forest management: A review. *Ann. For. Sci., 72*, 145–167.

Kemal, A., Mohammed, A.,&Lelamo, L. (2022). Pastoralists' Adaptation Strategies to Climate Change and Determinant Factors in Korahey Zone, Ethiopia. *American Journal of Climate Change*, *11*, 79-102. doi: 10.4236/ajcc.2022.112005.

Khanal, U., Wilson, C., Lee, B., &Hoang, V-N. (2018). Smallholder farmers'participation in climate change adaptation programmes:understanding preferences.*Nepal Clim. Policy, 18*(7), 916–927.https:// doi. org/ 10. 1080/ 14693 062. 2017. 13896 88

Kim, S.S., Nguyen,P.H.,Tran,L.M., Abebe,Y.,Asrat,Y.,Tharaney,M.,&Menon,P. (2019). Maternal behavioural determinants and livestock ownership areassociated with animal

source food consumption among young childrenduring fasting in rural Ethiopia. *Maternal and Child Nutrition, 15*(2), 12695.https://doi.org/10.1111/mcn.12695.

Kimaro, E.G., Mor, S.M.,& Toribio, JA.L.M.L. (2018). Climate change perception and impact on cattle production in pastoral communities of the northern Tanzana. *Pastoralism, 8*, 19. https://doi.org/10.1186/s13570-018-0125-5

Kothari, C.R. (2012). *Research Methodology: An introduction. In Research Methodology: Methods and Techniques.* New Delhi:New Age International.

Kumekpor, T. K. B. (2002). *Research Methods and Techniques of Social Research*.Sonlife Printing Press and Services, Accra

Kwan, M. P. (1998). Space-time and integral measures of individual accessibility: a comparative analysis using a point-based framework. *Geographical Analysis, 30*(3), 191–216. doi: 10.1111/j.1538-4632.1998. tb00396.x

Lasco, R. D., Espaldon, M. L. O., &Habito, C. M. D. (2016). Smallholder farmers'perceptions of climate change and the roles of trees andagroforestry in climate risk adaptation: evidence from Bohol,Philippines. *Agroforest Syst., 90,* 521–540. https:// doi. org/ 10.1007/ s10457-015- 9874-y

Levine, A. S.,& Feinholz, C. L. (2015). Participatory GIS to inform coral reef ecosystem management: Mapping human coastal and ocean uses in Hawaii. *Applied Geography*, 59**,** 60-69.

Liao, C., Agrawal, A., Clark, P. E., Levin, S. A., & Rubenstein, D. I. (2020). Landscape sustainability science in the drylands: mobility, rangelands and livelihoods. *Landscape Ecology,* 1-15.

Liao, C., Clark, P. E., DeGloria, S. D., & Barrett, C. B. (2017). Complexity in the spatial utilization of rangelands: Pastoral mobility in the Horn of Africa. *Applied Geography*, *86*, 208-219.

Lobell, D.B., Bänziger, M., Magorokosho, C.,&Vivek, B. (2011). Nonlinear heat effects on African maize as evidenced by historical yield trials. *Nat. Clim. Chang., 1,* 42–45.

Lomiso, T.F. (2020). Climate change, its effect on livestock production and adaptationstrategies in Hawassa zuria and Hula districts of Sidama region, southern Ethiopia.*Int. J. Environ. Monit. Anal., 8*(5), 117–129.

Little, P. D., Smith, K., Cellarius, B. A., Coppock, D. L., &Barrett, C. B. (2001). Avoiding Disaster: Diversification and Risk Management among East African Herders. *Development and Change, 32*, 401-433.

Ma, L. (2012). Some philosophical considerations in using mixed methods in library and information science research. *Journal of the American Society for Information Science and Technology, 63*(9), 1859-1867. https://doi.org/10.1002/asi.22711

Mabe, F. N., Sienso, G., & Donkoh, S. A. (2014). Determinants of choice of climate change adaptation strategies in northern Ghana. *Research in Applied Economics, 6*(4), 75-94.

Makepe, P.M. (2006). The evolution of institutions and rules governing communal grazing lands in Botswana. *Eastern Africa Social Science Research Review, 22*, 39–61.

Makondo, C. C., &Thomas,D. S. (2018). Climate Change Adaptation: Linking Indigenous Knowledge with Western Science for Effective Adaptation. *Environmental Science & Policy, 88*, 83–91. doi:10.1016/j.envsci.2018.06.014.

Martin, R., Muller, B., Linstadter, A.,&Frank, K. (2014). How Much ClimateChange Can Pastoral Livelihoods Tolerate? Modelling Rangeland Use and EvaluatingRisk. *Global Environmental Change, 24*, 183-192.https://doi.org/10.1016/j.gloenvcha.2013.09.009

Matthew D. Turner and Eva Schlecht (2019). Livestock mobility in sub-Saharan Africa: A critical review. https://doi.org/10.1186/s13570-019-0150-z

McCabe, J. T. (2004).*Cattle Bring Us to Our Enemies: Turkana Ecology, Politics, and Raiding in a Disequilibrium System.* Ann Arbor, MI: Michigan University Press.

McNamara, K. E., &Buggy,L. (2017). Community-based Climate Change Adaptation: A Review of Academic Literature. *Local Environment, 22*(4), 443–460. doi:10.1080/13549839.2016.1216954.

Mequannt, M., Fikadu, Y., Mebrahtu, H., & Filmon, T. (2020). Farmers' Choices and FactorsAffecting Adoption of Climate Change Adaptation Strategies: Evidence from NorthwesternEthiopia. Heliyon, 6, e03867. https://doi.org/10.1016/j.heliyon.2020.e03867

Miller, H. (1991).Modelling accessibility using space-time prism concepts within geographical information systems. *International Journal of Geographical Information System, 5*(3), 287–301. doi: 10.1080/ 02693799108927856

Ministry of Food and Agriculture Annual District Report (2020). District Directories, Upper West Region, Wa East report. http://mofa.gov.gh/site/directorates/district-directorates/upper-west-region/290-wa-east

M. Igshaan Samuels, Nicky Allsopp, M. Timm Hoffman (2019). Traditional Mobile Pastoralism in a Contemporary Semiarid Rangeland in Namaqualand, South Africa. https://doi.org/10.1016/j.rama.2018.08.005 1550-7424/© 2018 The Society for Range Management. Published by Elsevier Inc. All rights reserved.

M Igshaan Samuels, Nicky Allsopp & M Timm Hoffman (2021). Changes in pastoral mobility in a semi-arid montane region of South Africa: The role of policy and legislation.*African Journal of Range & Forage Science, 38*(1), 1-13, DOI: 10.2989/10220119.2020.1861096

Molefi, S.H., &Mbajiorgu,C.A. (2017). Assessing the potential of beef cattlefarming as contributor to income of communal households of Chief AlbertLuthuli municipality in Mpumalanga province, South Africa. *Indian Journal ofAnimal Research, 51*(2), 350–357.

Molina-Azorin, J. F. (2016). Mixed methods research: An opportunity to improve our studies and our research skills. *European Journal of Management and Business Economics*, *25*,37-38. https://doi.org/10.1016/j.redeen.2016.05.001

Moritz M, Soma E, Scholte P, Xiao N, Taylor L, Juran T. (2010). An Integrated Approach to Modeling Grazing Pressure in Pastoral Systems: The Case of the Logone Floodplain (Cameroon). *Human Ecology, 38*, 775–789. doi: 10.1007/s10745-010-9361

Moritz, Mark, Sara Handa, Yu-Jen Chen, and Ningchuan Xiao. (2015). Herding contracts and pastoral mobility in the Far North Region of Cameroon. *Human Ecology*, *43*(1), 141–151.

Msambichaka, S. J., & Onyango, P. O. (2019). The dynamics of pastoral mobility routes in relation to food security in semi-arid areas of Simanjiro and Handeni districts in Tanzania. *African Journal of Environmental Science and Technology*, *13*(10), 381-392.

Mubamba, C., Ramsay,G., Abolnik,C., Dautu,G., &Gummow,B. (2018). Analysing production and financial data from farmers can serve as a tool for identifyingopportunities for enhancing extension delivery among the rural poultry subsectorin Zambia. *Preventive Veterinary Medicine, 158*, 152–159. https://doi. org/10.1016/j.prevetmed.2018.08.005.

Naess, L. O. (2013). *The Role of Local Knowledge in Adaptation to Climate Change*. Wiley Interdisciplinary Reviews.*Climate Change, 4*(2),99–106. doi:10.1002/wcc.204

Napogbong, L. A., Ahmed, A., &Derbile, E. K. (2021). Fulani herders and indigenous strategies of climate change adaptation in Kpongu community, North-Western Ghana: implications for adaptation planning. *Climate and Development, 13*(3), 201-214.

Navchaa Tugjamba, Greg Walkerden & Fiona Miller (2021) Adaptation strategies of nomadic herders in northeast Mongolia: climate, globalisation and traditional knowledge.*Local Environment, 26*(4), 411-430, DOI: 10.1080/13549839.2021.1891032

Ndamani, F., & Watanabe, T. (2017). Determinants of farmers' climaterisk perceptions in agriculture – a rural Ghana perspective.*Water, 9*, 210. https:// doi. org/ 10. 3390/ w9030 210

Nyangena, J. (2018). Drought, land use change and livelihood diversification among pastoral communities in oltiasika, Kajiado County, Kenya. Thesis submitted to the School of Environmental Studies, Kenyatta University.

Oba, G. (2013). The sustainability of pastoral production in Africa. In: *Pastoralism andDevelopment in Africa: Dynamic change at the margins* (eds J. Lind, A. Catley, and I.Scoones) Routledge, London and New York.

Ojo, T.O., &Baiyegunhi,L.J.S. (2020). Determinants of climate change adaptationstrategies and its impact on the net farm income of rice farmers in southwestNigeria. *Land Use Policy, 95*, 103946. https://doi.org/10.1016/j.la ndusepol.2019.04.007.

Osumanu, K. I., Attakora, A. E., & Aduko, J. (2017). Awareness and Application of Climate Change Adaptation Strategies: Perspectives of Rural Farmers in The Bawku West District, Ghana. *KNUST Journal of Geography*, *1*(1).

Panneerselvam, R. (2008). *Research Methodology*, 6th Edition. PHI, New Delhi.

Pas Schrijver, A. (2019). Pastoralists, Mobility and Conservation: Shifting rules of access and control of grazing resources in Kenya's northern drylands (Doctoral dissertation, Department of Human Geography, Stockholm University).

Pas, A. (2018). Governing grazing and mobility in the Samburu lowlands, Kenya. *Land*, *7*(2), 41.

Pete Smith, Katherine Calvin, Johnson Nkem, Donovan Campbell, Francesco Cherubini,

Giacomo Grassi, Vladimir Korotkov, Anh Le Hoang, Shuaib Lwasa, Pamela McElwee, Ephraim Nkonya, Nobuko Saigusa, Jean-Francois Soussana, Miguel Angel Taboada, Frances C. Manning, Dorothy Nampanzira, Cristina Arias-Navarro, Matteo Vizzarri, Jo House, Stephanie Roe, Annette Cowie, Mark Rounsevell and Almut Arneth (2020). Which practices co-deliver food security, climate change mitigation and adaptation, and combat land degradation and desertification? *Glob. Change Biol., 26*(3), 1532-1575.

Pica-Ciamarra, U., Tasciotti,L., Otte,J.,&Zezza,A. (2011). Livestock assets, livestock income and rural households: Cross-country evidence from household surveys, Food and Agriculture Organization of the United Nations (FAO) ESA Working Paper No. 11-17. Rome: http://www.fao.org/3/am724e/am724e00.pdf.

Piya, L., Maharjan, K.L.,&Joshi, N.P. (2013). Determinants of adaptation practices to climate changeby chepang households in the rural mid-hills of Nepal.*Regional Environmental Change, 13*(2), 437-447.

Reid, R.S., Fernández-Giménez, M.E., &Galvin, K.A. (2014). Dynamics and Resilience of Rangelands and Pastoral Peoples Around the Globe. *Annual Review of Environment and Resources, 39*, 217–242.

Robbins, P. (2019). *Political ecology: A critical introduction*. John Wiley & Sons.

Rodriguez-Lopez, J. M., Schickhoff, M., Sengupta, S., &Scheffran, J. (2021). Technological and social networks of a pastoralist artificial society: agent-based modeling of mobility patterns. *Journal of Computational Social Science*, 1-27.

Samuels, M. I., Allsopp, N., & Hoffman, T. (2008). Mobility patterns of livestock keepers in semi-arid communal rangelands of Namaqualand, South Africa. *Nomadic peoples, 12*(1),123-148.

Samuels, M. I. (2013). Pastoral mobility in a variable and spatially constrained South African environment [dissertation]. University of Cape Town, Cape Town, South Africa, p. 203.

Samuels, M. I., Allsopp, N., & Hoffman, M. T. (2019). Traditional mobile pastoralism in a contemporary semiarid rangeland in Namaqualand, South Africa. *Rangeland Ecology & Management, 72*(1), 195-203.

Samuels, I., Allsopp, N., & Timm Hoffman, M. (2021). Changes in pastoral mobility in a semi-arid montane region of South Africa: The role of policy and legislation. *African Journal of Range & Forage Science, 38*(1), 1-13.

Sandrine O. H., Luc Hippolyte Dossa, Rodrigue V.C. Diogob, Marcel Houinato, Andreas Buerkertc, Eva Schlecht (2018). Change and continuity in traditional cattle farming systems of West African Coast countries: A case study from Benin. https://doi.org/10.1016/j.agsy.2018.11.003.

Sanou, C.L.,Tsado, D.N., Kiema, A., Eichie, J.O.,&Okhimamhe, A.A. (2018) Climate VariabilityAdaptation Strategies: Challenges to LivestockMobility in South-Eastern Burkina Faso.*Open Access Library Journal*, *5*, e4372.https://doi.org/10.4236/oalib.1104372

Schareika, B., and Moritz C., (2021). Transitions from Pastoralism to Ranching in Central Africa. *Current Anthropology*, *62*(1).

Shannon-Baker, P. (2016). Making paradigms meaningful in mixed methods research. *Journal of Mixed Methods Research*, *10*,319-334. https://doi.org/10.1177/1558689815575861

Shao, Q. M. (1999). Monte Carlo estimation of Bayesian credible and HPD intervals. *Journal of computational and Graphical Statistics*, *8*(1), 69-92.

Soglo, Y. Y., &Nonvide, G. M. A. (2019). Climate change perceptionsand responsive strategies in Benin: the case of maize farmers.*Climte Change*, *155*, 245–256. https:// doi. org/ 10. 1007/ s10584- 019- 02452-3

Stenning, D. J. (1957). Transhumance, migratory drift, migration; patterns of pastoral Fulani nomadism. *Journal of the Anthropological Institute of Great Britain and Ireland*, *87*(1), 57–73. doi: 10.2307/2843971

Stephanie H., and Daniel I. R., (2017). Pastoralist societies in flux: A conceptual framework analysis of herding and land use among the Mukugodo Maasai of Kenya.

Stojanowski, C. M., & Knudson, K. J. (2014). Changing patterns of mobility as a response to climaticdeterioration and aridification in the middle Holocene southern Sahara. *American Journal of Physical Anthropology, 154*(1), 79-93.

Stringer, L. C., Reed, M. S., Fleskens, L., Thomas, R. J., Le, Q. B.,&Lala- Pritchard, T. (2017). A New Dryland Development Paradigm Grounded in Empirical Analysis of Dryland Systems Science. *Land Degradation & Development, 28*, 1952-1961.

Sulieman, H.,&Young, H.(2019). *Transforming Pastoralist Mobility in West Darfur: Understanding Continuity and Change*. Boston: Feinstein International Center, Tufts University, 2019

Sunderland and Rowland (2019). "Forests, land use, and challenges to climate stability and food security" in *Sustainable Food and Agriculture*, Elsevier, 2019, pp. 95-116.

Tacoli, C. (2011). Not only climate change: mobility, vulnerability and socio-economic transformationsin environmentally fragile areas in Bolivia, Senegal and Tanzania (No.28). IIED.

Tadesse Ayele Belachew, Dereje Gebeyehu Ababu, "Statistical Modeling of Farmers' Preference for Adaptation Strategies for Climate Change: The Case of Dera District, Oromia, Ethiopia", Applied and Environmental Soil Science, vol. 2021, Article ID 6659859, 12 pages, 2021. https://doi.org/10.1155/2021/6659859

Tamou, C. (2017). Understanding relations between pastoralism and its changing natural environment, PhD thesis, Wageningen University, Wageningen, the Netherlands (2017) With references, with summaries in English and Dutch ISBN 978-94-6343-155-2.

Tasser, E., Leitinger, G., & Tappeiner, U. (2017). Climate change versus land-use change—What affects the mountain landscapes more? *Land use policy*, *60*, 60-72.

Teka, O, Houessou, G. L., Oumorou, M., Vogt, J.,&Sinsin, B.(2013). An assessment of climate variation risks on agricultural production: perceptions and adaptation options in Benin. *International Journal of Climate Change Strategies and Management*, 5(2), 166-180.

Thinda, K. T., Ogundeji, A. A., Belle, J. A., &Ojo, T. O. (2020). Understanding theadoption of climate change adaptation strategies among smallholderfarmers: evidence from land reform beneficiaries in SouthAfrica. *Land Use Policy*, *99*, 104858. https:// doi. org/ 10. 1016/j. landu sepol. 2020. 104858

Thomas, N., &Nigam, S. (2018). Twentieth-Century Climate Change over Africa: Seasonal Hydroclimate Trends and Sahara Desert Expansion. *Journal of Climate, 31*, 3349-3370. 10.1175/JCLI-D-17-0187.1.

Turner, M.D., McPeak, J.G., &Ayantunde, A. (2014). The role of livestock mobility in the livelihood strategies of rural peoples in semi-arid West Africa. *Human Ecology, 42,* 231–247

Twumasi, A. (2001). The use of GIS and Remote Sensing techniques as tools for managing mature reserves: the case of Kakum National Park in Ghana. Geoscience and Remote Sensing Symposium: IGARSS' 01. IEEE International 7: 3227-3229

Varkevisser, C. M., Pathmanathan, I., & Brownlee, A. T. (2003). *Designing and conducting health systems research projects* (Vol. 1). IDRC.

Vosloo, W., Bastos, A., Sangare, O., Hargreaves, S., &Thomson, G. (2002). Review of the status and control of foot and mouth disease in sub-Saharan Africa. *Revue Scientifique Et Technique-Office International Des Epizooties, 21*(3), 437–445.

Wa East District Assemble, Planning & Coordinating Unit, (2020). Summary of profile of Wa East District, Funsi.

Wa East District Assemble, Planning & Coordinating Unit, (2022). *Summary of profile of Wa East District, Funsi.*

Wisdom, J., & Creswell, J. W. (2013). Mixed methods: integrating quantitative and qualitative data collection and analysis while studying patient-centred medical home models. *Rockville, MD: Agency for Healthcare Research and Quality*. AHRQ Publication No. 13-0028-EF.

Zanmassou, Y. (2017). Smallholder Farmers' Adaptive Capacity and Choice of Adaptation Strategies against Weather Risks in Northern Benin. Doctoral Thesis, University of Ghana.

Zhang, C., Jin, J., Kuang, F., Ning, J., Wan, X., (2020). Farmers' perceptionsof climate change and adaptation behavior in WushenBanner, China. *Environ Sci Pollut R.*, *27*, 26484–26494. https:// doi. org/ 10. 1007/ s11356- 020- 09048-w

Appendix

Appendix 1

DEPARTMENT OF ENVIRONMENT AND RESOURCE STUDIES

SD DOMBO UNIVERSITY OF BUSINESS AND INTEGRATED DEVELOPMENT STUDIES

Household survey questionnaire

Mobility patterns of pastoralists under changing climate in the semi-arid zone of Ghana: A case study of Wa East District in the Upper West Region

Introduction

The purpose of this research is purely academic, and the data collected is for my PHD thesis. Every information you will provide will be treated with a high degree of confidentiality. Your right to privacy and anonymity during and after this interview is guaranteed. I will appreciate it a lot if you could participate in this survey. Apart from your time, there is no cost or remuneration for your participation.

Part A: General background information

(1) Name of community:

(2) Name or location of Track:

(3) Male ☐ Female ☐ (4) Age of respondent .....Years

(5) Occupation/ Livelihood activity:

(6) Educational level of respondent :

1=No formal education	2=Primary/Basic school	3=Junior secondary/high school (Middle School	4=Senior secondary/high school	5=Tertiary education

(7) Ethnic group/origin of header?.....

(8) Indicate household size……

(9) Number of years household head lived in this area?.....Years

(10)What is the main income source for household?

(11) Does your household have access to any agricultural land? Yes ☐

(12) By what arrangement do you have access to your land for farming activities?

(a) land purchased (b) land inherited (c) land rented (d) others (specify)

(13) Does your household have any livestock? Yes ☐ No ☐

(14) If yes, (Please use given codes: *1= Stall feeding (fodder, silage, hay), 2= Grazing, 3= Both

Type	**Present Number**	**Way of feeding***
Sheep		
Goat		
Cow/bull		
Horse		
Donkey		
Pig		
Poultry		
Other (please specify)		

(16) Livestock ownership Status..... a) Self b) Caretaker c) Others (specify)

(17) Who looks after your livestock/herds?

(18) What is your household header size?

Part B: The patterns and trends in climate change and changing mobile pastoral systems

(19) Do you perceive that there is climate change in your area? 1. Yes, 0. No

(20) Have there been any changes in the climate patterns (the intensity, quantity and time) in the last 10/20/30 years? 1. Yes, 0. No

(21) Have their frequency changed over time? 1. Yes, 0, No

(22) How would you describe the changes in the following climatic components?

Climatic Components	Increasing	Decreasing	Varies continuously	Same/Unchanged
Temperature				
Rainfall				
Drought				
Natural calamities (Storms, flooding etc..)				
Seasonal changes				

*Code 1 Strongly agree, 2=agree, 3=indifference, 4=strongly disagree, 5=disagree

(23) Do pastoralists from further areas arrive here to access grazing? Yes No

(24) In your opinion do you think the following climate change impact has effect on mobile herds?

Impacts	**Rank 0-5**
Animals travel longer distances for feed and drink	
Decrease in the number of births per year	
Drop in Milk production	
Death of livestock	
Excessive loss of weight	
Increase of infectious and parasitic diseases	
Appearance of new animals‘ diseases	
Abortion of livestock	
Specify others	

Rank codes, 5= very high 4= high 3= average 2= low 1=Very low 0=No effect

(25) In your opinion do you think the following climate change impact has effect on mobile herder‘s livelihoods?

Impacts	**Rank 0-5**
Long distance to fetch water for domestic use	
Increase in physical effort in herding	
Food insecurity	
Regression of animal heritage	
Decrease in incomes	
Loss of prestige	
Specify others	

Rank codes 5= very high 4= high 3= average 2= low 1=Very low 0=No effect

(26) What major shift in land use and cover have occurred owing to climate change and pastoral activities in this community in the last 10/20/30 years? (provide qualitative description; increase, decrease & No change)

Shift in Land use and cover	**Present time (2022)**	**30 years ago**
	Area	**Area**
Forest - Grazing land		
Forest/Grazing land – Cropland		
Cropland – Settlement		
Forest/Grazing land/cropland – bare		

land/soil		
Forest/Grazing land/cropland – fallow		
Bare land/soil – Regenerated land		

(27) Have you lived to another place prior to moving to the current location? Yes No

(28) why did you leave your previous location?

(29) What were your specific reasons for choosing your current location?

(30) When do you move your livestock? (a) wet season (b) dry season

(31) How frequent do you move you livestock?

(32) How long do you stay at an area?

(a). Depends (b). < Month (c). 1-3 Months (d).4-5 Months (e). > 5 Months

(33) Are you able to move your livestock freely to grazing areas in this District? (a) Yes, (b). No

(34) If No, why?.....

(35) Have there been any changes in access to grazing area in the last 10/20/30 years? Please describe the change e.g. (a) Decreasing (b) Increasing (c) Others (specify)

(36) In your opinion do you think pastoral activities affects climate change in the following ways?

Impacts	**Rank 0-5**
Source of greenhouse gas	
Water quantity and quality	
Soil erosion	
Deforestation	
Others (specify)	

Rank codes 5= very high 4= high 3= average 2= low 1=Very low 0=No effect

PART C: The underlying drivers of climate change and changing mobile pastoralism

(37) In your view, what do you think are the causes of climate change in this areas over the past decades?

(38) RANK ON ASCALE OF 1 TO 5; 1 = Very Important, 2 = Important, 3 = Moderately Important, 4 = Slightly Important, 5 = Not Important, your assessment of the causes of climate change listed above

(39) What is your assessment of the causes of changes in pastoral systems in your area? (RANK ON ASCALE OF 1 TO 5; 1 = Very Important, 2 = Important, 3 = Moderately Important, 4 = Slightly Important, 5 = Not Important).

Drivers of changing pastoralism	**Rank**				
Proximate causes	1	2	3	4	5
Environmental drivers					
Extreme temperature fluctuations					
Low rainfall					
Seasonal cycle,					
High variation between Seasons					
Soil moisture and hydrology					
Forage productivity, quality, phenology, digestibility and salinity					
Seasonal cultivation of crops that need to beprotectedfrom grazing					
Bushfire					
Other drivers					

Access to pastoral resources					
Avoiding Conflicts					
Temperature variability					
Wind intensity					
Social, economic and political drivers					
Demographic dynamics					
Migration					
Attitude					
Customary land tenure system					
Economic factors: Rising living standards					
Political: Governmental laws Institutional factors					
Others (specify) 1. 2. 3. etc.					

PART D: The Effects of climate change and changing mobile pastoralism on land use and cover

(40) Has climate change and changing mobile pastoralism affected land use/cover in this area?

(41) What are the most important effects of climate change and changing mobile pastoralism on land use/cover?

(42) Has there been any change in land use/cover in terms of their area over the last 30 years owing to climate change and Pastoral activities?

****Please use given codes:***1 = Decrease greatly 2 = Decrease 3 = slightly Stay the same 4 = Increase slightly 5 = Increase greatly)

Major ecosystems/land uses	**1990s: Indicator of Change**	**2022: Indicator of Change***
Grass savannah		
Wooded savannah		
Agriculture land		
Pastureland		
Water bodies (river/stream)		
Settlement		
Bare land		

Other (please specify)		

PART E: The adaptation strategies that smallholder farmers use to manage the effects of Climate change and changing mobile pastoralism on land use and cover change

(43) Which climate factor will you list as a greatest threat to LULC in your area?

Climate Threat	Reason (why)	Adaptation Strategy

(44) What are some of the ways you have used to cope with the effects of changes in climate and pastoralism on land use and cover dynamics within the past 30 years?

(a) Division of livestock: only the strongest animals are taken on longer migrations

(b) Rotational use of pasturelands

(c) Division of livestock: only the weakest animals are taken on longer migrations

(d) Raising different types of livestock (such as cattle and goats), which have different grazing habits and reduce herders' risk of losing all their animals to one disease;

(e) knowledge of rainfall and seasonal changes.

(f) Flexibility in the social organization of herders,movement patterns, and livestock management practices(such as controlling livestock reproduction rates and timing,or selling livestock before the winter to reduce feed amountsand costs)

(g) Planting forage grass,

(h) Buying fodder from the market,

(I) Renting pastures,

(j) Joining formal or informal cooperatives

(k) Diversifying their livelihoods (searching for alternative sources of livelihoods)

(45) Is there any factor that influences your choice of the above?

(46) Have you received any advice/training/Government or NGO support on how to deal with climate change and pastoralism effects on LULC? 1=Yes 2=No

If yes list the kind of support given.

Support	Priority ranking	Reason
Education and technical skills		
Financial support		

Given new lands and improving additional lands		
Other job opportunities		
Others		

(47) In your opinion, What are the most important things that could be done to adopt to climate change and changing mobile pastoralism in this area (socio-economic and environment)?

(48) Are there challenges that hinders your adaption strategies? Please mention if there are any

Thank you for your time and responses

Appendix -2

DEPARTMENT OF ENVIRONMENT AND RESOURCE STUDIES

SD DOMBO UNIVERSITY OF BUSINESS AND INTEGRATED DEVELOPMENT STUDIES

Guide for focus group discussions

Mobility patterns of pastoralists under changing climate in the semi-arid zone of Ghana: A case study of Wa East District in the Upper West Region

Introduction

The purpose of this group discussion is to collect data for my PhD thesis. Every information you give will be treated confidentially. Your right to privacy and anonymity during and after this interview is guaranteed. I will appreciate it a lot if you could participate in this study. Apart from your time, there is no cost or renumeration for your participation.

1) Have there been any changes in the climate patterns (rainfall and temperature)(the intensity, quantity and time) in the last 10/20/30 years? Please describe the changes
2) In your views, what are the underlying drivers of climate change in this area? Please explain
3) What can you say are some major climate change impacts in this community?
4) How has climate change impacted of land use and land cover?
5) How does the community (or you) adapt to these changes in climate and its effect on land cover?
6) What has been the trend and pattern in pastoralism in this community?

7) How has pastoralism in your (community) changed over the past 3 decades, please explain?
8) In your own assessment, what are the causes of the changes in pastoralism?
9) How has the changes in pastoralism affected or altered land use and cover dynamics in your community?
10) In response to the impacts of changes in pastoralism on land use and cover dynamics, what measures/strategies do you implement?
11) In your opinions, what are the most important things that could be done to adopt to climate change and changing mobile pastoralism in this area (socio-economic and environment)?
12) Are there challenges that hinders your adaption strategies? Please mention if there are any

Thank you for your time

Appendix -3

DEPARTMENT OF ENVIRONMENT AND RESOURCE STUDIES

SD DOMBO UNIVERSITY OF BUSINESS AND INTEGRATED DEVELOPMENT STUDIES

Interview Guide for Key Informants

Mobility patterns of pastoralists under changing climate in the semi-arid zone of Ghana: A case study of Wa East District in the Upper West Region

The purpose of this interview is to collect data for my PHD thesis. Every information you give will be treated with high degree of confidentiality. Your right to privacy and anonymity during and after this interview is guaranteed. I will appreciate it a lot if you could participate in this survey. Apart from you time, there is no cost or enumeration for your participation.

(Header leaders, Community opinion leaders, land managers, Chiefs, Agriculture Extension officers, Forestry commission officers).

(1) Name of interviewee

(2) Date and place of interview

(3) Brief background (education, position in society, work, social status)

(4) What havebeen the trends in pastoralism in your community over the past decade, two decades and three decades ago? Probes (1981 -During Rawlings regime, 2001-During Kuffour regime, 2010-During Mills and 2021-Now)

(5)Have you experienced any changes in climate over the past decades (1981-2021)? Probe for description on how climate change is perceive and changes experienced.

(6) In your opinion are there strategies that could be adopted which could reduce the impact of climate change and changing mobile pastorilism on land use and cover?

(7) What is your assessment about the driving causes ofchange in climate and pastoralismin your community (since the 1990s)? Probes

(8) How has changes in climate andpastoralism affected (altered) the land use and cover dynamics in your community? probes

(9) What are some of the measures farmers adapt to manage the effects of changing climate and pastoralism on land use and cover dynamics?

(10) Have you received any advice/training/Government or NGO support on how to deal with climate change and pastoralism effects on LULC? Probes

(11) In your opinion, What are the most important things that could be done to adopt to climate change and changing mobile pastoralism in this area (socio-economic and environment)?

(12) Are there challenges that hinders your adaption strategies? Please mention if there are any

(13) Any remarks

Thank you for your time!