UNIVERSITY OF NAIROBI

DROUGHT, VULNERABILITY AND ADAPTATION: RISK OF FOOD AND LIVELIHOODS INSECURITY FOR PASTORALISTS AND AGRO-PASTORALISTS IN BORANA ZONE, SOUTHERN ETHIOPIA

Thematic Area

Climate Risk Management and Food Security

By

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DECLARATION

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DEDICATION

I dedicate this work to my wife Tume, along with Andy, Amir, and Menelik, my three children. I believe that the hardships you have endured to allow me to follow my dreams will be repaid by offering you lots of opportunities for joy and accomplishment in the future.

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ABSTRACT

Ethiopia. a country in the Horn of Africa, is observing an increase in natural disasters, especially droughts. The impact of natural disasters and the ensuing economic harm they have caused have grown dramatically over the last three decades on a global scale. Ethiopia's prevailing acute food insecurity has gotten worsen because of the COVID-19 pandemic, desert locust's invasion, climate disasters. Climate hazards frequently affect pastoralists and agro-pastoralists in the southern Ethiopian of Borana Zone, endangering their traditional means of subsistence. The pastoralists and agro-pastoralists group are increasingly vulnerable long-term climate change particularly droughts due to long-term changes in precipitation, temperature, and extreme events. However, scholars studying climate risk in the area have not adequately addressed the impact of these changes, on rangelands, livestock, and other significant livelihood resources. The study aims to assess current and future risks to food security and livelihoods in southern Ethiopia, specifically in Borna zone to support pastoralists and agro-pastoralists in developing strategies for adaptation to drought, given the accelerated rate of climate change.

The study focuses on analyzing meteorological, remotely sensed, and local people's experiences on weather and drought patterns. The study examined temperature and blended rainfall from1983 to 2013 using statistical analyses like trend and the Standardized Precipitation Index (SPI). To supplement the blended data, the absolute Normalized Difference Vegetation Index (NDVI) was also examined from 2002 to 2020. Trends were evaluated using both parametric and non-parametric analyses. Future climate projections for the Borana zone were evaluated using historical climate data and the Coordinated Regional Downscaling Experiment (CORDEX). Three of the four Representative Concentration Pathways (RCPs) that were selected for analysis, 1981–2010 and 1983–2010 as baseline for of precipitation and temperatures respectively. The IPCC's future period of 2030, 2050, and 2080 serve as the standards for generating rainfall and temperature projections. The study collected representative household data from 11 districts in zone to assess food security and drought impact on livelihood assets. Landsat imagery was used to investigate of land cover changes, with images comparing between 1985 to 2020. The analysis aimed at to provide empirical evidence for the impact study, comparing images from 1985 to 2020 using 1985 as the starting point.

Climate risk was primarily caused by drought, rising temperatures, and rainfall variability. Extreme rainfall events, particularly in dry conditions becoming more frequent, with three to four dry conditions occurring every ten years. Low land areas were more susceptible to this risk because of greater seasonal and temporal rainfall variability and rising temperatures. Droughts that occurred every two years in the study area had an impact on livestock productivity and production by decreasing in the quantity and quality of feed and water resources. Land use and cover change have led to a decline in these vital resources since the late 1980s. Inadequate nutrition and water stress increase livestock mortality and morbidity, even in seemingly normal years. In years of drought, mortality and morbidity rates increase. During the 2016–2017 drought, sample households lost over 50% of their cattle, 25% of their small ruminants, and 20% of their camels due to malnutrition and dehydration. This led to a financial loss of almost 6.8 billion EB, or $300 million USD. The predicted increase in climate-related disaster events will exacerbate the food insecurity, promote maladaptation, and make it harder to attain the Sustainable Development Goals if not addressed at the local or national level.

This study highlights challenges faced by pastoralists and agro-pastoralists in implementing traditional strategies due to increasing rainfall variability, severity of drought, and land use and cover change. To mitigate the effects, pastoralists and agro-pastoralists are incorporating some livestock and crop production practices into their traditional strategies. The study provides recommendations for addressing the effects of droughts and climate change on livestock, agriculture, food security, water, and land for the various stakeholders and impacted sectors. The study underlines the importance of launching a participatory platform to discuss impact of climate change on Borana pastoral system and develop consensus. The platform will greatly benefit from the analysis and synthesis of the qualitative and climatic data provided in this study. This study recommends the use of mixed methodologies and local knowledge for a better understanding of climate risks, especially in the setting of restricted availability and quality of long-time series climate data.

TABLE OF CONTENTS

LISTS OF TABLES

LISTS OF FIGURES

CASE STUDIES

LISTS OF ABBREVIATIONS AND ACRONYMS

AAT	Average Annual Temperature
AR	Annual Rainfall
AR5	Fifth Assessment Report of the United Nations Intergovernmental Panel on Climate Change
ASAls	Arid and Semi-Arid Lands
CDD	Dry Days Index
CIFA	Community Initiative Facilitation and Assistance
CMIP5	5th phase of the Coupled Model Inter comparison Project.
CCPP	Contagious Caprine Pleuropneumonia
CHIRPS	Climate Hazards Group Infrared Precipitation with Station data.
CMI	Crop Moisture Index
CSA	Climate-Smart Agriculture (CSA)
CORDEX	Coordinated Regional Downscaling Experiments
COVID-19	Coronavirus disease
CRGE	Climate Resilient Green Economy
CST:	CAFOD, SCIAF and Trócaire
CSI	Coping strategy Index
CSV	A comma-separated values file
CV	Coefficient of Variation
DPPC	Disaster Prevention and Preparedness Commission
DRM	Disaster Risk Management
EU	European Commission
EM-DAT of CRED	Emergency Events Database of the Centre for Research on the Epidemiology of Disasters
eMODIS	Moderate Resolution Imaging Spectroradiometer
EVI	Enhanced Vegetation Index
ENACTS	Enhancing National Climate Services
EB	Ethiopian Birr
FAO	Food and Agriculture Organization of UN
FCS	Food Consummation Scores
FDRE	Federal Democratic Republic of Ethiopia
FEWSNET	Famine Early Warning Systems Network

FGDs	Focus Group Discussions
GCMS	Global Climate Models
GHGs	Greenhouse gases
GIS	Geographical Information System
GPS	Global Positioning System
HDD	Household dietary diversity
HDX	Humanitarian Data Exchange
HHS	Household hunger scale
HOA	Horn of Africa
HS	Haemorrhagic Septicemia
IBLI	Index Based Livestock Insurance
ICPAC	Intergovernmental Authority on Development (IGAD) Climate Prediction and Application Centre
ICPALD	IGAD Centre for Pastoral Areas and Livestock Development
IGAD	Intergovernmental Authority on Development
3I	Innovative Insurance Initiatives
ILRI	International Livestock Research Institute
IPC	Integrated Food Security Phase Classification
IPCC	Intergovernmental Panel on Climate Change
KIs	Key Informant Interview
LULC	Land Use Land Cover Change
LSD	Lumpy Skin Disease
LZ	Livelihoods Zone
MAM	March, April, and May (main rainy season)
MDC	Mobile Data Collection
MME	A Multi-Model Ensemble
NAP	National Adaptation Plan
NAPA	National adaptation programmes of action
NDVI	Normalized Difference Vegetation Index
NGOs	Non-Governmental Organizations
NMA	National Meteorology Authority
NOAA	National Oceanic and Atmospheric Administration
ODK	Open Data Kit

OPADC	Oromia Pastoral Area Development Commission
PDSI	Palmer Drought Severity Index
PHDI	Palmer Hydrological Drought Index
PZI	Palmer Z-index
PNDI	Percent Normal Drought Index
PSU	Primary sampling unity
PSNP	Productive Safety Net Program
R^2 (R-Squared)	Coefficient of determination
RAI	Rainfall Anomaly Index
RCM	Regional Climate Models
RCPs	Representative Concentration Pathways
RCA	Rossby Centre Regional Atmospheric Climate Model
rCSI	Livelihood coping, and Reduced Coping Strategy Index
RDI	Reclamation Drought Index
REDD	Reducing emissions from deforestation and forest degradation
RR1	wet day's index per time period
SDGs	Sustainable Development Goals
SDII	Simple daily intensity index
SON	September, October, and November (short rainy season)
SMHI	Swedish Meteorological and Hydrological Institute
SPI	Standardized Precipitation Index (SPI),
SPSS	Statistical Package for the Social Sciences
SSA	Sub-Sahara Africa
SSI	Semi Structured Interview
SSU	Secondary sampling unity
SWSI	Surface Water Supply Index
SWALIM	Somalia Water and Land Information Management
SWOT	Strength, Weakness, Opportunity, and Threat
TM	Thematic Mapper
TLUs	Tropical Livestock Units
UNDRR	United Nations Office for Disaster Risk Reduction
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change

UNCCD	United Nations Conventions for Combating Desertification
UN-OCHA	United Nations Office for the Coordination of Humanitarian Affairs
USAID	United States Agency for International Development
USD	United States Dollar
USGS	United States Geological Survey
VCI	Vegetation Condition Index
WASP	Weighted Anomaly Standardized Precipitation
WMO	World Meteorological Organization

CHAPTER 1: INTRODUCTION

1.1 General Background

Over the past three decades, climate-related natural disasters such as droughts, floods, hurricanes, typhoons, and cyclones, as well as the associated economic damages, have increased (IPCC, 2014; FAO, 2015). The acute food insecurity of 42 million people was worsened by swarms of desert locusts, the COVID-19 pandemic, and Atlantic Ocean storms that set records (FA0, 2021). The Global Climate Risk Index (Eckstein, 2017) shows that less developed countries are typically more affected by the impact of weather-related losses than industrialized countries, even though climate change generally poses significant challenges for the global population regardless of the level of development. Smith *et al*. (2001), UNFCCC (2007), and IPCC (2014) assert that the population of these nations are mostly dependent on natural resources that are vulnerable to climate change for their livelihoods, and that these vulnerabilities account for their limited capacity to influence the climate. The most vulnerable population affected by weather-related losses are rural communities in East Africa whose livelihoods depend on "rain-fed agricultural systems and fragile natural resources" (Schreck, 2004; Bowden, 2007).

Droughts pose a significant threat to sustainable development, particularly in developing countries, with a 29% increase in drought frequency and duration since 2000 compared to previous two decades (WMO, 2021). Between 2000 and 2019, drought affected over 1.4 billion people, making it the most devastating disaster. Africa experienced 134 droughts, with 70 in East Africa, making it the continent with the highest frequency of droughts (Wallemacq *et al.*, 2015). Between 1980 and 2014, droughts affected over 363 million people in sub-Saharan Africa, according to the Emergency Events Database of the Centre for Research on the Epidemiology of Disasters (FAO, 2015). The FAO reports that 56% of the 203 million impacted people in sub-Saharan Africa, including Ethiopia and Kenya, reside in eastern Africa, accounting for 30% of the affected population in SSA. Between 1980 and 2014, drought affected over 363 million people in sub-Saharan Africa (SSA), according to Emergency Events Database (EM-DAT) of the Centre for Research on the Epidemiology of Disasters (FAO, 2015). The FAO reports that 203 million or 56% of the SSA's impacted people reside in eastern Africa, including Ethiopia and Kenya, accounting for 30% of the affected population in SSA (FAO, 2015). Again, UN-OCHA estimated that at least 36.1 million people in Ethiopia, Kenya, and Somalia will experience severe drought because of the four poor cropping seasons that followed 2020–2022. Additionally, droughts that occurred in Sub-Saharan Africa between 1991 and 2013 resulted in crop and livestock production losses of roughly USD 31 billion, with eastern Africa suffering the largest losses with USD 19 billion (FAO, 2015).

The observed disasters and associated economic damage patterns worsened the food insecurity and nutrition situation in SSA worse. Additionally, the IPCC has predicted in its fifth assessment report that "frequency, intensity, and cost of natural hazards" will continue to rise in the ensuing decades (IPCC, 2014). According to Shibru *et al*. (2022), an increase in climate-related disaster occurrences is anticipated to exacerbate already-existing food insecurity and maladaptation, which will make it more challenging to fulfill the Sustainable Development Goals (SDGs). According to Bizimana *et al*. (2016), pastoral people in dry and semi-arid areas of East Africa are concerned about recurrent droughts. These issues are hampering the socioeconomic and cultural benefits of raising livestock for the populace. According to numerous studies (Bailey, 1999; Little *et al*., 2001; McPeak, 2004; Barrett and Luseno, 2004; AfDB, 2010; Bizaman *et al*., 2016), the risk that pastoralists in East Africa confront is significant and increasing because of climate change. Since the 1990s, there have been numerous droughts in the Horn of Africa, including those in the 1990s, 2000–2001, 2005–2006, 2008–2009, 2010–2011, and 2016–2017 (BIZIMANA, 2016). These events serve as evidence to validate the mounting concern. Furthermore, the HOA is already grappling with droughts that will endure for a long time.

Ethiopia has experienced severe droughts, including famines of historic proportions. According to EM-DAT-CRED statistics, the severe drought of 1973, and the widespread famine of 1983–85 were important events that caused an estimated 100,000 and 300,000 deaths, respectively (CRED, 2020). For instance, the recent droughts in 2003 and 2015 affected roughly 12.6 million and 10 million people in the nation, respectively (CRED, 2020).

Climate change risks are endangering the sustainability of the traditional livelihoods of the Borana pastoralist and agro-pastoralist communities in southern Ethiopia. According to Riché B. *et al*. (2009), pastoralists have a sophisticated system for managing resources that can be adjusted to climate variations that occur naturally as well as resources that are distributed both spatially and temporally. The indigenous East African cattle breeds, which they are the custodians of, are considered to perform well in arid and semi-arid lands' (SA, 2010) climate conditions. However, the increasingly severe climate variations seem to be placing pressure on pastoralists' management strategies. The frequency, scope, and impact of drought have increased because of climate change and other extreme weather and climatic phenomena.

Globally, data on damage and loss from disasters are not usually regularly collected or reported in the agriculture sector (FAO, 2015). Like this, damage and losses caused by droughts in Borana throughout time were not systematically gathered, despite the effect of recurrent droughts on livestock production and considerable economic loss. For example, pastoralists in Borana lost 35–67% of their livestock- which had a market worth of hundreds of millions of US dollars-during three major droughts that occurred in Borana between 1980 and 2000 (Desta and Coppock, 2002; Shibru, 2001). At least five significant droughts that occurred in Borana between 2005 and 2020-2022 (Morton, 2006; Angasse and Oba, 2007; Desta *et al*., 2008; USAID, 2011; Birhanu *et al*., 2015; Shibru *et al*., 2022) contributed to the progressive loss of livestock assets.

An extensive area of Ethiopia, including the Borana zone, was affected by El Nino-induced drought in 2015 and 2016 (FEWSNET, 2015; UN-OCHA, 2016). Approximately 400,000 animals (27–30% of the total livestock inventory in 2016–2017) perished in the Borana zone, according to the rapid situational assessment (Desk, 2017). Communities are continually struggling to recover from the impacts of drought, with a sizable percentage of households, especially the poor, being disproportionately affected.

Research and development projects have been conducted on Borana pastoralists in southern Ethiopia to address the effects of drought on their livelihoods. However, most efforts do not adequately address the threats they face. To prevent a "downward spiral," it is crucial to understand the risks to their livelihoods and their vulnerability. This study evaluates the hazards of drought and climate change for the Borana pastoral system in southern Ethiopia and offer important knowledge and information to support adaptation efforts.

Most pastoralists and agro pastoralists in the study region who rely on rearing livestock for a living have been impacted by this issue. Numerous people throughout the value chain have been indirectly impacted by the decline in livestock wealth, productivity, and production. The national and regional economy have suffered greatly because of losses in export revenue. The trans-disciplinary study allowed for a thorough understanding of the problems by facilitating the actors' organized involvement in the quest for a viable solution (s) that would ensure food security and the sustainability of local livelihoods, economies, and ecosystems.

1.2 Problem Statement

The pastoralist and agro-pastoralist people living in the southern Ethiopia of Borana zone is among the demographic groups most frequently affected by climate-related risks and extreme weather-related events, particularly drought. Their traditional way of life is in danger of becoming unsustainable. The pastoral system in the Borana is deteriorating, which makes it less stable and unable to sustain pastoral lifestyles (Desta, 1999). They are more vulnerable than ever to food insecurity, livestock loss, and a vicious circle of socioeconomic pressures (Desta, 1999). To tackle this challenging issue, the area has also received substantially from of development investment and humanitarian aid during the last few decades. Policymakers' misconceptions about pastoralists and their livelihoods, along with the development strategies and policies implemented based on these assumptions, hindered the effectiveness of investment in the region.

Markakis (2011) asserts that, there is not much proof that earlier development initiatives had a long-lasting positive impact. Markakis (2011) is more inclined to confirm Desta's (1999) earlier assessment of "the downward spiral" of the Borana pastoralist livelihoods system. Recurrent drought is one of the main factors contributing to the current problem and significant impact. They lost a significant percentage of their livestock's value and lived with a constant fear of further losses. Furthermore, the average number of livestock per household is lower. They are also being pushed to engage in maladaptation practices, and their level of food insecurity, poverty, and system dropout are rising. Most pastoralists and agro pastoralists in the study area who depend on raising livestock for their livelihood have been impacted by the problem. Numerous people along the value chain have been indirectly impacted by the decline in livestock wealth, productivity, and production. The national and regional economy have suffered greatly due to losses in export revenue. The trans-disciplinary study allowed for a thorough understanding of the problem by facilitating actors organized involvement in the quest for a viable solution (s) that would ensure food security and the sustainability of local livelihoods, economies, and ecosystems. These actors include, among others, policymakers, researchers, specialists in disaster risk reduction, and pastoralists.

1.3 Research Questions

The following list of questions serves as a guide for the research process.

- To what extent does the changes in precipitation, temperature, extreme events, and non-climatic factors affect the current and future food and livelihood security risks of households among pastoralists and agro pastoralists in the Borana zone of southern Ethiopia?

- How do the socio-spatial and social characteristics of pastoralists and agro pastoralists correlate with drought-induced risk patterns and its component parts?
- How can the food and livelihood insecurity brought on by the drought be reduced for pastoralists and agro-pastoralists in the Borana zone of southern Ethiopia?

1.4 Aim and Objectives

The main objective of this study is to assess current and future food security and livelihoods risks through transdisciplinary research and contribute to drought adaptation measures among pastoralists and agro-pastoralists of the Borana Zone in Southern Ethiopia. The specific objectives are:

1. To characterize climate variability and extremes including drought among the pastoralists and agro pastoralists of the Borana Zone in southern Ethiopia.
2. To assess the impacts of drought on rangelands, livestock, and other important resources of livelihood in the current and projected climate change scenarios.
3. To collate the adaptation strategies and actions aimed at reducing the risk that pastoralists and agro-pastoralists in the Borana zone, southern Ethiopia, face due to climatic variability and extremes.
4. To propose adaptation measures based on prevailing strategies and capacities aimed at reducing current and future risk facing Borana pastoralists in southern Ethiopia.

1.5 Justification and Significance of the Study

The study focuses on long-term changes and trends in precipitation and temperature, which are less-studied aspects of climate risk in the study area. It addresses gaps in local climate data by analysing residents' memories, observations weather patterns and drought trends, along with climate and remotely sensed data to fill the gaps and better understanding the current and future vulnerability of the system under investigation.

This study addresses the knowledge gap on the effects of climate change on livestock and the communities that depend on them, highlighting the lack of literature on livestock in comparison to most studies on agriculture's impact (Thornton *et al*. 2002). It builds on Yilma *et al*'s (2009) qualitative and participatory investigation, highlighting the importance of understanding the impact of climate change on livestock. The urgent need for understanding the impacts of climate change is crucial for planning adaptation to ensure food security and the sustainability of local livelihoods, economies, and ecosystems.

This study aims to address knowledge in incorporating contemporary climate risk concepts into local assessment. Only a few studies (Muccione *et al.*, 2016; Allen *et al.*, 2018). have operationalized climate risk components, particularly at local level since the introduction of the climate risk concept. This study is unique in incorporating risk components like hazards, vulnerability, and exposure to determine the level of food and livelihood insecurity and guide adaptation planning. This study is one of the few to include risk components such as. The information gathered will help identify those people and areas negatively impacted by climate change and prioritize adaptation planning.

The global and national conversation on pastoral livelihoods often revolves around notion of vulnerability and inherent ability to adapt. Without solid empirical evidence, these polarized assumptions will continue to guide decisions and policy, potentially negatively impacting pastoralists, and agro-pastoralists in the study area. This study aims to bridge this divide and initiate a discussion between science and policy using the concept of climate risk, aiming to bridge the current divide.

This study aims to address the recurrent or systemic problems faced by pastoralists in the Borana region using trans-disciplinary research methodologies. The "business as usual approaches" approach has been unsuccessful in resolving these issues, leading to a lack of progress in the research methodology and process. The study aims to address this flaw by utilizing trans-disciplinary approaches to address complex problems and improve the livelihoods of pastoralists. This study employs a trans-disciplinary research methodology to comprehend the complex challenges faced by various demographic groups, incorporating details from multiple production modes and key players in a structured manner, thereby enhancing comprehension.

1.6 Scope and Limitation of the Study

The trans-disciplinary research enabled a comprehensive understanding of the impact of drought on food security and livelihoods through the organized participation of participants. This study focused on the current Borana zone of Ethiopia's Oromia Regional State. According to reports, this area, one of Ethiopia's most important pastoral ecosystems, is still at risk of food insecurity due to the drought and other internal and external stressors. Since the target population group's sensitivity, impact, and vulnerability to climate change vary greatly across the zone, a wider scale of evaluation is required than a geographically restricted one.

The focus of the research was to understand one of the common climatic risks: a drought that increases the risk of food insecurity and has an impact on pastoral livelihoods both physically and socioeconomically. Specifically, this study is to assess how drought affects livestock and rangeland. The recent drought, which lasted from 2016 to 2017, is used as a benchmark for analyzing the socio-economic effects of drought at the household level. However, the ecological impact was excluded from this study since it was difficult to evaluate and attribute the impact (Thornton, 2002).

The research will help with problem solving and decision-making, as stated above and in the study's objectives. The research for the decision-support process, however, only focused on finding adaptation alternatives. The scope of the study did not permit ranking and evaluating the discovered adaptation possibilities due to time and resource limitations.

1.7 Structure of the Thesis

This thesis is organized into seven main chapters. Chapter 1 introduces the core research problem, questions, and aim of the research. The justification of the research is discussed in this chapter, in addition to the scope and limitations of the study. In Chapter 2, the existing knowledge and gaps in the research topic or area of the study are reviewed in depth. The gap filled by this research, considering the existing studies, is further expounded in this chapter. The review in this chapter informed the conceptual framework and methodology of the research presented in Chapter 3 of the thesis, in addition to the description of the study area. Results and discussions of the research are presented in chapters four to six by linking them with the specific objective of the study. The data analysis process followed is presented along with the presentation of the results. Key findings. The discussion chapter reviews the conceptual framework and existing knowledge about the subject. The last chapter provides a summary of the main results, conclusions, and recommendations.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

This chapter reviews existing knowledge, conceptual debates, and methods relevant to the research topic and area of study. This review process has helped the research in many ways. It helped in building the theoretical and conceptual framework underpinning the research. It also provided valuable insight into operationalizing the concepts in addressing the problem of the research. The research gaps that were initially identified during proposal preparation are expanded upon during the review process, which also acts as a "niche" for the study's significance. The knowledge and understanding gained from the review process also helped in interpreting the results of this research and assessing its methodological relevance.

An online search for literature, mostly journal articles, that was relevant to the research problem and questions was conducted using Google Scholar. The search was streamlined by utilizing both the research's primary ideas and Boolean operators due to the enormous volume of information on climate change and adaptation. The livelihood system and demographic category of the research focus (pastoralism/pastoralist) were two criteria for the literature's inclusion. The publication years helped to further focus the search and made it simpler to locate recently published works on the subject. The fifth IPCC assessment report (AR5), in particular Working Group Two (WG II), was one of the significant publications used as a source of literature due to its significance to the study. The research was unable to utilize the latest AR6[1] due to its release at the end of the research endeavour. The selected literature was then critically reviewed in relation to the study problem and questions. The main points, concepts, and knowledge gaps found during the review process are summarized thematically below.

The research problem is based on literature on climate change and adaptation, which significantly influences the conceptual framework and operationalization of the research variables. Supporting evidence for climate change and its connection to disaster risk comes is presented, and relevant literature is used to demonstrate the relationship and identify the research gap. The review of relevant drought measurements, its severity, and selected indices is highlighted, along with the issue of climate change, different impact dimensions, social vulnerability factors, and adaptation strategies in relation to pastoral livelihood. The theory and

[1] The UN's IPCC Sixth Assessment Report (AR6) evaluates climate change information from scientific, technical, and socio-economic perspectives. The report, published in 2021, 2022, and 2023, covers topics like Physical Science Basis, Impacts, Adaptation, and Mitigation of Climate Change.

practice of vulnerability and climate risk assessment are also studied, influencing the conceptual framework and research methodology.

2.2 Definition of climate risk and its components

This section aims to provide concise definitions of the important concepts used in the research based on the risk of climate change impacts framework (IPCC, 2014). These concepts served as a guide for developing the conceptual framework and design of the research that was subsequently presented.

Risk

The IPCC defined risk as the potential for consequences when something of value is at risk and the outcome is uncertain. The interplay of vulnerability, exposure, and hazards leads to risk (IPCC, 2014). The study's focus was on climate risk and its implications or impacts.

Adaptation

The process of adjusting to the existing or expected climate and its impacts. The process of adjusting human systems to the effects of the current or expected climate in order to minimize harm or take advantage of advantageous chances. The process of adjusting to the effects of the current climate on natural systems; human intervention could facilitate adjustment to the projected climate (IPCC, 2014).

Hazard

The potential occurrence of a physical event, trend, or impact caused on by a natural or human-caused event or activity that could cause deaths, serious injuries, or other health effects in addition to the destruction of property, infrastructure, livelihoods, service provision, ecosystems, and environmental resources (IPCC, 2014).

Exposure

The presence of people, livelihoods, species, or ecosystems, environmental functions, services, and resources, infrastructure, or economic, social, or cultural assets in places and settings that could be adversely affected (IPCC, 2014).

Vulnerability

The definition of vulnerability is "the propensity or disposition to suffer harm." According to the IPCC (2014), vulnerability comprises a range of ideas and components, including sensitivity to harm and a lack of ability to adapt and cope.

2.3 Climate variability and change evidence

Drylands currently make up 46% of the earth's surface and are home to 3 billion people, 90% of whom live in poor countries (IPCC, 2019; UN, 2011). A sizable section of these drylands is classified as ASAL due to their patchy rainfall patterns and arid or semi-arid environment. As well as receiving relatively little precipitation overall in the form of snow or rain, drylands also have high levels of inter-annual rainfall variability (UNEP, 2009; UN EMG, 2011). This fundamental climatic characteristic contributed to the occurrence of extreme events, including droughts and floods, as well as their consequences, as observed, for example, in the ASALs of Africa (ICPAC, 2007).

The global semi-arid land ecosystem has been found to be "fragile and sensitive to strong interactions between human activities and climate changes" because of current research from different parts of the world, as summarized in Huang (2015). According to numerous experts, these ecosystems have also suffered significant anthropogenic change because of urbanization and changes in land use (Huang, 2015), which has increased the ecosystem's vulnerability to climate change and variability. The observed patterns and impacts of climate change in the global drylands are not unique to the ASALs of eastern Africa. In a case in point, Omondi *et al*. (2014) stated that "rainfall and temperature are the two most important climatic variables that display high levels of variability across a range of spatial and temporal scales and exert significant impacts on human livelihoods, socioeconomic development, and ecosystems of East and Horn of Africa".

The two broader consensuses and evidence on climate change in the Eastern African region are discussed in a climatological report by Daron (2014). One of the more general conclusions stemmed from rising temperature patterns compared to regional climatic baselines. The consensus is supported by the 1–3°C mean temperature increases that have been recorded over the past fifty years in the region. Increasing changes in extreme temperature occurrences, including extreme maximum temperatures, warm days and nights, and the length of warm spells (Mekasha *et al*., 2013; Omondi *et al*., 2014), offer additional support. Second, "there were significant variations in the direction and magnitude of changes across the region, with rainfall trends over the past 50 years less evident than temperature." Rainfall varied according to the seasons and locations in the region, and overall patterns are weak and difficult to detect (Daron, 2014).

The temperature change in Ethiopia is in line with global and East African trends, according to the analysis. The NMA (2007) reported that Ethiopia experienced a 0.25°C and 0.1°C increase in annual minimum and maximum temperatures between 1950-2000. Meikle, (2010) reported 0.37°C annual warming trend in Ethiopia's minimum temperature from 1951-2006. The semi-arid lowland regions in the country, such as Borena, Guji, and South Omo, experienced higher temperature increases compared to the national average and highland areas, with a 0.40 C per decade increase from 1950 to 2000 (Amsalu and Adem, 2009).

The eastern, southern, and south-eastern regions were the main areas of precipitation declines (Seleshi and Zanke, 2004; Seleshi and Camberlin, 2006). Conway and Schipper (2011) observed a similar pattern of falling Belg rainfall in the eastern part of Ethiopia. Other studies conducted across Ethiopia's central and northern regions, however (Bewket and Conway, 2007; Mengistu *et al*., 2013; Mekasha *et al*., 2013), failed to detect any appreciable trends. In the study area, recurrent droughts and erratic rainfall patterns are manifestations of climatic variability and change. The population of the study area have been struggling to maintain their traditional livelihoods in the face of the impact of such events. Coppock (1994), Desta (2002), Angasse and Oba (2007), Riché *et al.* (2009), Birhanu *et al.* (2015), and Shibru *et al.* (2022) are just a few of the numerous scholars who have thoroughly documented the challenges and their impact over time. These studies have examined the impact of extreme weather events, like droughts, and the coping strategies used by pastoralists. However, long-term precipitation and temperature trends are under researched climate risk aspects in the study area, affecting system vulnerability and interplay between temperature change and precipitation impact.

2.4 Drought severity

The term "drought" was not well understood scientifically despite being commonly used in humanitarian operations in Africa (SWALIM, 2009). According to Moacelli (2005), one of the reasons for ambiguity is the conceptual definition of drought's reliance on precipitation deficits, which result in crop damage and yield loss. The analysis of "drought frequency, severity, and duration for a given historical period" can be done using operational definition in addition to filling in the gap, claim Wilhite and Glantz (1985). According to the National Drought Mitigation Centre, there are four different types of droughts: meteorological, hydrologic, agricultural, and socioeconomic. The significance of socioeconomic or economic elements in predicting the likelihood of drought has also been underlined by numerous other persons (https://drought.unl.edu/Education/DroughtIn-depth/TypesofDrought.aspx).

Drought indices are essential tools for characterizing and monitoring the severity of droughts for two main reasons. Indicators are a useful tool for quantifying anomaly' magnitude, duration, and frequency while also streamlining intricate meteorological processes. Second, they are very useful for making the severity of drought episodes understandable to a larger audience (Tsakiris *et al*., 2007).

In the climatological and meteorological literature, SWALIM (2009) identified two main drought-monitoring approaches, namely, statistical indices based on time series analysis and indices based on calculations of the water balance. The purpose of the water balance methodology is to calculate the crop's water deficit by using several climatic and physical variables at a certain time and location. Some of the most typical examples include the Palmer Drought Severity Index (PDSI), Palmer Hydrological Drought Index (PHDI), Palmer Z-index (PZI), Crop Moisture Index (CMI), Surface Water Supply Index (SWSI), and Reclamation Drought Index (RDI). Most statistical indexes are based on one, seldom two, usually temperature and rainfall. The Standardized Precipitation Index (SPI), the Precipitation Decile Index, the Weighted Anomaly Standardized Precipitation (WASP), and the Percent Normal Drought Index (PNDI) were some of the often-used indices in this category.

The practical usefulness of the several indices based on the two methodologies for monitoring drought in the Horn of Africa has been demonstrated (SWALIM, 2009). A limitation of water balance indices, according to the author, is that their applicability and usefulness in the Horn of Africa is hampered by their methodological complexity and data requirements.

Given the research focus on examining primarily hydro-meteorological drought stress in the area, this study used two statistical indices, namely the Rainfall Anomaly Index (RAI) and the SPI. RAI calculations rely solely on precipitation, making them easy to compute and analyse on a monthly, seasonal, and annual basis. It is superior to other drought indicators in identifying times of extreme wetness or drought. SPI, like the RAI indicator, is a simple and straightforward tool that relies on one input parameter, precipitation accumulations. However, these indices also rely on meteorological observations, which are frequently incomplete, as is the case in many African countries, which restricts their ability to conduct thorough analyses of the drought risk. The use of blended precipitation data from NMA will improve the completeness of data and effectiveness of the selected statistical indices. For a thorough examination of drought hazards, satellite Earth observation data has gained popularity as a supplement to weather stations and meteorological observations analysis. Over the past ten years, numerous remote sensing-based indices that monitor various drought hazards have been established (Graw *et al*. 2017). The most popular remote sensing-based indices for drought monitoring were the Vegetation Condition Index (VCI) and Enhanced Vegetation Index (EVI) (Unganai and Kogan, 1998; Quiring and Ganesh, 2010).

2.5 Climate change and pastoralism discourse

In his policy brief prepared for DFID, Morton (2011) predicted the adverse impact that climate change would have on pastoral areas, including the increased severity of droughts. Morton is concerned that the effect debate has frequently been oversimplified and polarized between those who foresee disaster and others who emphasize pastoralists' capacity for adaptation if the legislative context permits. Discussions have been divisive due to the changing climate predictions for pastoral areas.

In his most recent study on the Pastoral Development Orientation Framework in Ethiopia, Krätli (2019) drew attention to the two dominant discourses around pastoralism and climate change that were related to the two commonly held popular assumptions, i.e., vulnerability or intrinsic ability to adapt. One is that while pastoralism is adapted to deal with variability, the rise in variability brought on by climate change is tipping it over. The second is that pastoralism itself is the top livestock system in terms of greenhouse gas (GHG) emissions, which means it contributes to climate change. The validity of both claims was disputed by Krätli (2019). The author emphasized that "there is no self-evident explanation of increased vulnerability from increased variability in the pastoral system." The author claims that the second argument is based on "methodological flaws that are now acknowledged and under study, even in high-level policymaking processes like the Livestock Environmental Assessment and Performance (LEAP) partnership at FAO." According to Krätli (2019), "the annual carbon balance appears to be neutral when the carbon footprint of pastoral systems is measured with approaches relevant to the setting.

The polarizing viewpoint that dominated the national and international pastoral policy discourse is reflected in the research area's decision-makers, development players, and civic organizations. There is no consensus on this matter among the numerous players, including the pastoralists themselves. Lack of consensus has an impact on regional decisions regarding pastoral development, investment, and policy. Based on the opinionated policy (with scant supporting data), the actors are suggesting a mixed future course for pastoral livelihoods. The way forward is pastoral development policies, strategies, and programs that are based on the available evidence (vulnerability context and climate change impact information). During the research, this research also started a discourse with a wide range of players.

2.6 Climate change impact on Pastoral systems

Herrero *et al*. (2016) discussed about the first- and second-order impact of climate change on pastoralists. The effect of climate change on rangelands, livestock, and other natural resources is regarded as the first-order impact and contributes to higher (second order) impacts, including food security and pastoralists' livelihood outcomes. They detail the processes by which climate change impacts have an impact on food security and livelihood outcomes in rangelands around the world. According to Herrero *et al*. (2016)'s pathways of climate change impacts on pastoralists, the current climate change, together with other vulnerability variables, is having a cascading effect on pastoralist livestock productivity, food security, and livelihoods.

Thornton *et al*. (2002) defined the major categories of primary and secondary impacts of climate change on livestock. Thornton *et al*. (2002) lists these areas as feed quantity and quality, heat stress, water, livestock diseases and disease vectors, biodiversity, systems and livelihoods, and indirect impacts. Apart from ecological consequences, this research adopted and assessed these categories of climate change. Due to the difficulty in measuring and attributing the ecological impacts, they were not included.

2.7 Social vulnerability to climate change

Social vulnerability refers to characteristics that have an impact on how well a community can protect itself from risks and disasters, respond to them, and recover after them. According to Tierney *et al*. (2001) and Heinz Center (2002), social vulnerability explicitly focuses on the demographic and socioeconomic elements that either exacerbate or mitigate the effects of hazard occurrences on local communities, or more specifically, who is at risk and how much harm they can sustain. Regardless of the natural hazard of interest, social vulnerability is an inherent quality or pre-existing condition of existing communities.

In most of the social vulnerability literature, women, children (typically combined with women), pastoralists, smallholders, and individuals with HIV/AIDS were among the population groups deemed most vulnerable. For instance, according to NMA (2007) and

Amsalu and Adem (2009), females, people with disabilities, elders, and children, as well as the rural and urban poor, are particularly vulnerable to the effects of climate change and variability because these groups frequently have lower adaptive capacities and limited access to resources for adaptation practices.

2.8 Climate change adaptation

Over the millennia, humans have evolved to adapt to the variability and change of the climate (Biagini *et al*. 2014). It was also nothing new for pastoralism to manage climate risk and variability. To efficiently adjust to cycles of drought, floods, and "normal" rainfall years, both traditional nomadic or mobile pastoralism and mixed or agro-pastoral systems have been used (Ellis and Swift, 1988; Eliis and Galvin, 1994; Scoones, 1995; Oba, 2013). The mechanisms developed in the past to deal with climate variability may, in many circumstances, not be sufficient to adapt to the unprecedented impacts of climate change (Kates *et al*., 2012; Bierbaum *et al.*, 2013), which is unfortunate given the pace and scale of changes currently unfolding.

According to Riché *et al*. (2009), the Borana have a resource management system and an evolved traditional management system that have become embedded in their social structures. Pastoralists in southern Ethiopia have adopted various management strategies to adapt to climate and resource variability. Mobility is a timeless strategy, while herd maximization and diversification are key adaptations. These strategies minimize losses and help pastoralists bounce back quickly after adverse conditions like drought. Experienced range scouts ensure a conducive environment, such as absence of disease and community hostility, before trekking mobile stock. Traditional resources management systems and institutions, such as governance, help deal with intra and inter resource use conflicts and promote reciprocal resource sharing. These strategies, nevertheless, appear overstretched, and their efficacy has waned over time because of climate change, the breakdown of customary institutions as seen in other pastoral systems (Barrow *et al*., 2007), and non-climatic drivers (indigenous and exogenous factors). For the pastoralists to survive the increasing unpredictability and extreme weather and climatic events influencing their production system, these strategies were either adjusted or additional adaptation measures were implemented, either by the pastoralists themselves or with the support of humanitarian actors. With the help of typologies of adaptation activities, this research has compiled a list of the current adaptation activities taking place in the study area and categorized them into major groups. This study has taken stock of the current adaptation efforts in the research area and divided them into key groupings using typologies of adaptation activities as a basis.

Biagini *et al*. (2014) conducted a literature review on the various adaptation effort typologies. They classify these activities into five main groups based on their form (e.g., technological, behavioral, financial, and institutional), timing in relation to the stimulus (anticipatory, concurrent, and reactive), intent (autonomous, planned), spatial scope (local, regional, and national), and degree of the necessary change (incremental, transformational) (Carter *et al*., 1994; Wilbanks and Kates, 1999; Huq *et al*., 2003; Smit and Wandel, 2006; Fidelman *et al*., 2013). Some trends and patterns of maladaptation have been identified in the study. Particularly considering the growing impact of climatic variability and change, these trends will increase pastoralists' vulnerability.

2.9 Theory and practice of vulnerability / climate risk assessment

Numerous studies on vulnerability and risk assessment have used the IPCC's Third and Fourth Assessment Reports as a "conceptual starting point for their assessments" (Schneider *et al*., 2007 research quoted in Jurgilevich *et al*., 2017). The vulnerability of a system is to climatic stresses can be determined by combining exposure, sensitivity, and adaptive capacity.

The concept of climate risk and its components, however, are used as per the IPCC's Fifth Assessment, according to studies by Cardona *et al*. (2012) and Oppenheimer *et al*. (2014) that were cited in Jurgilevich *et al*. (2017). The research is guided by the researcher's shared perspective of Hammill *et al*. (2013), which indicates that vulnerability is not an outcome but rather pre-existing and predisposing factors that shape the outcome. The research intends to use the most recent risk framework (risk assessment), in contrast to the widely used vulnerability assessment framework. Additionally, they need to understand the risks posed by current and projected climate change trends and their implications for adaptation, which influenced the IPCC's latest definition and strategy for addressing climate risk.

Fussel and Klein (2006) identified three main frameworks for conceptualizing and assessing vulnerability. The risk-hazard model is number one. 2) The framework of social constructivism 3) Using an integrated strategy Ibid, in their work, go into detail about the fundamental characteristics, philosophical underpinnings, and historical origins of each model. They also investigate the connections between the IPCC and vulnerability. To better understand the dynamic character of climate risks, this study employs the third school of thought that combines the two frameworks. The research used a transdisciplinary research process to better understand the dynamic, complex, and systemic challenges facing the area of study. The authors of Jahn and Keil (2012) define transdisciplinarity as "a critical and self-reflexive research approach that links societal with scientific problems; it produces knowledge by integrating different scientific and extra-scientific insights; and its aim is to contribute to both societal and scientific progress."

Fussel and Klein (2006) defined four generations of assessment, namely climate impact assessment, first- and second-generation vulnerability assessment, and adaptation policy assessment, in their study of the development of methodologies for assessing vulnerability to climate change. They characterized the many generations of assessments using a conceptual framework that outlines the assessment's major concepts and their links to one another analytically. Fussel and Klein (2006) claim that the development of approaches was marked by the increasing integration of non-climatic variables of vulnerability to climate change, including adaptive capacity, and the move from calculating expected damages to seeking to reduce them.

The literature that was relevant to the study's topic and area of study was reviewed in the preceding chapter and presented thematically. It is made simpler by this research to comprehend the risk provided by current and projected trends in climate change, which are rarely considered in vulnerability studies (McDowell *et al*. 2016), and their implications for adaptation in the study area. In particular, the study fills in the knowledge gaps about potential future scenarios for drought conditions in the study area. In due course, the research will provide insight into how projections of the future are utilized to assess climate risk and provide information on pastoral area adaptation techniques. Theoretical and methodological approaches to the subject that influenced the research's conceptual framework and methods are discussed in the succeeding chapter.

CHAPTER 3: STUDY AREA, METHODS, AND DATA

This chapter is divided into three main parts. A description of the study area is followed by the presentation of a conceptual framework and data collection methods.

3.1 Study area

This study focused on the Borana zone. One of the 18 administrative zones in Ethiopia's Oromia Regional State, the region has a total area of 55,711 km2. Located between 3°30' and 5°30' North latitude and 36°30' and 39°50' East longitude, Yabelllo is the zone's capital. The zone is divided into thirteen districts, as shown in Figure 3-1. It borders with Northern Kenya to the south the Somali Regional State to the east, the two Guji's Zones to the north, and the Southern Nations, Nationalities, and Peoples Regional State (SNNPRS) to the west.

The Yabello-Mega plateau, which rises to a height of 2000 meters, is one of the most notable highland sections of the Borana zone (Federal Democratic Republic of Ethiopia, 2015).

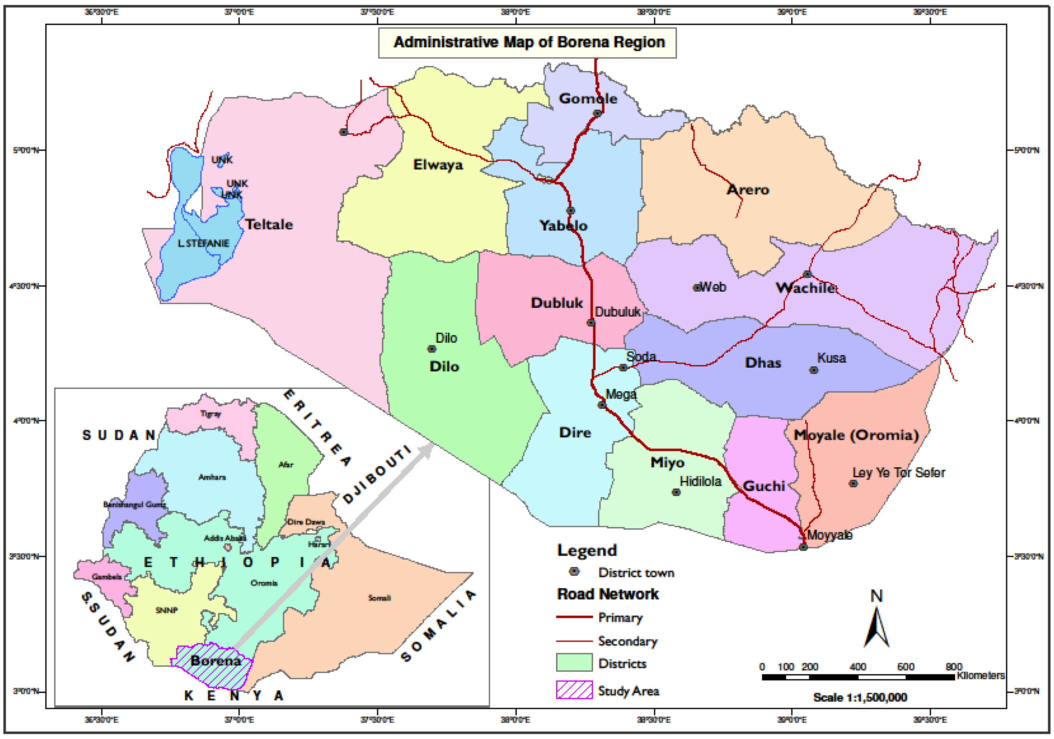


Figure 3-1: Administrative Map of the study area, Borana zone, Southern Ethiopia
Source: Humanitarian Data Exchange (HDX)-Ethiopia sources of shape file: https://data.humdata.org/dataset/ethiopia-cod-ab

3.1.1 Climatology of the study area

The Borana rangelands have arid and semi-arid climates with a few isolated pockets of sub-humid zones, according to Coppock (1994) and Lasage *et al*. (2010). The classification was mostly based on native vegetation types associated with climate, temperature changes, and average monthly and yearly precipitation (Borana zone, 2018). The zone is primarily composed of warm, semi-arid lowlands. The districts of Moyale, Dire, Arero, and Yabello are situated in the southwest and east of the zone, respectively. Cool-humid highlands (more than 1500 m above sea level) are only found in a small portion of the southern side of the zone, mainly in the Yabello and Dire districts. The area is also regarded as one of Ethiopia's warmest lowlands, with an average yearly temperature of 20 to 25 ^{o}c (Coppock, 1994). The warmest time of the year is from March to May, while the coldest time is from November to January (NMA, 2007). The Borana Zone experiences bimodal patterns of rainfall. The main rainy season, locally called "Genna," lasts from March through May. A short rainy season known as "Hagaya," which lasts from September to November, follows it. The cold ("Adolessa") and long ("Bonna Hagaya") dry seasons come after each of the wet ("rainy") seasons. With an average annual rainfall between 286 and 896 mm, the region has high inter-annual variability, ranging from 18% to 69% of the mean annual rainfall (Angassa and Oba, 2007). The zone's major drought episodes are highlighted in Section 1.1.

3.1.2 Physiography and drainage

The only river or stream that drains into the Borana zone is the Segen River, which rises at the Burji-Teltele line and runs to the north-west before entering the Chew Bahir (Lake Stefanie) wetland (Office, 2018). In the zone, both traditional and modern water systems serve as the primary sources of water for humans and livestock (Lasage *et al*., 2010). Lasage *et al*. (2010) further classified traditional sources into three categories. These comprise: 1) Traditional wells, or "Tullas," as they are known locally as singing wells 2) Ponds referred to as "Harros" 3) springs, shallow "Addadis" wells, and scoop wells on sand riverbeds Modern types of water sources include hand-dug wells, cisterns, rooftop rainwater harvesting systems, and boreholes. The Borana rangeland is one of the productive rangelands in East Africa that is managed using customary practices, according to Cossins and Upton (1987). It was mostly covered with tropical savannah flora, with varying quantities of open grasslands and perennial woody vegetation, although unwelcome bush was posing a growing threat (Coppock, 1994; Oba, 1998; Homann *et al*., 2008).

3.1.3 Land Uses and Resources

The primary land use in the Borana Zone, as in other lowland areas of Ethiopia, is still pastoral production (Coppock, 1994). These people often raise a variety of livestock species (cattle, sheep, goats, and camels) in varied numbers, depending on the climate and rangeland conditions. The zone's livestock population is estimated to reach 1.5 million, 1.8 million, 185,000, and 77,000 heads of cattle, small ruminants, camels, and horses, respectively, according to an unpublished report by the pastoral development office from 2018–2019. A limited number of agro-pastoralists who depend on farming a mix of crops and animals for a living also live in the study region. The pastoralist and agro-pastoral communities in the study area were further separated into five livelihood zones, as shown in Figure 3-2., in accordance with similarities in opportunities for obtaining food, income, and access to markets (FEWS NET, 2015).

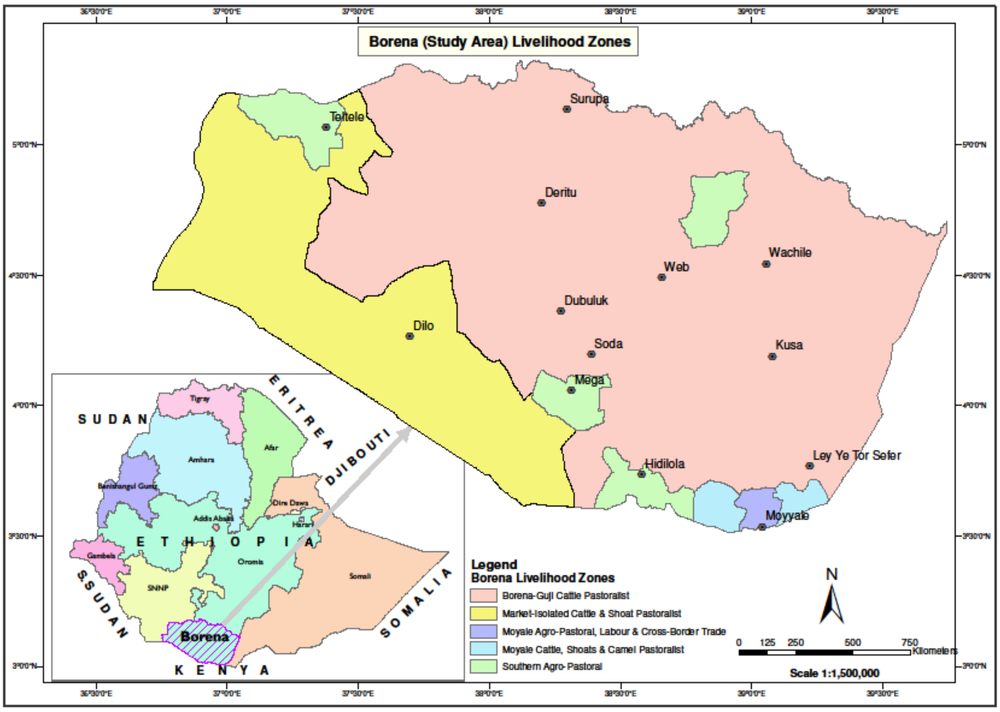


Figure 3-2: Livelihoods zones of the study area, Borana Zone, Southern Ethiopia
Source: FEWSNET-Ethiopia livelihood zone shapefile-2009.

3.1.4 Socio-economic Setting

The population of Borana Zone, which is projected to be over 0.5 million (Office, 2018), is increasing at a rate that is getting near the national average (2.7%), with an annual growth rate of roughly 2.5 to 3 percent (Homan *et al*. 2003). Using data from the 2007 census, the Finance and Economic Development Bureau for the Borana zone projected that inter-annual population growth over a five-year period may reach 3%. At a growth rate of 3%, the population will double in 24 years.

The Borana are the main ethnic group in the zone. Borana coexisted with Guji, Gabra, Geri, Konso, Burji, and other ethnic groups in some of the districts. Most of these people speak Oromiffa, while others are bilingual and follow similar religious and cultural practices. These tribes have historically interacted with one another in the area through reciprocal resource sharing arrangements, cultural exchange, intertribal marriage, and conflict.

The socio-political and cultural facets of Borana are still predominantly under the Gada system, despite government efforts to institutionalize the "formal" governmental system. According to Helland (1998), the system is seen as a highly developed, intricate, and all-encompassing social structure that has existed for many centuries. The social support network known locally as "Buusa Gonofa" is another characteristic feature of traditional governance (Lasage *et al*. 2010). This process has helped low-income households adjust to the consequences of both natural and man-made shocks throughout time, and it has also helped society survive and operate in the face of increasing shocks. It also plays a crucial role in the governance of the environment and natural resources, although the current political and environmental climate limits the effectiveness of this role.

3.1.5 Policy and governance

The National Adaptation Plan (NAP-ETH) is among the important initiatives Ethiopia has taken since the Parliament adopted and ratified the Paris Agreement on Climate Change in 2017. In line with the nation's development policy framework, the NAP aims to build on current efforts to deal with climate change (Ethiopia, 2019). The planned study's impetus comes from the NAP's list of adaptation options. The National Policy and Strategy on Disaster Risk Management, whose implementation started in 2013, also envisioned a decentralized DRM system, early warning and risk assessment, information management, capacity building, and the integration of disaster and risk reduction into development plans (FDRE, 2013), which was another supportive policy environment for the study's findings. There is no national legislation that protects groups like the pastoralists and agro-pastoralists who are the subject of this study, even though indigenous people make up a large portion of the population in Ethiopia. The group is now battling issues with the management of common property resources, traditional systems, and development strategies that aren't in line with the livelihoods of the populace.

3.2 Conceptual framework

The conceptual framework was shaped by a literature review particularly relevant to theory and practice of vulnerability / climate risk assessment. The study problem was further constructed using climate risk and its components, as defined in the IPCC AR5, and provided in Section 2.2. Nelson *et al*. (2010) pointed out the distinction between a theoretical concept's definition and its application in a conceptual framework for decision-making. Therefore, it is essential for this research to operationalize these scientific concepts to create the research's aim effectively, which will help in adaptation planning and decision-making down the road. Figure 3-3 presents the conceptual framework along with its operational constructs.

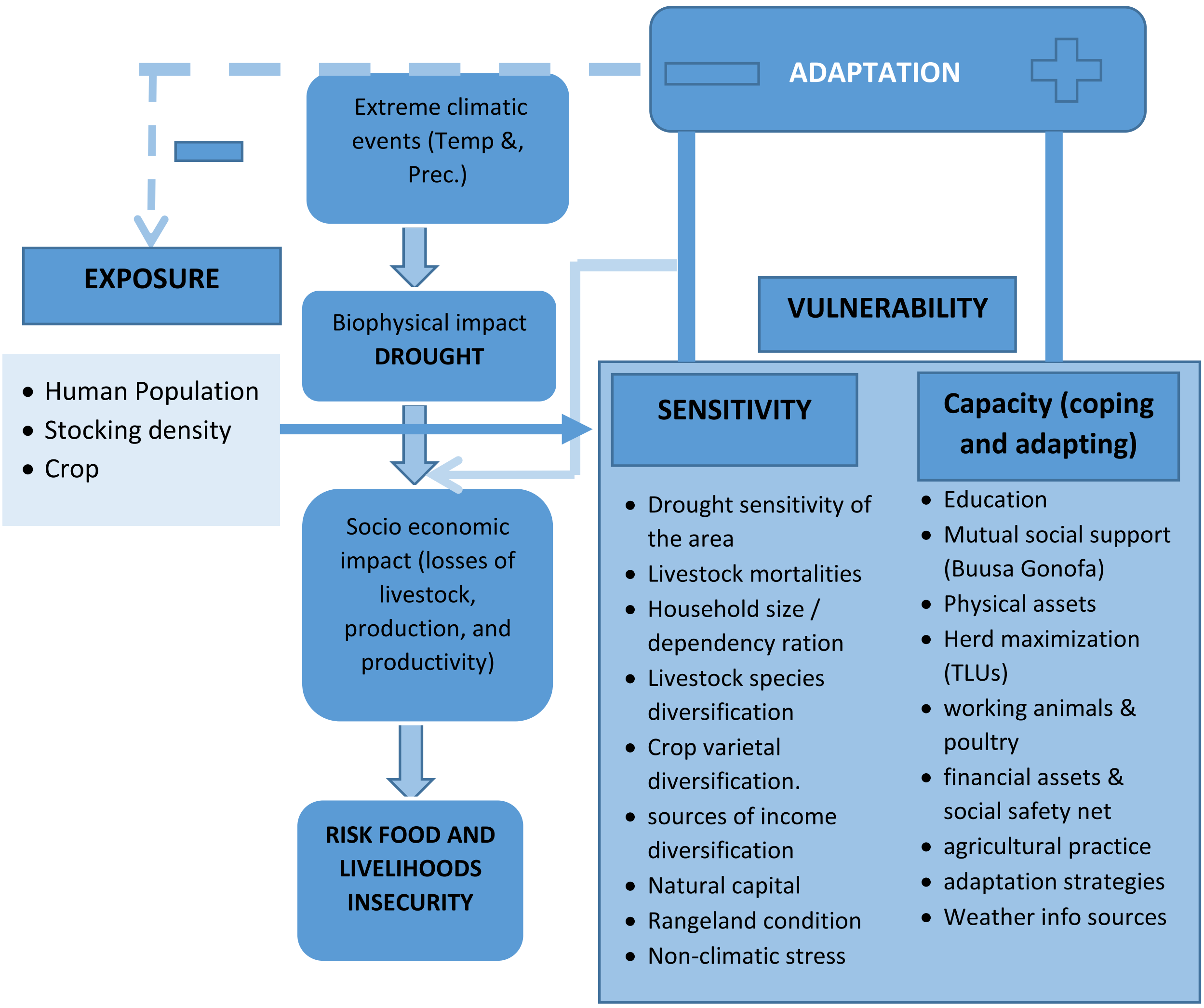


Figure 3-3: Conceptual framework of the study
Source: Author's formulation based on IPPC AR5 recent concept of risk and its components

The concept of climate risk associated with food insecurity envisaged in the research is considered a complex problem whose resolution depends on several variables. According to the IPCC (2014), climate risk is influenced by vulnerability, exposure, and hazards. Food insecurity and poverty are believed to be predominantly brought on by climate variability and environmental degradation in both East Africa and Ethiopia. (NMA, 2007; Funk *et al*., 2008; FDRE, 2010, 2011; Brown *et al*., 2011).

Rainfall variability, which is aggravated by frequent drought and flood events, is the main climatic and weather element affecting ecosystem services, agricultural productivity, and socioeconomic development of the region in East Africa (Dinku *et al*., 2008; Demeke *et al*., 2011; Omondi *et al*., 2014). Drought was therefore given priority as a climate-related event due to its frequency in the study area and effect on the target population's livelihoods and ecological services.

Pastoral and agro-pastoral households in the Borana zone rely largely on climate-sensitive natural resources for their livelihood. This group (the population and their means of livelihood) is frequently exposed to extreme climatic events (temperature, precipitation), including drought hazards that have cascading socio-economic impacts (e.g., losses of livestock and crops, production, and productivity), as well as food and livelihood insecurity. However, depending on the sensitivity and capacity (coping and adapting) of households, the extent to which these occurrences have an influence on the exposed unit varies dramatically within the zone. Figure *3-3* framework helps provide decision-makers and stakeholders with a comprehensive understanding of such climate risks.

3.3 Data collection and analysis methods

The following sections provide a description of the many types of data, data collection methods, and tools used to achieve the objectives of the study.

3.3.1 Climate data collection and quality control

Meteorological data is one of the primary types of data collected to fulfil the study's specific objective one. The National Meteorological Agency (NMA) of Ethiopia provided information on observed temperature and precipitation that is relevant to the study area. Figure 3-4 below and Annex 1 provide an overview of the basic data regarding the weather stations.

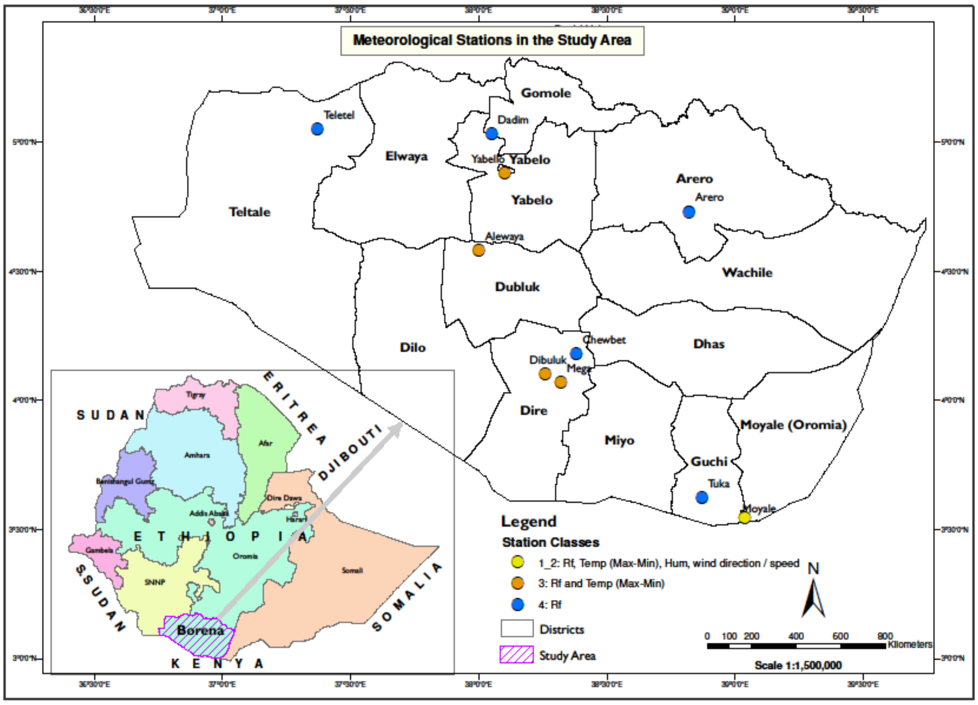


Figure 3-4: Meteorological stations in the study area, Borana Zone, Southern Ethiopia
Source: Humanitarian Data Exchange -Ethiopia Shape file and NMA stations GPS points

Most of the stations' data are characterized by incomplete observation, as is frequently the case in many African nations. For some of the stations, there was a gap in the observations (consecutive and non-consecutive). Additionally, although the extent varies from station to station, daily and monthly missing data were frequent. To fill such a gap, it would have been standard practice to estimate the missing data. To close the data gap that exceeded the permissible amount of data estimation, a significant level of estimation (15%) is needed. It is advised that no more than 10% of the data set should be used for estimation (WMO, 2007).

To fill the gap in the observed precipitation data, the Enhancing National Climate Services (ENACTS) project's blended data that is pertinent to the study area was also obtained from NMA (NMA, 2020). The agency's monthly gridded rainfall data incorporates observed, satellite-estimated (rainfall), and enhanced data sets. To close the gap, NMA has carried out the necessary quality control and interpolation. In comparison to rainfall, the availability and quality of measured temperatures are more daunting. To overcome such restrictions, satellite-derived temperatures are frequently used. To fill the gap, a long-term gridded daily temperature data set (maximum and minimum) was collected from the NOAA Data Library Map Room specifically designated for the study area.

3.3.2 Remotely sensed data

Moderate Resolution Imaging Spectro-radiometer (eMODIS) normalized difference vegetation index (NDVI) data processed by United State Geological Survey (USGS) has been widely used by Famine Early Warning Systems Network (FEWSNET) for drought monitoring. The available Decadal raster datasets from 2002 to 2020 were acquired from FEWSNET data portal[2].

3.3.3 Future climate data

Future climate data was projection in addition to historical climate data to achieve the study's second specific objective. Future projections of rainfall and temperature (maximum and minimum) are assessed using climate model simulations from the Coordinated Regional Downscaling Experiments (CORDEX)[3]. For this study, climatic data from five global climate models (GCMs) for the Africa domain (AFR44-domain) under CORDEX (Rummukainen *et al*., 1997) were downscaled using the Rossby Centre Regional Atmospheric Climate Model (RCA) from the Swedish Meteorological and Hydrological Institute (SMHI). The RCM data was downloaded using the Grid of the Earth System Federation[4].

Climate models use Representative Concentration Pathways (RCPs) to simulate future climate changes based on economic, social, and physical changes. These assumptions are captured through scenarios, which are then used to model the possible evolution of climate due to the conditions of each scenario. The four Representative Concentration Pathways (RCPs), abbreviated as RCP2.6, RCP4.5, RCP6, and RCP8.5, are commonly used as a broad range of climate scenarios with possible future outcomes for climate modelling studies, including the IPPC Fifth Assessment Report. As shown in Table 3-1, each of these pathways led to a different range of rises in the global mean temperature over the 21st century compared to the pre-industrial period (1850–1900).

[2]https://earlywarning.usgs.gov/fews/datadownloads/East%20Africa/eMODIS%20NDVI%20C6

[3] The CORDEX refer to an international program that offers a common protocol for downscaling Global Climate Model Inter-comparison Project under the fifth phase (CMIP5) at regional levels.

[4] https://esg-dn1.nsc.liu.se/search/esgf-liu/ or https://esgf-data.dkrz.de/projects/esgf-dkrz or https://esgf-index1.ceda.ac.uk/search/esgf-ceda/ or https://esgf-node.ipsl.upmc.fr/projects/esgf-ipsl/

Table 3-1: Global warming increase (°C) projection

RCP	Increase in global mean temperature (°C) and likely range by 2081-2100
RCP2.6	1.6 (0.9-2.3)
RCP4.5	2.4(1.7-3.2)
RCP6.0	2.8(2.0-3.7)
RCP8.5	4.3(3.2-5.4)

Source: IPCC AR5 WG1 Table 12.3.

In this study, three of these scenarios—namely, the 2.6, 4.5, and 8.5—were used. These scenarios were utilized in the CORDEX-CMIP5 archive, the fifth phase of the Coupled Model Inter-comparison Project (Osima *et al*., 2018). Three driving GCMs, MIROC5, MPI-ESM-LR, and EC-EARTH, have been found to effectively simulate eastern Africa rainfall (Ayugi *et al*., 2020). The four GCMs were combined into a multi-model ensemble (MME) to evaluate the climate projection for Borana in the future. The maximum and minimum temperatures were derived from CHIRTS (Verdin *et al*., 2020), whereas the reference rainfall data was derived from CHIRPS (Funk *et al*., 2015). The 1981–2010 climatic normal for precipitation and 1983–2010 for both the maximum and minimum temperatures were used as the reference periods. The first year for temperature data (CHIRTS) is 1983.

Climate models have intrinsic errors; hence, the bias correction techniques suggested by Mishra et al., (2014); Mishra *et al*., 2018; Vishwakarma *et al*., 2022; and Dosio *et al*., 2022 were employed to fix the simulation's errors before making climate change projections. For temperature, "linear scaling" was used, whereas for precipitation, a simple "delta" bias correction method was applied. Each model output was separately corrected for biases prior to the multi-model ensemble (MME).

The MME was used to generate projected temperatures and precipitation for the early (2011-2040, or simply the 2030s), mid- (2041-2070, or simply the 2050s), and late (2071-2100, or just the 2080s) centuries. After adjustment, the MIROC5 model has the fewest biases; however, the MME is still used to provide rainfall projections for the future since it can sample the strength and weakness of each model, hence reducing the uncertainty that could be derived from a single model.

3.3.4 Land use and Land Cover (LULC)

To examine the changes in land use and land cover, Level-1 processed Landsat imagery spanning the years 1985 to 2020 was chosen and acquired from the USGS Earth Explorer website[5]. This data provides empirical evidence for the study's second objective. Landsat satellites have the best ground resolution and spectral bands for monitoring changes in land use and land cover induced by a variety of natural and human-made variables, such as urbanization, drought, wildfire, and other factors.

The images were collected using Thematic Mapper (TM) sensors from Landsat 4 and 5, 7 ETM, and 8 OLI, which operate in a range of spectral bands. Images with close dates from January to March and the least amount of cloud cover (0 to 10%) are the two criteria and standards that guide the selection of the best images from the USGS website. Additionally, to minimize the data gap, Landsat 5, Landsat 7 SLC-on, and Landsat 8 are preferred over Landsat 7 SLC-Off while acquiring the image. Table 3-2 presents a list of the selected spectral bands' temporal images.

Table 3-2: Landsat temporal images selected from the different spectral bands.

Year	Satellite	Sensor	Resolution	Data	Date/Month
1985/1986	Landsat 5	TM	30m	Tier 1	January
1990	Landsat 5	TM	30m	Tier 1	February and March
2000	Landsat 7	ETM	30m	Tier 1	January and February
2010	Landsat 7	ETM+	30m	Tier 1	January
2020	Landsat 8	OLI/TIRS	30m	Tier 1	January and February

3.3.5 Household data

A household survey was one of the primary sources of data for this study's specific objectives 2 and 3. The survey instrument with closed-ended questions was developed during the proposal's development and improved over time as a tool to collect household-specific data. Key elements of the questionnaire covered household demographics, assets for sustaining livelihoods, common livelihood risks in order of importance, perceptions of drought, climate variability and change along with climate trends, degree of food insecurity impacts of droughts, and strategies for adaptation and coping, and more. (See Annex 2 for the household survey questionnaire). The variables (indicators) that were included in the household survey instrument were guided by the original operationalization of climate risk and its components. The instrument was further digitized into Open Data Kit (ODK) software to allow mobile data

[5] https://earthexplorer.usgs.gov/

collection using a smartphone. The study considers the benefits of mobile data collection (MDC), including its efficiency, cost-effectiveness, and data quality check method. The research team looked over the uploaded forms and saw that the gaps were gradually filled in. Enumerators were instructed to obtain the GPS position after completing the survey questions. The saving of the answers to the questions and the transmission of data when the internet connection allowed it were part of the practical demonstration given to the enumerators.

Sampling procedures and Sample Size: The sample size is important in the sampling process. The sample size for this study was consequently determined using a two-stage cluster sampling procedure, levels of acceptable error, confidence level, design effect, and non-response rate. 845 households were determined as the study's initial sample size (n) based on the equation presented below.

$$\mathrm{n} = \frac{\mathrm{d} * \mathrm{z}^2 * \mathrm{p} * \mathrm{q}}{\mathrm{a}^2} + \mathrm{nr} * \frac{\mathrm{d} * \mathrm{z}^2 * \mathrm{p} * \mathrm{q}}{\mathrm{a}^2} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots. (1)$$

n	Sample size
z	alpha risk expressed in Z-score (this is 1.96 for 95% confidence level)
p	Expected prevalence (unknown assumed to be 50%)
q	1-p (50%)
d	design effect (assumed to be 2 although this is on the high side, and it can be reduced to 1.5
a	Absolute precision (margin of error ±5%)
nr	Non-response rate (assumed to be 10%)

$$n = \frac{2 * 1.96^2 * 0.5 * 0.5}{0.05^2} + (10\% * 768) = 845\ HHs$$

Equation 1: Equation for calculating sample size.

45 sample clusters were chosen based on sample sizes for 845 households that were determined using equation 1 and proportional probability sampling (PPS). Due to conflict, population displacement, and general instability in the region, Moyale and Guchi woreda—which made up 13 of the 45 sample clusters—were excluded from the final sample clusters. The reduced sample size of the study consisted of 627 households and 32 clusters. The study team subsequently generated a list of households in each of the sample clusters (PSU) to assist in the selection of sample households (SSU). Using the MS-Excel Rand function, the researcher selected 19 households (sample size per cluster) from the established list of households (except for the largest cluster, Grincho-34 households). Comparisons of the total number of households selected and interviewed by cluster and woreda are presented in Annex 3.

Finally, 529 out of the 627 planned households were reached through interviews in 11 of the zone's 13 districts, achieving an 84% response rate (Figure 3-5). Despite the research team's best efforts, the sample households' involvement in cultural events, immunizations, meetings, and other private issues had an impact on the rate of response.

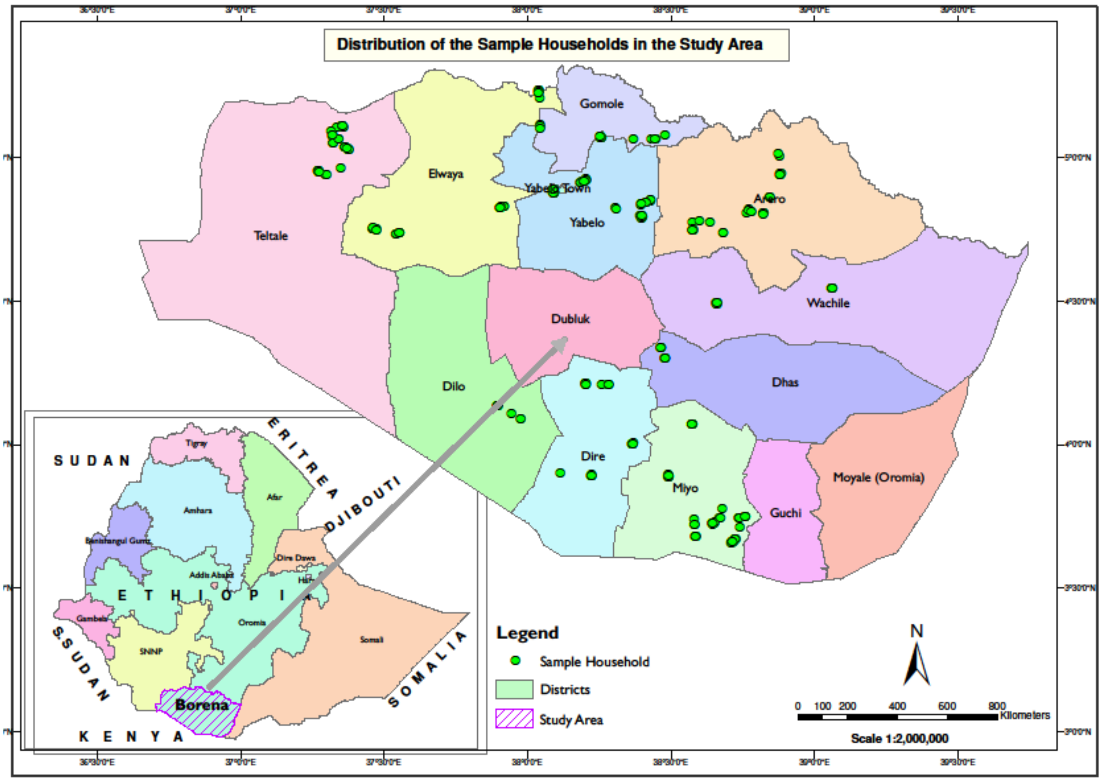


Figure 3-5: Distribution of the sample households in the study area, Borana Zone, Southern Ethiopia
Source: HDX-Ethiopia Shape file and GPS points of Household survey

3.3.6 Qualitative Data

Qualitative data was the other primary type of data collected to complement climate data. The data primarily contributes to the study's first specific objective while also addressing the other two. This study also used key informant interviews (KII) and focus group discussions (FGDs), two frequently used qualitative assessment methods. The semi-structured interview (SSI) checklist was established for each of the categories in a coherent manner to acquire an in-depth understanding of the context from the local perspective.

Focus Group Discussions (FGDs): Initially, it was intended to conduct multiple FGDs of homogenous groups (with similar socio-demographic characteristics) in chosen clusters. However, due to the extensiveness of the assessment and its financial and logistical implications, it became necessary to conduct a mixed group of FGDs instead. FGDs included women and men, youth, elders, and members of vulnerable groups. In areas where mixed-group residents coexist, the facilitation team made sure to include members of several ethnic groups. A variety of topics, such as the significance of common livelihood concerns, views of drought, climate variability, and changing trends, are included in semi-structured questions in addition to the community sketch and resource map (see Annex 4 FGD guiding questions). For the perception question, the previous 30 years served as the reference period.

Apart from Teletel, which had two FGDs due to its size and variety of livelihoods, each district held one FGD for a total of twelve as shown in *Figure 3-6*. The interview audio files, and the sketch maps were collated for additional transcription and analysis.

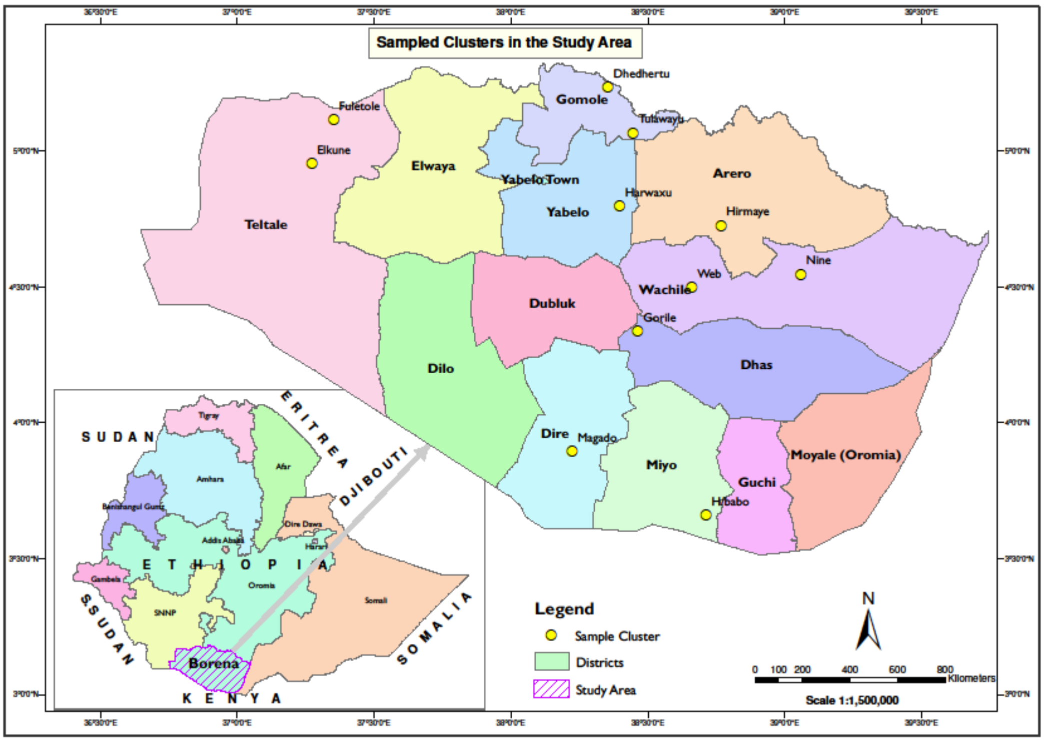


Figure 3-6: Distribution of the FGDs facilitated in the sample clusters.
Source: HDX-Ethiopia Shape file and GPS points of FGDs collated

Key Informant Interview (KII): The key informants were people with first-hand knowledge of the topic. One of the KI's categories is what locals refer to as "Jarsa Deheda," or traditional grazing managers. The resource management system and a relatively homogenous agro-ecological zone in Borana are known as the "grazing unit," or "Dheda," locally. The unit also has a traditional grazing manager by the name of "Jarsa Deheda," who is given final authority over the unit. Currently, Globo, Malebee, Wayama, Gomole, and Dire are the five grazing units in Borana, each with its own grazing manager. The research team spoke with Globo, Malebee, Wayama, and Gomole, four of the five "Jarsa Deheda" in Borana.

The Dire Grazing Manager's health issues prevented him from being reached, therefore there was no means to carry the interview. Some local weather forecasters were also used as key informants. Traditional weather forecasters were divided into four groups: livestock behaviorists (Waragu), Borana cyclical calendar experts, uuchuu experts in livestock entrails, and traditional astrologers (Ayyaantuu). The research team conducted interviews with Waragu, a renowned authority on animal behavior, and Mara, cyclical calendar practitioners in Borana. The meeting with the various government department representatives of Borana Zone was also used as KI. In total, seven KIIs were conducted by the research group.

The key informant's knowledge of common livelihood risks and their ranking, significant droughts and their characteristics, changes in land use and cover, perceptions of the pattern trend of climate change, the vulnerability of pastoralists and agro-pastoralists, and aggravating factors, among other topics, were assessed using semi-structured questions (see Annex 5 for sample questions). The last 30 years were utilized as a point of comparison in this study, just like they were in the focus group discussion for the perception questions. During the interview process, informants expanded the "timeline" of key drought experiences from the 1990s to the early 1960s, except for stakeholders from the government department. Temperature, rainfall (amount, rainy days, and timing- on set or cessation, distribution), Drought (frequency, duration, severity, and intensity), floods (frequency), and other key characteristics were all considered. The probing questions and techniques used to enrich the discussion with each key informant.

3.3.7 Secondary data

The United Nations Office for Disaster Risk Reduction (UNDRR) has collected data on Ethiopia's disaster-related losses and damage from a variety of sources between 1994 and 2013. The Humanitarian Data Exchange (HDX) platform hosts the digitized data. HDX was used to download significant historical disaster data that was pertinent to the study area. The key informants' historical timeline was combined with this information to further characterize the study's common disasters. As supplementary information, food security indicators, IPC phases, estimates of the people suffering from acute food insecurity, and humanitarian aid were compiled from unpublished sources. Additionally, data on human and animal populations were gathered from the zone's pertinent departments and used as secondary sources.

3.3.8 Data analysis

3.3.8.1 Climate, NDVI and LULC data analysis

The spatial analytic tool GeoCLIM is used to analyse blended rainfall and temperature data. The GeoCLIM program was developed as one of the agro-climatic study tools by the United States Geological Survey (USGS) and the Department of Geography at the University of California, Santa Barbara. The application allows climatological analysis of data on precipitation, temperature, and evapotranspiration. The spatial analysis feature of the tool addressed the inherent problem with point estimates of observed data. Statistical features of combined rainfall and temperature data, such as the mean and coefficient of variation, were easier to calculate and show, attributable to the program. Trends and SPI were also calculated using the built-in tools to further identify the severity of the drought in the study area. The SPI point estimate is further interpolated from the spatial maps (raster datasets) for each station in the research area to analyse the severity and frequency of drought.

The absolute Normalized Difference Vegetation Index (NDVI) anomalies (Dekadal) between 2002 and 2020 were calculated using the same techniques as the rainfall anomalies of the observed data. This analysis complemented the SPI of the blended data. Absolute NDVI anomalies (Dekadal) trends were also assessed based on parametric and non-parametric analysis to identify seasonal index anomalies trends and their statistical significance. To determine the direction, statistical significance, and magnitude of the trends, the NDVI data were examined using the XLSTAT 2017 program, Sen's slope estimator, and the non-parametric Mann-Kendall (M-K) test. An NDVI anomaly map was generated to study the historical pattern of vegetation cover and departures from "normal" brought on by rainfall, internal causes, and external factors.

To better understand climate change in the study area, projected anomalies for annual and seasonal precipitation and temperature were generated by comparing projection data from MME for three emission scenarios at three reference periods with a climatological baseline. These anomalies were then presented in spatial maps, box plots, and trends. To determine future wet and dry conditions, projected SPI (12-month and 3-month) was compared with the CHIRPS reference period of 1981–2010. To determine the changes in extreme occurrences, in addition to the change from the average condition, the predicted consecutive dry days index (CDD), wet day's index per time period (RR1), and simple daily intensity index (SDII) were compared with the reference period.

The concept of layer stacking was applied to ERDAS Imagine 2015 to display and classify the various land use and land cover classes. It was necessary to do this by selecting bands and combining them to produce a multi-spectral image. Along with the other six bands that enhance vegetation, the thermal, panchromatic, cirrus, and coastal/aerosol bands—which are inappropriate for measuring vegetation cover—were excluded from the layer stacking procedure. Images were cropped to remove pixel noise at image boundaries and ensure that a consistent null value (DN zero) is set for all non-data areas.

Using an R script, the Random Forest Methodology was utilized to classify the images for the LULC study. This method was chosen because R is open source, it maintains threshold and uncertainty assessment data that are necessary for change detection and analysis, it has higher accuracy, and it calls for heterogeneous training sites, making it simpler to gather training data. To increase classification precision and shorten classification time, images were stratified into zones with similar spectral signatures.

Some of the classes of LULC study were settlement/build-up area, forest, woodland (Acacia woodland), bushland, grassland, cultivated land (farmland), and barren land, including gullies. The training data from the user, where the user gives the functional class, was used to construct these classes. The user-specified ROI polygons that were discovered inside the relevant class were used to determine the user class area of interest, from which the training data was gathered. To enable a training dataset that defines the numerous classes needed, the enumerators have gathered GPS points for each class throughout the study area, excluding settlements. This is due to the settlement's extremely wide spectral signal fluctuation. As a result, this class was chosen based on supplementary data (information on towns and other settlement areas, as well as high resolution from Google Earth). The farmland class was edited after classification. The settlement and the classification from the training data were mosaicked to create the final classification image for a particular year. ArcGIS 10.8 was used to create the LULC map layouts for the identified periods.

3.3.8.2 Household data analysis

The household serves as the main analytical unit in this study since most decisions on adaptation to climate change are undertaken at the household level (Thomas *et al*. 2007). The household survey's comma-separated values (CSV) file was downloaded from the ODK server, converted to MS Excel compatibility, and then imported into the SPSS software version 23 for additional analysis. When analysing household data, the appropriate statistical analysis techniques are used based on the scales of measurement of the variables.

Frequency distribution, for example, can be used to display the distribution of the variable (individual measurement or classes) across activities, people, and geographical areas. In addition to univariate analysis, multiple response frequency analysis was used for items that each participant in the survey answered more than once. The graphical capabilities in SPSS and MS Excel allowed for the creation of a wide variety of graphs to clearly depict analytical data. The primary characteristics of household data (demographic and socio-economic) are typically described using the standard measures of central tendency and dispersion. To analyse the link between two variables, cross-tabulation and correlation were also used when applicable, and adequate statistical significance was performed. Using 2016–2017 as the reference period, average statistics at the household level (such as the mortality rate of livestock by species/ ages, livestock holding in absolute number or TLUs before and after drought, species composition/ herd structure before and after drought etc.) were further aggregated to the study area level to obtain overall statistics. These statistics were then used to determine the impacts of drought.

The various food security indicators, including the Food Consumption Score (FSC), Household Dietary Diversity (HDD), Household Hunger Scale (HHS), Livelihood Coping (LC), and Reduced Coping Strategy Index (rCSI), were calculated from the household data by using the appropriate food security analysis methods, and they were then compared to international thresholds and the IPC reference table. Comparing the IPC classification result of the household survey with the following seasons reveals trends in acute food insecurity.

This study's concept of climate risk in relation to food insecurity is complex, which means that many features will influence how it turns out. The composite indicator is one of the helpful tools for distilling such complex and/or multi-dimensional situations to support decision-makers. Using a composite measure and multivariate analysis techniques, the concept of climate risk was established in this study. The outline of the framework for assessing climate risk provided by AR5 served as the basis for the initial categorization of the variables into their respective risk components. The household survey data, climatic data, and secondary data were combined to construct a list of variables and related indicators for each component of the risk framework (Table 3-3).

Table 3-3: List of variables and indicators for each of climate risk components

Climate risk component	Factors	Indicators and measurement unit	Scale of measurement
HAZARD	Precipitation	Average rainfall (in mm) main rainy season from 1983-2016	Metric
		Average rainfall (in mm) for short rainy season from 1983-2016	Metric
		Average annual rainfall (in mm) two seasons and annual rainfall from 1983-2016	Metric
	Temperature	KI ranking order intensity of temperature change of the five-grazing area (very low, low, medium, high, very high)	Ordinal
	Drought	Household drought risk ranking order 1-4th.	Ordinal
EXPOSURE	Exposed element	Stocking rate -TLUs /square km	Metric
VULNERABILITY			
SENSITIVITY	Livestock mortalities rate per household by species	Mortalities rate for each species of livestock (Cattle, sheep / goat, and camel) sustained by households in recent drought used as proxy indicators.	Metric
	Household size	Number of persons per family	Metric
	Dependency ration	Measure number of dependents (aged zero to 14 and over the age of 65) compared with the working aged (15 to 64)	Metric
	Livestock species diversification	Number of livestock species raised ranges between 0-4	Metric
		The ration of the cattle vs goat/sheep and camels (sum) calculated by converting the common TLUs.	Metric
	Diversification of income sources	Number of cash income sources that a household drive its cash income	Metric
	Social support receives by households	Number of social supports received by households	Metric
	Access of common property resources	Number of pasture sources for normal and drought year	Metric
		Number of water sources for normal and drought year	Metric
	Crop diversification	Number of crop varieties cultivated by households	Metric
COPING / ADAPTING CAPACITY	Education	Educational level of the head of the household in terms of formal education	Ordinal
	Physical assets	Physical assets that include agricultural implements and non-agricultural assets (radios, mobile phones, iron roof houses in urban / peri urban centres, car/ truck, motorbike) owned by a household	Metric
	Livestock asset holding	TLUs of livestock per household	Metric
	Ownership of pack animals and poultry	Pack animals (donkey and mule) and poultry ownership	Nominal
	Social support provided	Number of social supports provided by households	Metric

Access to financial services and social safety net	Number of financial assets, services, and social safety household access	Metric
Agricultural practice change practiced	Number of agricultural practice change household engaged	Metric
Adaptation strategies adopted	The adaptation strategies household has engaged, livestock production practice change related to water and feed scarcity)	Metric
Livestock production practice change	Number of livestock production practice change adopted to water and feed scarcity	Metric
Sources of weather information	Number of weather information sources for the household	Metric

The various characteristics of the compiled variables were measured using different scales and units. To convert the collected variables to the same unit of measurement, normalization is the first step in multivariate analysis. Using the linear normalization (Min-Max normalization) equation below, the data were rescaled to a range of 0 to 1. It was important to establish the functional connections between the chosen indicators and the factor and risk components, whether they were positive or negative.

$$Xnormalized = \frac{X - Xmin}{Xmax - Xmin}$$

Equation 2: Linear normalization equation used to indicators to the same unit of measurement.

X	Indicator value that measures the factor
Xmin and Xmax	Minimum and Maximum value of variable X (indicator)
Xmax-XMin	Range of X variable

The research has adopted two methods of determining climate risk associated with food insecurity, and these are the simple mean aggregation method and Principal Component Analysis (PCA).

Simple mean aggregation method: The simple mean aggregation approach is used to further summarize the normalized variables into their respective components and overall index. Given the lack of direct (household) and proxy indicators, the exposure of the household is the same. Each component's variable was given equal weight in the component and total climate risk, according to the research's assumption. Given that many of the variables were gathered from households, the household was selected as the principal scale (unit) of the analysis of climate risk.

The generated indexes (continuous variable) for each of the components except exposure and overall score were further reclassified into ordinal variables (Table 3-4 for classification) to assess the level and variation of the climate risk and its component among the sample households. The overall household climate change impact risk index for the current and near-future reference periods was created using the component scores added together. Three-dimensional impact risk analysis, which was inspired by the vulnerability cubes, was used to visualize the household inside the cubes and understand the level of risk posed by their placement.

Table 3-4: Classification of the composite scores

Range of composite scores	Level of risk and its components	
0-0.2	1	Very low
0.2-0.4	2	Low
0.4-0.6	3	Intermediate
0.6-0.8	4	High
0.8-1	5	Very High

3.3.8.3 Qualitative data analysis

The researcher also turned each audio recording from the 20 interviews in the FGD and KII into text to start the qualitative analysis. The transcription was further refined, synthesized, and analyzed using content analysis to address the study question. The researcher has quantified qualitative data and performed quantitative analysis using nonparametric statistical approaches. The mapping, ranking, timelines, trend analysis, and rating produced from participatory tools gave qualitative data analysis context.

CHAPTER 4: HISTORICAL AND FUTURE PATTERN OF DROUGHT, CLIMATE VARIABILITY AND CHANGE

4.1 Introduction

This chapter begins with a description of the climate variability, change, and drought in the study area using findings from the analysis of blended and geospatial climate data. Household and qualitative data were provided to bolster the characterization. The examination of future climatic data was then presented to supplement the historical data. The results discussed in this chapter mainly contributed to the achievement of the study's first objective while also helping it achieve its other two objectives.

4.2 Descriptive analysis of rainfall and temperature

The main (MAM), short rainy seasons (SON), and annual average rainfall and temperature were calculated for the research area for the years 1983 to 2013 using Geo-CLIM's the climatological analysis tool and average analysis methods and. The yearly rainfall and temperature (Min and Max) are shown in Figures 4-1, 4-2, and 4-3 spatial analysis maps below, respectively. Seasonal averages for rainfall and temperature (Min and Max) maps are presented in Annex 6 and 7.

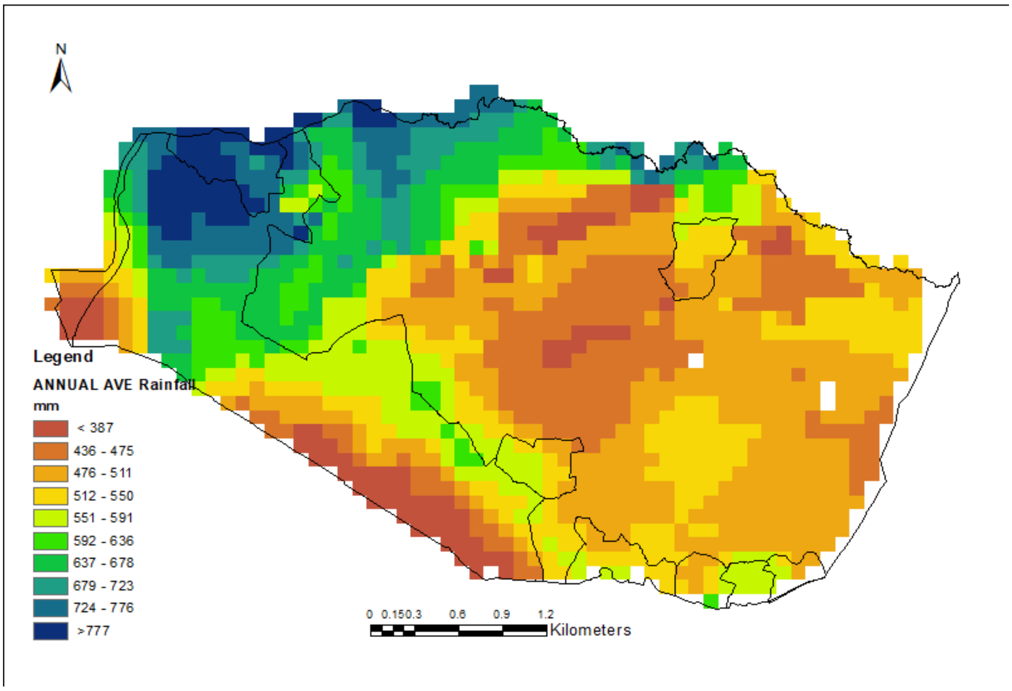


Figure 4-1: Average annual rainfall of Borana Zone from Jan-Dec (1983-2013)

The study area has a bimodal pattern of rainfall, with the main rains (Genna) falling between March and May and the shorter rains (Hagaya) falling between September and November.

According to the spatial map, the research area's predominant portion received average yearly rainfall in the range of 436 to 550 mm. The average yearly rainfall in places with higher altitudes and closer to some natural forests has also been observed to be about 550 mm. However, several pockets in the centre and southwest border areas only received 387 mm or less of the annual average rainfall.

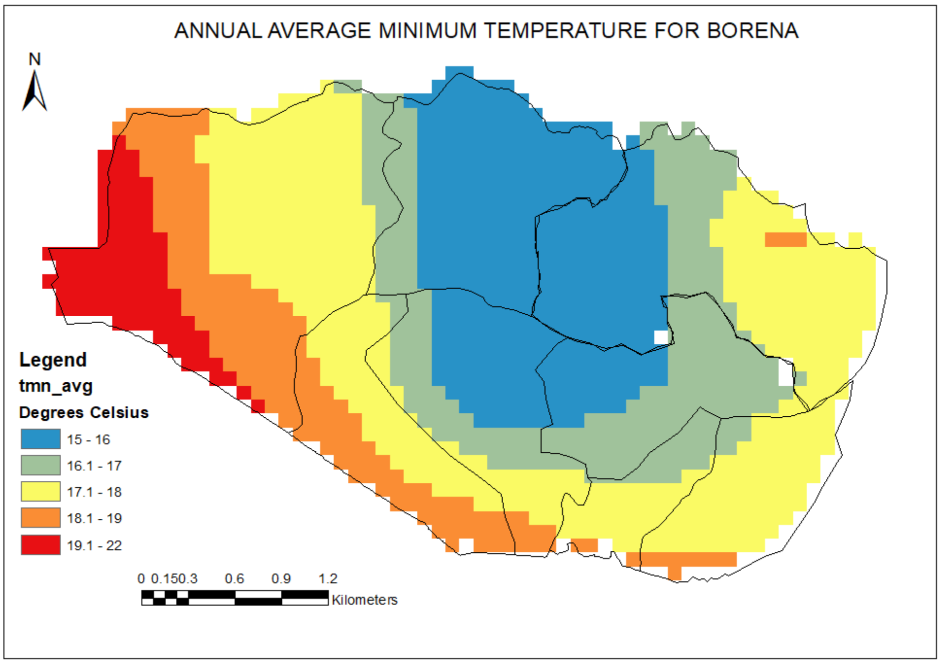


Figure 4-2: Average annual MIN temperature *in Borana zone from Jan-Dec* (1983-2013)

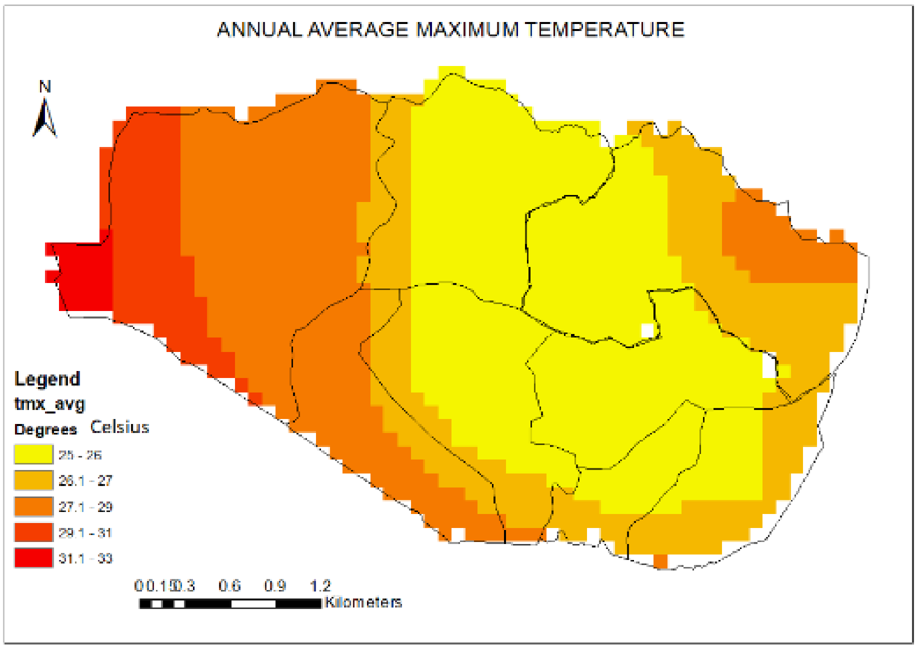


Figure 4-3: Average annual MAX temperature *in Borana zone from Jan-Dec* (1983-2013)

As compared to other research areas, the Gomole and Dire Grazing area in the center of the study exhibits comparatively low annual average min (15-16°C) and max (25-26°C) temperatures. As you head south, east, and west in the research area, the annual average minimum and maximum temperatures rise. 16.1-22°C to 26.1-33°C are the average annual minimum and maximum temperature ranges, respectively. With some degree of variation, a similar trend is also seen in the seasonal average temperature. In contrast to other areas, the western tier of the study is notably characterized by higher seasonal and annual average temperatures (min and max). It has also been demonstrated that the short rainy season is typically colder than the big rainy season in terms of average temperature (min and max).

The corresponding coefficient of variation statistics for rainfall and temperature (min and max) are also calculated and presented in Figure 4-4, Figure 4-5 and Figure 4-6, respectively. The maps display the area's annual variation in rainfall and temperature compared to average conditions. Annex 8 provides a comparable graphic showing season-to-season variations. These statistics are used for relative comparisons of variability between locations and take deviations from averages into account regardless of whether an area has high or low rainfall or temperature. The degree of variability of rainfall occurrences is categorized using Hare's (2003) CV classification as low (CV <20), moderate (20< CV <30), and high (CV> 30) variables.

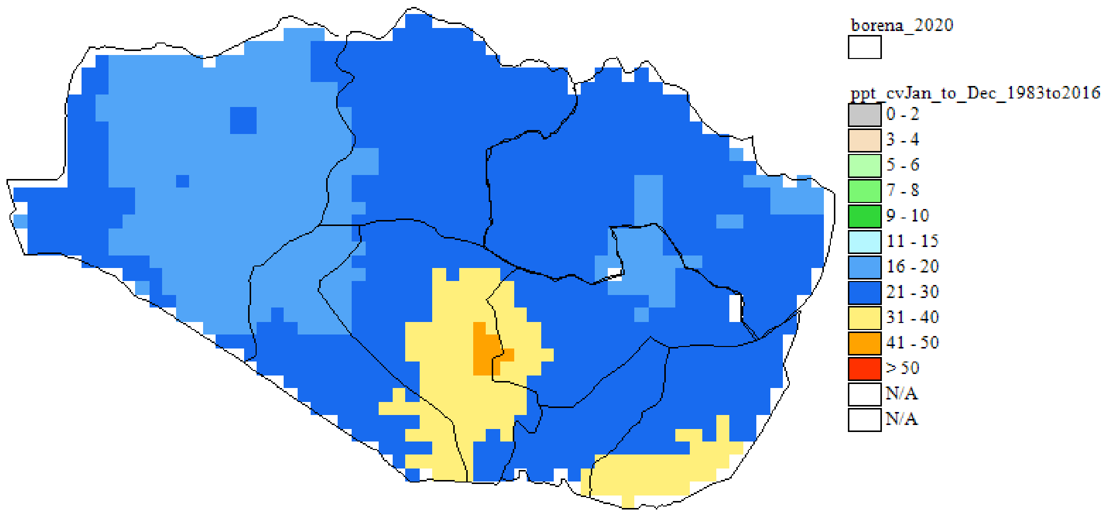


Figure 4-4: Coefficient of Variation (CV) in % for Mean Annual Rainfall in Borana zone from Jan-Dec (1983-2016)

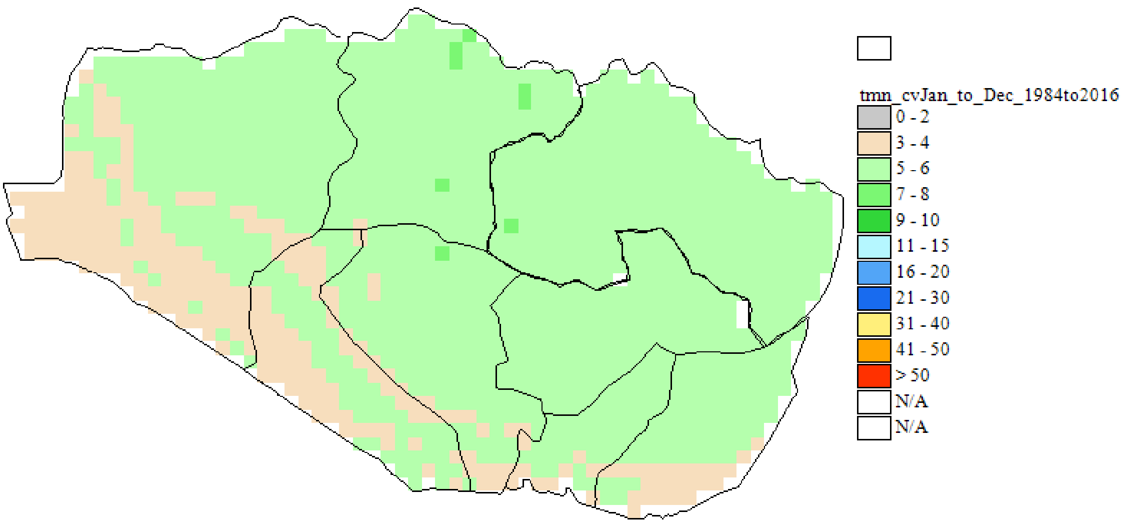


Figure 4-5: CV in % for Mean Annual MIN temperature in *Borana zone from Jan-Dec* (1984-2016)

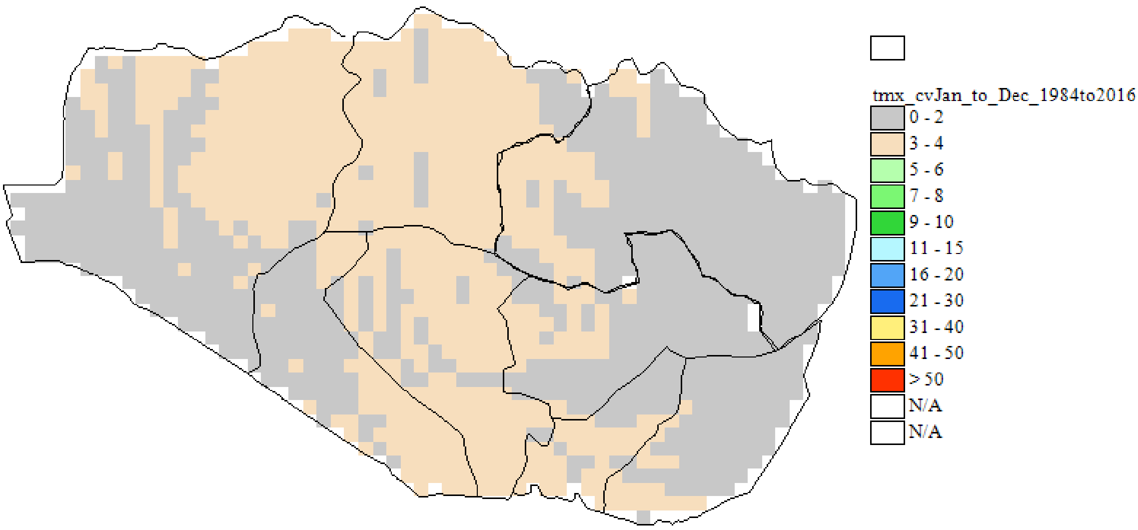


Figure 4-6: CV in % for Mean Annual MAX temperature in *Borana zone from Jan-Dec* (1984-2016)

The study area is characterized by greater inter-annual rainfall variability, which ranges from 16 to 50%. Quite a significant part of the study area likewise exhibits high rainfall variability (31–40%) in the main season, but some pockets of area in the Northeast and West are observed to be moderate (21–30%). The CV of the short rain season was observed to be larger than 40 over the research area. The overall variability of seasonal and annual average temperatures is lower. However, it has been found that the seasonal or yearly minimum temperature is more variable (5–6%) than the maximum (3–4%).

The research area shared many of the climatic characteristics of dry lands, including relatively low annual rainfall and large levels of inter-annual variability in rainfall (UNEP, 2009; UN EMG, 2011). For instance, in Africa's ASALs, this inherent climatic characteristic contributed to extreme events like droughts and floods (ICPAC, 2007). According to numerous researchers (Bailey, 1999; Little *et al*., 2001; McPeak, 2004; Barrett and Luseno, 2004; AFDB, 2010; Bizaman *et al*., 2016), East African pastoralists faced a significant and rising risk due to increased climate variability. According to studies by Omondi *et al*. (2014), rainfall and temperature are the two most important climatic variables that demonstrate high levels of variability over a variety of spatial and temporal scales.

4.3 Trend analysis of rainfall and temperature

The GEOCLIM trend analysis function was used to determine trends in the study area's yearly average rainfall and temperature. After calculating the yearly average rainfall for each year between 1983 and 2016, a regression analysis was used to produce a linear trend line. The trend analysis generated two maps. The slope of the regression line, or the average amount of rain gained or lost per decade (10 years), is shown, for instance, in Figure 4-7 (a). Positive slopes represent gains in mm per decade, whereas negative slopes represent losses in mm per decade. The coefficient of determination (R^2, or R-squared) of the regression is displayed in Figure 4-7(b) as a sign of the trend's consistency.

The results show that annual precipitation at the same location (a and b) is increasing at a rate of 31–50 mm per decade, but only 11–20% of the increase is explained by R-square. Similar trend analysis maps generated for the main and short rainy seasons are included in the appendix. The positive tendency is more obvious during the short rainy season than it is during the main season. The R-square was only 20% or less, making it a non-significant predictor, but the regression analysis of the short rainy season revealed two emerging trends: an increase of 11–30 or 31–50 mm per ten years.

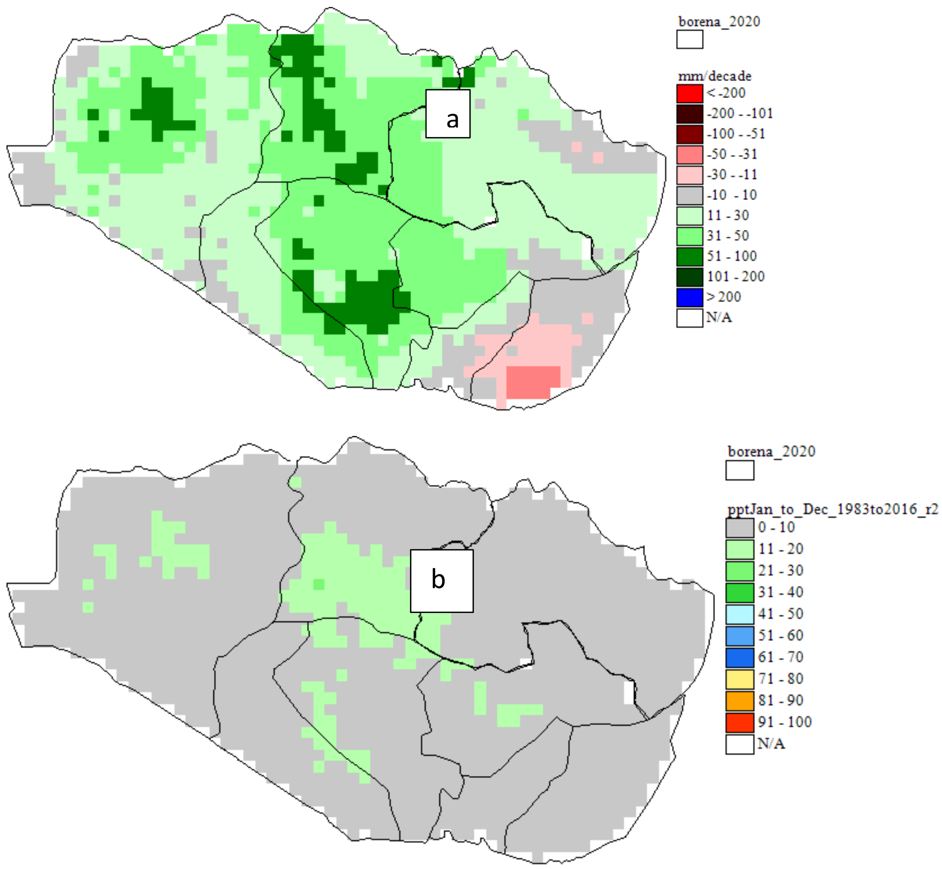


Figure 4-7: Trend analysis for Mean Annual Rainfall in Borana Zone from Jan-Dec (1983 - 2016)
(a) shows the slop or change in mm/decade whereas (b) R^2 of the regression.

The annual average temperature (max and min) was analysed for trends using the same methods. The map on the top of Figure 4-8 and Figure 4-9 shows the slope of the regression in mm lost (- on red) or gained (+ green blue) for the Annual Max and Min temperatures, respectively. The corresponding bottom of map of Figure 4-8 and Figure 4-9 show the matching R^2 of the regression. This analysis considered temperature change per decade to find the longer-term trend caused by climate change rather than by the inherent variability of the climate.

The maximum temperature was found to be rising by 0.1–0.2 °C per decade, despite the R-square being just 20% or less. Compared to the maximum temperature, an extensive positive trend was seen in the minimum temperature. The research region typically saw an increase in minimum temperature of 0.5–1 °C per decade, with greater R-square values in most locations (61–80%), except for the western part of the study zone (21–50%).

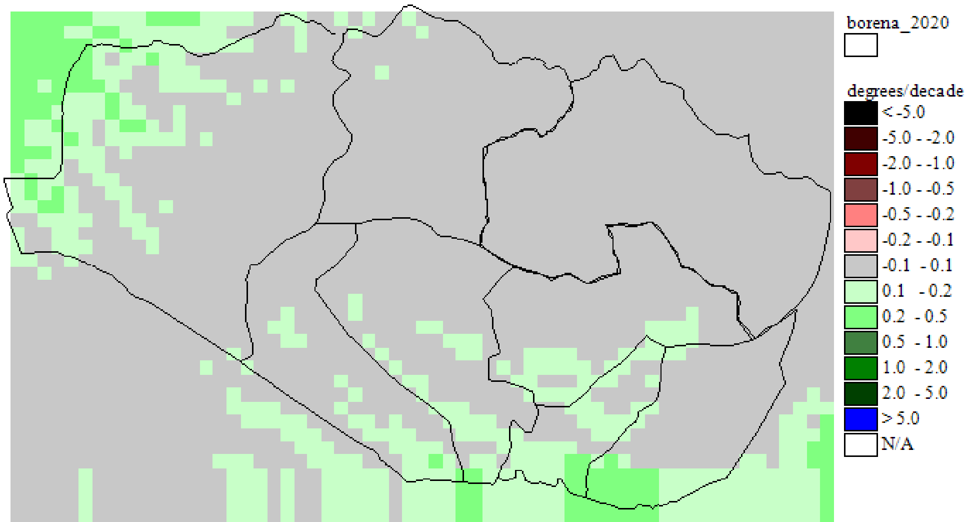


Figure 4-8*a*: Trend Analysis (in °C/decade) for Mean Annual Max temperature in Borana Zone from Jan-Dec (1983 -2016)

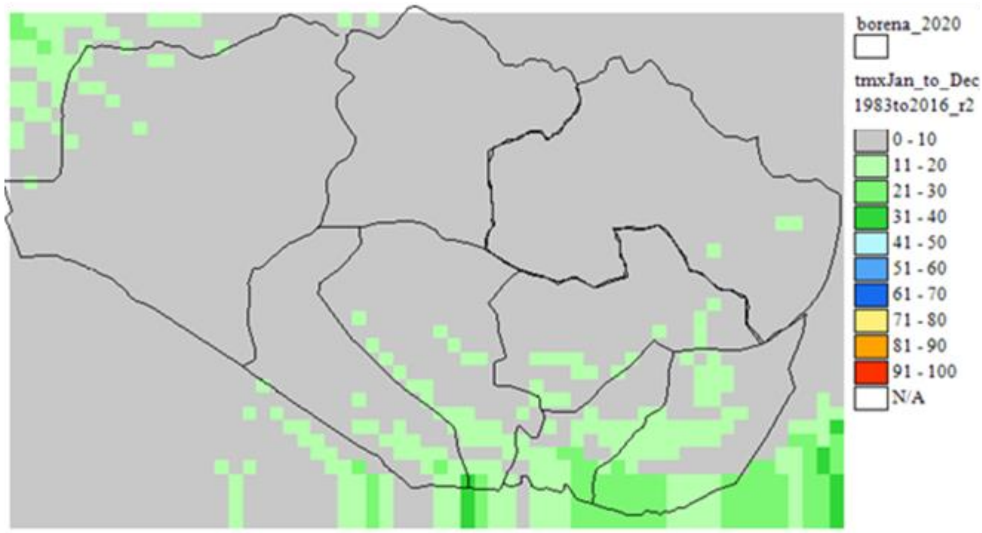


Figure 4-9b: Trend Analysis R^2 (%) for Mean Annual Max temperature in Borana Zone from Jan-Dec (1983 -2016)

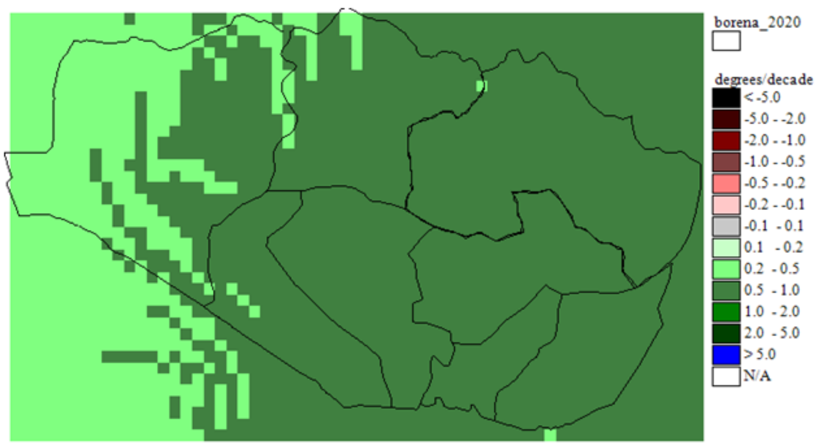


Figure 4-10a: Trend analysis in °C/decade for Mean Annual MIN temperature in Borana Zone from Jan to Dec (1983 -2016)

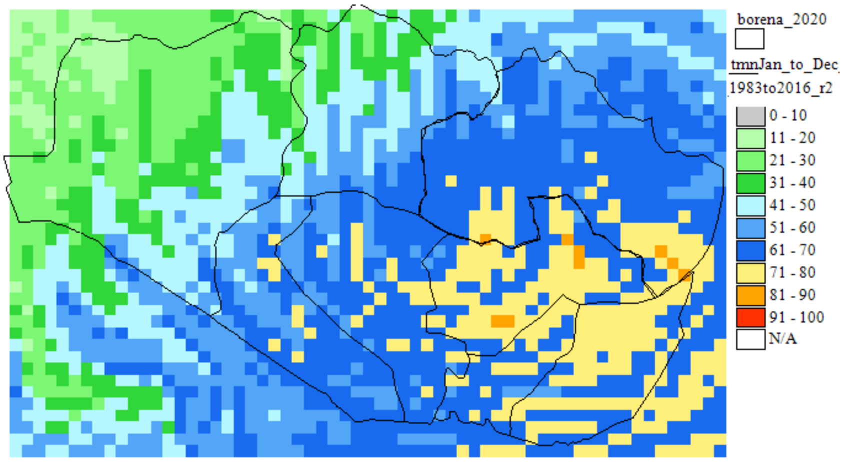


Figure 4-11b: Trend analysis R^2(%) for Mean Annual MIN temperature in Borana Zone from Jan to Dec (1983 -2016)

The observed trend in this study is consistent with the two more general consensuses and pieces of evidence on the Eastern African region's climate change that are highlighted in the climatological report (Daron, 2014). Regional trends show a rise in mean temperatures by 1 to 3°C over the past 50 years, while rainfall trends are less evident than temperature, with large variations in direction and magnitude. Some regions experience an increase in rainfall during certain seasons, while others experience a decrease. Overall, trends are weak and hard to detect (Daron, 2014).

4.4 Characterization and severity of drought

Droughts are usually identified by their severity, duration, frequency, and spatial extent. Intensity refers to both the extent of the deficit's impacts and the size of the precipitation deficit. Rain-based measures like the Standardized Precipitation Index (SPI), Normalized Difference Vegetation Index (NDVI), and Rainfall Anomaly Index (RAI) are commonly used to quantify drought and its severity as a tool for drought monitoring.

The Standardized Precipitation Index (SPI) of blended data set provides greater spatial, temporal, and quality coverage to describe meteorological droughts in comparison to analysis based on a restricted number of priority stations. This is in line with the suggestion made by McKee *et al*. (1993) to use high-quality data spanning at least 30 years. The indicator makes it easier to comprehend conditions of extreme precipitation, such as drought or surplus precipitation.

Meteorological droughts can be characterized by SPIs of various accumulation periods. For each year from 1983 to 2016, the SPI-3 months were calculated from the combined data at two reference points, namely the end of the main rainy season (May) and the beginning of the short rainy season (November). A SPI-3 is a comparison of the precipitation deviation accumulated over three consecutive months with the long-term mean for the same period (March–May and Sep–Nov) in all prior years (1983–2016) of accessible data. To understand the spatial characteristics of the drought through time, the SPI spatial maps have been generated for the research area at two reference periods for each year. To analyse the severity and frequency of drought, the SPI point estimate was further interpolated from the spatial maps for each station in the study region using their respective geo-reference points. The resulting index values were subsequently assessed against seven classifications of scheme—from extremely wet to extremely dry—proposed by McKee and others (1993) (Table 4-1).

Table 4-1: Classification of the period based on SPI values.

≥2.00	Extremely wet
1.5 to 1.99	Severely wet
1.00 to 1.49	Moderately wet
0.99 to -0.99	Near Normal
-1.0 to -1.49	Moderately dry
-1.5 to -1.99	Severely dry
≤-2.00	Extremely dry

The probability of SPI of various intensities and occurrences was calculated based on the number of years the SPI value fell into each of the seven classes of scheme proposed by McKee and others (1993), ranging from severely wet to extremely dry, as shown in Table 4-1 above. Table 4-2 displays the analysis's findings for the two reference periods.

Table 4-2: SPI_3 for main and short rainy season (# yrs.) and probability of drought

Station	Extremely /severely wet		Moderately wet		Near Normal		Moderate dry		Extremely/Severely dry		Prob. of dry cond
	May	Nov	May	Nov	May	Nov	May	Nov	May	Nov	
Aleweya	2	2	5	3	21	26	4	1	2	2	26%
Arero	2	3	2	1	24	25	4	3	2	2	32%
Chew Bet	2	2	3	3	21	24	7	5	1	0	38%
Dibluq	2	2	2	3	22	25	7	4	1	0	35%
Mega	2	2	2	3	22	25	7	4	1	0	35%
Moyale	1	2	5	2	22	25	4	2	2	3	32%
Teltele	1	1	4	5	22	21	4	7	3	0	41%
Tuka	1	2	3	1	24	26	3	2	3	3	32%
Yabello	3	3	3	2	21	24	5	3	2	2	35%

According to the SPI analysis, there was a 25–40% possibility that dry conditions would exist in the study area. This probability states that 3–4 years in the area endure varied degrees of dryness every ten years. Extremely dry conditions persisted for one to two of those years.

Furthermore, estimations of the recurrence interval or return time based on historical data suggest that dry conditions, including droughts of varied intensities, happen every four to seven years.

The absolute decadal NDVI anomalies from 2002 to 2020 are displayed in a line graph through time to look for any apparent trends. Figure 4-10 displays the results for the annual and two important seasons. Absolute decadal NDVI was predicted using a simple linear regression equation for a unit charge of the dependent variable (time in years). The built-in tool also generated a linear trend line and R-squared statistics for the purpose of assessing the direction of change and accuracy of the fit. The line graphs comprise these statistics for the yearly and two-season periods.

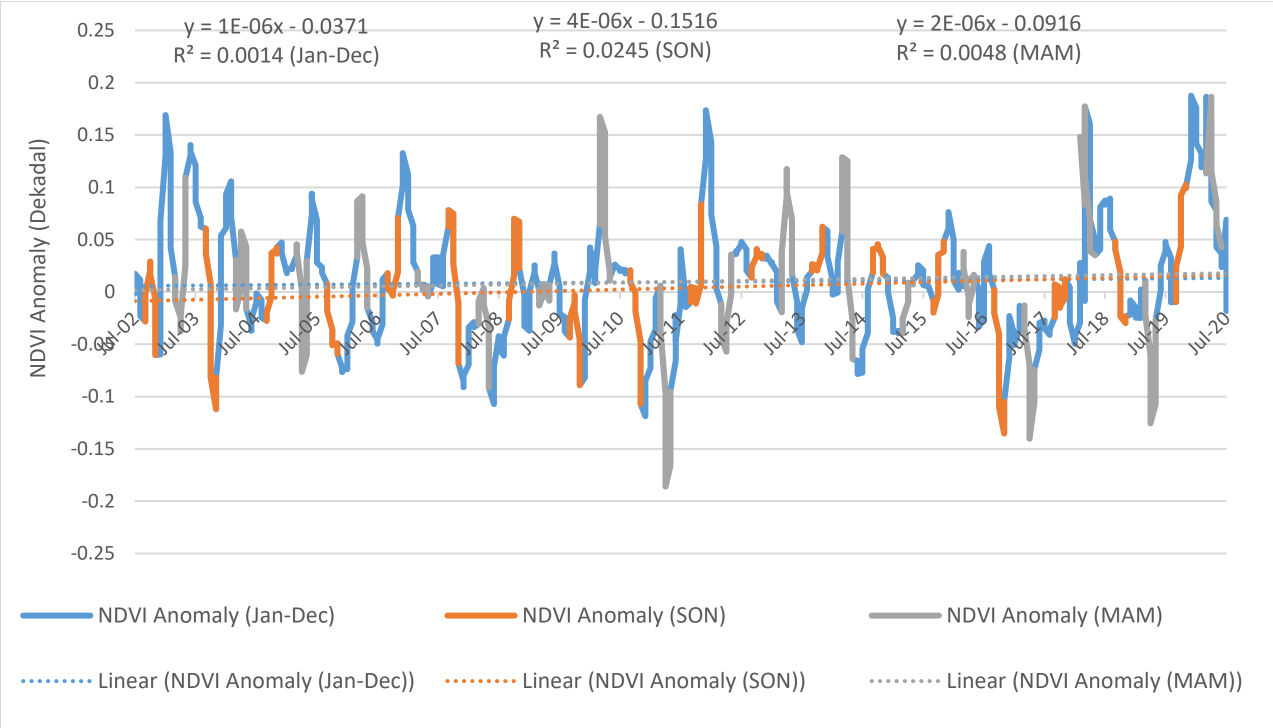


Figure 4-12: Trend of Absolute NDVI anomaly of MAM and SON seasons for Borena zone 2002-2020

Source (Author): Computed based on data from FEWS NET

The research area's vegetation state had significantly improved in 2003, 2009/2010, 2011, 2018, and 2019, according to the positive decadal NDVI anomaly difference (> 0.15). On the other hand, there was a significant reduction in vegetation condition between 2010 and 2011 and 2016 and 2017 (< -0.15). The vegetation condition showed a statistically significant downward trend over the short rainy season.

Non-parametric trend analysis employing the M-K test and Sen's slope is used to establish the decadal NDVI trend's magnitude, direction, and statistical significance.

Table 4-3: M-K Test for Trends of NDVI anomalies from 2002 to 2020, Borana zone.

	NDVI Anomaly (Annual)	NDVI Anomaly (MAM)	NDVI Anomaly (SON)
Mann Kendall (S)	3121	228	1502
Var(S')	30583987	467964	467961
Kendall's tau	0.015	0.018	0.117
Sen's slope	-0.0012	0.0144	-0.0281
P-value (Two-tailed)	0.573	0.74	0.028
alpha	0.05	0.05	0.05
Test Interpretation	Accept	Accept	Reject
Trend	NST	NST	ST decreasing

An anomaly map, which may be produced for decadal, month, and season data sets, is the most utilized product for NDVI anomaly analysis. It is useful to understand how and where vegetation development deviates from the norm due to rainfall and other factors (stocking rate and LULC). A deviation (either positive or negative) from regular vegetation development can be seen in anomalies in the NDVI. Positive NDVI deviation indicates improvement in vegetation, regardless of size, while negative deviation is opposite. This study employed a temporary smoothed NDVI mean to determine whether there was a measurable increase or decrease in the NDVI values in the study area between 2002 and 2020. The NDVI anomaly map generated for the study's area is shown in Figure 4-11.
The vegetation in the study area has slightly improved, except for a few months in 2003 and 2010. The vegetation also improved in 2012 even after the main season's failure, contributing to the dryness. The most recent droughts in the area, 2011 and 2016-17, have shown their vegetative states on the map. From October to June, vegetation conditions deteriorated, leading to the widespread dryness. Over two years have passed since the 2016-2017 drought, with vegetation either improving or showing no change. The subsequent recovery of the vegetation in the study area following the major drought is associated with a reduction in grazing pressure (stocking rate) because of the extensive mortality caused by the drought.

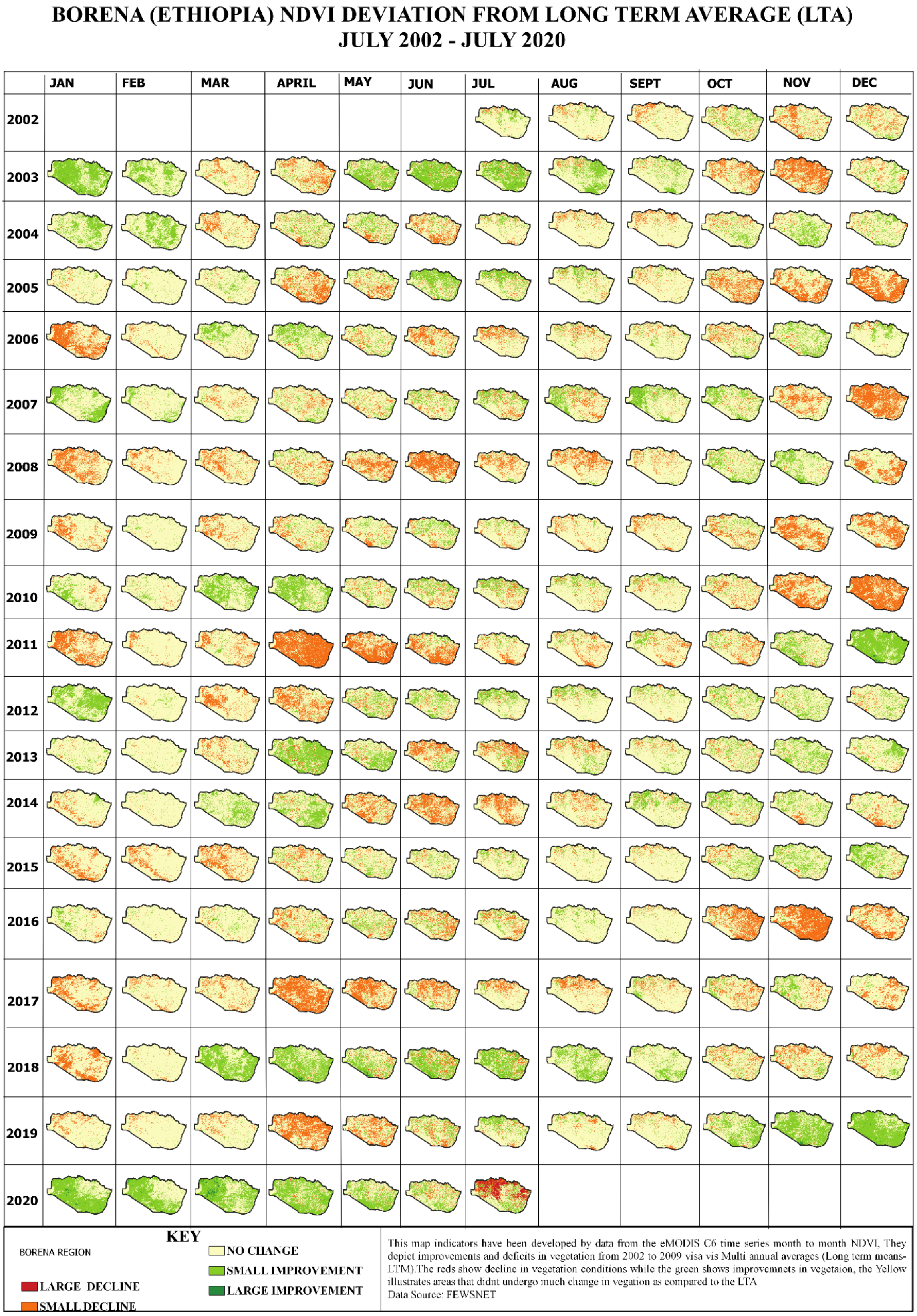


Figure 4-13: NDVI deviation from long-term average (LTA) July 2002- July 2020

4.5 Local perspective of climate change and drought

4.5.1 Local perception of climate change and drought

In a situation where weather and climate monitoring systems are inadequate, local knowledge is essential for understanding historical and present patterns of climate change and related hazard. The "recall period" for the household perception question was the most recent ten years due to the age differences among the respondents. Interviews were conducted with people ranging in age from 20 to 95, which will aid in overcoming generational gaps in ideas and beliefs. The results of the household's perception analysis were triangulated using the climate, secondary data, and key informants.

Figure 4-12 summarizes and presents the analysis of household perceptions of climatic variability and changing pattern responses. Data from households clearly shows that temperature, drought frequency, and severity have all increased in comparison to the previous ten years. The frequency of floods and extreme temperatures was widely considered to have increased, even though household responses were not as consistent as those of the preceding categories. Households all responded in the same way to the decline in rainfall totals and the number of days during the two main rainy seasons. They all concurred that compared to the previous ten years, the rainfall patterns in recent years have been more erratic.

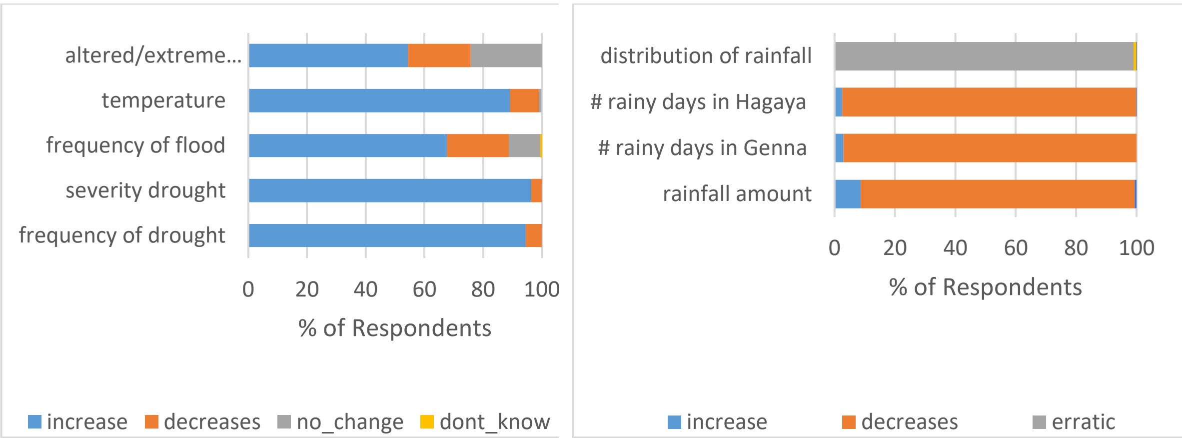


Figure 4-14: Respondent perception on climate change indicators

KI's assessment has provided insight into the factors affecting climate change in addition to complementing the household analysis displayed in Figure *4-12*. A reference period of 30 years was used to assess how well the KI perceived parameters related to droughts, climatic variability, and change. One evidence of the observed shift that informants have often highlighted is a change in rainfall patterns. The informants looked at rainfall trends over the last 30 years in terms of time, volume, and distribution to substantiate their statements, as shown in Table 4-4.

Table 4-4: Comparisons of past and current rainfall patterns of the two rainy seasons based on KIs analysis.

Rainfall patterns	**Main rainy season (Genna)**		**Short rainy season (Hagaya)**	
	Past	**Current**	**Past**	**Current**
On-set of rains	February	March / April	August	October
Cessation of rains	April	End of April	October	October
Months /days of rainy season	3 (90days)	1-2 (30-60 days)	3	Unreliable (a month or less
Probability of missed/ failed season	Unlikely to occur	May / May not occur	Likely to occur	Likely to occur (increased)
Rainfall amount	Adequate	decrease / Inadequate	Adequate or inadequate	No rain/ rarely received
Early shower	January	No shower as per recent trend.	July	No shower at all recently.
Days of long dry season	90	100-140		
Timing of rainfall	Predictable	Unpredictable	Predictable	Extremely unpredictable.
Distribution	Well distributed	Erratic	Erratic	Very erratic

Source: Key Informants Interview, July-August 2019

All the informants claimed that the temperature had been increasing in the area. The informants recalled historical and present-day temperature trends and timing to substantiate their claim. In the past, the long dry season, also called "Bonna Amaji," was marked by high temperatures during the day and low temperatures, including chilly conditions that were uncomfortable (referred to locally as "Meganu") during the night (midnight). However, during the cold, dry season, both daytime and overnight low temperatures (coldness) were noted ("Bonna Adolesa"). Additionally, there were a few light raindrops and clouds. A recent rise in temperature has been noted, regardless of the time of year or the length of the day and night.

The elders divided the places with rising temperatures into two categories: historically considered "cool land," locally known as *"Qabale,"* and hot lands, primarily low and arid land (Golibo, Malbee Wayama grazing area). Gomole grazing areas were known primarily as cool land, and the nearby area was also thought to be relatively cool. These previously hot lands grew hotter and are now even hotter. The increase in temperature (hotness) both during the day and at night Seasonal and yearly trends of increasing temperature were linked to climatic changes like rainfall.

The informants also described the severity and frequency of droughts to support their claim that climate change is at play. The results of the analyses shown in Table 4-5.

Table 4-5: Drought frequency and severity comparisons in Borana.

	Past	**Current**
Drought occurrence	Once every 7-8 years	Recurrent (frequency increased)
Drought severity		Severity increased
Warming Temperature	Dry season	Increase in temperature observed regardless of the season or day and night (year-round)

Source: Key Informants Interview, July-August 2019

4.5.2 Drought hazards

According to the key informants, drought and dry spells were the main hazards that pastoralists and agro-pastoralists in the research area grapple with cyclically. Drought and other hazards, such as livestock diseases, market price fluctuations, etc., threatened a population group's ability to support their livelihoods. The key informant assessment is further supported by the sample household ranking results, which are presented in Figure 4-13 in order of these common risks. The frequency analysis used percentages of each response option divided by the total number of responses.

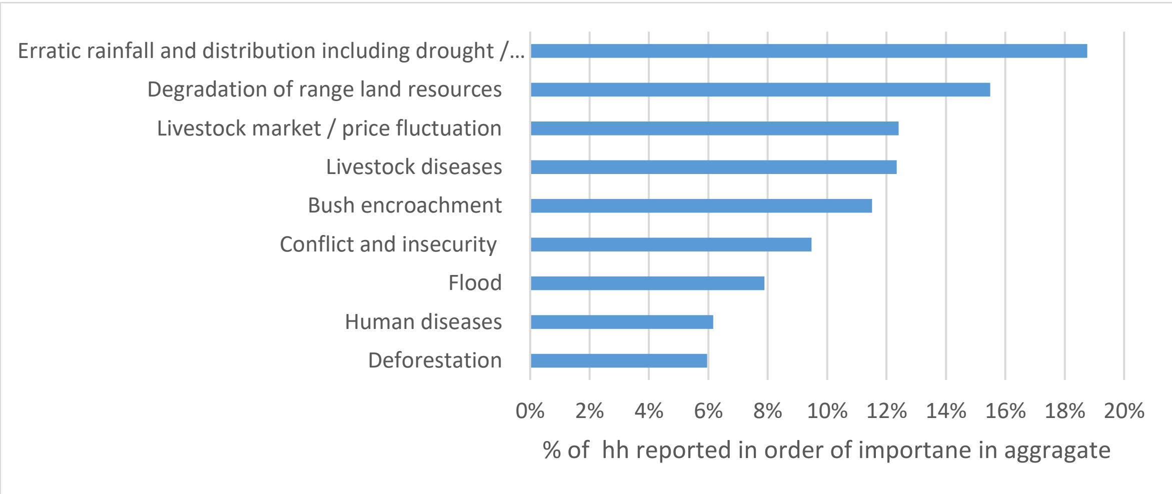


Figure 4-15: Ranking order of common hazards by sample household

Table 4-6 shows that droughts were the most common type of disaster, according to an analysis of digital data that was retrieved from 1994 to 2013. Drought occurrences were spatially widely spread throughout the zone, in contrast to other threats that only affected areas (localized) of the zone.

Table 4-6: Number of reported disasters in Borana zone from 1994-2013

Disaster Event	Arero	Dire	Miyu	Moyale	Teletele	Yabelo	Total	% of the total reported event
Drought	16	29	9	19	18	17	108	60%
Biological (livestock diseases)	2		8	3	2	5	20	11%
Conflict	1			17		1	19	10%
Plague		4		4	3	2	13	7%
Flood	1		4	3	2	2	12	7%
Fire/Forest Fire	5					2	7	4%
Landslide	2						2	1%
Total	27	33	21	46	25	29	181	

Source: UNDRR, 2016

The historical timeline constructed with key informants and FGDs has given additional information regarding the temporal dimensions of significant hazards. A 60-year drought event timeline was developed using information from FGD and KII, with additional information being contributed by KII using the local calendar. The analysis accurately reflected the main drought occurrences and their characteristics that the population has endured since the early 1960s (Jeledesa Liben Gada). A 60-year drought event timeline was constructed using data from FGD and KII, as summarized in Table 4-7 by Gada.

Table 4-7: Chronology of major drought events and its impacts in Borana

Reigns of Abbaa *Gadaa**	Abba *Gadaa*	Key characteristics/ impact / coping
1962-1968	Jeledesa Liben Guyo	No major drought. His Gadaa was marked by conflict, also known as *"Olki Roba*" locally.
1970-1977	Goba Bule Dabasa	Its defining characteristics are conflict and drought. There were two droughts during his Gadaa. The severe one was referred to as *"Ola aduni Dote"* locally. Significant loss of livestock occurred, and the human population was severely affected by famine-related illnesses like edema (also known as *"bobos")* and bloody diarrhoea. The droughts that came before this Gadaa were manageable, except for the *"Ola Kolege"* drought, which was the worst in Borana history. The impact started to worsen from his Gadaa's. Emergency molasses and dry animal feed started to be distributed, saving both human lives and livestock from unnecessary deaths.
1978-1985	Jilo Aga Adi	Its defining characteristics are conflict and drought. Unusually high numbers of livestock perished, and the last remaining animal was weak and worthless. The extreme drought that the nation was experiencing made the harm much worse by completely reducing the supply of grain from the market. Due to this, it became more difficult for the drought-affected population to obtain food, leading to an increase in the number of fatalities from starvation and malnutrition.

		Most individuals affected undertook distress migrations and joined relief camps. Relief camps like Dolo Makala, Miyo, etc. were established at this period.
1986-1993	Boru Guyo Boru	Drought, conflict, and diseases that afflicted both humans and livestock marked this, Gadaa. The "*Drought of Black Flies*" was a drought that was characterized by swarms of black flies devouring dead animals. Conflict worsened the widespread drought. In addition to the widespread ethnic conflict and displacement, the movement of animals made the situation worse. The change in government that occurred close to the end of this Gada made the situation worse. Animal diseases Babesiosis, also known as *"Birte"* locally, and Foot and moth (FMD)-*Oyali* killed more cattle than drought did. In addition to widespread starvation, the impacted population also suffered from numerous diseases. The human population has limited access to livestock products and is affected by diseases *("Lakama")* associated to hunger and malnutrition, with documented mortality.
1994-2001	Boru Madha Galma	In his Gadaa, Borana has had two droughts, one in the fourth and one in the final year. The later one was seen as significant. This drought, also known as the "windy drought" or *"Ola Bube"* locally, was a result of the extremely windy weather that persisted. First, the Genna season wasn't good, subsequently, we completely missed Hagaya. Before it rained, the dry season dragged on for almost 140 days. Some livestock keepers "abnormally" migrated to the Burji, Konso, and Sagan Rivers to safeguard their herd because of high livestock mortalities. Those who kept livestock in Borana territory lost significantly.
2002-2009	Liban Jeledesa Liban	No significant drought was noted, only a dry spell. There was also minimal impact on livestock. Six years of his Gadaa were believed to be better than two years, which were deemed to be unfavourable owing to the dry spell.
2010-2017	Guyo Goba Bule	There were two droughts during his Gadaa, one as he took office and the other in the final year of his rule. The subsequent drought was thought to have had a major adverse impact. Some of the elders claimed that Borana lost many of its animals and fell into a terrible state of poverty. Guyo Goba had one of the worst droughts in recent memory in Borana. The effects of the drought were also ranked by elders in order of importance: Guyo Goba, Boru Madha, and Boru Guyo.

Source: Key Informants Interview and Focus Group Discussion, July-August 2019
* The Abbaa Gadaa serves for a single term of eight years.

4.5.3 Causes, intensity and aggravating factors of climate change.

The majority of the informants' perceived drought and climate change as being part of the Borana environment. Informants disagreed on exactly when the impacts of climate change in

Borana began appearing in the Gada calendar, though. According to informants, observable climate change may have begun to show signs as early as Jeledesa Liben (1962–1968) or during Gada Boru Guyo (1986–1993). Most of the informants, however, agree that each Gadaa, regardless of when it began, is making the transformation worse.

The opinions of informants from the local communities on the causes and aggravating or contributing elements of climate change were also mixed. However, most elders really think that climate change is an "act of God" and do not accept the scientific validity of the anthropogenic (human-caused) causes of climate change. Some of the informants attributed the change to the declining of traditional practices and customs. One of the grazing managers and most of the government KI acknowledged the link between deforestation and climate change, in contrast to the other grazing manager who was interviewed. KI highlighted gradual deforestation some of pocket of forest area in Borana (Miyo, Arero, and Yabello) due various human activity believed to have contributed to the local climate change particularly warming of temperature. These forests play a critical role in regulating microclimates. Land use and land cover change (LULC) that occurred in the area because of internal and external influences may have contributed to or aggravated local climate change (see LULC impact analysis).

In terms of the severity of climate change, grazing areas vary depending on their level of aridity and altitude (low or high land). Overall, KIs indicated that Gomole and Dire had less severe climatic change than Wayama, Malbee, and Golbo (located in a low-lying, arid part of Borana). The increased temperatures in Golbo and Malbee compared to other grazing areas further aggravated the severity of climate change. The five grazing areas of Borana exhibit commonalities in terms of rainfall change patterns, despite disparities in the endowment and distribution of rangeland resources. According to informants, growing settlement patterns and increasing livestock populations in Borana have exacerbated the effects of localized climate change. One of the aggravating issues mentioned was the weakening of traditional grazing management systems and institutions.

4.6 Projected climate change

4.6.1 Rainfall projections

Future projections of annual, main (MAM), and short rainy season rainfall (SON) in comparison to a climatological baseline (1981–2010) are shown in Figures 4-14, 4-15, and

4-16, respectively, based on three representative concentration pathways (rcp26, rcp45, and rcp85) for the three reference periods.

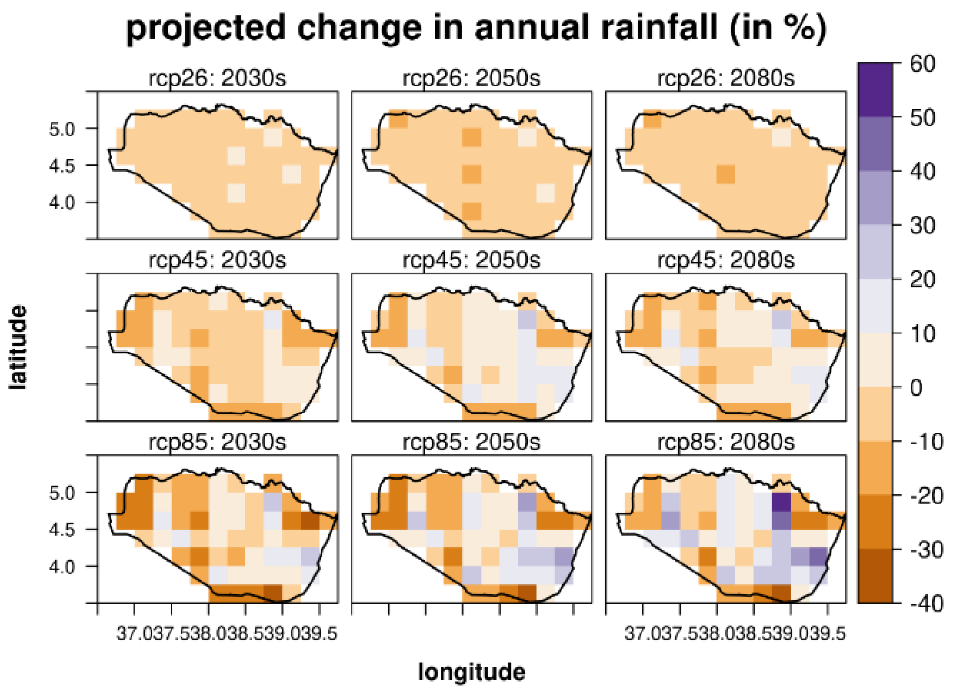


Figure 4-16*:* Projected change of AR compared with baseline (%) under the three RCPs and reference periods.

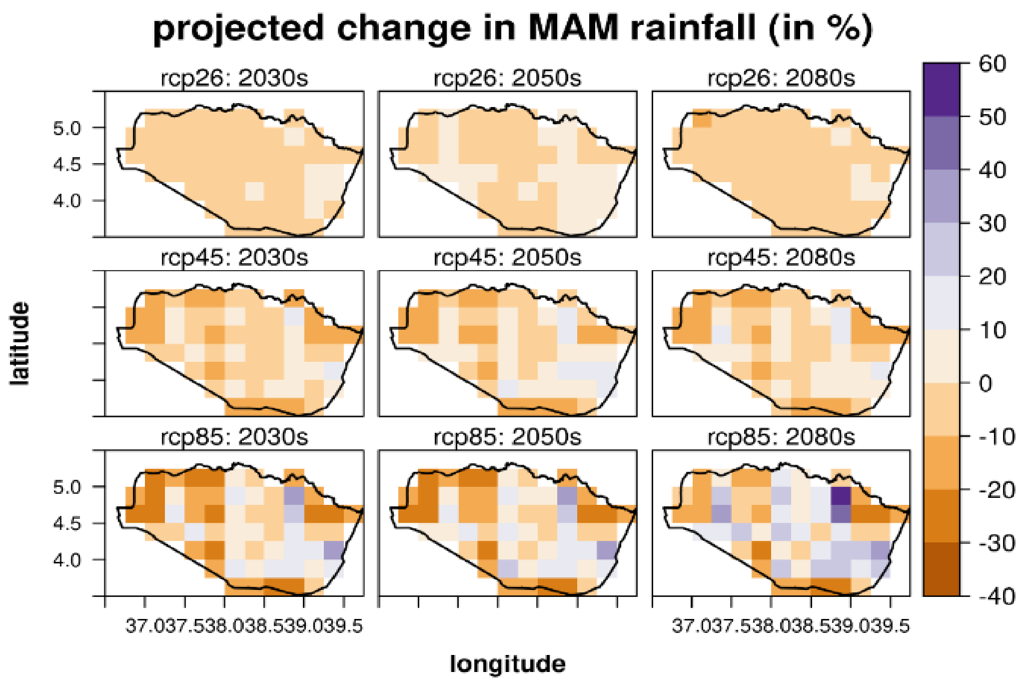


Figure 4-17*:* Projected change of MAM compared with baseline (%) under the three RCPs and reference periods.

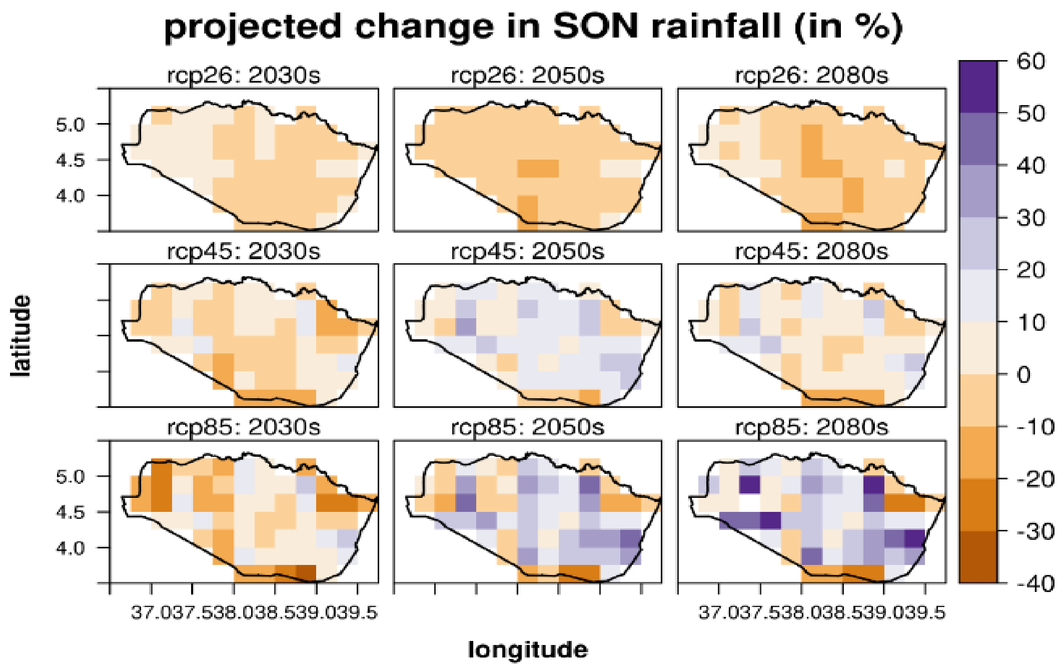


Figure 4-18: Projected change of SON compared with baseline (%) under the three RCPs and reference periods.

Figures Figure 4-17 through Figure 4-19show the range of percentage changes in annually, MAM, and SON rainfall, respectively.

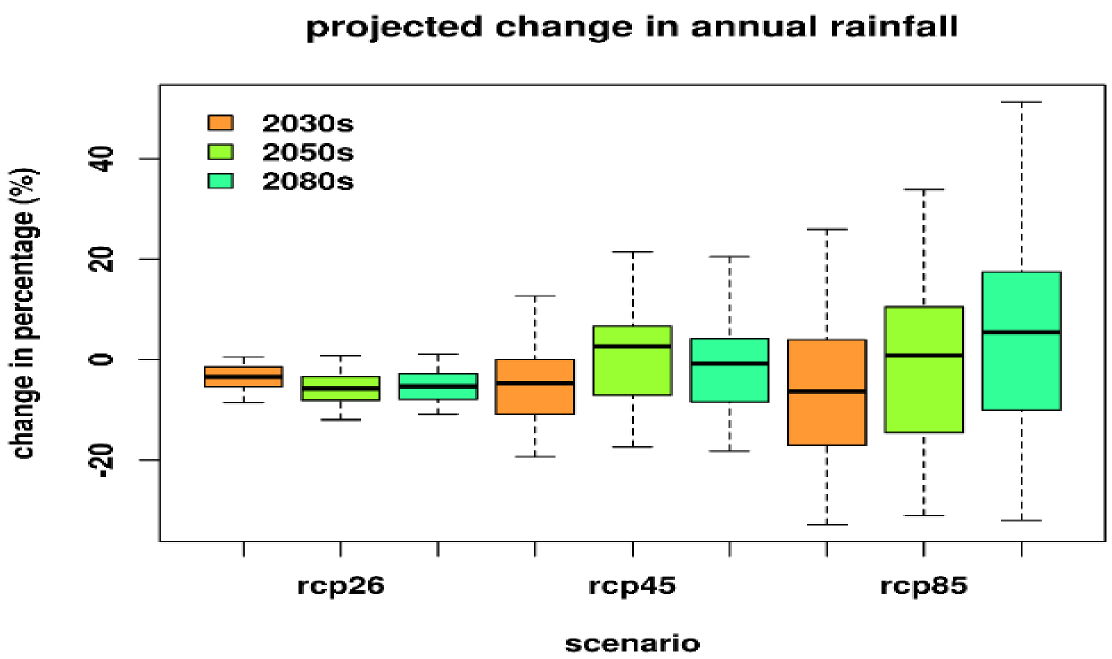


Figure 4-19: The spread of projected changes (%) of AR under the three RCPs and reference periods

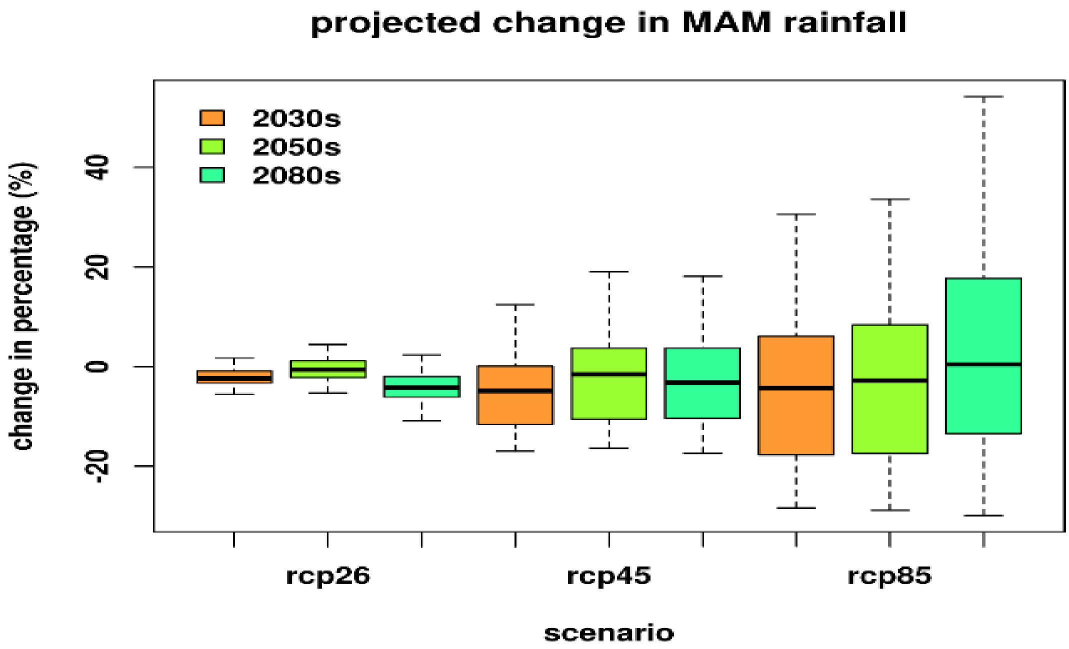


Figure 4-20: The spread of projected changes (%) of MAM under the three RCPs and reference periods.

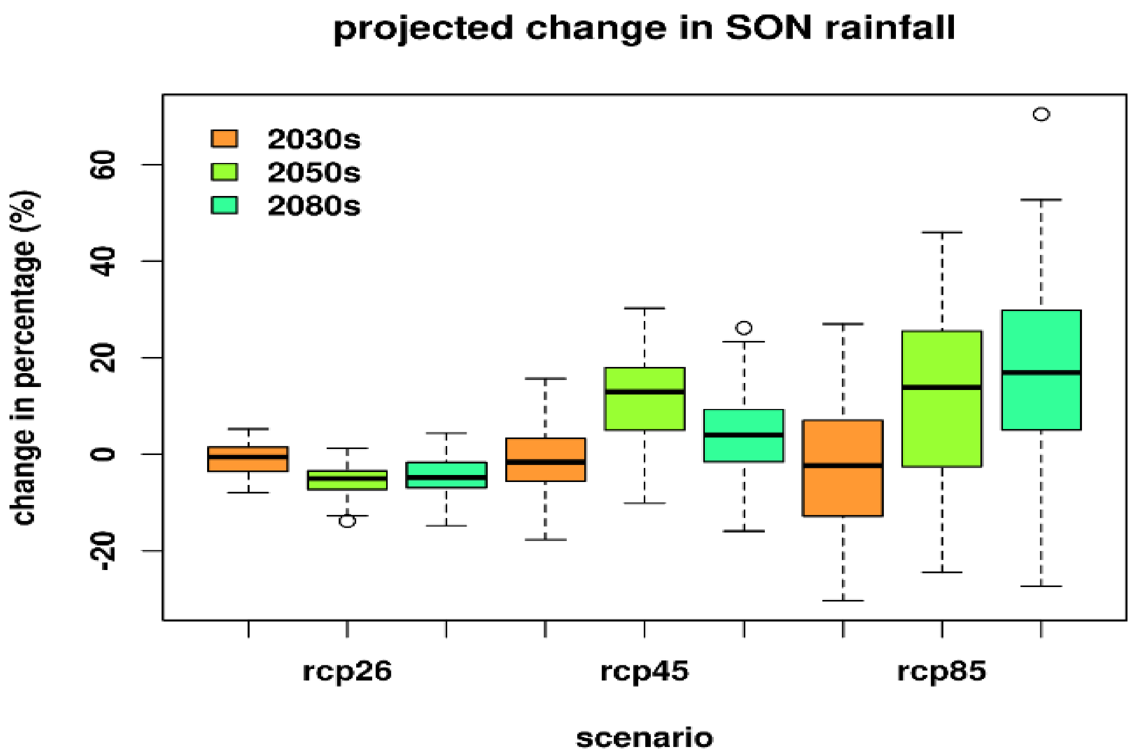


Figure 4-21: The spread of projected changes (%) of SON under the three RCPs and reference periods.

The RCP26 projects a median reduction in annual rainfall of 10% over the course of the next century. The median value of the change in rainfall under the RCP45 is roughly -10%, while some grid cells show a larger reduction. Under rcp85, the early and mid-century decline in annual precipitation predominates, with some cells showing a very minor increase. Although the changes under RCP 26 are more certain, the projected changes under RCP 85 have a wider spread.

It is projected that rainfall in MAM will either decrease or remain same throughout the next century. A projected decrease dominates with the spread shown in Figure 4-15 i.e., some grid cells show an increase of up to 20% under the rcp45, and changes in -30% to >40% under the rcp85 in the 2080s.

According to the RC26 scenario, rainfall in the SON season is projected to drop over the course of the century, whereas the RC45 scenario projects a modest rise in the 2050s and 2080s and essentially no change overall. In many grid cells, rainfall is projected to increase in the 2080s, sometimes by up to 40%. But in every case, as seen in Figure 4-16 and Figure 4-19, the median SON rainfall is projected to fall. According to Figure 4-20 annual rainfall time series plot, the overall picture is that rainfall in Borana will either increase or decrease in the coming years.

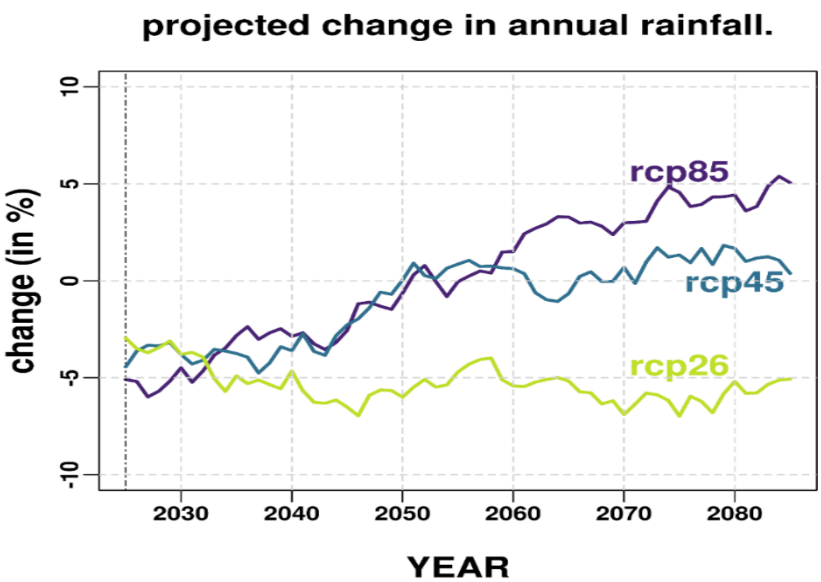


Figure 4-22: Future change of annual rainfall for the three RCPs and reference periods.

4.6.2 Temperature projections analysis

Figure 4-21 shows the projected change in maximum temperature under RCP26, RCP45, and RCP85 relative to the baseline (1981–2010). The early century (2011–2040), mid-century (2041–2070), and late century (207–2100) projected changes are shown in the first, second, and third columns, respectively. The rcp26 (top row), rcp45 (mid row), and rcp85 (final row) are where changes are displayed.

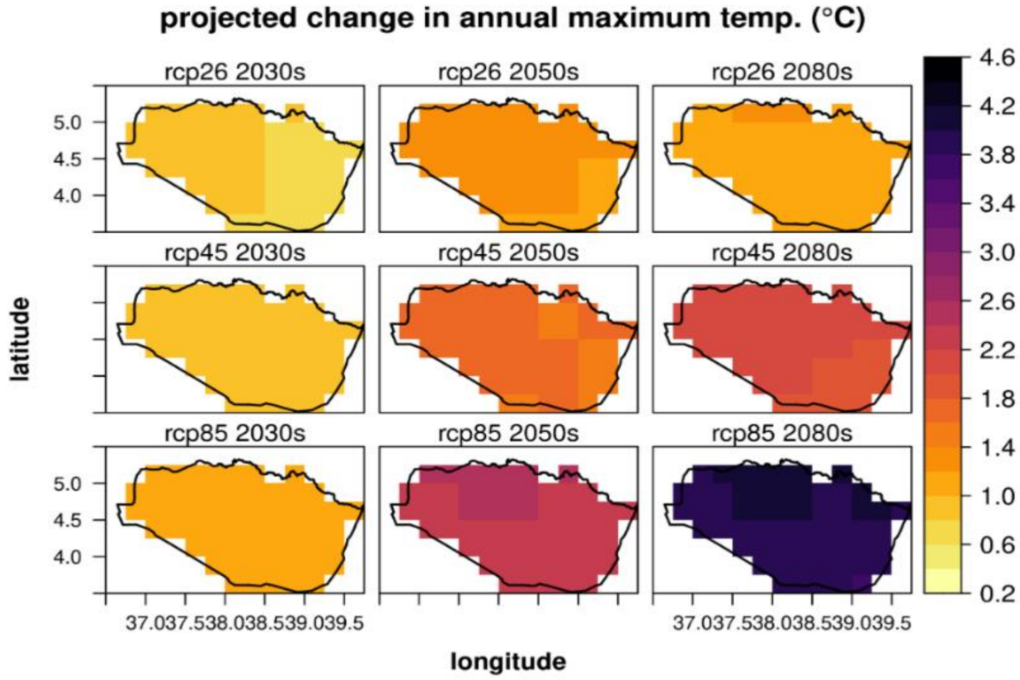


Figure 4-23: Projected change in maximum AAT (in °C) compared with baseline for the three RCPs and reference periods.

The maximum temperature in Borana is projected to change under each of the three emission scenarios. Under the RCP26 scenario, the maximum temperature is projected to increase by 0.6 to 1 degree Celsius in the 2030s, 1.2 to 1.8 degrees Celsius in the 2050s, and 1.2 to 1.4 degrees Celsius in the 2080s compared to the baseline. Under rcp 45, the maximum temperature is predicted to rise higher than it would under rcp26. Projections made under rcp85 are anticipated to range significantly more between 2.2 °C and 2.6 °C in the 2050s and 3.4 °C and 4.6 °C at the end of the century. In general, it is expected that for the entire century, the maximum annual average temperature in Borana will increase. The direction of change is shown by the time series plot in Figure 4-22.

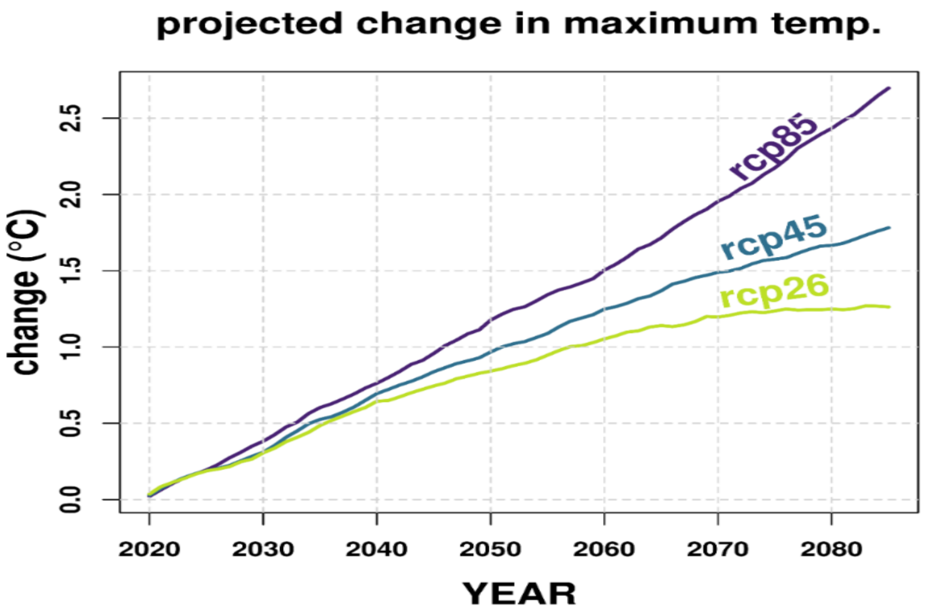


Figure 4-24: Direction and magnitude of projected change in maximum AAT temperature under three RCPs.

Figure 4-23 shows projected future changes in minimum temperature relative to the base period of 1981–2010. All emission scenarios call for an increase in the minimum temperature in Borana. Regardless of the scenario, higher magnitudes of change are projected at the end of the century. For instance, the rcp26 scenario projects that the minimum temperature will vary by 0.6 °C to 1.0 °C in the 2030s and by 1.4 °C to 2 °C in the 2050s and 2080s.

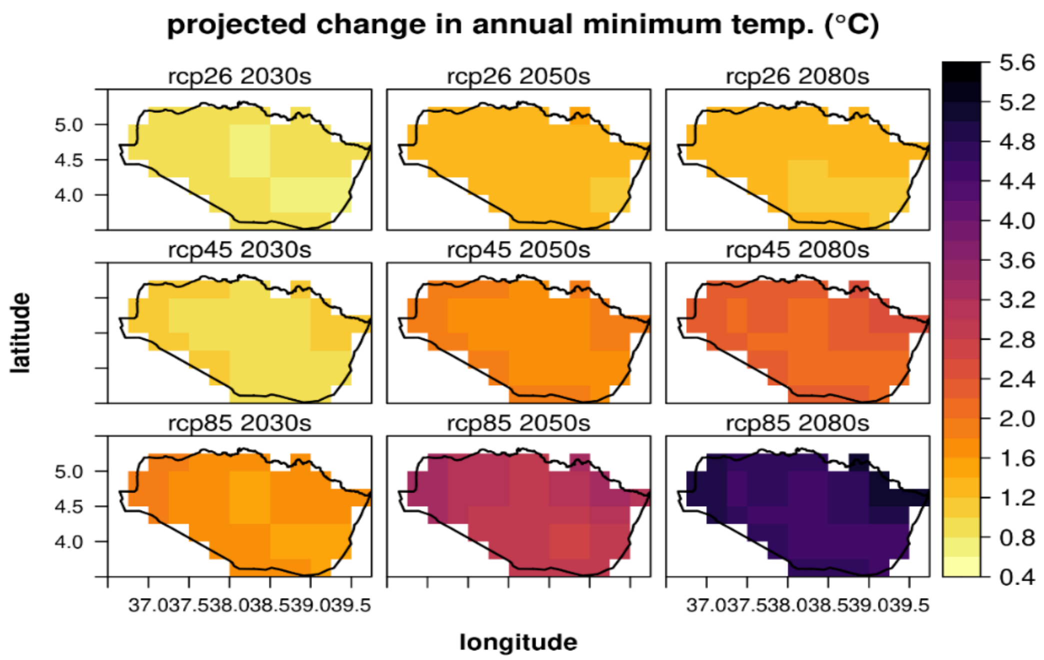


Figure 4-25: Projected change in minimum AAT (in °C) compared with baseline for the three RCPs and reference periods.

The minimum temperature is projected to change under the rcp45 scenario by 0.8 °C–1.4 °C in 2030, 1.8 °C–2.2 °C in 2050, and 2.2 °C–2.6 °C in 2080. Changes during the late 20th and early 21st centuries ranged from 4 to 5.4 °C, and the rcp85 is projected to produce bigger changes than the rcp26 and rcp45. However, it is generally expected that under all emission scenarios, the minimum temperature in Borana will rise more quickly than the maximum temperature. The time series graphic in Figure 4-24 indicates the change's direction and amplitude.

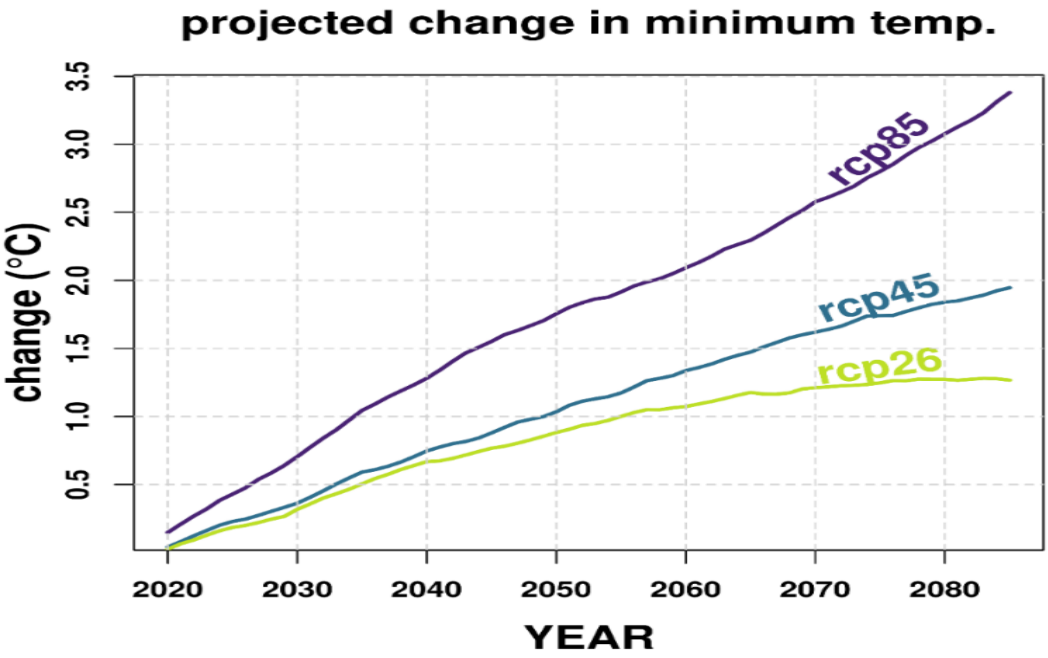


Figure 4-26: Direction and magnitude of projected change in minimum AAT under three RCPs.

4.6.3 SPI projections analysis

The SPI time series in *Figure 4-25* and the frequency of occurrence of each SPI category in Figure 4-26, respectively, indicate the 12-month drought conditions. Figure 4-26 displays the future SPI (2011–2100) under rcp2.6, rcp4.5, and rcp8.5 in the rows below the historical SPI in the top row. Events that are wet are shown in "blue" hues, while those that are drier are shown in "red" colours.

According to Figure 4-26 (row-4) projection, there will be fewer near-normal events than there were during the reference period. Extremely wet events occurred more frequently during the reference period (1981–2010) than was projected for the 2030s, 2050s, and 2080s under the three emission scenarios.

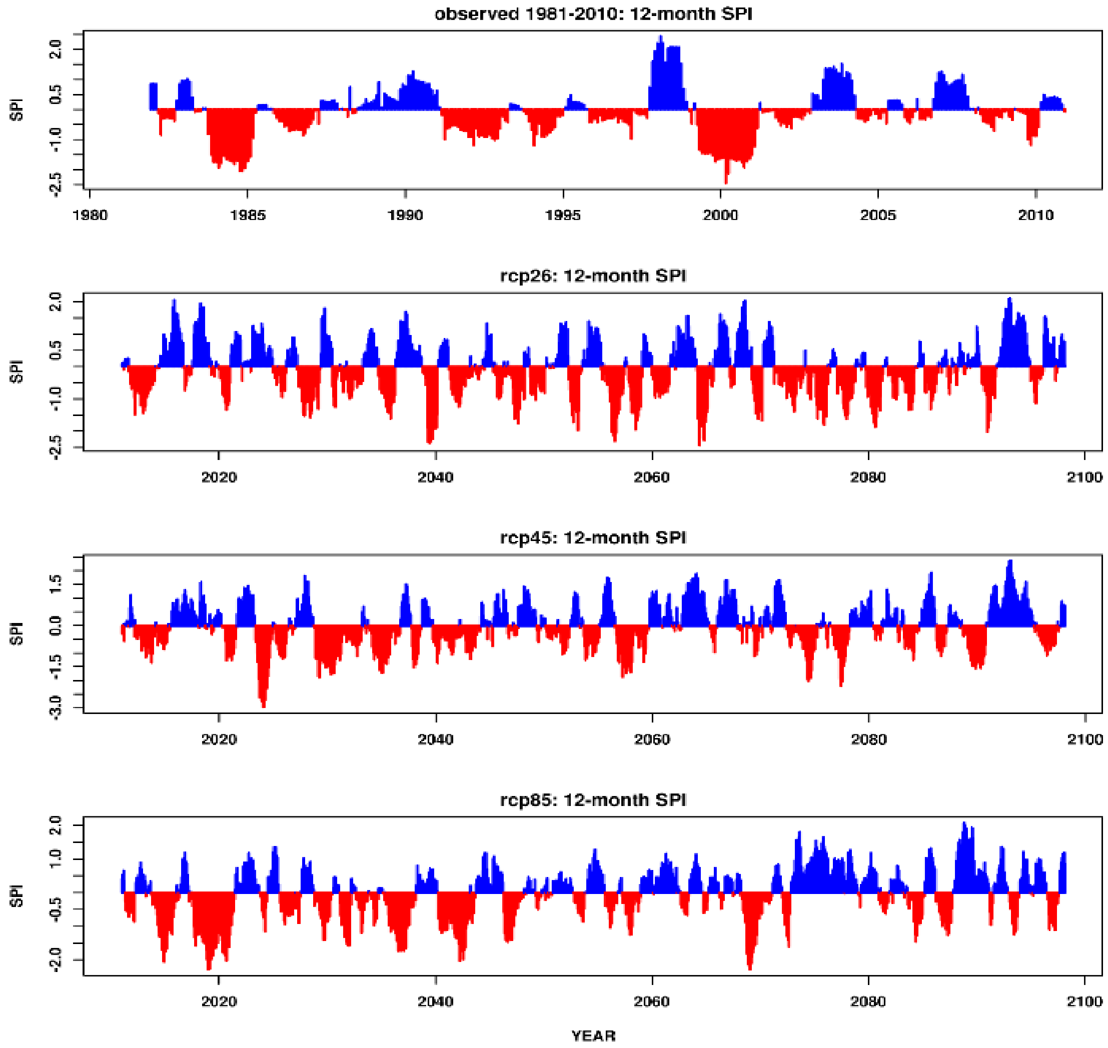


Figure 4-27: 12-M SPI for the historical and future period under three RCPs emission scenarios

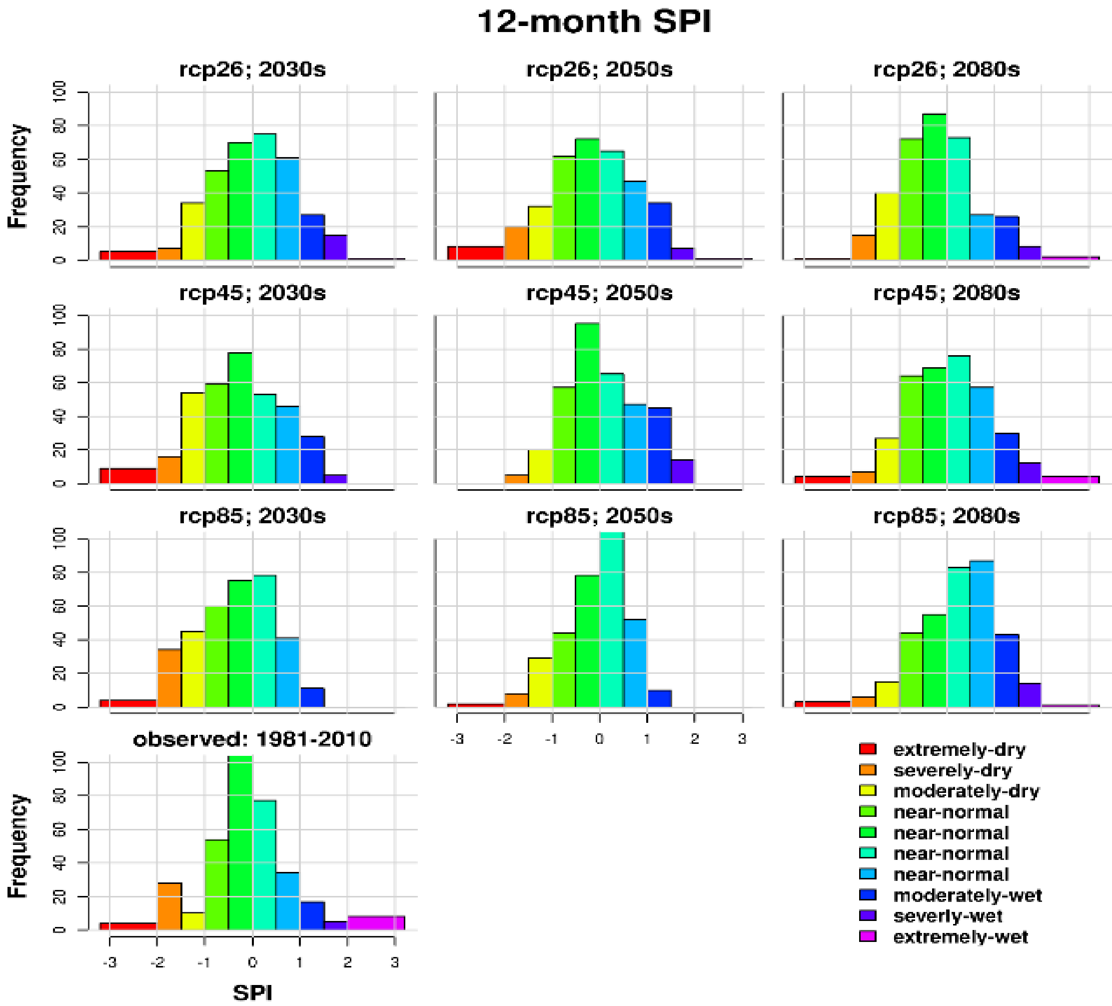


Figure 4-28: Frequency of dry and wet events *based on* 12 M SPI for the historical and future period under three RCPs.

Figure 4-25 (row-2) and Figure 4-26 (row-1) under rcp2.6 projected a higher frequency of extremely dry occurrences and a lower frequency of highly wet events up until the middle of the century. The 2080s will have less extreme moisture and dryness than the reference era. More severe and moderately dry events are projected to occur frequently until the end of the century.

The frequency of extremely dry events is projected to be higher in the early and late centuries under rcp4.5 than in the reference period in Figure 4-25 (row-3) and Figure 4-26, (row-2). Situations that are extremely wet are projected to happen less frequently. The rcp8.5 scenario projects more drought conditions and less moderate to extremely rainy weather for Borana compared to the reference period Figure 4-25, (row-4) and Figure 4-26 (row-3])

In general, it is projected that Borana will see more dry conditions than in the reference period, as well as more moderately wet conditions than in the past. However, the frequency of moderate to extremely wet conditions is anticipated to decrease over time.

The 3-month SPI in Figure 4-27 and Figure 4-28 indicates a higher frequency of dry spells in the future based on the three emission scenarios. In the near future (early century), it is expected that the frequency of exterem wet events would rise under rcp2.6. There will be more drought episodes in the early and middle of the century, even though there will be fewer extraordinarily wet events in the 2080s than there would be in the early and middle of the century. This is most likely a result of more frequent near-normal events in the 2080s.

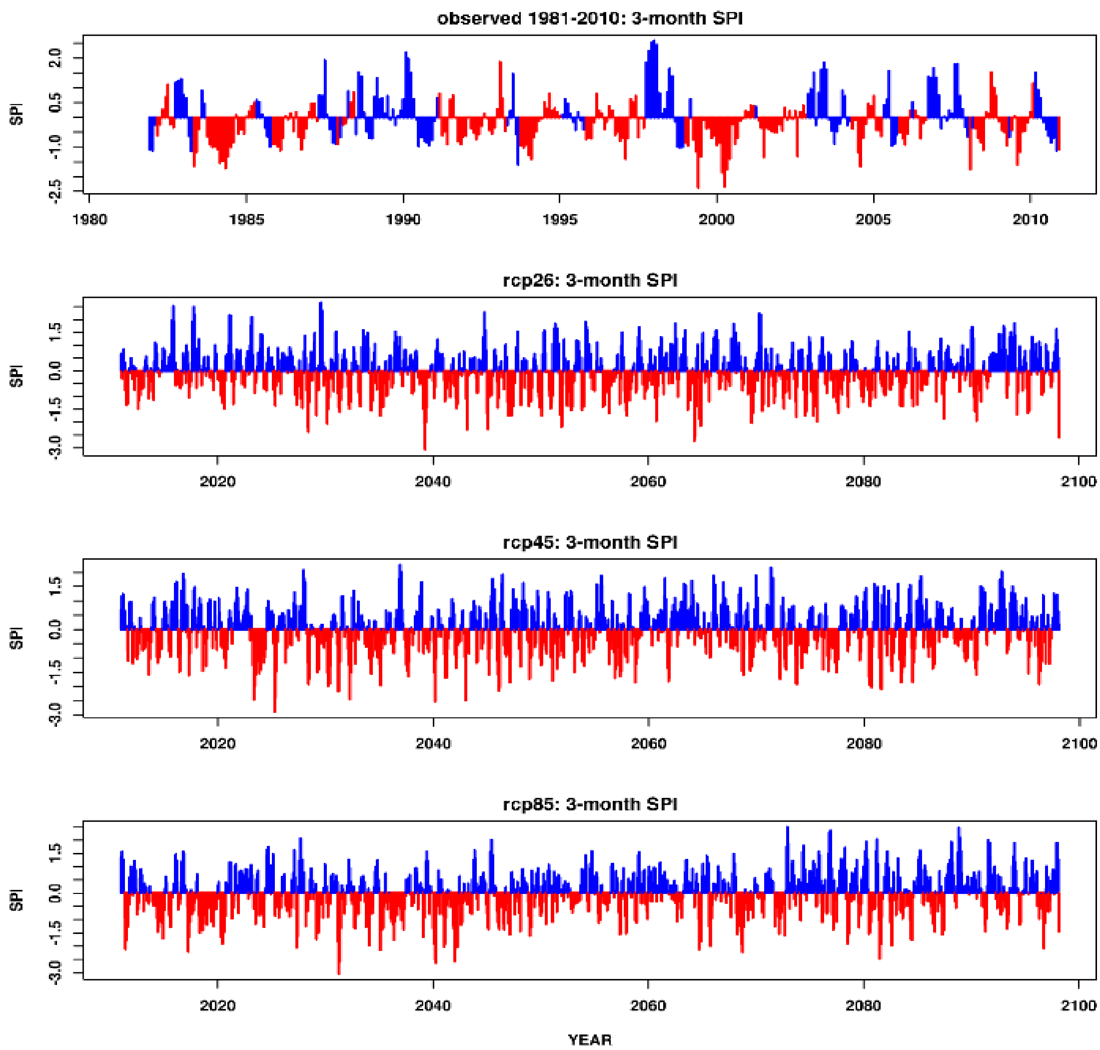


Figure 4-29: 3-M SPI for the historical and future period under three RCPs

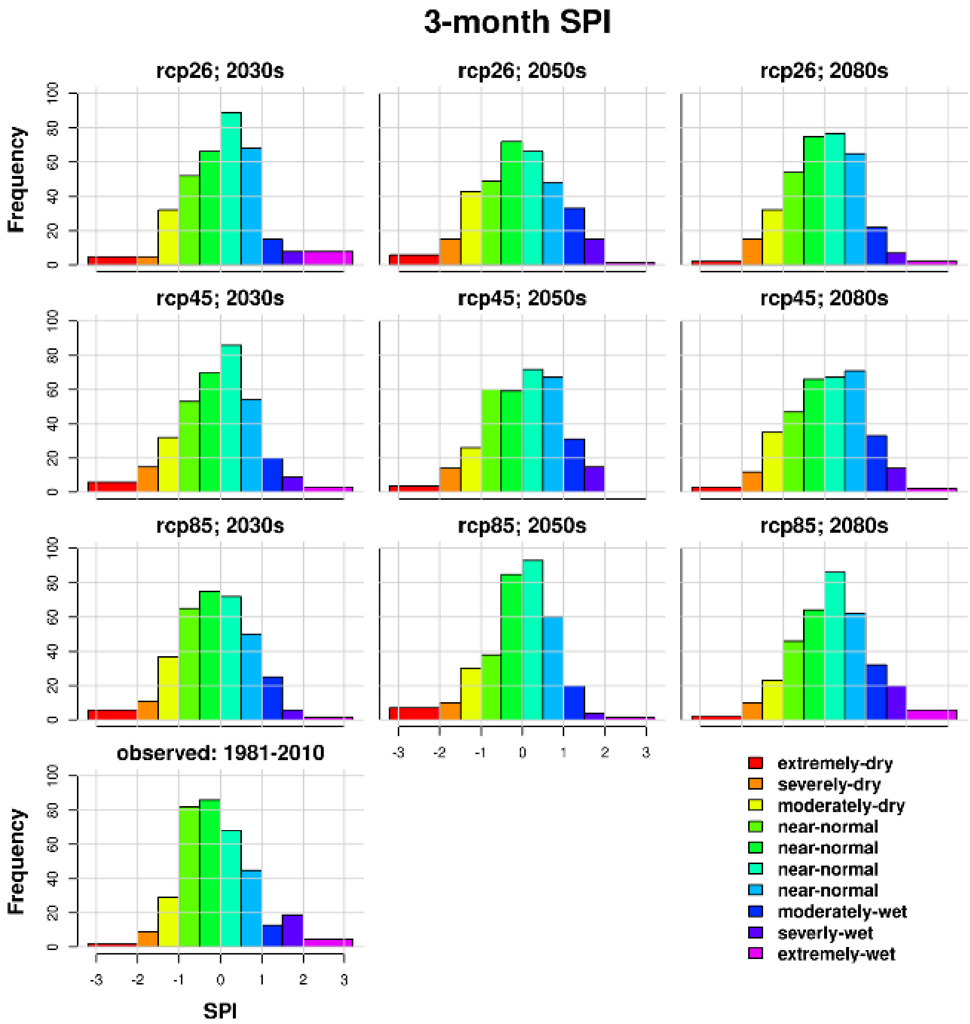


Figure 4-30: Frequency of dry and wet events *based on* SPI 3 month for the historical and future period under three RCPs.

The 3-month SPI generally shows more droughts and fewer extremely wet events in the future. Near-normal occurrences will continue to occur with a frequency similar to the historical period (see Figure 4-28).

4.6.4 Rainfall extremes

The wet day's index per time period (rr1) displays the number of days with at least 1mm of precipitation, often known as the number of rain days. The time period for this study is one year. In the rcp2.6 scenario, more rainy days are projected than during the reference period, although by the end of the century, they should be decreasing in most grid cells as presented Figure 4-29. The same is shown for the rcp4.5 and rcp8.5 situations, excluding some grid cells. Figure 4-30 shows the time series plots of rr1 for the years 1981 to 2100. The number of rainy days will increase under all emission scenarios, but under rcp2.6 the increase will be greater.

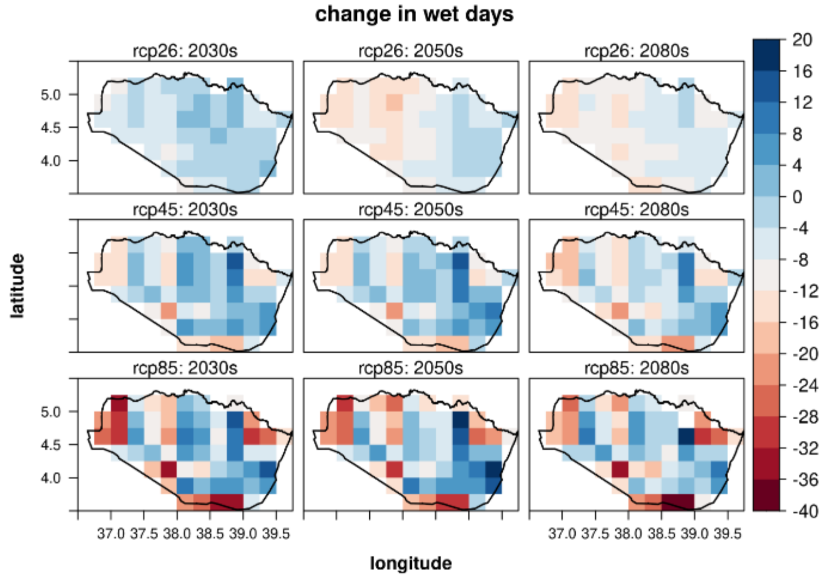


Figure 4-31: Projected Change (projected-observed) rr1 for future period under three RCPs.

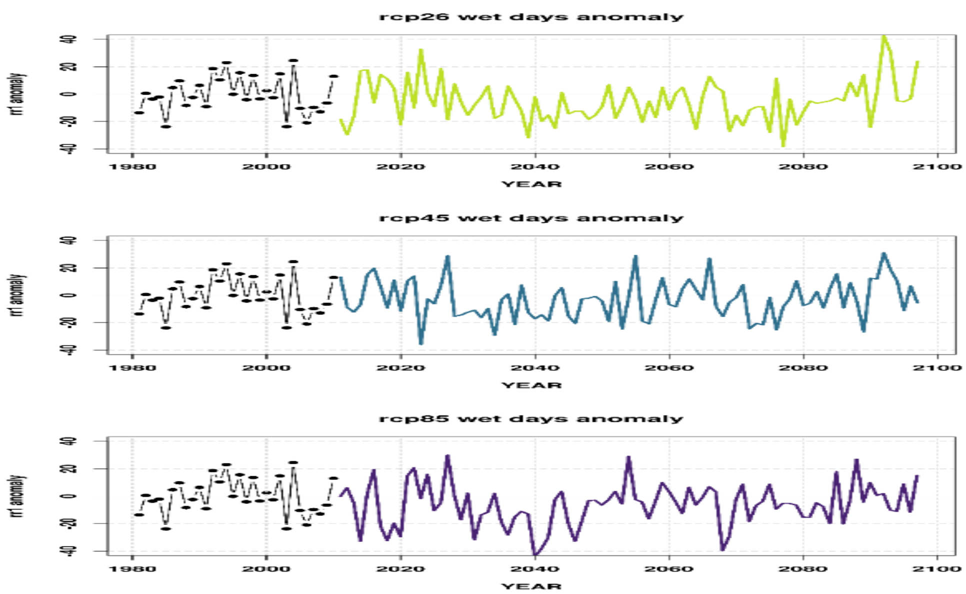


Figure 4-32: rr1 anomaly average of Borana historical period compared with future under three RCPs.

The average daily rainfall (rainfall intensity) for a certain time period is shown by the simple daily intensity index (sdii). By dividing the total amount of precipitation on wet days (days with > 1mm of precipitation) by the total number of wet days, it is calculated. *Figure 4-31* shows that the rainfall intensity index is projected to rise in the rcp4.5 and rcp8.5 scenarios, with barely any change under the rcp2.6 scenario. Figure 4-32 displays a time series of the same data, similarly, showing a steeper change under the higher warming scenarios.

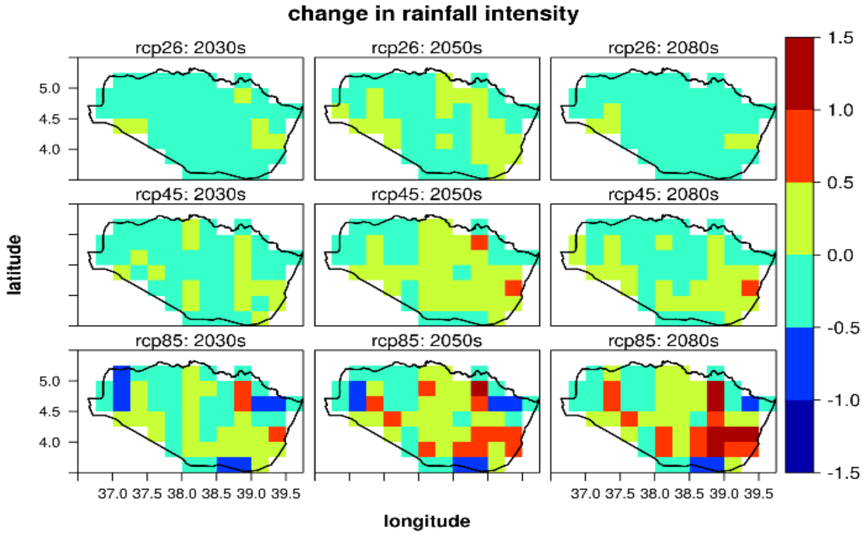


Figure 4-33: Projected Change (projected-observed) sdii for future period under three RCPs.

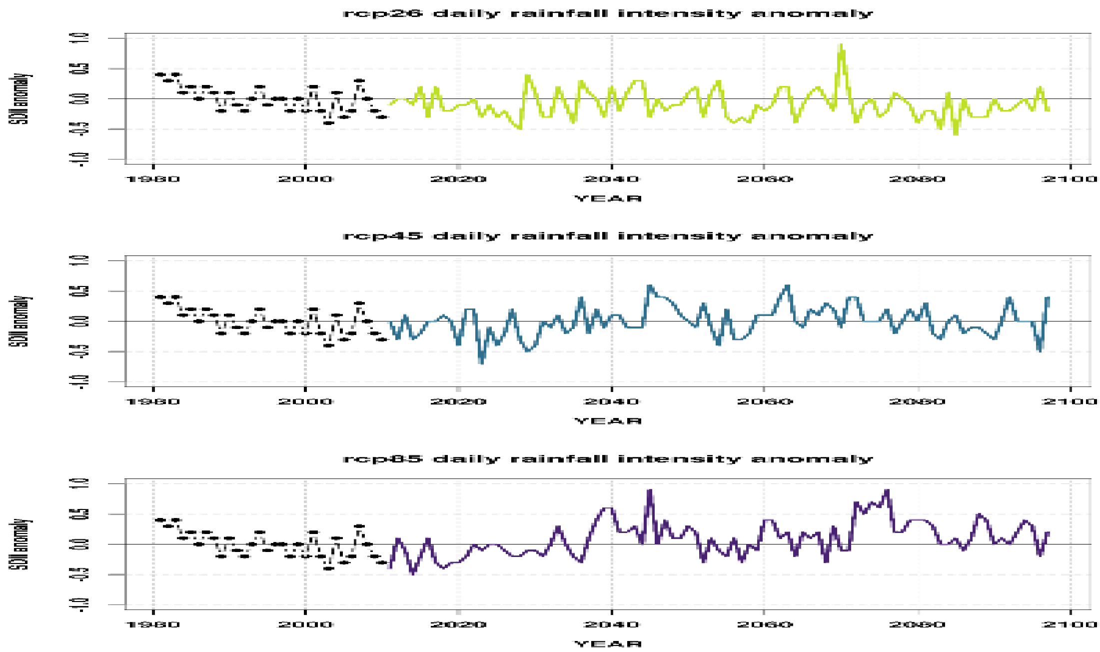


Figure 4-34: sdii anomaly average of Borana historical period compared with future under three RCPs.

Higher intensity of rainfall under higher global warming has been reported by the IPCC. More rainfall days, accompanied by higher intensity events could result impact activities that are rain dependent. This can also be seen in a reduction of cdd towards the end of the century.

CHAPTER 5: IMPACTS OF DROUGHT ON LIVELIHOODS AND FOOD SECURITY

5.1 Introduction

This chapter discusses the analysis findings from the household survey, qualitative research, and changes in land use and cover. The presentation aided in attaining the study's second objective, which focused on the effects of drought on rangelands, livestock, and other significant livelihood resources. The recent drought that pastoralists and agro-pastoralists in southern Ethiopia endured in 2016 and 2017 was used as a point of comparison to show the effect on the assets that support livelihoods at the household level. The sample household's socioeconomic profile and livelihoods were first discussed to set the stage for the findings. To complement the characterization, several drought impact aspects, analysis findings on changes in land use and cover are presented.

5.2 Socio-economic profile of the sample households

5.2.1 Demographic Characteristics of Sample Households

Most respondents to this survey (82%) were of the Borana (Oromo) ethnic group, while just 18% of the households were from the other five ethnic groups (Guji (Oromo), Konso, Gabra, Shewa (Oromo), and Burji). The age group of dependents made up more than half (55%) of the entire family. The Borana zone has an average dependency ratio of 147 dependents for every 100 working-age individuals, with individuals aged 0-14 and over 65 relying on the 15-64 working age group.

The average family size was five, and 16% of the households were headed by women.

Only 15% of respondents have some form of education, most often at the primary level, and the majority (85%) are uneducated or illiterate. Only 21 of the households that were surveyed (4%) have completed secondary or post-secondary education (college and university). Nearly all the respondents who had some forms of education were men. The demographics of the sample households are shown in Annex 11.

5.2.2 Livelihoods of the sample households

The main livelihoods for about 90% of the households were livestock or crop farming. According to Figure 5-1, just 5% of the households were predominantly involved in non-traditional activities such as non-agricultural trading, petty trading, casual labour, sales of charcoal and firewood and etc,

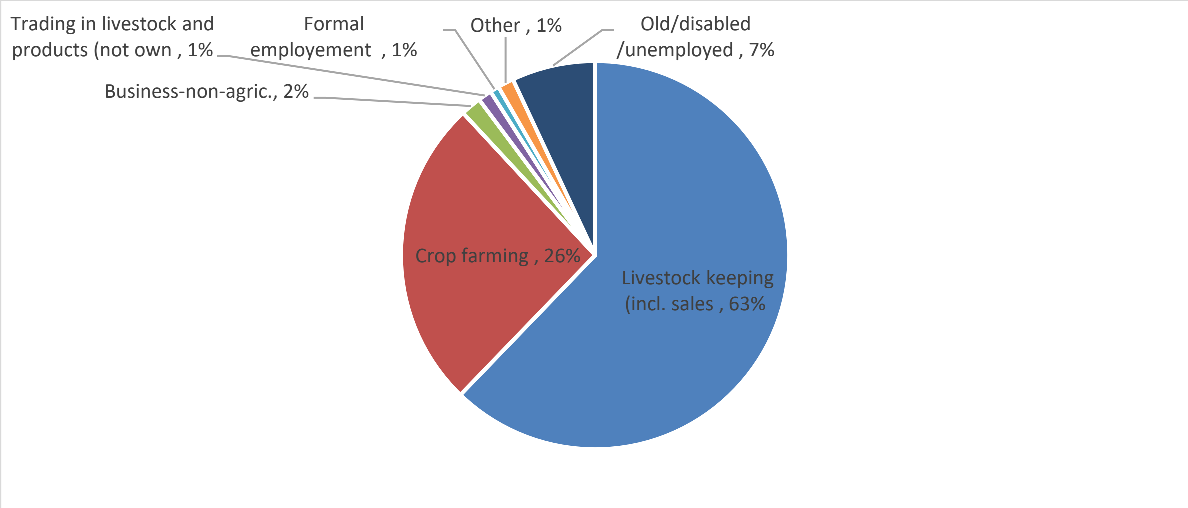


Figure 5-1: Relative importance of primary activities

The importance of livestock keeping to the sample household's livelihoods, as shown in Figure 5-2, is further confirmed by the contribution of sales of livestock and products to the household's annual cash income. The second largest source of cash income for households in the year prior to the study was assessed to be remittances or monetary gifts. More than 25% of households engaged primarily on crop farming for their livelihoods, but it only made up a small portion of total annual cash income (approximately 1%). Over half of the sample households (55%) had two or more sources of cash income, compared to four out of ten having one or no sources. The percentage of sample households with four to five different sources of income is only around 3%.

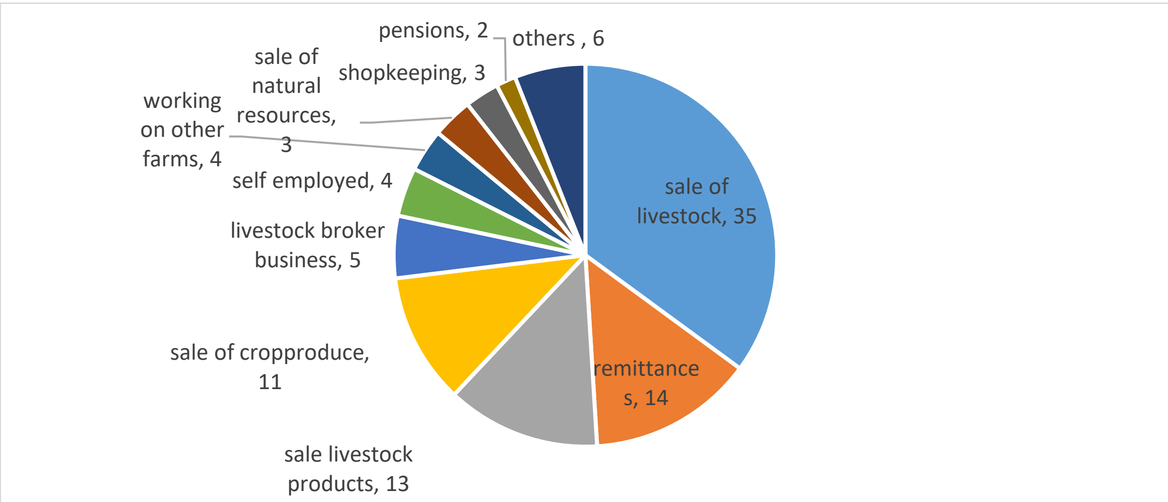


Figure 5-2: Household main sources of income and relative contribution of each (%)

Given the region's socioeconomic and cultural values, cattle continue to make up the majority of average households' livestock species composition. According to agro-climatic and socio-economic parameters, around 87% of the sample households' rear cattle exclusively or in combination with other species. Given that just roughly 12 % of the sample households own the three principal kinds of livestock in the area, known as "triple sweet milk animals," it has a less diversified production system. Furthermore, despite growing knowledge of camels' ability to withstand drought, only 17% of respondents said they owned one (a small number of heads).

The declaration of dry land farming practice was made by 56% of the 490 sample households (excluding missing values). Women make up 23% of those who responded and engage in this practice. Most survey participants cultivate a variety of crops to varying degrees. According to the analysis of crop diversification, 75% of respondents cultivate 2-3 crops, while 17% grow 4-5 crops. Sorghum, maize, and haricot beans are primarily grown for human use, while some respondents reported that haricot beans were grown for commercial purposes. Contrarily, Teff and wheat are primarily grown for their market value and to a lesser extent for consumption. The remaining crops include barely and horticultural and sparsely grown, mostly in southern agro-pastoral livelihoods zone (Hidilola).

5.3 Household's perception of drought impacts

The magnitude of the impact of the recent drought (2016–17) on several aspects of household livelihoods is assessed by households using a Likert scale, and the results are summarized in Figure *5-3*. The study utilized qualitative data from KI, FGDs, and LULC analysis to validate on the assessment of household perception.

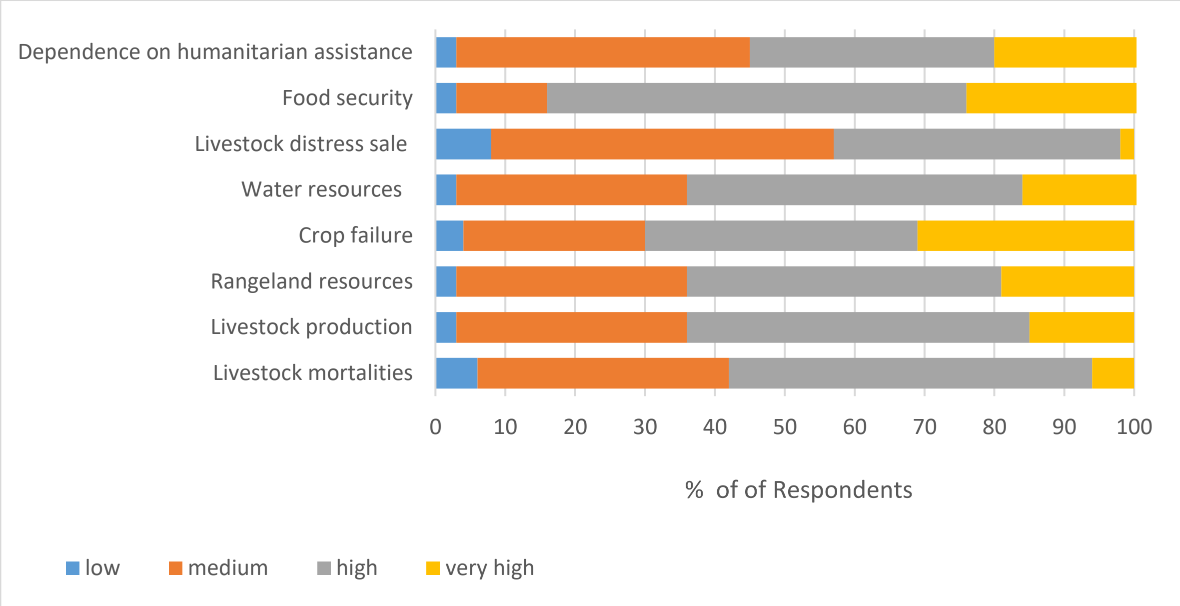


Figure 5-3: Respondent perception impacts of drought on Likert scale.

To make summarization and analysis of the data easier, the Likert scale data were further turned into a scale using the median value. The outcome of the analysis is shown in Table 5-1. Most respondents, or 51%, think that the drought has a high to very high impact on household livelihoods. Among the impacts ranked high to extremely high in comparison to other factors are the effects on crop production, food security, and water and rangeland resources. However, roughly 5 out of 10 respondents believe that the drought's overall effects are low to medium. Among low effect categories include withdrawing kids out of school, selling breeding animals, and emigrating young adults.

Table 5-1: Summaries of respondent perception drought impact (aggregate)

Significance of drought impact	# of households reported	% of households reported
Low	24	5
Medium	238	45
High	239	45
Very high	28	5
	529	100

5.4 Impacts of drought on Rangeland resources

Figure *5-4* illustrates the results of a perception analysis of the overall effects of the drought on water and rangeland resources. Most of the households believed that this essential resource would continue to decline throughout the drought, which would negatively affect animal production. A thorough knowledge of the causes of the reported decline and its effects was provided via qualitative analysis.

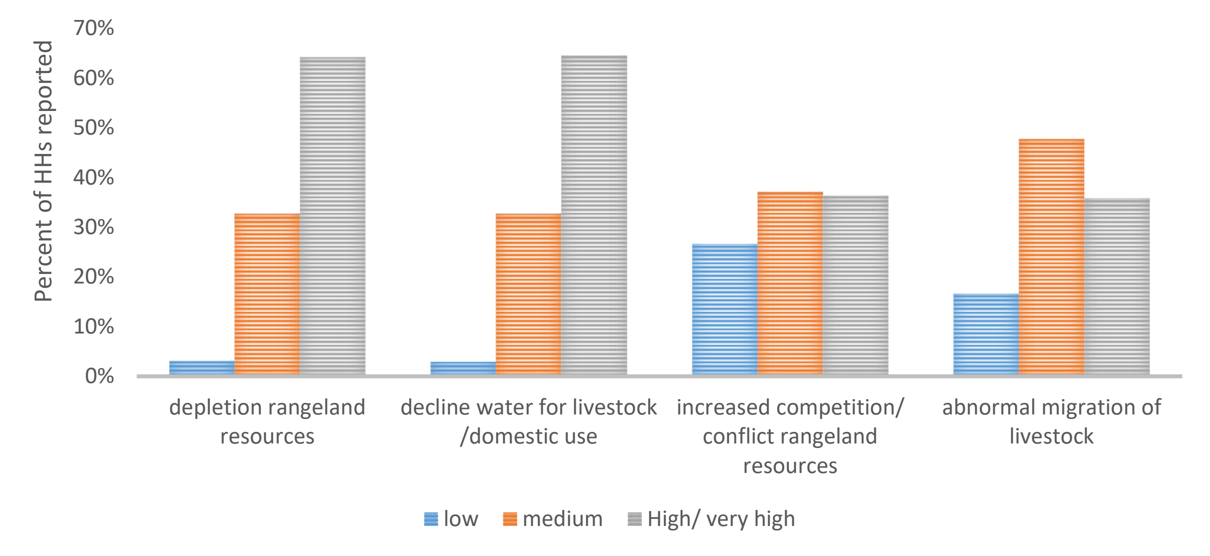


Figure 5-4: Respondent impacts of drought perception on water and rangeland using Likert scale.

Due to the shortening main rainy seasons, the amount of rainfall has decreased, and its distribution has become unpredictable, which has an impact on how much water replenishes ephemeral water structures like puddles, pools, and ponds. During the main rainy season, open surface ponds were the primary source of water for livestock among these structures (74% of the sample household). The high temperature that prevailed further increased the evaporation of the water that had been collected from these structures.

According to the local "Gofi" term, certain traditional spring-fed water sources are allegedly drying up because of shifting rainfall patterns, and some wells have reportedly completely disappeared (Balayi) because of hydrological dryness. Some of the "Addai" wells dried up as well and ceased to be able to supply water for people and animals. Water levels in permanent water sources frequently drop because of the recharge of wells, even deep ones. In times of drought, about 77% of households rely on traditional wells, including deep wells. Despite not mentioned as frequent, flooding has also contributed to the damage and siltation of some significant wells, rendering them inoperable.

The impact on the various water sources mentioned above has increased livestock keepers' reliance on permanent water sources and their need for increased watering interval as shown in Table 5-2. For instance, livestock keepers quickly exhaust the "limited" surface water obtained and become dependent on permanent water sources (such as traditional wells) earlier than is typical. In other communities, access to permanent water sources for a longer period required significant treks by livestock, which had an impact on watering frequency. The deep well water levels are dropping, which further restricts livestock access to water sources or necessitates increased watering interval.

Table 5-2: Comparisons of livestock watering time from permanent water points

	Main rainy season (Genna)		**Short rainy season (Hagaya)**	
	Past	Current	Past	Current
Starting time of Watering of livestock from permeant water points	Mid-June	End of April	End of Dec	Mid Nov

Animals exposed to trypanosomiasis (locally known as "Luta" or "Awarsa") due to physical weakness and loss of disease resistance (immunocompromised) during drought years because of the lack of feed and water compel them to travel large distances.

The LULC analysis below indicates that during the late 1980s, the study region has gradually lost grassland covering and the accompanying pasture grasses. Drought makes the already limited availability of feed resources worse. The key informants further substantiate this. Sometimes, because of this condition, livestock are forced to eat feeds that are not typical of their normal diet. For instance, informants have noted that cattle increasingly graze on browsing plants and some fodder trees because of the disappearance of native grasses. In times of extreme scarcity (hunger), cattle eat unappealing feed like green bushes and Forbes mixed with soil. As a result, many cattle succumb to gastrointestinal problems locally known as "Sombesa Bella," which appears as pica. It is said that during droughts, this behaviour is common.

Due to the extreme lack of pasture during the drought, livestock in Arero that are particularly close to patches of forest have been seen feeding on some of the forest's trees. Respondents alleged that they exposed livestock to GANDALE, an unnamed disease that may have been caused by a toxin.

5.5 Land use and land cover change (LULC)

Ten-year interval maps of land use and cover change were produced from 1990 to 2020 based on the classification. In addition, 1985 served as the analysis's base year. Figure *5-5* below, from left to right, shows the baseline and current period LULC maps. Additionally provided in Annex 10 are the remaining reference period maps. Due to problems and the fact that they reflect the same in some locations, the woodland and bushland classes were combined into one class in the final LUCC analysis.

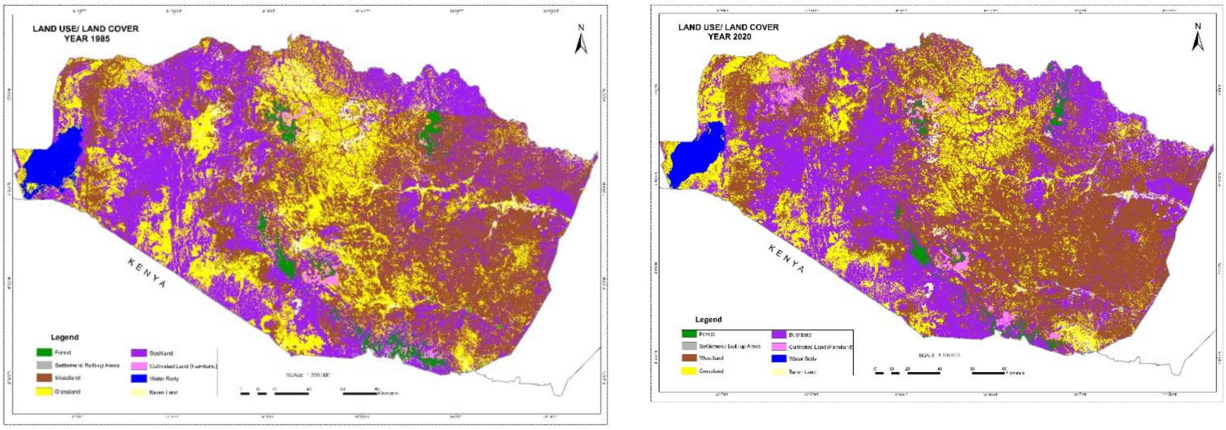


Figure 5-5: LULC maps of the study area for baseline and current reference period

Table 5-3 summarizes the land use and change area in square kilometres from the raster dataset's attribute table using the pixel count from 1985 to 2020. Graph 5-6 display the primary and secondary land cover classes in the research area along with historical trends in terms of square kilometres covered.

Table 5-3: Summary of land use and land change (LULC) of area from 1985-2020

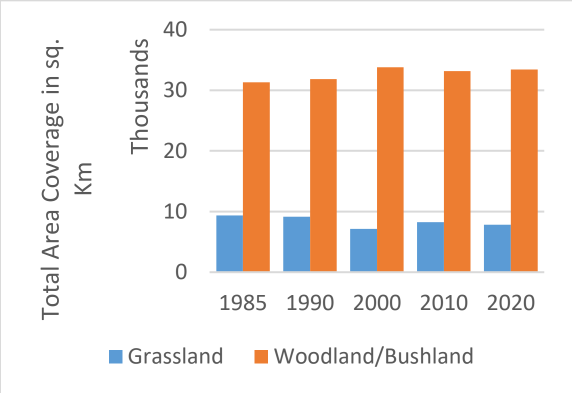
LULC classes	Total area coverage in sq. Km				
	1985	1990	2000	2010	2020
Forest	816	764	643	609	603
Settlement Built-up Areas	20	21	25	29	32
Grassland	9,361	9,176	7,152	8,232	7,825
Woodland/Bushland	31,307	31,838	33,796	33,192	33,456
Cropland	246	304	290	323	475
Water Body	867	904	875	776	782
Barren land[6]	1,413	1,022	1,249	868	855
Total area	44,030	44,030	44,030	44,030	44,030

The water body is also gradually declining, most likely because of some ephemeral or seasonal water structures disappearing because of hydrological drought and siltation. The percentage of total area covered by the barren land class is falling. Because the affected area was so small and patchy, it was challenging for Landsat to capture degraded areas and gullies. This helps to explain the unexpectedly considerable decline in barren land that occurred in the years following 2000.

A consistent drop in the forest class has also been seen over time, with an early rate of loss being more pronounced (0.4-0.5% each year). It is thought that the gradual loss of forestland in Borana's Miyo, Arero, and Yabello pockets has been a factor. The KI emphasize the forces

[6] Barren land: A land cover/use category used to classify lands with limited capacity to support life and having less than 5 percent vegetative cover according to United States Department of Agriculture (USDA)

and pulls of deforestation in Borana. One of the driving forces behind the current deforestation is the increased need for timber[7] to build homes for the region's expanding urban population. According to key informants, limited livelihood options and rising poverty are the driving forces for increased deforestation.



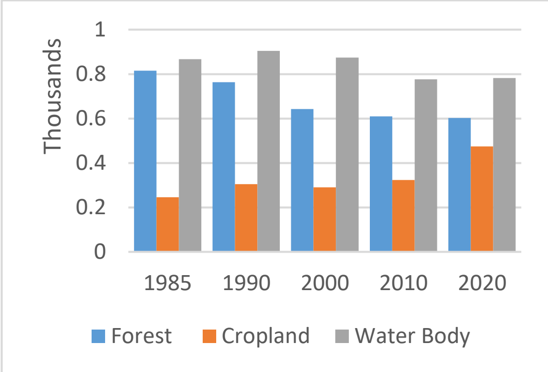


Figure 5-6: Dominant (left) and secondary (right) land cover classes in the study area

When compared to the percentage of the overall area, the area covered by wooded and bushland has significantly increased, especially in the late 1980s and early 1990s (4–5% every year). On the other hand, the grassland had a significant decline of 3-3.5% year throughout the same period. Given the once-open savannah grasslands that were now overrun by undesirable bushes, the dramatic increase in bushland was not unexpected. Oba (1998) estimates that 82.8% of the Borana rangeland's landscapes face bush invasion, with 24.1% of those already reaching the bush climax. The LULC research indicates an overall increase in wooded area and bushland, while key informants say there has been a decline in woodland. There is a steady loss of some acacia species due to ongoing land-use change, which has a variety of negative effects on their ability to provide feed, shade, and regulate the local microclimate (thereby sequestering carbon). One of the reasons given by KI for the decline in woods is the increasing involvement of poor and destitute households in crop farming, charcoal production, and firewood sales due to a lack of alternative economic alternatives in urban and peri-urban centers. It is believed that the tendency will continue until the stakeholders successfully solve the development challenge of poverty.

Due to the scarcity of such valuable fodder trees, pastoralist conservative practice of only using branches of these trees during drought or for other purposes to allow regeneration to have been

[7] Timber has been and is still the main means of house construction in Borana zone.

noted to be less common. Reduced availability of fodder trees and weakened fodder tree utilization and management practices were results of the bush encroachment control measures, particularly non-selective bush clearance, that were supported by many parties. During times of severe feed shortage and drought, valuable acacia species like Acacia tortilis (Urbu) and Acacia nilotica (Burkuke) can be used as sources of food. On contrast, Acacia mellifera, Acacia reficiens, and Acacia nubica are regarded as encroachers on the rangelands (Coppock, 1994). The herders claimed that bush encroachment caused the grazing land and its quality to drastically decrease. Therefore, grazers (cattle) are more vulnerable to feed shortages or depletion than browsers (camels, sheep, and goats).

The rate of growth for settlement areas and cropland over time, respectively, has been 0.5 and 0.4%. The growth in settlement is noticeable in the forthcoming urban centres, particularly along the roadways (accessible area). It is significant to note that tiny farms and homestead were challenging to find because of the image resolution. Over time, some of the bushland in the Dire and Teletele districts was turned into cropland. The Elwaya district has experienced a greater increase in cropland.

The increasing patterns of settlement, cultivation, and related clearing and bush encroachment have contributed to the loss of grassland cover. Qualitative investigation that points to a notable decline in grassland and the disappearance of several valuable grass species from rangeland support each other. This observed decline is the result of several different processes. The study revealed that climatic conditions, including frequent droughts, often resulted in insufficient rainfall and soil moisture during period of pasture growth. Due to its strength, the rainfall also had rapid runoff and poor soil permeability (soil is still dry). A decrease in soil moisture was also a result of the raising of the temperature and the corresponding rise in evapotranspiration. The early-stage productivity and reproduction of the grassland are further hampered by livestock grazing on it continuously. The rangelands experience reduced maturation and seed shedding, two essential processes for the spread and expansion of pasture. As a result, it has been claimed that several of these precious species have over time either been disappeared or have become extremely rare. Localized overgrazing and degradation were caused by livestock movement and concentration to areas with richer pasture and rainfall due to irregular pasture distribution. Table 5-6 present some of the endangered perennial grasses species in Borana rangeland collated from KI.

Table 5-4: Endanger perennial grasses species in Borana rangeland.

Type of grass species (vernacular name)	Scientific name	Quality (characteristic) / nutritive value	Status
Ogoondhicho	*Pennisetum mezianum* (Bamboo grass)	Tolerant to high temperature	Highly Scarce
Sokorsa	*Panicum ruspolii*	Tolerant to high temperature	Highly Scarce
Alaalo	*Chrysopogon aucheri*	Tolerant to high temperature High nutritive value	Highly Scarce
Gaguro	*Themeda triandra*	Better nutritive value Tolerant to high temperature	Disappeared from communal land, found in some enclosure
Metegudasa	Cenchrus Ciliaris	High nutritive value Less tolerant to high temperature	Highly Scarce
Sardo	*Digitaria milanjiana*	High nutritive value Less tolerant to high temperature	Highly Scarce
Bukicha		Less tolerant to high temperature	Highly Scarce
Sericha	*Heteropogon contortus*	Very less tolerant to high temperature	Highly Scarce

Source: Key Informants Interview

5.6 Impacts of drought on livestock production and productivity

Over 60% of the sample households ranked the effects of the drought as very high to high in terms of how it affected livestock production and productivity. The drought-related drop in the availability of water and feed resources, which was previously mentioned, is thought to have negative effects on livestock's ability to meet their physical and physiological needs. The herd had a low conception rate, according to a key informant, even pregnant animals experienced stillbirths or abortions because of the drought. According to the local vet, there are a lot of goat and camel abortions in the area because of heat stress and a lack of nourishment.

The acute lack of feed during a drought has a substantial impact on lactating animals' ability to produce milk. The young and pre-weaning claves have little milk to nurse on and little nourishing forage at this young age. The loss of colostrum—the nutrient-rich first milk, locally referred to as "sila"—from lactating cows is thought to have an impact on calf mortality and morbidity even in years with acceptable diet quality. Poor nutrition significantly impacts the development, quality, and production of the next generation of a breed, despite sharing the same genetic heritage.

The Table 5-5 below summarizes key informant comparisons between indigenous cattle from Borana and neighbouring communities (Jem-Jem breeds) based on the most important criteria. However, Borana cattle breed is in danger because of several issues, including frequent droughts, a lack of organized selection and breeding programs, and dilution with other breeds (Assefa and Hailu, 2018). To make use of the few resources available during hard times, Borana pastoralists frequently travel and settle among Konso, Guji, Burji, Hammer, and Erebore. According to KI, this drought-related movement was the primary cause of interbreeding and had an impact on the production and productivity of the Borana cattle breed. The genetic dilution was also influenced by market exchanges between nearby settlements, especially during herd replacement or reconstitution following a drought.

Table 5-5: Comparisons of indigenous cattle of Borana and Jem-Jem breeds

	Korti (Borana breed)	**Geleba (Ayuna)- Jem-Jem breed (neighbouring communities)**
Feed requirement	High (sabdi)	Not that high as compared to Korti
Susceptibility to drought	High (particularly cows because of high feed and maintenance requirement.	Moderate compared to Korti Drought resistant
Body conformation	Physical body conformation good	
Productivity	High milk production and meat (beef Caracas. High quality hide (heavy)	Milk and meat production are limited
Market price	High	Limited market value as compared to others / demand low
Area the breed predominant	Moyale / Arero –Wayama- Negelle	Konso / Guji / southern nations

Source: Key Informants Interview

Impact on fertility/reproduction: The average age that female reproductive animals, such as heifers and camels, achieve "puberty age[8]" has increased in recent years due to changing climatic conditions as shown in Table 5-6. In the past, the majority of the herd's heifers reached puberty at 3–4 years of age (on average), and then became pregnant for the first time. Depending on the pasture, water, and climatic conditions, the fastest one can become pregnant as early as 3 years old. However, in recent time, the ability of reproductive animals to conceive is unpredictable and constrained by the prevailing climatic conditions. Heifers' first conception will occur after about 5–6 years. Like this, camels' average fertility attainment age has increased from 3 to 4-5 years. Although ruminant reproduction was unaffected, illnesses posed a challenge.

Table 5-6: Comparisons of average age of first conception of livestock

	Past	Current
Heifers	3-4 years	5-6 years
Camels	3	4-5 years
Goats/ sheep	No significant change	

Source: Key Informants Interview

[8] Puberty is defined in heifers as the time when they first ovulate and show an estrus or heat period.

5.7 Impacts of drought on livestock assets

5.7.1 Livestock mortalities estimate by species.

Livestock mortalities were one effect drought in 2016 and 2017. The mortality rate (in percentage) is calculated using the reported number of animal deaths (by species) by households as compared to livestock holdings before the drought. To calculate the total mortality rate, the average statistics from the household level were then combined to the area level. As shown in Table 5-7, the typical sample household is thought to have lost 50% of its cattle (55%), 25 % of its small stock (23%), and 20% of its camels (19%) primarily because of drought.

The excessive livestock deaths were primarily attributed to malnutrition and dehydration because of severe pasture and water shortages during the drought. In their study of livestock mortalities in Ethiopia, Catley *et al*. (2014) concluded that malnutrition and dehydration were the primary causes of excess livestock mortality in Borana during the drought.

Table 5-7: Descriptive statistics of livestock mortalities in 2016/ 2017 drought by species

	n	Mean	Median	SE	Range
cattle	491	0.55	0.56	0.01	0-1
sheep /goats	420	0.23	0.18	0.01	0-1
camels	90	0.19	0	0.03	0-1

According to a household survey and an analysis of key informants, cattle were the most susceptible to drought-related fatalities, followed by sheep, goats, and camels as shown in Table 5-7. Old stock, calves, and cows were the first animals to perish in a drought. Compared to dry cows and heifers, milking cows were more vulnerable to drought-related deaths as mean mortality rate in Table 5.8 demonstrates.

Table 5-8*:* Descriptive statistics of cattle herd mortalities in 2016/ 2017 drought

	n	Mean	Median	SE	Range
bull / oxen	491	0.19	0.17	0.01	0-1.0
cows	491	0.21	0.19	0.01	0-1.0
heifers	491	0.06	0.00	0.00	0-0.6
immature male	491	0.04	0.00	0.00	0-0.36
calves	491	0.15	0.13	0.01	0-0.6

5.7.2 Household’s livestock inventory

Before the 2016–2017 drought, pastoralists and agro-pastoralists in the research area owned, on average, 20, 15, and 1 cattle, goats/sheep, and camels, respectively (see Table 5–9). The entire value of this holding is around 17 TLUs. TLUs are a reference unit that make it easier to combine livestock from different species and age groups into a single unit. For camels, cattle, and small ruminates, conversion factors of 1, 0.7, and 0.1 by Hoste and Houerou (1977) were used in this study based on recognized coefficients derived from each species' nutritional or feed requirements.

Before the drought, the typical household's species composition consisted of around 84% cattle, 12% sheep/goats, and 4% camels, respectively, of the total TLUs. TLUs were used to calculate the species and herd composition (ratio) from the heads of animals. Following the drought, sample households' average numbers of camels, cattle, sheep/goats, and TLUs declined by 64, 49, 33%, and 61%, respectively. Cattle still make up around 77% of a household's species composition, followed by sheep/goats and camels with 17% and 6%, respectively, after the drought. As demonstrated in the table, the mean holding has improved recently, but it is still far from its pre-drought level.

To determine statistical significance, a paired-samples t-test was used to compare the mean livestock holding including TLUs before and after the drought. According to the results shown in Table 5-9, there was a substantial difference in the livestock statistics for the three reference periods in each case.

Table 5-9: Households mean livestock holding for three references period.

	before drought	after drought	Current	change after Vs before	change after Vs current	t (df)	P-value
Mean # of cattle	20.3±0.9	7.3±0.5	8.5±0.5	-64%	16%	22.31 (528)	<0.01
Mean # sheep and goats	14.6±0.7	7.4±0.5	8.1±0.5	-49%	9%	21.08 (528)	<0.01
Mean # camels	0.9±0.1	0.6±0.1	0.6±0.1	-33%	0%	5.27 (528)	<0.01
Mean TLU	16.6±0.7	6.4±0.4	7.4±0.4	-61%	16%	22.9 (528)	<0.01
Total TLUs	8781	3411					

n=529

A comparison of the number of households and the number of different species of livestock owned before and after the drought shows the influence of the drought on livestock holding at the household level. For instance, households without any cattle, or stockless, or Qolle as they are known locally, have increased following the drought, largely because of the mortality caused by the drought, as seen in Figure *5-7*. These households struggled to make ends meet by cultivating crops, selling firewood, and engaging in other opportunistic income-generating activities in addition to continued humanitarian aid (83% of these households were recipients of the safety-net program run by the government).

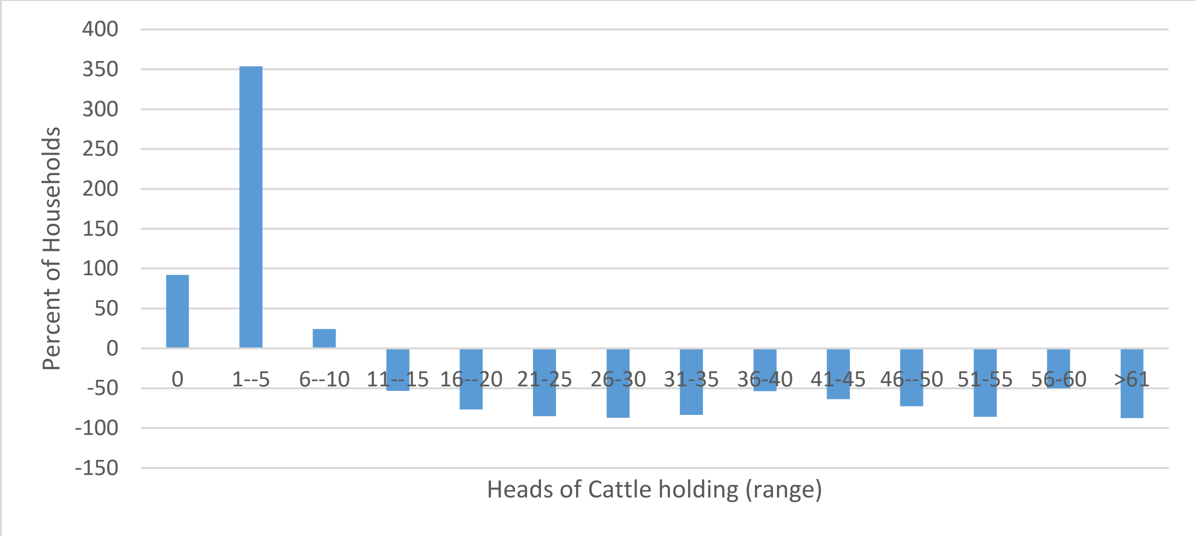


Figure 5-7: Comparisons of percent of household's cattle holding before and after drought

When comparing the pre-drought figure to the post-drought number, livestock holding in the lower holding category (less than five heads of cattle), which is frequently regarded a poor (Iyyessa) wealth group, has also increased 3.5 times in Borana. After the drought, the second level of the lower wealth band also grew, but more slowly. As shown in Figure 5-7, the relative higher wealth band (more than 11 heads of cattle) had a fall of 25–100%. Similar trends were seen for all TLUs held, as shown in Figure 5-8.

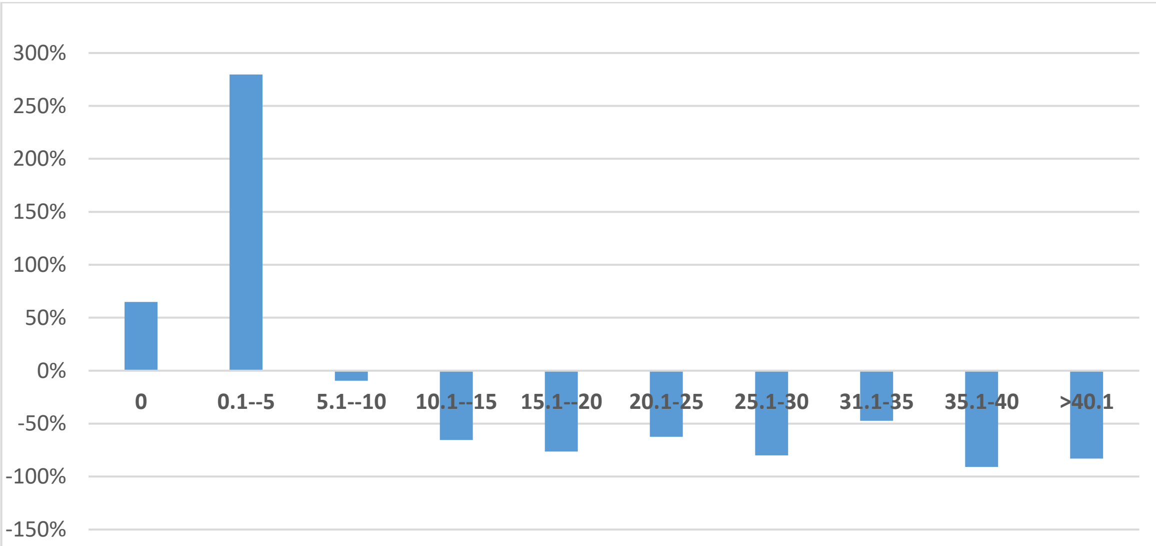


Figure 5-8: Comparisons of percent of household's TLUs before and after drought.

5.7.3 Economic losses estimation in monetary values

The estimated number of livestock by species held by those households before to the drought was multiplied by the mean livestock mortality rate to get the total number of dead livestock by species for sample households. The estimated dead livestock is multiplied by the current average unit price for cattle and the long-term price for goats to get the economic loss in monetary values for the sample households. The price information was obtained from the Inter-agency drought impact assessment study (Borana zone, 2017).

The proportion of cows in the sample household's total cattle herd that were killed during the drought and the amount of milk and butter lost as a result were estimated. According to CSA, 2000/2001 and PAGOT (1993), a herd's total number of cows is around 60% milk producers each year. The estimation of milk production also included the use of production parameter data from a milk value chain analysis carried out in Borana (CARE-Ethiopia, 2009). Calculated from the evaluation report (IGAD, 2017) and direct communication, the estimated milk loss in lost litres times the current market price. It is expected that shared insurance will provide 10.5% of the total livestock value lost in the region (IGAD, 2010).

In 2015, the Borana zone's estimated population was 718,000 (or 120,000 households), with an average family size of six (Borana zone, 2018). By excluding the urban population, the number of pastoral and agro-pastoral households will drop to 101,600. To calculate the total financial losses due to the drought in Borana, multiply the average loss per family by the projected pastoral and agro-pastoral HHs. Table 5-10 summarizes economic losses per household, per capita, and at the level of the research area in local money (EB) or equivalent in USD (1 USD equalled 22.6 Ethiopian Birr in 2016).

Table 5-10: Drought induced livestock asset losses and monetary value estimation.

	Cattle	Goats /sheep	Camels	Total in EB	Total in USD
Total value of lost livestock in EB	23,159,520	1,157,429	951,900	25,268,849	
Value of lost from milk / butter (EB)	6,114,016	32,048	1,216,060	7,362,124	
Shared Insurance Values lost (EB)	2,431,750	121,530	99,950	2,653,229	
Total loss	31,705,286	1,311,007	2,267,910	35,284,202	
Loss per HH	59,934	2,478	4,287	**66,700**	**2,951**
Loss per person	9,989	413	715	**11,117**	**492**
Total loss for entire Borana	6,087,414,835	251,713,353	435,438,624	**6,774,566,812**	**299,759,593**

Drought has caused financial losses totalling an average of 2951 USD for the pastoral and agro-pastoral HH in Borana. For the research area, this resulted in an estimated $300 million USD in overall financial loss.

5.8 Impacts of drought on livestock diseases

According to the household disaster risks ranking order (Figure 4-15), livestock disease was the fourth largest production risk. In the Borana zone, a biological disaster caused by a livestock disease is the second most frequently recorded incident after a drought (UNDRR, 2016).

Among the persistently reported animal illnesses include anthrax, Black Leg (Black Quarter), Contagious Caprine Pleuropneumonia (CCPP), Haemorrhagic Septicemia (HS), Lumpy Skin Disease (LSD), Sheep and Goat Pox, and Unknown Camel Disease.

One of the effects of the drought that a quarter of the HHs reported as being high was stillbirth or abortion. It is common for goats and camels in the area to have abortions, which are linked to heat stress and made worse by a lack of feed. Stress frequently lowers an animal's immunity, which makes animals more susceptible to opportunistic illnesses. The other prevalent disease during a drought when feed scarcity was severe was foot-and-mouth disease (FMD). A locally recognized disease known as "Diga finchasa" was also observed in a specific area and was reportedly linked to animals feeding “undesirable" fodder (which contained some chemical component) during a drought.

One of the newly emerging and unnamed diseases that predominated in some patchy forest was "Gedela." This disease has been seen to occur during drought and is linked to grazing on green plants called Gedela in the forest, which are suspected of being poisonous. According to local veterinarians, the infections were seen in donkeys and goats and led to paralysis.

Figure 5-9: suspected poisons plant (Gedela) and infected ruminants
Credit: Dr. Garu Lolo, Yabelo Lab Branch PPR Project coordinator**.**

The other newly emerging disease, which primarily impacted camels and other ruminants, are commonly known as "mysterious/unidentified camel disease" and have been widely reported throughout Borana. The disease primarily affects adult camels, which die suddenly despite having no clinical symptoms. According to the local vet, Kenya, and Somalia, which are in the Horn of Africa, are also affected by the disease, which is particularly common in camels. Between 2005 and 2007, camel deaths were reported in numerous nations, including Ethiopia, at an extremely high rate. The quest to identify the diseases has been ongoing for some time, with samples being submitted to national laboratories and outside (UK), but the disease's diagnosis is still difficult. A mysterious camel disease outbreak has been reported

in Kenya, Ethiopia, and Somalia's borders between May 2020 and May-June 2021.
IGAD Centre for Pastoral Areas and Livestock Development (ICPALD) held a virtual regional meeting on July 5, 2021, with technical teams from various countries to address the issue. A road map was developed for both immediate and long-term detection and management of the disease.

The other emerging ruminant disease is reported frequently and extensively in the area. This disease is suspected to be Nairobi sheep disease based on experience from south Omo suspected to be related to tick-borne diseases. The regional lab and vet team was recommending strengthening the tick control measure. A sample was also sent to a national lab without any recourse.

5.9 Impacts of drought on crop production

The high degree of climate variability and drought make dry land farming a particularly risky endeavour. One of the perceived effects of the drought is widespread crop failure, which is assessed as high and extremely high by roughly 70% of the respondents. The 2016–2017 drought is regarded by the KI as one of the worst in recent memory in Borana since the early 1960s. The dekal NDVI anomaly lends more support to the KI assessment of the severity of the drought. Determine the degree of crop failure by comparing the average area planted by respondents with various crops and their corresponding yield for two main growing seasons (Genna) during the drought period (Table 5-11).

Table 5-11: comparisons of area cultivated and harvest for main season of 2016-17

	n	Genna 2016		Genna 2017	
		Mean cultivated area / hh in timad[9] ±SE	Average yield / hh in quintals ±SE	Mean cultivated area / hh in timad ±SE	Mean yield / hh in Quintals ±SE
Maize	265	3.4 ± 0.13	2.8 ±`0.16	2.7 ± 0.15	1.6 ± 0.15
Sorghum	64	2.2 ±0.2	2.1 ±0.24	1.8 ±0.24	1.1 ± 0.22
Teff	109	3.5 ± 0.23	2.9 ±0.29	2.7 ±0.23	1.4 ±0.28
H.Bean	218	2.7 ± 0.13	1.9 ± 0.13	2.2 ±0.13	1.1 ± 0.12
Wheat	30	2.8 ± 0.41	2.7 ± 0.83	1.6 ± 0.41	0.8 ± 0.29

Due to a lack of labour, ploughing power, and other resources, the sample households' cultivated land shrunk by roughly 15-20% in the second year of the drought. As a result of the reduction in planted area and overall effects of the drought, the yield was also substantially reduced by 40–50%.

[9] *Timad* is locally used *unit* to *measure area* of *land* and equivalent to 1/6 of hectare or 1667 square meter. Crop production statistics collected using this unit for easy of understanding and later converted to SI unit.

5.10 Food security analysis

As was previously mentioned, one of the most significant effects of the drought that households perceived was food insecurity. To support the claims of the households with empirical data, the food security condition of the sample households was further examined using common food security indicators. Indicators that are frequency-based and experiential are used to assess the results of food security. The household data were used to calculate the Food Consumption Score (FSC), Household Dietary Diversity (HDD), Household Hunger Scale (HHS), Livelihood Coping, and Reduced Coping Strategy Index (rCSI). These were compared to the Integrated Food Security Phase Classification (IPC)[10] reference table's internationally recognized thresholds.

The IPC household reference table, which provides qualitative, graded descriptions of the five acute food insecurity phases as well as thresholds for important household-level outcome indicators, is used to classify the severity of acute food insecurity. The outcome indicators and phase categorization listed below represent a snapshot analysis of acute food insecurity as of the survey period in July/August 2019 based on the convergence of the outcome indicators in the study area. To assess the situation during the 2016–2017 drought patterns of food insecurity, the research additionally collected information on the level of humanitarian assistance in the region and estimates of populations with acute food insecurity.

Food Consumption Score (FSC): is a composite number based on dietary variety, frequency of food consumption, and the relative nutritional content of various food groups. The frequency of consumption of several food groups by a household over the course of the seven days preceding to the survey was used to calculate the FCS. Each household is classified as having poor, borderline, or satisfactory food consumption depending on its score, which were clustered into three categories (28 or less, 28 to 42, or greater than 42).

[10] The Integrated Food Security Phase Classification (IPC) is a set of tools and procedures for classifying the severity of chronic and acute food insecurity across geographic areas and time using a convergence of available data.

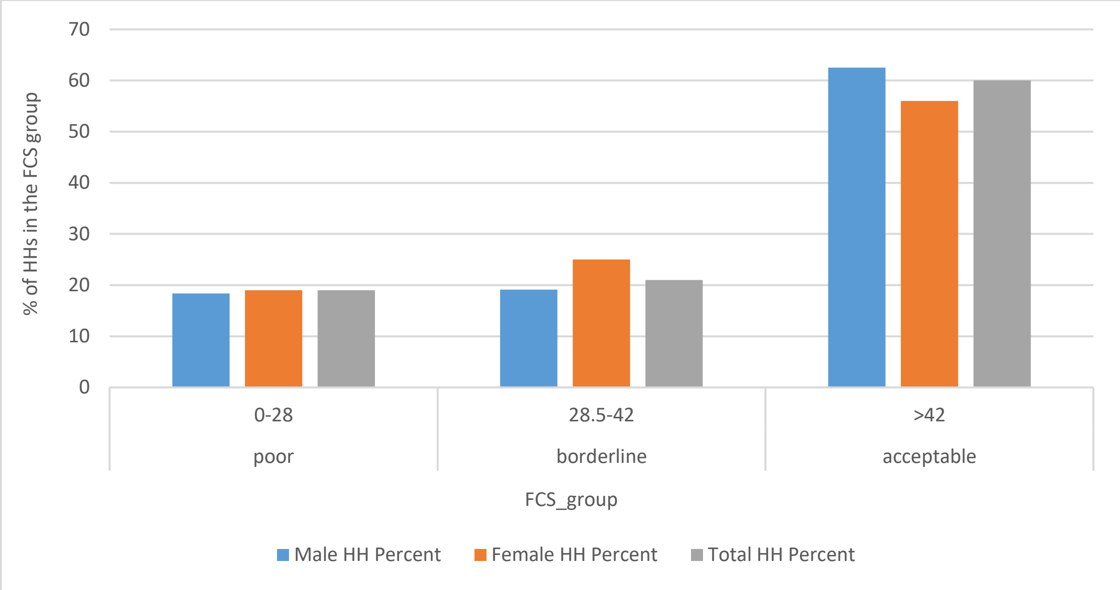


Figure 5-10: Food Consumption Scores of sample household August 2019

About 40% of the sample families fall into FCS groups that are either poor or borderline, which involves consumption gaps to meet calorie requirements and diet quality with the typical production system. In comparison to male households, female households tend to have a somewhat lower FCS, which suggests that access to food was a problem at the time of the study. Cross tabulation and Chi-square statistics, however, show that there was no statistically significant difference in FCS between the male and female households (Pearson Chi-square test P-value of 0.321). As the validation studies show FCS and HDDS associated with caloric intake (Coates *et al.*, 2007; Weismann *et al.*, 2009), the two groups of households do not differ in terms of their calorie intake and food quality.

Households Dietary Diversity Scores (HDDS): Dietary diversity is assessed by the number of distinct food groups (out of 12) consumed over the course of a 24-hour period. Only roughly 8% of the sample households had medium HDDS (5–6 food groups), whereas 92% of them had low HDDS. As Chi-square statistics was not significant (Pearson Chi-square test P-value 0.548), there is no difference between male and female households in terms of their HDDS. The sample household eats a less varied diet in general.

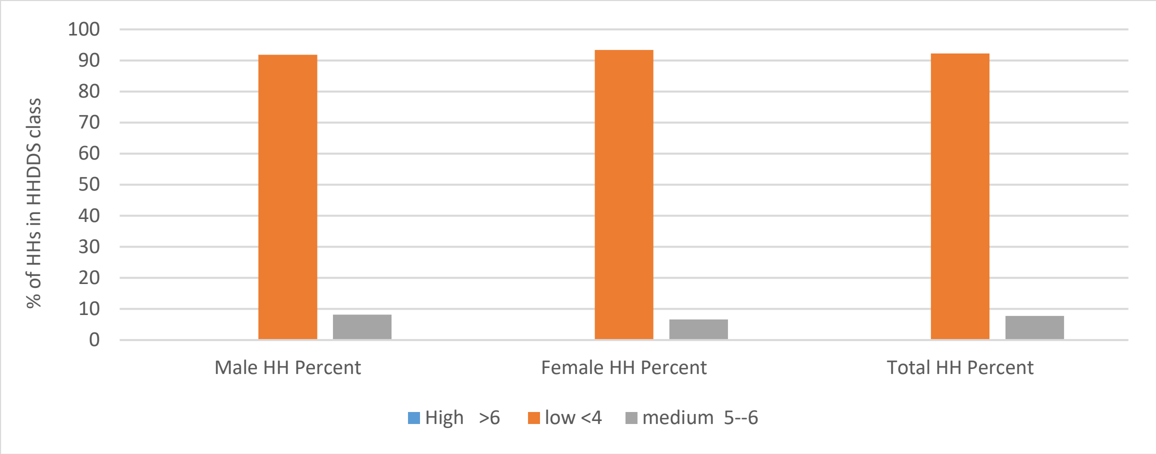


Figure 5-11: Household Dietary Diversity Score (HDDS) of sample household August 2019

Household Hunger Scale (HHS): is a behavioural (severe one) measure for assessing excessive hunger in households. The HHS is made up of three variables and three frequencies that, when used in a population-based household survey, enable estimation of the proportion of households that experienced three different levels of household hunger over the previous month. In the month preceding the study, two out of every ten households claimed to have experienced moderate to extreme hunger. The HHS of male and female households are same because the Chi-square statistic was not significant (Pearson Chi-square test P-value 0.444).

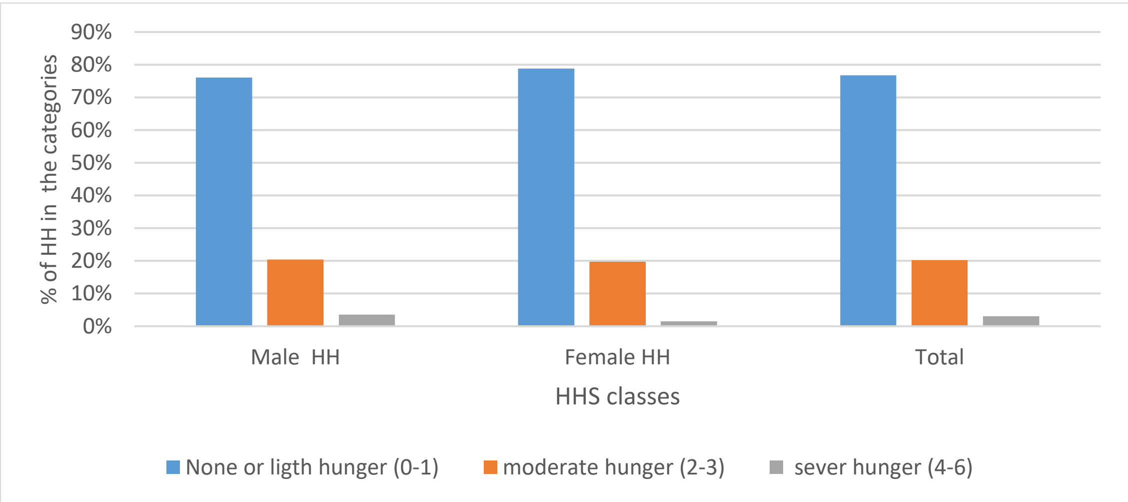


Figure 5-12: Household Hunger Scale (HHS) of sample household August 2019

The Coping Strategies Index (CSI) is a behavioural indicator of family food security based on a wide range of responses to the question, "What do you do when you don't have enough food and don't have the money to buy food?" When a household does not have adequate resources, they may adjust their food consumption habits, cut costs, or increase their income. Five common techniques and weights form the foundation of the Reduced CSI. The information below relates to food-based coping strategies.

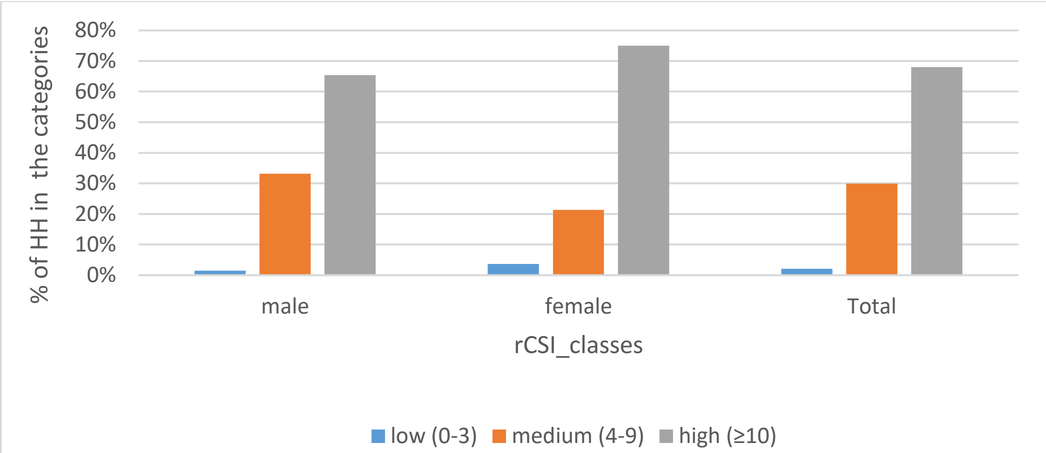


Figure 5-13: Reduced Strategies Index (rCSI) of sample household August 2019

When households did not have enough food or money to buy food in the week prior to the study, about seven out of ten households used severe forms of tactics such as reduce number of meals, restrict consumption by adults to prioritize children, limit portion size at mealtimes etc. more frequently. Chi-square test results show that the female has, on average, had greater rCSI than the male (Pearson Chi-square test P-value 0.035).

Food security indicators and associated IPC phases: The four outcomes' indicators and the previously stated categories are used to determine the indicative IPC phase for food security. The suggested phases for categorizing a region according to worst-off ≥20 percentage of the population. The study used an unstructured approach to get the data. This requires data collection for the entire study area—the Borana zone—as well as for each direct evidence assessed for the worst-off phase that affected at least 20% of the population. Based on the convergence of the result indicators, it was determined that the area was in IPC phase 3 at the time of the assessment.

Table 5-12: Food security indciators and indicative area IPC phase

Borana	**Minimal**	**Stressed**	**Crisis**	**Emergency**	**Famine**	**Indicative phase**
FCS	**61%**		**21%**	**19%**		**3**
HDDS	**8%**		**56%**	**34%**		**4**
HHS	**69%**	**7%**	**20%**	**2%**	**1%**	**3**
rCSI	**2%**	**75%**	**12%**	**11%**		**3**
Ranges						
LC						
Ranges						

Source: Household survey result, July-August 2019

After the survey (July–Sept 2019), the IPC conducted a seasonal analysis based on a stratified sample of the Livelihoods Zones (LZs) and a consensus-building process. According to the analysis's findings that were pertinent to the research region, 30–50% of evaluated LZ were anticipated to face severe acute food insecurity (IPC 3 and 4) and need immediate humanitarian assistance and livelihood protection (Figure *5-14*)

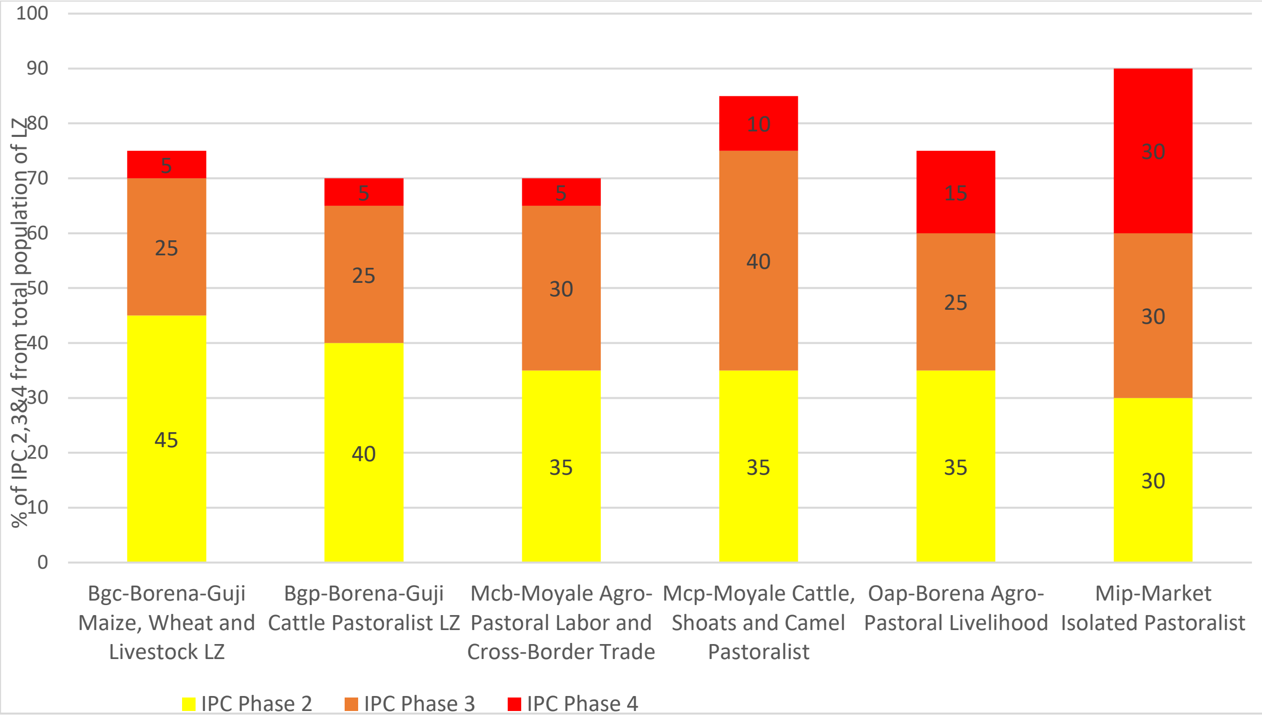


Figure 5-14: percentage of IPC 2, 3 and 4 from total population of LZ (July-Sep 2019)
Source: FAO-Ethiopia

The IPC analysis also included population estimates for various LZs with acute food insecurity. According to population projection at the time of the assessment, the aggregated LZ[11] data at the overall area level show that 34% of the zone's population (434,819) is anticipated to be experiencing severe acute food insecurity (IPC 3 and 4). Acute severe food insecurity grew or remained depending on the LZ, according to the two subsequent seasons IPC projections (Oct-Jan 2020 and Feb-June 2020). IPC, which was only recently adopted in Ethiopia, was unable to offer sufficient trend data (similar) to identify the patterns of severe food insecurity.

[11] Pastoralist and agro-pastoral groups in the study area were classified into livelihood zones (LZs) based on the similarity of options in obtaining food and income and access to markets.

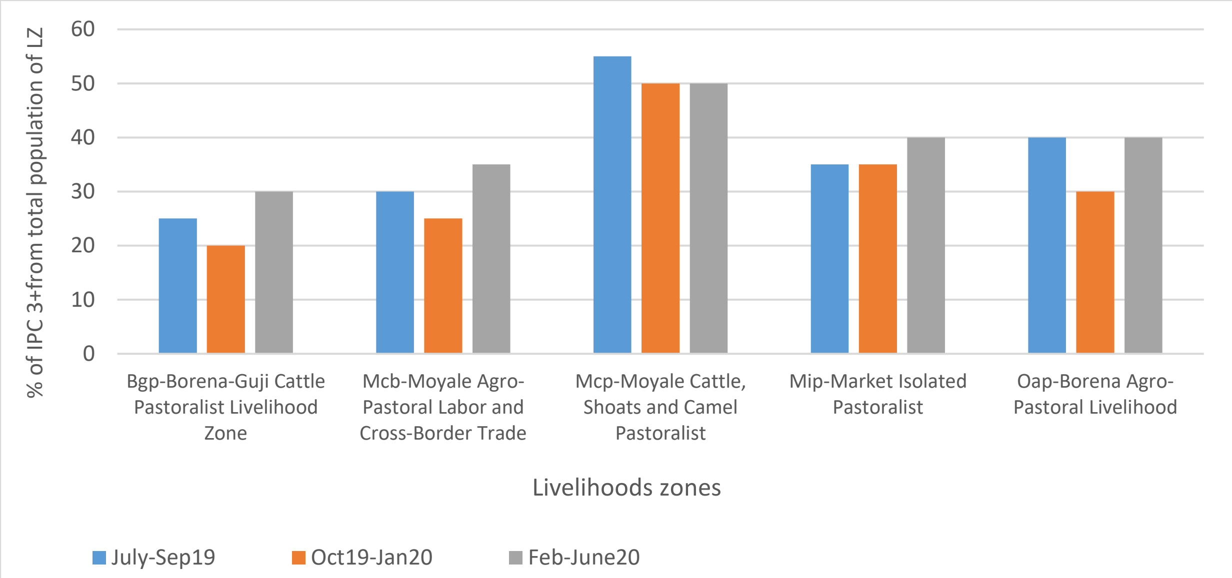


Figure 5-15: Percentage of IPC 3+ from total population of LZ for the last three seasons
Source: FA0_Ethiopia

The government and humanitarian organizations developed destocking facilities where livestock could be salvaged and falling trade terms that harmed the affected population's food security and way of livelihoods were addressed. Government and humanitarian actors offer a wide range of humanitarian aid and livelihood protection measures to lessen the severity of the effects (Figure *5-16*).

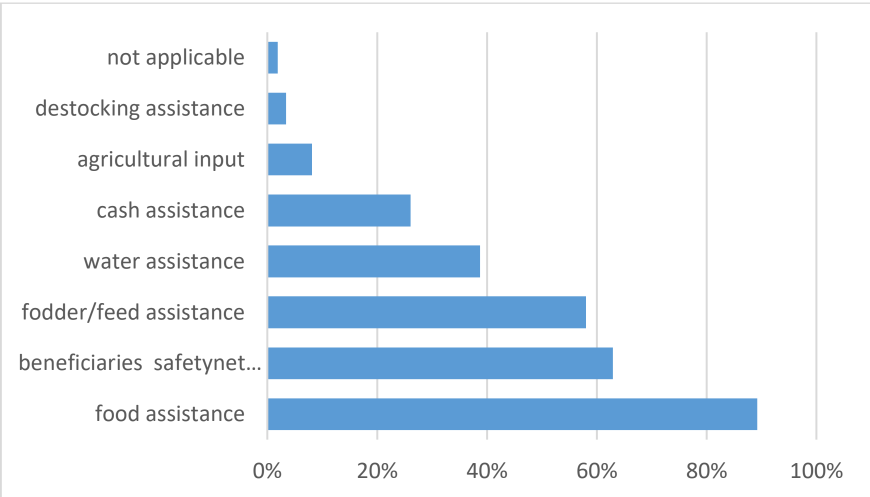


Figure 5-16: % of HH receiving various forms of humanitarian and livelihood assistance during drought.

After the severe drought ended, reliance on a productive safety net became necessary, which is a sign of persistent food insecurity. In the study area, seven out of ten sample families (68%)

still depend on the PSNP[12]. Poor households participate in opportunistic crop farming, the sale of firewood, and other income-generating activities to supplement the PSNP. There is now little traditional support or social safety net in place, and it is unlikely that households will be able to recover from the effects of the drought through clan restocking. According to KI, the rich are unable to contribute sufficiently due to the general reduction in their assets. Additionally, recipients in peri-urban areas preferred alternative income sources than depend on transferred assets.

5.11 Climate Risk determinants

Most households are at an intermediate level of climate risk. According to Figure *5-17*, around 70% of the sample household's current level of hazard is very high to high, while the other 30% describe an intermediate level of hazard. Most households are vulnerable on either an intermediate (64%) or low (36%) level. Figure 5-18 illustrates the current vulnerability's high to intermediate hazard sensitivity or/and very low to low level of adaptive capacity.

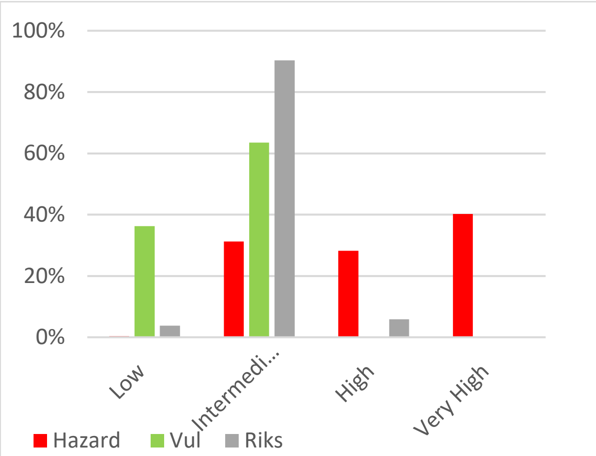


Figure 5-17: Proportion of HHs (%) experienced various level hazard, vulnerability, and risk

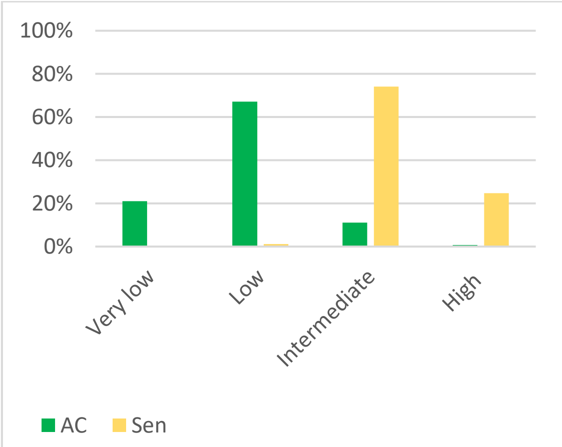


Figure 5-18: Proportion of HHs (%) various level of Adaptive capacity and sensitivity

Average scores for risk and its component were calculated at overall area level. The analysis reveal that the area has about 0.7 (0.9-0.4), 0.4 (0.6-0.3) and 0.5 (0.7-0.3) scores of hazards, vulnerability, and risk respectively and very insignificant standard error (0.003-0.006). The study suggests that vulnerability indicators, such as sensitivity and coping abilities, may not always impact component and overall risk equally. Oversimplification may contribute to

[12] The fourth phase of the Ethiopia PSNP began midway through 2015 with the objectives of increasing shock resilience, improving food and nutrition security, and improving environmental management. PSNP provides pay to physically fit community members who participate in labour-intensive public works projects.

intermediate vulnerability, and the vast range of indicators and extreme values could distort the conclusion.

The overall scores plotted in radar chart relative to central points to visual present the linkages. These scores also disaggregated for male and female households to see if there is any significant difference between two groups of sample household. There was not any appreciable difference between male and female group of households about these composite scores. The three parts of the radar graph overlapped as presented in Figure *5-19*.

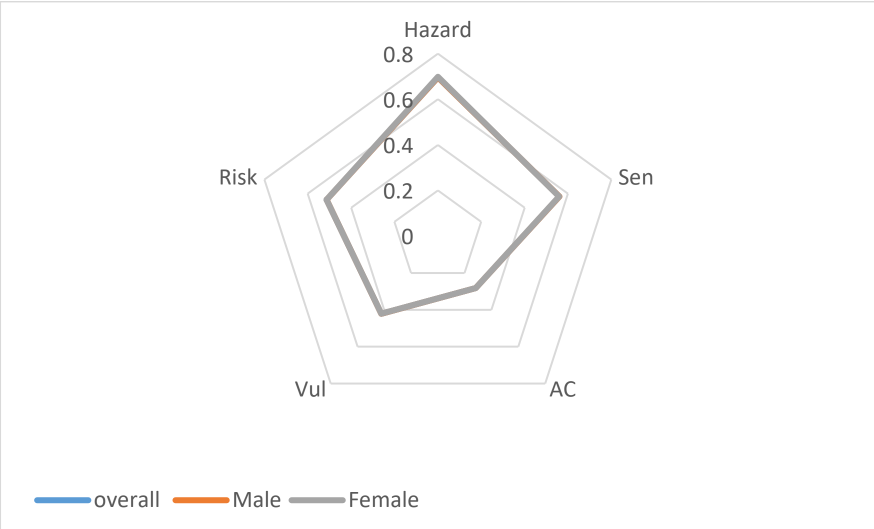


Figure 5-19: Linkage of climate risk and component

Cross tabulation and chi square test of independence was performed to examine any association between the generated composite scores and socio-economic characteristic of sample households (gender and education). Similarly, using chi square test linkages between household level food security indicators with these composite scores was explored. (Table 5-13 and 5-14)

Table 5-13: Chi-square test of composite scores and socio-economic characteristic of households

Variables	Chi-square test result	Interpretation
Gender and Risk	X^2(2, N=529) =1.05, P=0.59	NS*
Gender and Vulnerability	X^2(2, N=529) =11.52, P=0.03	S** (Phi=0.148, sex has small to moderate effect on vulnerability score)
Gender and Adaptive capacity	X^2(3, N=529) =23.27, P=0.00	S (Phi= 0.21, sex has small to moderate effect on vulnerability score)
Gender and Sensitivity	X^2(2, N=529) =0.47, P=0.79	NS
Education and risk	X^2(10, N=528) =5.09, P=0.75	NS
Education and Vulnerability	X^2(10, N=528) =17.63, P=0.01	S (Phi=183, education has small to moderate effect on vulnerability score)
Education and Adaptive capacity	X^2(15, N=528) =24.8, P=0.022	S (Phi=0.217)
Education and sensitivity	X^2(10, N=528) =2.13, P=0.1	NS

Source: *Household survey result, July-August 2019*

NB: NS*: Non-significant S**: Significant

Table 5-14: Chi-square test of composite scores and food security indicators of households

Variables	Chi-square test result	Interpretation
Hazard and FCS	X^2(6, N=529) =21.17, P=0.02	S (Phi=0.204)
Hazard and HDDS	X^2(3, N=529) =2.75, P=0.43	NS
Hazard and rCSI	X^2(6, N=529) =8.82, P=0.18	NS
Hazard and HHS	X^2(6, N=529) =7.49, P=0.28	NS
Vulnerability and FSC	X^2(4, N=529) =42.16, P=0.00	S (Phi=0.282)
Vulnerability and HDDS	X^2(2, N=529) =7.25, P=0.03	S (Phi=117)
Vulnerability and rCSI	X^2(2, N=529) =1.89, P=0.39	NS
Vulnerability and HHS	X^2(4, N=529) =6.16 P=0.19	NS
Adaptive capacity and FSC	X^2(5, N=529) =47.23, P=0.00	S (0.299)
Adaptive capacity and HDDS	X^2(3, N=529) =12.75 P=0.01	S (0.155)
Adaptive capacity and rCSI	X^2(6, N=529) =8.26, P=0.22	NS
Adaptive capacity and HHS	X^2(6, N=529) =9.81, P=0.12	NS
Sensitivity and FSC	X^2(4, N=529) =3.06 P=0.55	NS
Sensitivity and HDDS	X^2(2, N=529) =0.81, P=0.67	NS
Sensitivity and rCSI	X^2(4, N=529) =3.76, P=0.44	NS
Sensitivity and HHS	X^2(4, N=529) =4.99, P=0.29	NS

Source: *Household survey result, July-August 2019*

5.12 Projected impacts of climate change

Impact on rangeland resources: According to the LULC analysis of this study, the study area has gradually lost water bodies since 1990. Due to hydrological dryness and siltation, certain ephemeral water bodies vanished, which contributed to this decrease. The expected unfavourable precipitation pattern, recurrent dry spells, and rising temperature will have greater effects on the groundwater and surface drainage systems that are already in place. This will make the area's already acute water shortage and stress worse for livestock and other purposes, especially considering the expanding human and livestock population. The amount of water consumed by animals may rise by a factor of two to three because of a rise in temperature (Nardone *et al.*, 2010), which will further increase the demand for the region's diminishing water supplies unless livestock keepers switch to raising animals that require less water. More quickly and significantly than any other nutrient shortage, restrictions on water intake reduce animal performance (Sileshi *et al.*, 2022). Lack of water will further reduce animal productivity, which is frequently exacerbated by heat stress.

The current state of rangeland degradation will worsen because of the expected rainfall pattern, persistent dry spells, rising temperatures, and changes in land use. Grasslands and their accompanying grazing grasses will continue to diminish, and in the future, the rangeland of the study region will be dominated by wood and bush species, particularly undesirable bushes. One of the contributing elements is the anticipated unfavourable rainfall pattern, namely amount, timing, and distribution. This pattern will have a detrimental impact on the growth and reproduction of important forage species.

Hoffman and Vogel (2008) emphasized these important factors on rangeland species composition through their differential effect on the growth and reproduction of key forage species in the short and long term. They also asserted that an extended drought (projected in the study area) is the other contributing factor to the mortality of perennial plants and the dominance of an annual flora often less tolerant to rising temperature. Perennial grasses will have a reduction in growth and reproduction because of warming of temperature-associated increases in evapotranspiration and a decrease in soil moisture. Extreme weather conditions, including floods, can change the shape and structure of roots, alter the rate at which leaves grow, and reduce overall output (Baruch and Mérida, 1995).

Impact on livestock production and productivity: As a result, the observed decline or disappearance of some of the valuable grass and fodder species from rangeland will also continue, and feed scarcity and quality will worsen, posing a threat to the region's ability to produce livestock and be productive. Some of the observed effects linked to the decline of water and feed resources (quantity and quality) expected to heighten in the future include a decline in milk production, limited pregnancy in the herd, an increase in the average age at which female reproductive animals reach puberty, mortalities, and morbidity of new offspring. In the absence of systematic selection and breeding programs to maintain the genetic variety and fitness within populations, the Borana cattle breed will continue to face risks from expected changes in rangeland resources as well as from continued genetic dilution brought on by changes and other factors.

Impact on traditional resources management strategies and livestock species mix: Traditional management approaches will face new difficulties because of the anticipated loss in rangeland resources, and conflicts over important and scarce rangeland resources are likely to worsen. The transition from cattle to small ruminates and camel production—which can sustain comparatively projected water and feed stress—and extended treks in quest of these essential resources—may be aided further by this forecast. To effectively manage these species' diseases through effective disease control strategies, including vaccinations, more study is required.

Impact of increased frequency and magnitude of drought: Drought and dry spells are among the main risks that pose a threat to the population's livelihoods. According to the study, droughts of varying intensities occur on average every two to four years Shibru *et al* (2022). Due to this, pastoralists and agro-pastoralists continued to lose livestock assets of significant financial value despite the "predictable" nature of drought (Desta and Coppock, 2002) and early warning indicators. In the future decades, as natural hazards become more frequent, and more intense, more losses are likely (IPCC, 2014). The shortened time between drought occurrences will put further strain on the pastoralists' already fragile post-drought recovery. The pattern will increase maladaptation, exacerbate current food insecurity, and act as a barrier to attainment of the SDGs.

CHAPTER 6: ADAPTATION TO DROUGTH AND CLIMATE CHANGE

6.1 Introduction

This chapter examines the measures taken by pastoralists and agropastoralists to augment traditional strategies to reducing and adapting to the risks associated with climate change and drought. The measures compiled from qualitative investigations are shown below; to determine the extent of adoption of the practices, they were further triangulated using data from household surveys.

6.2 Rangeland resources management

6.2.1 Traditional water resource management and emerging water sources

With the support of customary institutions, pastoralists continue employing water resource management as a common practice to reduce or adjust the effects of water stress on livestock production. Case Study 1 detailed the pastoralists from Borana's traditional management of water resources, for example.

Case study 1: Traditional water resource management of Borana pastoralist

Borana pastoralists are known for their astute management of existing water resources (ephemeral and permanent) to fulfil the need of livestock. Any available surface water is utilized first before resorting to permanent water points. The watering cycle is also determined based on the available water in the area and the need/ number of different livestock species in each area. Daily ("taka"), once every other day ("Dabisu"), once every second day ("limalima"), and once every third day ("sadden") were the most common water frequency regimes determined for various livestock species based on water stress coping of livestock species and distance from water points. The watering schedule manager "Haregitu" of each water point play important role in maintaining smooth watering of livestock as determined by the grazing meeting. Livestock beyond available watering resources capacity is advised to move (non-lactating stock) to other water points of better capacity or increase watering frequency to match the need with available resources.

The extent and severity of the drought, according to KI, may have reduced the efficacy of these traditional management practices. The current exogenous and endogenous elements have already made the classic system's operation difficult. As a result, emerging water sources like boreholes and cisterns were becoming more significant in the region to deal with water scarcity, especially during drought. Figure 6-1's graph illustrates the various sources of water that households can access, both traditional and emergent. To collect rainwater for use in times of need, some households-built cisterns individually or collectively. Water from cisterns has helped water calves and weak/ill animals at the homestead by reducing the amount of water that women and draught animals had to collect. Due to this, women's workload and water stress have been somewhat lessened. In times of need, cisterns also used as places to store purchased water (water tankers[13]). In times of drought, purchasing water tankers either individually or in groups is growing in popularity among pastoralists. It was also noted that several wealthier families pre-positioned temporary water storage facilities (such as Roto) to off-load water as a drought mitigation technique (in some cases, the cisterns had not yet been built).

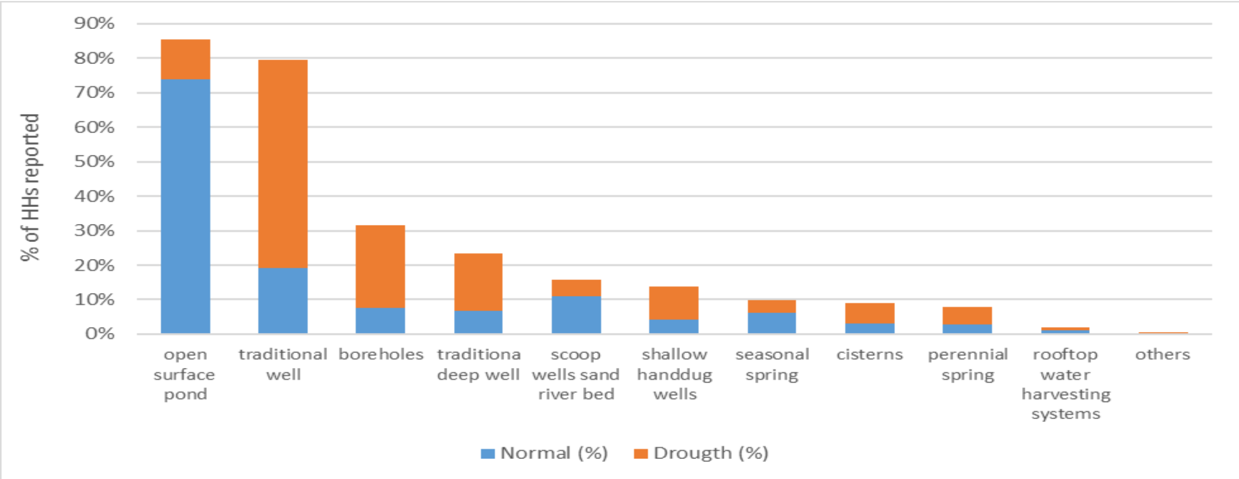


Figure 6-1: Multiple sources of water for households

Figure 6-2 illustrates the variety of water shortage coping strategies used by the sample households. One of the coping mechanisms mentioned by households during the drought was the water tracking services offered by humanitarian organizations and the government. However. If the drought or water stress was severe and extensive, KI imply that the expense of water tracking is high and prohibitive. Provision of desert or succulent plants was mentioned as one way to cope with water stress, however the KI said that these plants had become scarce or disappeared owing to the drought or dryness.

[13] a tanker cost on average about 8000 EB during the survey

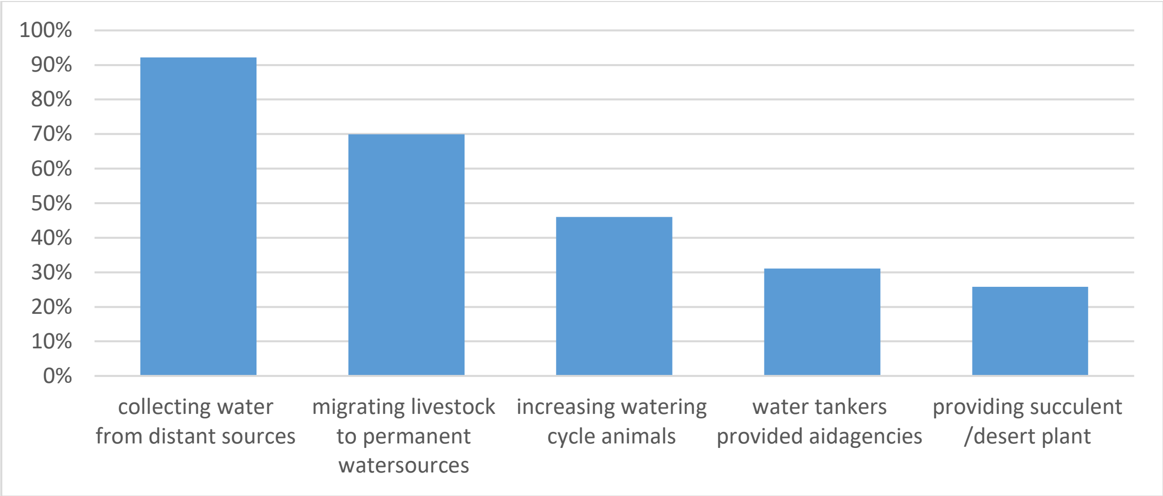


Figure 6-2: Percentage of HH reporting water coping strategies.

Figure 6-3: Community travelled long distance to collect water during 2017 drought.

Figure 6-4: Women collect water for domestic use and to water weak animals. (Arabale PA)

6.2.2 Traditional grazing management and emerging feed coping strategies

Although less frequently recorded, one of the efficient drought management strategies still used by pastoralists is the use of warra and forra grazing areas and livestock dispersal. When pastoralists prioritize cattle production and easy access to large grazing lands, this tactic was frequently used and reasonably successful. According to KIs, the level and efficacy of traditional rangeland management were impacted by current internal and external influences, including increased camel production. Informants claim that the population affected by the drought has also developed various coping mechanisms to deal with the scarcity of feed.

According to the elder, some of the regularly reported coping strategies used by families over the previous 10 years (Figure 6-5) to address the growing feed scarcity (quantity and quality) include collection of cut and carry by women (Oka), creating and enlarging enclosure, and so on. The adopted solutions are limited to providing feed for calves, sick, and weak animals. Making hay and using crop residue as shown in Figure 6-6 are also mentioned as coping strategies. Historically, an enclosure was built as a risk-reduction strategy to preserve grazing for vulnerable animals at critical times. However, more pastoralists are using similar tactics and expanding their enclosure beyond what is considered acceptable. Pastoralists are gradually enclosing portions of shared grazing area closer to their homesteads to provide their animals with pasture in dry and drought-prone conditions. This is taking place out of the guise of customary institutions and has escalated into a contentious issue due to the shrinking "pastoral common".

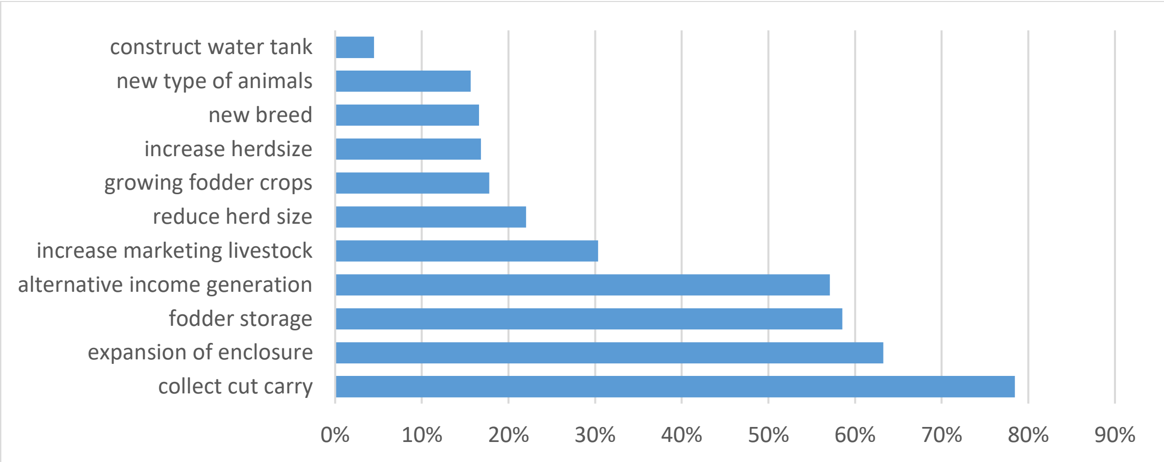


Figure 6-5: Change in livestock management practice observed over the last 10 years.
NB: n-422 out of 529

Figure 6-6: Women collecting cut & carry in Miyo and utilization of crop residues in Fuletole PA
Photo credit: Field enumerators

Another highly promoted drought management strategy is the expansion of dry season grazing reserve locally called "mirti". The term "dry season grazing reserve" refers to a very big reserve that is kept being used during critical times, such as drought, to endure feed scarcity. Depending on the settlement layout and grazing space available, the reserve is frequently surrounded by several communities and occasionally pastoral associations. Additionally, everyone involved agreed on the use's time and terms. Given the proximity of their reserve to other (hostile) ethnic groups, conflict and security issues have limited the success of these measures in some grazing areas, such as Wayama.

6.2.3 Livestock mobility / migration

Borana's land resources are primarily managed through communal and customary tenure systems, allowing pastoralists mobility for pasture and water resources despite challenges. One of the "timeless" managements used by pastoralists to address the naturally variable climate and related resource variability (both geographically and temporally) is mobility. Before trekking mobile stock in the past, experienced range scouts would analyse the available range resources and the presence of a suitable environment (lack of diseases and enmity of the community).

This age-old custom is still carried out by pastoral households. However, it has been severely impacted by the effects of climate change, as well as localized internal and external causes. For instance, the degree of pastoral mobility and access to grazing land have been impacted by the increasing level of enclosure and cultivation. Conflict and the occupation of the area by pastoralists from the neighbouring region (near to the border) have a negative impact on mobility. The KI claims that traditional range resource scouting is no longer as frequently employed to support livestock migration. The efficiency of pastoral mobility is being hindered by the intrusion of formal governance and the need for "payment" in various forms, which goes against free access to common property resources. In recent years, instead of providing pastoralist access to geographically and temporally dispersed rangeland resources, this strategy has become causes of conflict. Some analysis suggest that the likelihood of such conflicts has changed and is on the rise.

6.3 Increase livestock sales and alternative investments.

According to the KI, pastoralists' practices for selling cattle have gradually improved because of their concern over losing livestock to drought. When the market is favourable and the livestock are in good physical condition, they sell. Pastoralists are shifting their proceeds from the sale of livestock to other forms of investment, such building urban houses and putting money in the bank. The growth in livestock sales (off-take) and investments in alternate sources of income generation are results of NGOs' efforts to promote such practices. The positive deviants' role in the community in encouraging their families and clan members to work in the market and diversify their sources of income also made a significant influence. Only 5% of the studied households claimed to have a bank account, despite KI's claims that many pastoralists had opened savings accounts as shown in Figure 6-8. Case study 2, which is provided below, amply illustrated the importance of bank savings in managing drought, even though relatively few pastoralists have savings accounts yet.

Case study 2: Bank Savings' contribution to 2016/2017 drought management

For instance, one of the KI used almost 120,000 EB (5300 USD[14]) of his bank savings to buy feed for his livestock to lessen the effects of the 2016–2017 drought. To protect his animals from the impact of drought, the responder purchased a total of six tracks of feed, both individually and in collaboration with other pastoralists. The informant drew parallels between the xcash in the bank and mobility as drought management tactics. Mobility to pasture and water was one of the pastoralist's primary drought management strategies. The money that was saved in the bank during good times is now used by pastoralists to buy feed, medicine, and water for their livestock. The money is also used to purchase food for people who work hard to keep their livestock alive. Had it not been for the new strategies that assisted in keeping mortalities under control, the impact of cattle mortalities in 2016–2017 (Guyo Goba Gada) could have been even more devastating.

The other common alternative investment listed by KI was the building of permanent houses in urban and peri-urban centres. These houses were constructed by pastoralists nearby the town for renting purposes. In urban and peri-urban areas, about 11% of the sample household reported having iron sheet houses. Additionally, 5% of people reported owning a motorcycle, bicycle, vehicle, or truck as presented in Figure 6-7.

[14] 1 USD equivalent to 22.6 Ethiopian Birr

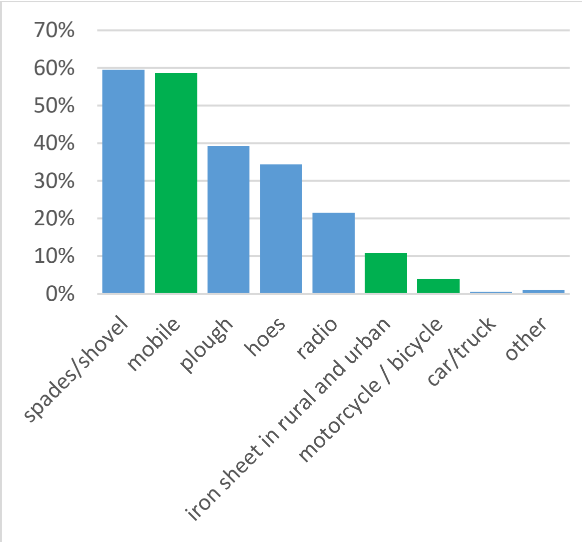


Figure 6-7:: Physical assets ownership of households

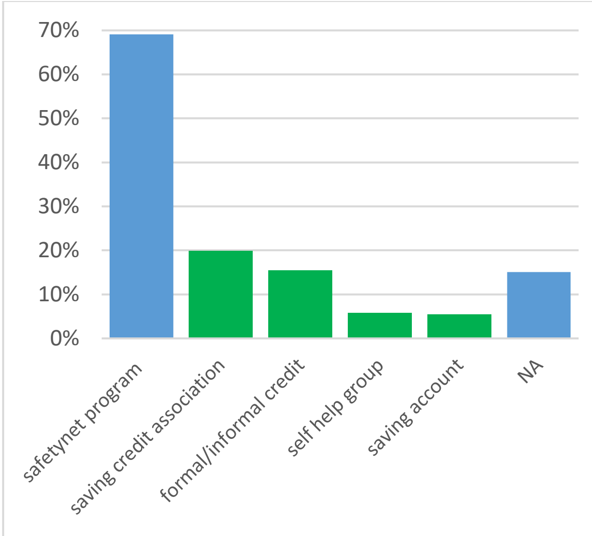


Figure 6-8:: Percent of HH report accessing financial services and social safety net.

6.4 Increase camel and small ruminant production.

Some pastoralists sold their cattle to purchase goats, or camels, which are thought to be drought-resistant livestock species. Informants are aware that these species experience drought-related effects, albeit to varying degrees. They stated that, for instance, camel deaths during drought are lower than those of cattle (this study's drought mortality rates per species support their claim). The insufficient rainfall for cattle will suffice to produce goats and camels. These species will be only slightly impacted by droughts that have a large negative influence on cattle production. These species can survive droughts but are prone to disease. The herd's ability to adapt to shifting rangeland conditions (from grassland to bush land) is one of the other factors contributing to the growth of the goat and camel populations. The elder from the Golbo gazing unit provides testimony on the production of camels and goats as discussed in case study 3. Emerging diseases, however, limit the diversification of these species. The pastoralists also expressed concern about the role that rising camel production trends are playing in intensifying bush encroachment.

Case study 3: Golbo gazing unit elder testimony on production of camel

Golbo has several pastoralists that rear cattle. Nowadays, many households keep goats in their herd. The area is suitable for Goats production. Now, goat milk benefits pastoralists more than cow milk. Additionally, efforts were being made to integrate more camel and goat into the herd. When compared to cattle, goats do well even under conditions of little rainfall. Camels and goats are browsers, and the current vegetative situation is in their favor. In addition, they can endure drought better than cattle. Cattle suffer from droughts first, followed by goats and camels. The main issue with these species is that they are prone to diseases. When there is little available feed, both species can survive. With the current state of climatic uncertainty, households with 20 goats can easily secure their household food security. Twice a year, it reproduces. Gained marketable weight in just six months. Even in times of drought, camels still offer small amounts of milk to households. Even during droughts, goats are a valuable source of income.

The Borana pastoralists are well renowned for their cattle. Depending on the AEZ, they blend these with small ruminants. One of the KI views the trend of households retaining goats and camels in their herds as a reactive response rather than a proactive adaption. In fact, the KI recommends a general decrease in the number of livestock, especially goats. According to the elder, it is challenging to maximize productivity for two types of livestock (cattle vs. goats/camels) in the current environment. The elder was adamant that pastoralists shouldn't have cattle and goats in the same area or at the same time. According to the elder, having both causes collateral damage for both species. Goat production must be decreased if the pastoralists want to keep raising cattle. Given the restricted availability of rangeland resources, the elder believes that livestock holding should be reduced overall. The eastern portion of the rangeland that served as a refugia during drought for the Borana pastoralists has been lost. The current level of livestock could hardly be supported by the scarce rangeland resources. This is especially true when there is irregular (inadequate) rainfall. If pastoralists do not balance the number of cattle with the available land's carrying capacity, there is a risk of constant livestock losses. According to the elders, even if rainfall is insufficient, if the population of livestock is manageable, the available resources will enable them to withstand the drought. It lessens the level of competition for rangeland resources as well.

6.5 Livestock insurance

The Index Based Livestock Insurance (IBLI) initiative was first launched in 2010 in Marsabit, in Northern Kenya, by the Cornell University Kenya-based Innovative Insurance Initiatives (3I) and the International Livestock Research Institute (ILRI). According to Mude *et al*. (2010), IBLI was developed as a strategy to assist herders in recovering from losses brought on by recurrent, severe droughts. Along with Community program Facilitation and Assistance (CIFA) Ethiopia, Oromia Insurance Company (OIC), and CST, the promoter has further developed and tailored the program to the needs of pastoral households in southern Ethiopia. Since 2012, the partners have been piloting a scheme in the Borana zone's drought-prone Miyo and Moyale woreda. Using participatory research approaches, CIFA Ethiopia evaluated the program's success as a pro-poor climate risk management strategy in the pilot area (Keno *et al*, 2018). Case study 4 provides testimony from proponents of Index Based Livestock Insurance (IBLI) on its advantages, challenges, and future directions in the study area.

Case study 4: Testimony of Index Based Livestock Insurance (IBLI) Promoters.

The researcher interviewed two employees of the Oromia Insurance Company the benefits and difficulties of livestock insurance. The team members were facilitating training for village insurance promotors (VIPs) during the research.

Through research, training, and marketing, the International Livestock Research Institute (ILRI) and the Oromia Insurance Company promoted this innovative strategy throughout the study area. Although it has taken a long time for it to gain popularity, the approach may be able to lessen the effects of persistent droughts in the research area. According to the promoters, the insurance premium is dependent upon the number, type and value of the livestock as well as the risk of the agro ecological zone (the possibility of losses) as assessed by the availability of feed based on the NDVI. The promoters said they were switching from paying for the lost asset to protecting assets. This change is required for mobility (adapting to local livestock-keeping practices) and is more focused on protection than it is on recovering lost livestock assets. The initiative's promoters have created interactive mobile-based educational materials that will increase financial literacy. The resources might also help the community comprehend the effects of the drought and help shift attitudes and behaviours. The insurance company was concerned about the risk to the initiative's financial viability if the pastoral and agro-pastoral were not properly admitted into the scheme and implemented. According to the promoters, assistance and financial backing from outside parties is essential until the effort has a strong foundation.

6.6 Crop production practice change

Only 3 out of 10 households have altered their practice since beginning crop production. Most of the practice changes that were reported by households are shown in Figure 6-9. One of the most popular methods indicated by households is early land preparation and planting. Other popular strategies include crop rotation, soil fertility management, intercropping, and new varieties.

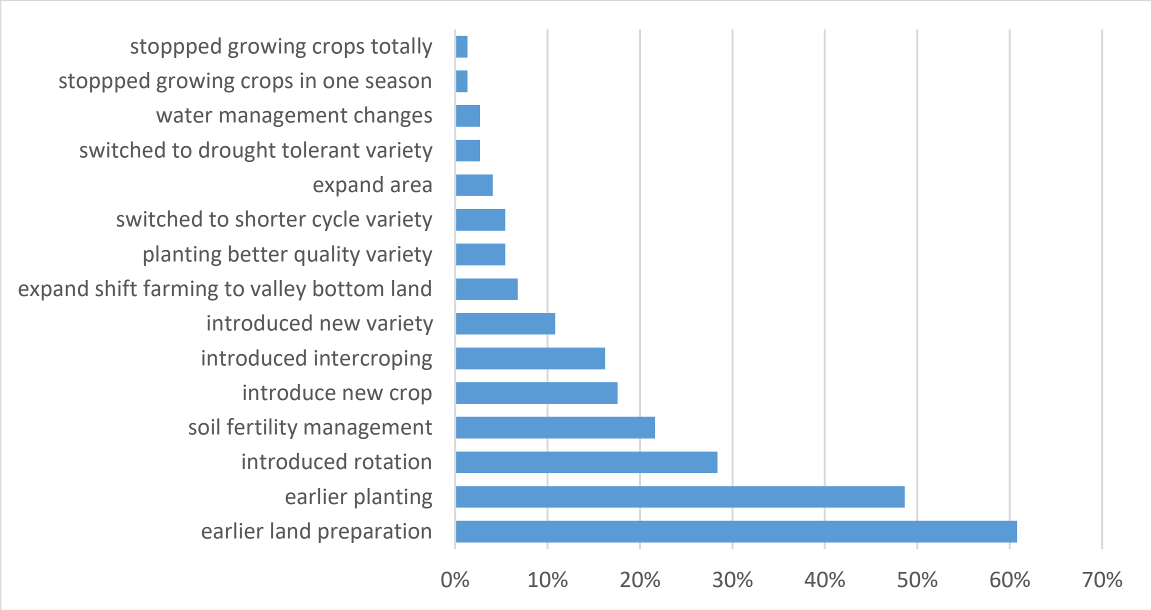


Figure 6-9: Percentage of HH report various agricultural practice change.

To reduce moisture stress, early land preparation and planting were the main practice changes. However, it has reportedly been less effective due to poor germination and the possibility of birds eating the seed. Crop diversification is a continuing approach to minimize market risk and mitigate common drought risk. Due to low yield and recurring failure of maize crops, some farmers in the Yebello district have switched from cultivating maize to Teff (80% of respondents already do so). The market's rising price and the benefit of using its residue as feed are other factors contributing to the increased diversification toward Teff. Although just a few households have reported it, the conversion of bottom valley land into more farmland is a worrying trend in Borana. The expansion took place at the expense of the livestock's pasture in an area that is sometimes referred to be a "fall back area" for livestock production. More households turning to opportunistic cultivation to mitigate the effects of recurrent drought and food insecurity raised fears that the situation will get worse. For instance, throughout the previous five years, 28% of the sample households (excluding the missing numbers) were engaged in crop cultivation. Over the past 35 years, the area covered by farmland has nearly doubled in size per square kilometre (83%) possibly because of expansion by both existing and new entrants. One of the main factors influencing the reported change in agricultural practice was the climate (Figure 6-10). Rainfall-related climatic characteristics like diminishing volume, unpredictable distribution, late onset and early cessation, and recurrent drought are some of the manifestations of climatic change and are thought to be a driving force behind observed changes in agricultural practices (Figure 6-11).

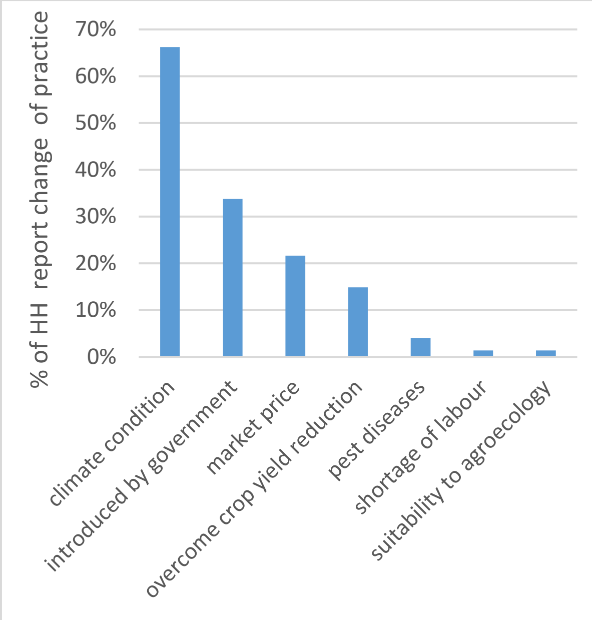


Figure 6-10: Percentage of HHs reported reasons for changing agricultural practice

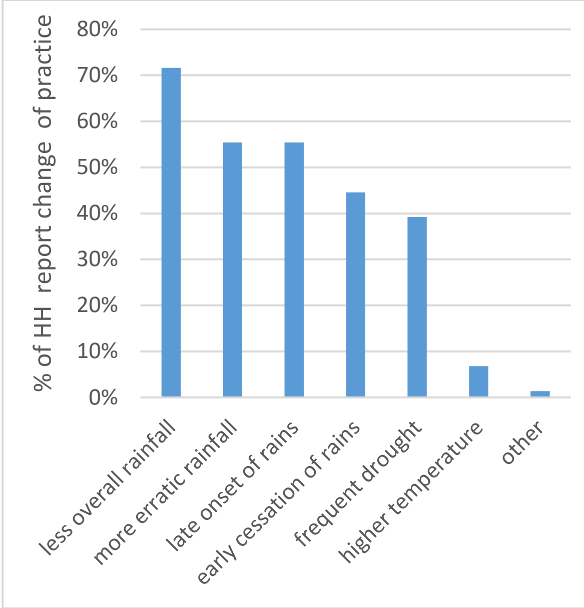


Figure 6-11: Percentage of HHs reported climate change as reasons for practice change

Among the common social support techniques mentioned by the respondents as providers and recipients are food sharing, financial gifts, and gifts of or transfers of animals. Borrowing milking animals, oxen for lowing, and restocking (Busa Gonoffa) are further prevalent social assistance systems in the region. Despite the fall in net livestock wealth, the high percentage of cases where restocking occurs after food and monetary gifts shows that clan members are willing to support their affected members.

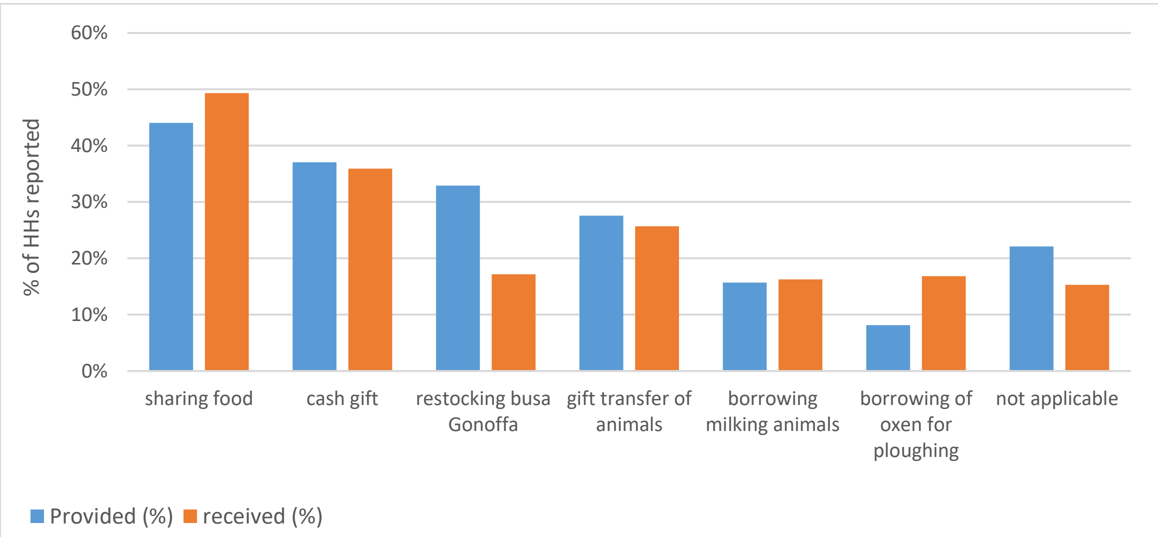


Figure 6-12*: S*ocial support provided and received by sample households (multiple responses)

The drought's impact on wealthier households indirectly affects the mutual assistance network, which includes borrowing oxen for impoverished households.

6.7 Traditional weather and drought forecasting and its challenges.

Most of the traditional weather and drought forecast information, which is frequently referred to as indigenous knowledge, comes from knowledgeable individuals in Borana. These personalities were typically categorized by the KI into four groups according to their knowledge or wisdom: Livestock behaviourists' (Waragu), experts in the Borana cycle calendar (Mara), specialists in livestock entrails (uuchuu), and traditional astrologers (Ayyaantuu) are the first four groups. Most of these individuals have their own unique expertise in weather forecasting. Additionally, the behavior or performance of birds and plants can be used to forecast, indicating the likelihood of either favorable or unfavorable weather and their performance in the future. In Annex 12, each forecast's thorough explanation and operational principles were presented. Case Study 5 presents a case study demonstrating traditional prediction reliability validated using local climate data.

Case study 5: Animal behaviourists' 2019 SON forecast.

Dika Wako Jilo is a well-known animal behaviourist (Waragu) in Borana who specializes in weather forecasting and the behaviours and performance of cattle. During the interview process, he made a forecast about the upcoming Short rainy (Hagaya) season based on his evaluation as a waragu and information he supplemented from the uuchuu. After analysing his own and uuchuu sources, he made the right judgment about the then Hagaya season (SON 2019).

The forecaster claim was retrospectively confirmed by the NDVI anomaly and rainfall data from the FEWS NET CHIRPS.

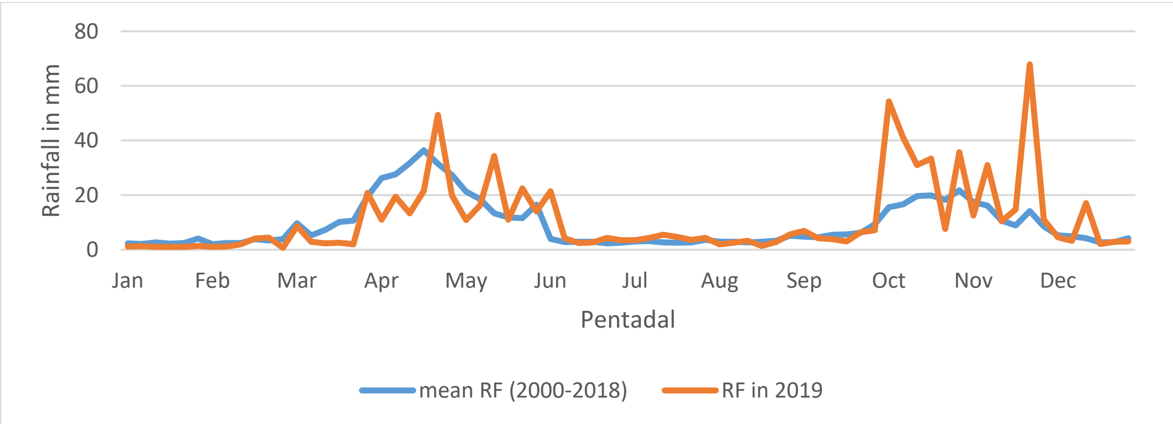


Figure 6-13: Comparsions of mean and Hagaya 2019 rainfall in Borana Zone

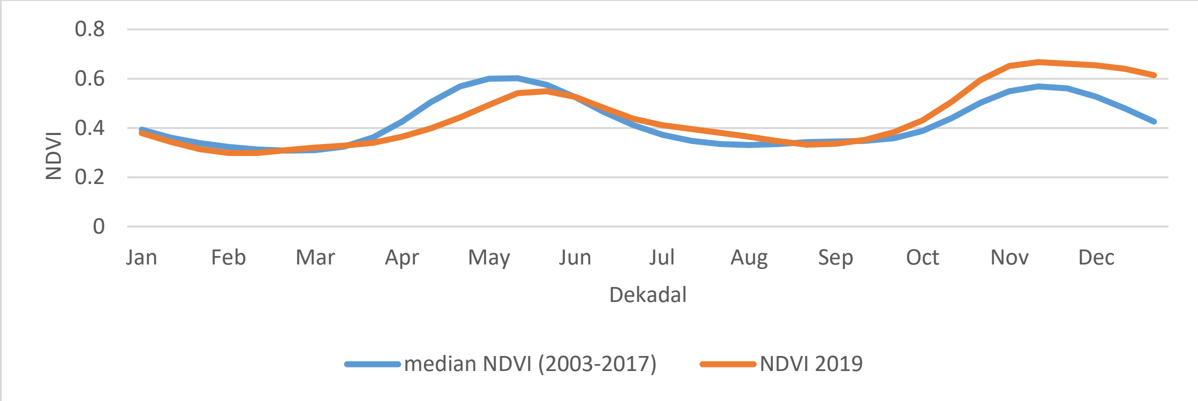
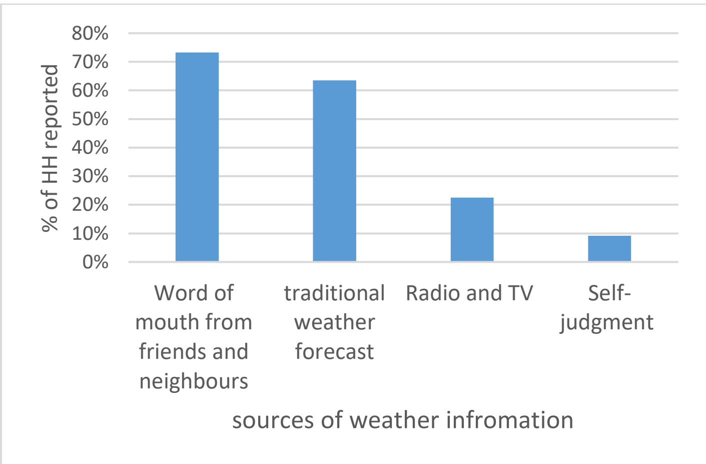


Figure 6-14: Comparsions of Median NDVI and Hagaya 2019 NDVI in Borana Zone

Source: FEWS NET/ USGS *CHIRPS* data (Ethiopia+ Oromia+ Borena)

Weather forecasters were once respected and asked to give their information on future droughts, rain, fertility, conflicts, etc. The knowledge from these sources was also spread via the already popular Grazing meetings (Kora). It would assist in reducing the impact of crop production losses and notify the households of the need for preparedness for livestock to endure the effects of drought. Even though over 60% of households acknowledged their reliance on traditional weather forecasts as a source as shown Figure 6-15, according to KI, only a small number of worried individuals are currently accessing this information. Compared to earlier times, most people today do not seek to such information.



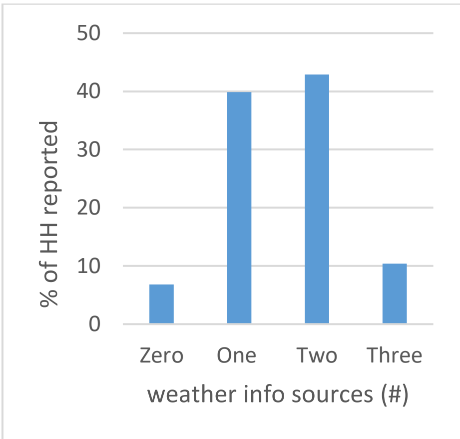


Figure 6-15: Sources of weather information for the sample households

One of the problems highlighted as impeding the utility of traditional forecast information was the recipients of the forecast information's lack of receptivity to the information. Because they believe that "only God knows the future," recipients frequently discount the knowledge and fail to take the necessary measures to lessen the effects. The spread of mainstream religions (including Islam and Christianity) in Borana, which go against traditional beliefs, is one of the elements contributing to the recipients of such knowledge gradually losing trust. This had an impact on how traditional climate information was disseminated and used. KI accuse some of the pastoralists who are young and educated of not upholding the customary knowledge and practice. Religious and educational systems in the modern world are obstructing or influencing practice. The elders claimed that the educated and mainstream religious believer was downplaying the importance of this ritual. This is thought to be one of the limitations of the practice. The keeper of such knowledge, for instance, by observing the stars, can alert the community to the impending signs of drought and advise them to take preventive action before the crisis arises (selling the livestock while in good physical condition), but they won't act and end up losing it due to drought. Given the likelihood (uncertainty) that the "usa" would present the distant future as if it were closer, some of these "Uuchuu" were cautious with their forecast information in recent years. If the Uuchuu offer the information as such and the anticipated event does not occur, their credibility is in jeopardy. There is hope yet. Some pastoralists move to better areas because of being open to the prediction information to protect their animals from adverse effects. Additionally, some NGOs have recently made encouraging efforts to bring together meteorological scientists and traditional knowledgeable people in meetings twice a year (before Genna/Hagaya) to learn their perspective on the future season(s). The traditional forecasters can make predictions that go beyond a single season.

In accordance with their forecast, they will also suggest to you a possible course of action. They advise selling livestock and preserving pasture and fodder resources if the forecast shows an unfavorable season. At the Dheda meeting, this kind of information will be distributed to a larger audience to raise awareness and provide guidance for potential action. The two sources of information occasionally come to the same conclusion (converge), but occasionally, their predictions are at variance.

6.8 SWOT analysis of adaptation measures

Table 6-1 presents the consolidated strengths, weaknesses, opportunities, and threats (SWOT) of the traditional and emerging strategies (adaptive and coping) of pastoralists to changing patterns of drought and climate to inform the development of the adaptation strategies.

Table 6-1: SWOT analysis of adaptation measure in study area.

STRENGTH

- Adequate understanding of climatic variability and drought risk management strategies among the affected people, as well as among the customary institutions that assist them.
- The need to strengthen drought management measures is a topic of ongoing discussion in several fora. Additionally, the country's Climate Resilient Green Economy (CRGE) policy is being operationalized locally by the climate change office, which is promoting conversations and enlisting various stakeholders on the topic.
- Despite the changing settings, pastoralists and agro-pastoralists continue to manage risk using their traditional strategies, however their efficacy has been limited by several factors. As a result, Pastoralist and agro-pastoralists are altering their existing strategies or adopting new ones to withstand the growing climate risk.
- Several steps taken by pastoralists and agro-pastoralists either on their own or as part of a strategy (supported by actors in the fields of aid, development, and research) to manage the effects of recurrent droughts. Among the prevalent practices of the pastoralist and agro-pastoralist in the research area included depositing money in banks, buying urban houses, and diversifying their livestock herds to include additional species.
- Zonal Rural Land Administration Office in collaboration with partners has made positive efforts to strengthen the current management and usage of rangeland resources and customary institutions.
- Some NGOs are making positive efforts to bring together traditional weather forecasters and meteorological experts twice a year (before Genna and Hagaya) to exchange ideas on seasonal outlook.
- The existence of disaster risk management strategies highlights the significance of mainstreaming disaster risks, including those associated with climate change, into pertinent sectors to lessen or minimize its impact. Numerous training programs are offered at the zonal and woreda levels to improve knowledge.

WEAKNESS

- The wealth of knowledge in practices linked to drought management and adaptation that was present among the affected community, as well as in customary and supportive institutions, was not considered in the NAPA and NAP processes.

- The outcomes of the continuing discussion on drought and climate risk and efforts to promote adaptation measures are limited by the lack of established institutions or platforms that coordinate these efforts.
- Inconsistent actions taken by the various actors on safety net, climate change, and watershed management. The effort is somewhat disjointed, and several committees established by various departments with the agriculture sector occasionally contradict one another's messages and activities.
- The bush control program involved a wide spectrum of actors who were not coordinated to produce the desired outcome. The control measures' methods were likewise disjointed and currently counterproductive.
- Weakening of the traditional scouting methods used to determine the range conditions, pasture conditions, and water availability before migration. Mobility as a risk management strategy is less successful when livestock movement decisions are based solely on hearsay.
- After the certification procedure, Aba Dheda had little support and direction in carrying out their assigned duties.
- The grazing meetings' (Kora Dheda) decisions weren't always followed through on or put into practice, which reduced the efficiency of the traditional approach for managing resources.
- The traditional governance system was also impacted by the involvement of formal government structure. Lack of or insufficient resources for various government department to perform their duties.

OPPRTUNITIES

- The opportunity for discussion to include existing knowledge and practices of drought management and adaptation in the NAP through vertical integration to lessen the vulnerability of the pastoralist.
- Expanding the reach and coverage of existing drought management strategies (banking, building urban houses, introducing new livestock species, and livestock insurance)
- Expanding the Index Based Livestock Insurance (IBLI) initiative to reduce the effects of recurrent drought.
- Goats and camels are kept in the right places as part of a livestock species diversification strategy to take full advantage of the changing vegetation conditions.

- To recognize customary land rights and reinstate the traditional authorities in resource management decision-making, it is crucial to legalize and certify the remaining grazing areas.
- Using positive deviants to promote drought-resilience strategies and serve as role models.
- Existing zonal and woreda level task forces can act in a multi-sectoral or actor-coordination capacity if their roles are reformulated.

THREATS

- The timely sales of livestock, particularly cattle, are impacted by cultural and societal values associated with cattle.
- If admission and consistency of the pastoral and agro-pastoral are not at the desired level and the current financial subsidy from external players is removed, there is a risk to IBLI's ability to remain financially viable.
- Access to and use of wet (for a) grazing lands and enclosures were impacted by border-area and neighbouring ethnic groups conflict and insecurity. Certain feed responses have a reactionary nature and are ineffective at addressing root causes.
- Growing challenges to pastoralists' access to pasture and water, as well as the separation of wet and dry seasons' grazing, are brought about by both endogenous and exogenous factors.
- Emerging diseases affecting camels and goats are limiting pastoralists' continued efforts to diversify their species.
- Impacts of degradation and climate change are exacerbated by incoherent methods to bush control, management, and exploitation.
- Consistent monitoring and execution of numerous projects were hampered by personnel turnover and instability in the government.
- Increasing levels of government involvement in traditional governance issues.
- The significance and credibility of customary institutions and indigenous knowledge are increasingly being challenged by mainstream religions (such as Christianity and Islam).

CHAPTER 7: SYNTHESIS, CONCLUSION AND RECOMMENDATIONS

This chapter concludes the study by providing a summary of the major findings in regard each study objective and the value addition. It makes recommendations for the many stakeholders involved and sectors impacted by droughts and climate change. It acknowledges the study's limitations and suggests areas for additional research.

7.1. Research summary

7.1.1. Historical and future pattern of climate variability, change and drought.

The first specific objective of this study reveals that rainfall and temperature are the most significant factors affecting the vital natural resources that supporting pastoralists and agro-pastoralists in the study area. The study area experienced significant inter-annual variability, with main season variability (31-40%), moderate Northeast and West pockets, and a short season with CV greater 40%. The qualitative investigation revealed that the unpredictable nature of rainy seasons, particularly during the short rain season, further supports this pattern. The study area's high rainfall variability is like Eastern African drylands, which have high inter-annual variability in the length of the growing season (De Leeuw *et al*, 2014). However, the higher temporal and spatial variation coefficients in the study area compared to estimate (15-25%) Eastern Africa (De Leeuw *et al*, 2014) are concerning and indicate increasing extreme rainfall events.

The direction and magnitude of yearly and main season precipitation change are conflicting not statistically significant. The dominant trend is an increasing tendency for short rainy season rainfall, which contradicts the NDVI trend, the community's general perception, and the findings of the qualitative investigation. the vegetative condition trend (NDVI) of the short rainy season shows a statistically significant decreasing trend that is directly correlated with the amount of rainfall received in semi-arid regions of Africa (Zhang, 2005). Studies in Ethiopia have shown downward trends in precipitation, primarily in the eastern, southern, and south-eastern regions (Seleshi *et al*., 2004 and Camberlin, 2006)

The study found that the average seasonal and annual temperature indicates overall warming, with variation in rate extent, and its statistical significance. The minimum warming rate was higher than maximum, qualitative evidence strongly suggests a warming tendency in terms of temperature. The low land and arid part of the study area showed a higher rate of warming compared to the mid and highland regions.

This study pattern is consistent agrees with the two broad consensuses and the evidence of climate change in Eastern Africa (Daron, 2014). The increasing trends in temperature from climate basslines were one of the primary lines of the evidence at the regional level. rainfall trend assessments were weak and challenging to determine generally, despite reports of declining or increasing trends depending on specific locations and seasons.

The Borana zone's annual rainfall is expected to either decrease or remain unchanged, as per projected climate data analysis. The study revealed mixed results on projected changes in mean precipitation, like East African projections, with significant uncertainty in the direction and magnitude of the trend. The annual average temperatures are projected to rise in the coming century, influenced by greenhouse gas concentrations, with more significant end-of-century developments. Borana is projected to experience a faster increase in minimum temperature as compared to Max under all emission scenarios. The study area's projected temperature increase is comparable the 21st-century projection in the African Rangeland (Hoffman and Vogel, 2008), with temperatures expected to rise by 2-6°C (3.6-10.8°F) by the end of the century, depending on the region and greenhouse gas emission scenario.

Drought and dry spell posed the most risks to pastoralists and agro-pastoralists in the research area. Drought events are broadly spread within the zone in comparisons to other threats, and SPI analysis suggests that thy happen 25–40% of the time. The significant events that have occurred in the study area from the early 1960s have provide ample evidence of the “downward spiral" of the population's livelihoods have experienced because of recurrent droughts. The region is expected to experience more frequent dry conditions than usual or heavy precipitation situations in the future. Human-induced climate change has significantly increased the likelihood of global droughts (Hoegh-Guldberg et al, 2018), with droughts increasing by 29% since 2000 compared to the previous two decades (WMO, 2021). Emerging research in the African Rangeland suggests that droughts and heavy precipitation events are likely to increase in total affected areas, despite limited studies and data support (Hoffman and Vogel, 2008).

7.1.2. Impact of drought and climate change on livelihoods and food security.

The study's second specific objective aimed to assess the impact droughts and climate change on livelihood assets like rangelands and livestock in 2016-2017, and how these impacts might have affected food security outcomes. According to Herrero *et al*. (2016), the impact relating to assets used for subsistence is the first-order impact. These effects help to produce higher (second order) effects like outcomes on livelihoods and food security.

Changes in rainfall patterns, hydrological drought, and siltation brought on by flooding all contributed to the early drying up and disappearance of ephemeral/seasonal of water structures in the study area. The current climatic conditions also have an impact on water recharge and level in permanent water sources. The warming that prevailed also hastened transpiration and evaporation of harvested water. The watering interval has increased, livestock/ people must travel farther to get to water, and livestock are drinking less water as a result. Livestock performance is negatively impacted by water intake restrictions more quickly and severely than by any other nutrient shortage (Sileshi *et al*., 2009).

Impacts on the groundwater and surface drainage systems that are now in place are further exacerbated by the projected unfavourable precipitation pattern, persistent dry conditions, and elevated temperature. This will make the current water shortage and stress for livestock and other purposes worse, especially given the increasing human and livestock population. According to Nardone *et al*. (2010), a rise in temperature may result in an increase of two to three times in animal water consumption, which will further increase the pressure on the region's diminishing water resources unless livestock keepers switch to raising animals that use less water. Lack of water will further reduce livestock productivity, which is frequently exacerbated by heat stress. Traditional management strategies will be put to the test, and tensions around already scarce water resources are likely to rise because of the projected decline in the amount of water resources that are available and an increase in the amount of water that people and livestock need because of rising temperatures and increasing human and livestock populations.

Since the late 1980s, the study area has been gradually losing grassland coverage and the accompanying pasture grasses, according to the LULC analysis. Some valuable perennial grass species for cattle production are said to have grown increasingly rare or to disappear from the rangeland over time as the result. In addition, some important acacia species that provide feed during drought and pasture shortage are in decline. The rapid increase in extinction rates and decline in biodiversity is directly linked to the rapid rise in surface temperature (Nath *et al*., 2021; Peace, 2020). The current state of rangeland degradation will worsen because of the projected rainfall pattern, persistent dry spells, rising temperatures, and changes in land use. Hoffman and Vogel (2008) suggested that extended drought contributes to perennial plant mortality and the dominance of annual flora, which is less tolerant to rising temperatures. Over the past 40 years, the proportion of plants impacted by drought globally has more than doubled,

and each year, drought and desertification cause the loss of roughly 12 million hectares of land (FAO, 2017).
Livestock production and productivity have been negatively impacted by the deterioration of feed and water resources. Climate conditions and nutritional stress have led to increased or unpredictable puberty and pregnancy ages, with low pregnancy rates and even stillbirths or abortions. Colostrum, or nutrient-rich first milk, is disappearing from lactating cows due to worsening feed quality, impacting calf mortality and morbidity. Poor nutrition and water stress have also led to increased mortality and morbidity in livestock, even in normal years. Animals under stress frequently lose their immunity and become vulnerable to opportunistic diseases. Extreme feed shortage (hunger) causes livestock to consume unpalatable or undesirable feed and succumb to digestive issues or an unknown disease.

Land use changes and droughts are causing a shift in livestock species and breeds from cattle to small ruminants and camels. For example, when the Desta (2002) figures were compared with the data prior to the 2016–2017 drought, the percentage of cattle to the total TLUs of three species decreased from 89.6% to 80.6%. Both small ruminants and camels see increases, rising from 3.7% to 10.9% and 6.7% to 8.4%, respectively. As a way of adjusting to the land resources that have becoming marginal, it is anticipated that this trend would continue.

Forests have continuously declined over time, with an earlier period's rate of reduction being more pronounced (0.4-0.5% per year). The decline of forestland in Borana was caused by the slow removal of forest from pockets of areas. One of the driving forces behind the current deforestation is the increased need for timber to build homes for the zone's expanding urban population. Accelerated deforestation is attributed to a lack of viable livelihood options and rising poverty. Through the delineation and mapping of the Arero forest, the Borana Zone Environment Protection, Forestry, and Climate Change office developed a community-based conservation and sustainable management plan. This demonstrates a sustained effort to stop the current deforestation and forest degradation. This supports the nation's efforts to reduce emissions caused by deforestation and forest degradation (REDD+)[15] framework. To lessen

[15] The UNFCCC Conference of the Parties (COP) developed the REDD+ framework to direct activities in the forest sector that lower emissions from deforestation and forest degradation, as well as the sustainable management of forests and the preservation and improvement of forest carbon stocks in developing nations.

deforestation and forest degradation, the office must continue to develop the project in additional significant forest area in Yabello and Dire woreda.

The recent drought that pastoralists and agro-pastoralists in southern Ethiopia endured in 2016 and 2017 was used as a point of comparison to show its impact on the assets that sustain livelihoods at the household level. According to estimates, the sample households' sustained cattle losses of 50% (53%), small ruminant losses of 25% (23%), and camel losses of 20% (19%) due to the drought. Due to severe pasture and water shortages during the drought, starvation and dehydration were the primary causes of the excess livestock mortality. In their analysis of livestock mortalities in Ethiopia, Catley *et al*. (2014) concluded that dehydration and starvation were the primary causes of excess livestock mortality in Borana during the drought. Even in good years, the mortality rate of livestock owing to inadequate nutrition has been rising recently. The excessive livestock deaths contributed to the large fall in the average number of livestock held per household and to impoverishment. The number of households (Qolle) that have completely lost their animals has increased since the drought. Following the drought, the number of households in lower livestock holding categories (less than five heads of cattle) has increased 3.5 times. The relative wealth band (11 heads of cattle or more) households shows a drop of 25–100%.

According to the data, the financial losses sustained by pastoral and agro-pastoral HHs in Borana due to mortality averaged 66,700 EB (2,951 USD). In comparison to losses in the 2011 drought (1784 USD), which were calculated by (Shitarek, 2012), this drought's economic losses per household were higher by 55%. These losses equated to estimated total financial losses for the entire research area of 6.8 billion EB, or $300 million USD. Had the expenditures associated with providing aid and supporting livelihoods been factored into the overall calculation, the costs would have been significantly greater.

Despite the drought's predictability (Desta and Coppock, 2002) and early warning signs, Ethiopia's recurring losses of livestock assets point to the shortcomings of current policies or implementation issues. This pattern was noted even though the Ethiopian government's National Policy and Strategy on Disaster Risk Management (FDRE, 2013) stresses the necessity of mainstreaming climate change-related disaster risks within pertinent sectors. The IPCC highlighted that the frequency, severity, and cost of natural disasters will significantly increase in the coming decades in its fifth assessment report (IPCC, 2014). The World

Meteorological Organization (WMO. 2021 b) reports a significant increase in economic losses due to drought over the past few decades.

Most households that primarily rely on livestock keeping for their livelihoods and sources of cash income have been impacted by this drop in livestock holding. The families' ability to produce milk and their ability to expand their herd in the future have both been impacted by the higher rate of lost cows and calves. Due to a severe feed shortage during the drought, the lactating animals that survived were also severely undernourished. Livestock losses have significantly reduced households' revenue generation, as they primarily rely on selling livestock and its products to buy food and non-food items. The high supply of emaciated livestock and low quality of remaining animals led to a sharp drop in market values. For example, the cost of a quintal of maize increased by 25%, while the cost of a goat dropped by 70%. Government and humanitarian organizations have built destocking facilities to save cattle and address lowering trade terms, ensuring food security and livelihood.

The quantity and quality of milk and animal-source meals available to and consumed by households significantly dropped during the drought because of the consequent losses of livestock assets, particularly female reproductive animals. Both the outcome indicator and the individual food security indicator were impacted by this. Lack of good protein-based foods (milk and animal sources of diet) affected everyone, including children, women, and the elderly. The already scarce availability of food for women was made much worse by the increased labour demands and workload connected with the search for water, hay, and firewood during drought. Water collection, particularly in drylands, disproportionately affects women (72%), girls (9%), who may spend up to 40% of their calorific intake carrying water (UNDRR, 2021). Adult male access to such food is also constrained due to their migration with dry stock in search of pasture and water. Due to a decrease in the consumption of foods derived from animals, there have been reports of higher levels of malnutrition (both severe and moderate).

The government and humanitarian actors offered a variety of humanitarian aid as well as support for livelihood protection, which lessened the intensity of the effects. Following the conclusion of the severe drought, seven out of ten sample households (68%) are still reliant on the Productive Safety Net Programme, a sign of continued food insecurity. According to the LZ, the two successive seasonal IPC analysis estimates showed that the extreme acute food insecurity either became worse or stayed the same. Households (poor households) relied on crop farming, selling firewood, and other opportunistic revenue sources, along with a continual dependency on safety-net program. The frequency and severity of drought variations may hamper risk management plans, which are widely employed for livelihood sustainability. This could make recovery more difficult because recovery times between major events may be shorter (Hoffman and Vogel, 2008)

7.1.3. Adaptation to drought and climate change

The study's third and fourth specific objectives were to compile practices of pastoralists and agro-pastoralists in the study area and analyse their SWOT to complement current strategies to reducing and preparing for the effects of drought and risks associated to climate change.

Pastoral households are still using their "timeless" strategy for adjusting to the resources and climates that are spatially and temporally diverse by nature. One of the strategies employed by pastoral households to face the issues is the delineation of warra and forra grazing areas and animal dispersion. However, over the past ten years, as new coping mechanisms to deal with feed scarcity have emerged, households have established or increased enclosures beyond their typical appearance. Hay and crop residue utilization are frequently noted as coping mechanisms, as is an increased level of cut and carry collection. Another widely promoted drought management technique is the expansion of grazing reserves for the dry season.

To meet the needs of livestock, the watering schedule manager continues to play a crucial role in the management of current water resources (ephemeral and permanent). In times of shortage, pastoralists and agro-pastoralists utilize a variety of strategies, such as collecting water from remote sources, moving livestock to permanent water sources, and increasing watering intervals for livestock, to minimize or adapt the effects of water stress on livestock production. However, the scope and severity of the drought have reduced these management measures' efficacy. To cope with water scarcity, particularly during droughts, non-traditional water sources like boreholes and cisterns were becoming more significant in the area. One of the newly reported coping mechanisms used by households is the water-tracking service offered by aid organizations and the government during droughts. If the drought or water stress were severe, water tracking would be expensive and prohibitive.

Three out of every ten agro-pastoral households have modified their crop production practices, primarily to adapt to weather shocks. One of the most prevalent strategies reported by households is early land preparation and planting. Other popular practices include crop rotation, soil fertility management, intercropping, and new crops. To reduce the common risk

of drought and increase market potential, crop diversification, particularly from maize to teff, is an ongoing strategy.
One of the issues mentioned as having an impact on the efficacy of traditional and emerging strategies was the significant drop in the utilization of traditional weather and drought forecast information to make informed decisions on resources and drought risk management. The difficulties have also been exacerbated by the weakened traditional scouting procedures that once evaluated range conditions, pasture, and water availability prior to migration. The current initiatives by several NGOs to convene traditional weather forecasters and meteorological scientists twice a year (before Genna and Hagaya) to exchange viewpoints on the seasonal outlook are anticipated to reverse this tendency. This program is thought to increase the value of weather and drought forecast information, allowing for improved resource and risk management.

IBLI is becoming more popular in the research area and has the potential to lessen the impact of recurring droughts and monetary losses. According to the CIFA's evaluation, the number of pastoralist households acquiring insurance policies and having livestock insured gradually grew from 2012/13 to 2017/18, especially in the final two years of the pilot (CIFA, 2018). The interactive mobile-based training materials created by the promoters will increase financial literacy and might be utilized to help the community understand how the drought has affected it and bring about behavioural and practice change.

By establishing the Dheda system as a legal framework, the Rural Land Administration Office[16] is attempting to support the traditional grazing system and customary institutions. The regional authorities gave the Aba Dheda a certificate, and three of the five grazing systems have already been granted legal status. Both the Gomole and Wayama grazing systems are anticipated to do the same. Recognizing customary land rights and the institutions needed to properly engage in land and resource governance requires the legalization and certification process, which is a crucial first step. As a result of the effects of the persistent drought, climate change, and localized LULC change that prevailed in the area, the usage and regulation of the resource are currently under threat. This program is expected to give traditional institutions and authorities more authority to defend those practices.

[16] The Ethiopia Land Administration to Nurture Development (LAND) project support of the USAID

There has been a gradual increase in pastoralists' use of alternative income sources (57% of sample households) and sales of livestock for purposes other than food in the study area (30% of sample households), especially when the animals are in good physical condition and fetch a decent price. Pastoralists are investing the money they make from selling their livestock in other ventures, including small businesses, building urban houses, and putting money away in the bank for emergencies. The sale of livestock and the investment in alternative investment forms were strongly encouraged by NGOs and positive deviants. Some pastoralists were also selling cattle to purchase camels, goats, or other livestock that were thought to be drought resistant. Emerging diseases, however, are restricting the diversification of these species. The increased camel production's potential drawback of contributing to a worsening of bush encroachment worries the pastoralists just as much.

7.2. Conclusions

The study examined drought patterns, climate variability, and change in the study area, affecting rangelands, livestock, and natural resources. Unfavourable patterns were observed in in households and qualitative research. Climate data showed temperature rise, rainfall variability, and the recurring dry and drought conditions. However, precipitation trends did not show a unified pattern, and future rainfall projected suggest a decrease or stay the same. All the possible emission scenarios projected a rise in the yearly average maximum and minimum temperature over the course of the century. The study also emphasizes the lack of consensus among the stakeholders on the root causes and exacerbating factors of the observed change, which impacts adaptive measures.

Rising temperatures and rainfall variability are the main causes of the climate risk affecting livestock and agricultural production in the research area, leading to extreme events like drought and flooding, and affecting livelihoods, socioeconomic development, and ecosystems. The study reveals that people in low land areas are generally at greater risk due to low precipitation, variable rainfall, and higher temperatures. The study reveals that people in low land areas are generally at greater risk due to low precipitation, variable rainfall, and higher temperature.

This study aims to explore long-term precipitation and temperature changes associated with climate risk in the in the Borana zone of southern Ethiopia. It emphasizes the importance of blended precipitation and temperature gridded data for improved local climate risk management. The research also highlights the value of a mixed method, including local knowledge, in understanding climate risk, especially when weather and climate monitoring systems are weak. The article published in the Scientific Report Journal shares information and lessons learned on understanding physical climate risks and their implications for community adaptation.

The study reveals that recurrent droughts and climate change have led to a decline in feed and water resources, impacting livestock production and productivity in a region. Land use and cover change since the late 1980s have led to the depletion of these resources. Factors contributing to this decline include forest clearing, non-selective bush clearing, decline in fodder tree management, and cutting down valuable tree species for charcoal and firewood. The lack of livelihood options and rising poverty are driving this trend. Addressing this development challenge is crucial to mitigate local climate change and its repercussions.

The study reveals that recurrent droughts and climate change have led to decline in feed and water resources, impacting livestock production and productivity in the studied area. Land use and cover change since the late 1980s have led to depletion of these resources. Factors contributing to this decline include forest clearing, non-selective bush clearing, decline in fodder tree management, and cutting down valuable tree species for charcoal and firewood. The lack of livelihood options and rising poverty are driving this trend. Addressing this development challenge is crucial to mitigate local climate change and its repercussions.

The age at which the reproductive herd reached puberty and became pregnant increased or remained unpredictable due to the current and projected climatic condition together with accompanying stressors connected to nutrition and water. Due to heat stress and drought, even pregnant animals gave birth to stillbirths or abortion, resulting in a low conception rate within the herd. The amount of milk that lactating animals produce is impacted by feed scarcity. During their early years, newborns and calves undergoing pre-weaning have restricted access to milk and nutrient-rich grass. Even in years when the rangeland resources are in good condition, the reduction in colostrum—the first milk rich in nutrients from lactating cows—influences calf mortality and morbidity. The current resource scarcity and frequent droughts will exacerbate the genetic dilution caused by interbreeding if efforts to conserve animal genetic resources are not strengthened. This could accelerate drought-related migration to neighbouring communities to obtain scarce resources during hard times.

The socioeconomic impact of drought is amply demonstrated by the study's findings regarding livestock asset losses and the corresponding monetary value estimation. The IPCC predicts a significant rise in the frequency, intensity, and cost of natural catastrophes in the coming decades, as per its fifth assessment report. If climate-related disasters are not addressed holistically at the local or global level, they may worsen food insecurity that already exists, promote maladaptation, and hinder the achievement of the SDGs. The estimation of future losses and damage in the pastoral area is made possible by the study's estimate of livestock asset losses, which is based on representative and systematic household sample surveys. The article published in the International Journal of Disaster Risk Reduction (IJDRR) shares the results of the study with scholars, decision-makers, and practitioners on impact of 2016–2017 drought on household livestock assets and food security.

The Ethiopian government's National Policy and Strategy on Disaster Risk Management emphasizes the importance of mainstreaming disaster risks, particularly those related to climate change, within relevant sectors to mitigate their effects. However, the study area's actors have been focusing more on urgent needs than developing plans to mitigate droughts, despite the predictable nature of drought and early warning indicators. This highlights the need for a more comprehensive approach to disaster risk management. The 2018 EC-commissioned assessment on the local operationalization of the DRR system (Biru and Dibaba, 2018) is expected to provide valuable insights into challenges, lessons learned, and best practices for institutionalizing decentralized disaster risk management, a crucial policy and mainstreaming element.

Pastoralists and agro-pastoralists in the research region have been consistently searching for techniques that supplement their traditional measures to minimize and adapt to the effects of drought and risks associated to climate change. This study has demonstrated that, despite challenges, pastoralists and agro-pastoralists still employ a variety of traditional strategies. These strategies seem to be losing effectiveness as the variability, size, and severity of the drought and LULC changes increase. Consequently, some livestock and agricultural production techniques are being adopted by pastoralists and agro-pastoralists. Expanding enclosures, opportunistic farming, and camel herding were some of the new strategies that were employed in a spontaneous manner. The process has also been helped by actors in the development, research, and humanitarian sectors. These actors also contributed to the planned adaptation. Prominent ones were the promotion of pastoral education, the diversification of sources of income (savings and credit, small businesses, etc.), the encouragement of livestock sales during good times, and the investment in alternative forms of investment (bank savings, urban houses, pastoral insurance).

The study examines the indigenous weather and drought forecasting system built by pastoralists to cope with climate variability and drought. It found that despite high dependence on these sources, their usefulness is declining, especially among young and educated pastoralists. A new initiative, involving meteorological scientists and traditional weather predictors, was developed with the help of non-governmental organizations. This forum exchanges ideas on seasonal outlooks and recommends actions based on consensus-based forecasters.

The finalized national adaptation strategy for Ethiopia appears to have benefited from qualitative input from the SWOT analysis of the traditional and emerging strategies through vertical integration, hence reducing the vulnerability of pastoralists. The NAPA and NAP procedures must consider local characteristics, livelihood systems, climatic hazards, traditional knowledge, and resource management for the adaptation plan to be successful. The research's drawback is the requirement for more cost-benefit assessments (CBAs) of adaptation choices in the future to assist decision-makers in selecting the best course of action.

7.3. Recommendations

The research offers recommendations, organized by research objectives broadly, on droughts and climate change and their effects on land, water, livestock production, and food security. It provides suggestions on how affected sectors and stakeholders might lessen their effects, emphasizing the importance of taking these suggestions in entreaty to achieve the desired results.

Historical and future pattern of climate variability, change and drought.

The Oromia Pastoral Area Development Commission (OPADC) and the Oromia Environment, Forest, and Climate Change Authority should establish a participatory platform by bringing together the impacted population and stakeholders to talk about the impacts of climate change on the Borana pastoral system and to determine future course of action. There will be opportunities throughout the discussion to create a formal framework, which has not yet been

established in the area, for regular gatherings to discuss climate change. To generate support, increase awareness, and promote the development of a workable plan or strategy to direct the policy-making process, the forum may consider forming an advocacy group for climate change adaptation.
The observed and anticipated climate data from the study provide this forum with important information on current and future patterns in the climate change of the area. Enhancing the understanding of the region's climate can also be facilitated by the NDVI anomaly analysis maps, which span the period from July 2002 to July 2020. The qualitative analyses and wealth of indigenous knowledge gained in this research can help to promote consensus by illuminating the local context.

The collaboration between meteorological experts and traditional weather forecasters to exchange seasonal outlook views is a crucial initiative that requires financial and logistical support from non-governmental actors. The actors must discuss the idea with institutions and plan for institutionalization. They should expand their assistance with early warning dissemination and initiate preparedness action. Additional channels, such as mobile phones and traditional methods, can be considered to enhance real-time weather and drought forecast services and reduce climate-related risks. Climate change and disaster risk management organizations should institutionalize this initiative to improve local climate-related hazards and real-time forecast services. This initiative can enhance decentralized disaster risk management, particularly contingency planning and disaster mitigation and adaptation planning. It also enhances the utility of traditional weather and drought forecasting systems.

Impact of drought and climate change on livelihoods and food security.

The Borana rangeland is further degrading due to drought and climate change, and the strength of existing institutions and customary land rights will play a significant role in adapting to climate change and limiting further degradation of rangeland resources. Recognizing customary rights and certification of traditional grazing units can strengthen traditional resource management and governance. Inter-grazing gatherings can address territorial-wide problems jointly. Addressing fundamental concerns and elevating traditional authority, such as Rabaa Gadas and Gumi Gayo[17], can help lessen societal risk and vulnerability to drought and

[17] The largest social-political assembly in Borana is called Gumi Gaayoo. It occurs once every eight years in a location called Gaayoo in the Borana Zone. Borana from everywhere, including neighbouring Kenya attend.

climate change. International support is essential for the certification of the final two significant grazing units (Wayama and Gomole) and preparing for climate change. International partners can support livelihood projects for vulnerable pastoralists who are increasingly using risk-taking coping mechanisms to survive, exacerbated by LULC change.

The Yabello Pastoral and Dryland Agriculture Research Centre is collaborating with formal and traditional organizations to promote community-based participatory research (CBPR) on rangeland rehabilitation and dry land practices. They are establishing grazing regulations with the leadership of grazing manager to allow degraded land to rest for a predetermined period, protecting livestock from grazing and promoting soil and vegetation recovery. Replanting desirable acacia species and grasses in degraded areas can reverse the trend. Micro catchments (semi-circular bunds) can conserve soil and water. The research institute is promoting conservation agriculture as a climate-smart agriculture practice, which could improve food security and rehabilitate damaged land. The Agriculture Research Centre is also supporting ongoing conservation activities for the Borana indigenous cattle breeds to prevent further dilution and support sustainable cattle breed development.

The Environment Protection Forestry and Climate Change Office in the Borana Zone must expand its community-based forest conservation initiative to Yabello and Dire woreda to reduce deforestation and forest degradation. The office must collaborate with governmental and non-governmental organizations to improve livelihoods and reduce climate change effects. A proactive approach is needed to coordinate stakeholders in the bush control initiative, harmonize control measures, and involve scholars, practitioners, policymakers, and donors. The focus should be on acacia species (C4 and C6 plants) in carbon sequestration, as the livestock species diversification to camel and goat is changing. The office must also consider the potential of acacia species in carbon sequestration.

Adaptation to drought and climate change

The climate change office, in coordination with the zonal offices for disaster preparedness, economic planning, and finance, needs to facilitate ongoing discussions and mobilize various stakeholders on climate change and adaptation plans for the country's Climate Resilient Green

Economy (CRGE) strategy to be operationalized at the local level. The potential for developing a participatory platform at the zonal level should be taken into consideration, and this effort needs to be coordinated with the regional government. To develop solutions, this would include bringing together interested parties and the affected population to talk about climate change and its effects on the Borana pastoral system.

Traditional authorities and customary institutions are aware of the weaknesses in traditional management systems and increased vulnerability of pastoralists to drought and climate change. To address these issues, traditional leaders need to discuss topics such as valley bottom land cultivation, enclosure outside traditional boundaries, a dry season grazing reserve, reciprocal resource sharing, mobility, scouting, tree management, and the usefulness of traditional climate and weather forecasts.

The Federal Democratic Republic of Ethiopia should consider expanding livestock insurance in the pastoral area through satellite-based index insurance, which protects livestock against drought-related risks. The CIFA study using Participatory Research Methods to evaluate the impact of Index Based Livestock Insurance (IBLI) as a climate risk management strategy in the Moyale and Miyo woredas of the Borana Zone offer valuable insights for scaling up the initiative. The initiative should also expand the scope of interactive mobile-based training resources for financial literacy to help the community understand drought effects and support changing attitudes and behaviours in livestock production. Promoters and international partners should assist in research, education, and promotion for IBLI, which helps livestock keepers lessen the impact of droughts and recover from them. External actors' participation and financial assistance are essential for the project's long-term financial viability. The initiative's promoters should discuss information that could improve community understanding of drought and climate change effects and help shift attitudes and behaviours.

The Federal Democratic Republic of Ethiopia's Disaster Prevention and Preparedness Commission (DPPC) should prioritize integrating drought risk management in pastoral areas within its disaster prevention and preparedness policy. This should be done in collaboration with disaster management structures at regional, zonal, and woreda levels. Effective implementation will reduce the effects of recurrent droughts and livestock asset losses. The 2016-17 drought highlighted the urgent need for policy intervention. The 2018 assessment by the EC on the operationalization of the decentralized disaster risk management system at the local level will be helpful in identifying challenges and best practices for institutionalizing decentralized disaster risk management. This will enable actors to fulfil their individual responsibilities for minimizing common risks like droughts, rather than prioritizing emergency needs.

The SWOT qualitative analysis of the current traditional and emergent strategies is thought to provide vital information for Ethiopia's recently completed national adaption plan through vertical integration. For the adaptation strategy to be successful, the livelihoods system, climate hazards, traditional knowledge, and resource management must all be considered during the NAPA and NAP process.

7.4. Further studies

To accurately estimate future drought-related damage and losses in pastoral areas, it is crucial to consider the indirect cost of humanitarian assistance and livelihood protection support, to accurately reflect the monetary value of the drought impact.

Research is focusing on identifying and treating new diseases in camels and small ruminants, including "mysterious diseases" found in Kenya and Somalia. Unidentified small ruminant diseases are also reoccurring in the region. To increase production and support pastoralist efforts towards species diversification, it is crucial to investigate, isolate, and treat these new livestock diseases.

A cost-benefit analysis (CBA) of the present adaptation options (measures) will be crucial missing in this study in assessing the advantages and disadvantages of each alternative, helping decision-makers decide which adaptation alternatives to support in response to climate change. As a result, NAPs can evaluate and prioritize adaptation strategies based on the benefits and drawbacks they offer to society.

REFERENCES

AFDB. (2010). *Regional Study on the Sustainable Livestock Development in the Greater Horn of Africa. LOG Associates.* Nairobi, Kenya.: African Development Bank Group (AFDB).

Allen S.K, B.-C. J. (2018). Translating the concept of climate risk into an assessment framework to inform adaptation planning: Insights from a pilot study of flood risk in Himachal Pradesh, Northern India. *Environmental Science and Policy 87*, 1-10.

Amsalu, A. A.A. (2009). Assessment of climate change-induced hazards, impacts and responses in the Southern Lowlands of Ethiopia. Addis Ababa, Ethiopia: Forum for Social Studies, Cordaid.

Assefa A., A. H. (2018). Ethiopian Indigenous Cattle breed's Diversity, Distribution, Purpose of keeping and their potential threats. J. Bio Innovation, 7 (5): 770-789.

Ayugi, B. , G. T. (2020). Historical evaluations and simulations of precipitation over East Africa from Rossby centre regional climate model. Atmospheric Research, 232. 104705.

Bailey, D. B. (1999). Livestock Markets and Risk Management Among East African Pastoralists: A Review and Research Agenda. GL-CRSP Pastoral Risk Management Project Technical Report No. 03/99. Logan, UT: Utah State University: GL-CRSP Pastoral Risk Management Project.

Barati, B. A. (2008). Meiotic competence and DNA damage of porcine oocytes exposed to an elevated temperature. *Elsevier, 69*, 767-772.

Barrett, C. (2004.). Decomposing Producer Price Risk: A Policy Analysis Tool with an Application to Northern Kenyan Livestock Markets . *Food Policy, 29(4),*, 393-405.

Barrow, E. D. (2007). Pastoral Institutions for managing natural resources and landscapes. In Policy Brief No. 3. IUCN Eastern Africa Regional Office. Nairobi, Kenya.

Bewket, W. (2007). A note on the temporal and spatial variability of rainfall in the drought-prone Amhara Region of Ethiopia. *International Journal of Climatology 27*, 1467–1477.

Biagini, B., Bierbaum, R., Stults, M., Dobardzic, S. and McNeeley, S. (2014). A typology of adaptation actions: A global look at climate adaptation actions financed through the Global Environment Facility. *Global Environmental Change Volume 25*, 97-108.

Bilinsky, P., J. C. (2007). Household Food Insecurity Access Scale (HFIAS) for Measurement of Food Access: Indicator Guide. Washington, DC: Food and Nutrition Technical Assistance III Project (FANTA).

Birhanu Z., B. N. (2015). Rapid Appraisal of Resilience to the Effects of Recurrent Droughts in Borana Zone, Southern Ethiopia. Jimma University, Ethiopia: Horn of Africa Resilience Innovation Lab (HoA RILab), .

BIZIMANA, J.-C. (2016). The 2010-2011 Drought Impacts on Cattle Market Integration in the Horn of Africa: A preliminary Evaluation using VAR and Structural Break Analysis, Selected Paper prepared for presentation at the Southern Agricultural Economics Association's 2016 Annual M. San Antonio, Texas USA.

. Bowden, J.H. and Semazzi, FHM. (2007). Empirical analysis of intraseasonal climate variability over the Greater Horn of Africa. *Journal of Climate, 20 (23)* , 5715-5731.

Brown, D.R., Dettmann, P., Rinaudo, T., Tefera, H. and Tofu, A. (2011). Poverty alleviation and environmental restoration using the clean development mechanism: A case study from Humbo, Ethiopia, *Environmental Management, 48,* 322–333.

Boran Cattle Breeders' Society of South Africa. (2010). *Journal of Borana Cattle Breeders' society in South Africa.* Boran Cattle Breeders' Society of South Africa.

Boran Zone. (2017). Current Situation of Borana Zone, Seasonal food security assessment report, unpublished. Disater prevention and Prepardnes Desk of Borana Zone, Yabello.

Cardona, O D, V. A. (2012). Determinants of risk: exposure and vulnerability. Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change (IPCC), Field, C.B, et.al, (Eds). Cambridge, UK, and New York, NY, USA: Cambridge University Press.

CARE-Ethiopia. (2009). Value Chain Analysis of Milk and Milk Products in Borana Pastoralist area: Regional Resilience Enhancement against Drought Project. Addis Ababa: Yonad Business Promotion and Consultancy PLC.

Catley, A, J. L. (2013). Pastoralism and Development in Africa. Dynamic change at the Margin. Newyork: Routledge.

Coppock, D. (1994). The Borana plateau of southern Ethiopia: Synthesis of pastoral research, development and change, 1980–91. Systems study No.5. Addis Ababa, Ethiopia : International Livestock Centre for Africa.

Cossins, J. (1987). The Borana pastoral system of Southern Ethiopia. Agricultural Systems. *Agricultural Systems. vol. 25, issue 3*.

CRED. (2020). Emergency Events Database (EM-DAT) of Centre for Research on the Epidemiology of Disasters (CRED). Brussels, Belgium: EM-DAT CRED.

CSA. (2013). Population Projection of Ethiopia for All Regions at Wereda Level from 2014 – 2017: Central Statistical Agency (CSA), Federal Demographic Republic of Ethiopia. Addis Ababa, Ethiopia

Daron, J. (2014). Regional Climate Messages: East Africa. Scientific report from the CARIAA Adaptation at Scale in Semi-Arid Regions (ASSAR) Project.

De Leeuw J, N. M. (2014). The need for resilience in the drylands of Eastern Africa. In Treesilience: An Assessment of the Resilience Provided by Trees in the Drylands of Eastern Africa . World Agroforestry Centre (ICRAF) .

Demeke, A. K. (2011). Demeke, AB., Keil, A. and Zeller, M. 2011. Using panel data to estimate the effect of rainfall shocks on smallholders food security and vulnerability in rural Ethiopia. . *Climate Change108:*, 185–206.

Desta, S., B. W. (2008). *P*astoral drop out study in selected weredas of Borana zone, Oromia regional state,. Addsi Ababa, Ethiopia : CARE-Ethiopia .

Desta, S., C. D. (2007). Building Effective Community Participation and Stakeholder Partnerships to Promote Positive Change in the Southern Ethiopian Rangelands Pastoral Risk Management Project. Utha: PARIMA.

Desta, S., D. C. (2002). Cattle population dynamics in the southern Ethiopian rangelands, 1980-97. *J. Range Manage*, 55(5), 439-451.

Desta, S. (1999). Diversification of Livestock Assets for Risk Management in the Borana Pastoral System of Southern Ethiopia. PhD dissertation . Utah, USA: Utah State University.

Dinku, T., Connor, SJ., Ceccato, P. and Ropelewski, CF. (2008). Intercomparison of global gridded rainfall products over complex terrain in Africa. *International Journal of Climatology 28*, 1627–1638.

Eckstein, D. , V. K. (2017). *G*LOBAL CLIMATE RISK INDEX 2018 Who Suffers Most From Extreme Weather Events? Weather-related Loss Events in 2016 and 1997 to 2016. Bonn, German: Germanwatch e.V. Office Bonn.

Dosio, A., C. L. (2022). Projections of indices of daily temperature and precipitation based on bias adjusted CORDEX Africa regional climate model simulations. *Climatic Change, 170, 13*.

FAO. (2015). *T*he impact of natural hazards and disasters on agriculture, food security and nutrtion. Rome, Italy: FAO.

FAO. (2017). Drought & Agriculture. http://www.fao.org/3/i7378e/i7378e.pdf

FDRE. (2019). Ethiopia's Climate Resilient Green Economy, National Adaptation Plan. Addis Ababa, Ethiopia : Federal Democratic Republic of Ethiopia (FDRE.

FDRE. (2010). Growth and Transformation Plan (GTP) 2010/11-2014/15 (Draft), Federal Democratic Republic of Ethiopia. Addis Ababa, Ethiopia.

FDRE. (2011). Ethiopia's climate-resilient green economy: Green economy strategy, Federal Democratic Republic of Ethiopia . Addis Ababa.

Federal Democratic Republic of Ethiopia, O. B. (2015). *Crop and Rural Development Bureau. Technical Manuals for Resilience Enhancement in Pastoral Areas.* Addis Ababa, Ethiopia.

FEWSNET. (2015). Illustrating the extent and severity of the 2015 drought. Ethiopia Special Report,. Famine Early Warning System Network (FEWSNET).

Funk, C., Dettinger, MD., Michaelsen, JC., Ver. (2008). Warming of the Indian Ocean threatens eastern and southern African food security but could be mitigated by agricultural development. PNAS – Proceedings of the National Academy of Science 105: 11081–11086.

Füssel H-M, Klein RJT. (2006). Climate change vulnerability assessments: an evolution of conceptual thinking. *Clim. Change, 75,* 301–329.

Ganesh, S. M. Evaluating the utility of the vegetation condition index (VCI) for monitoring meteorological drought in Texas. *Agric. For. Meteorol. 150,*(3), 330–339.

Graw, V., G.H. (2017). Drought Dynamics and Vegetation Productivity in Different Land Management Systems of Eastern Cape, South Afric. *Sustainability*.

Guldberg, H. , O. J. (2018). *Global warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change.* Intergovernmental Panel on Climate Change (IPCC).

Hammill, A. B. (2013). *Comparative analysis of climate change vulnerability assessments. Lessons from Tunisia and Indonesia.*

Heinz, C. (2002). *Human Links to Coastal to Coastal Disasters. Washington, DC, The H. John Heinz III Center for Science, Economics, and the Environment.*

Helland, J. (1998). Institutional erosion in the drylands: The case of the Borana pastoralists. Eastern Africa social science research review, 14(2), p.49. *Eastern Africa social science research review, 14(2),* 49.

Herrero, M. A. (2016). Climate change and pastoralism: impacts, consequences and adaptation. *. Rev. Sci. Tech. Off. Int. Epiz., 35 (2), ,* 417–433.

Hinkel, J. S. (2010). Review of methodologies for assessing vulnerability – Report submitted to GTZ in the context of the project Climate Change Adaptation in Rural Areas of India, European Climate Forum (ECF), Stockholm Environment I. Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ), s.l.

Homan, S. D. (2003). *P*otential and constraints of indigenous knowledge for sustainable range and water in the pastoral land use systems of Africa: A case study in Borana lowlands of southern Ethiopia. Unpublished Report.

Homann, S. R. (2008). The effect of development interventions on the use of indigenous range management strategies in the Borana Lowlands in Ethiopia. . *Land degradation & development*, *19(4)* , 368-387.

Hoste, H. N. (1977). Rangeland production and annual rainfall relations in the mediterranean basin and in the african sahelo-sudanian zone. *Journal of range management*, *30 (3)* , 181-189 .

Huang J, J. M. (2015). Global semi arid climate change over last 60 years. *Clim Dyn (2016) 46*, 1131–1150.

Huq, H. R. (2003). *Mainstreaming Adaptation to Climate Change in Least Developed Countries (LDCS), International Institute for Environment and Development, 57 pp.*

ICPAC. (2007). Climate Change and Human Development in Africa: Assessing the Risks and Vulnerability of Climate Change in Kenya, Malawi and Ethiopia.

IGAD. (2010). The Contribution of Livestock to the Ethiopian Economy – Part II. IGAD LPI Working Paper No. 02 - 11. Great Wolford and United Kingdome.: Roy Behnke, Odessa Centre, .

Hoffman, T, V. ,C. (2008). Climate Change Impacts on African Rangelands. Rangelands, 12-17.

IPCC. (2014). Summary for policymakers. In: Climate Change 2014: Impacts,Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B., V. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 1-32: IPCC.

IPCC. (2014). Summary for policymakers. In: Field CB, V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (ed) Climate C. Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press.

Jahn, T., B. M. (2012). Transdisciplinarity: between mainstreaming and marginalization . *Ecological Economics 79.* , 1-10.

Jurgilevich, A. R. (2017).. A systematic review of dynamics in climate risk and vulnerability assessments. *Environmental Research Letters*, *12(1)*, 013002.

Kamara, A. (2001). Property rights, risk and livestock development in southern Ethiopia.

Keno, T., D. D. (2018). Participatory research on the effectiveness of index based livestock insurance as a pro-poor climate risk management strategy in Borena Zone. CAFOD / SCIAF / Trócaire.

Kates, W. R. (2012). Transformational adaptation when incremental adaptations to climate change are insufficient. Proceedings of the National Academy of Sciences. PNAS, 109 (19), 7156-7161.

Krätli, S. (2019). Pastoral Development Orientation Framework focus on Ethiopia Bischöfliches Hilfswerk MISEREOR e. V.,Aachen, Germany. Bischöfliches Hilfswerk MISEREOR e. V.,Aachen, Germany .

Lasage, A. S. (2010). Report on general characteristics of the Borana zone, Ethiopia..IVM Institute of Environmental Studies, Report R-10/03.

Little, P. K. (2001). Avoiding Disaster: Diversification and Risk Management among East African Herders . *Development and Change, 32:*, 401-433.

Mérida, Z. B. (1995). Effects of Drought and Flooding on Root Anatomy in Four Tropical Forage Grasses. *International Journal of Plant Sciences. 156 (4).* 514-521 .

Markakis, J. (2011). *Ethiopia: The Last Two Frontiers.* Woodbridge, Suffolk; and Rochester, NY: James Currey.

McDowell G., F. J. (2016). Community-level climate change vulnerability research: trends, progress, and future directions. *Environmental Research Letter, Volume 11, Number 3*.

McPeak, J. (2004). Contrasting income shocks with asset shocks: livestock sales in Northern Kenya. *Oxford Economic Papers, 56,* 263–284.

McPeak, J. a. (2001). Differential risk exposure and stochastic poverty traps among East African pastoralists. *American Journal of Agricultural Economics*.

Meikle, A. (2010). Africa Climate Change Resilience Alliance (ACCRA) Ethiopia Country Level Literature Review.

Mekasha, A. T. (2014). Trends in daily observed temperature and precipitation extremes over three Ethiopian eco-environments. . *International Journal of Climatology 34* , 1990–1999.

Mengistu, D. B. (2014). Recent spatio-temporal temperature and rainfall variability and trends over the upper Blue Nile River Basin, Ethiopia. *International Journal of Climatology 34*, 2278–2292.

Mishra, S. , S. S. (2018). CMIP5 vs. CORDEX over the Indian region: how much do we benefit from dynamical downscaling? Theoretical and Applied Climatology 133 (3) . 1133–1141.

Mishra, V. , D. K. (2014). Reliability of regional and global climate models to simulate precipitation extremes over India. *Journal of Geophysical Research: Atmospheres119 (15)*, 9301–9323.

Moacelli, G. (2005). WMO Drought Assessment and Forecasting. Weather, Climate and Water; Draft Report 2005,WGH/RA.

Morton, J. (2006). The 2006 Drought and Pastoral Communities of Southern Ethiopia: Report on a study of the perceptions of the drought and impacts of drought emergency responses in Borena zone (Oromia region) and adjoining areas of Somali region. USAID-Pastoral Livelihood I.

Morton, J. (n.d.). Pastoralism and climate change. Pastoralism information note 5:. Natural Resources Institute, University of Greenwich.

Muccione, V. A. (2016). Differentiating regions for adaptation financing: the role of global vulnerability and risk distributions. Wiley Interdiscip. Rev.: Clim. Change.

Mude, A., C. B. (2010). The Performance of Index Based Livestock Insurance: Ex ante Assessment in the Presence of a Poverty Trap.

Nardone, A. R. (2010). Effects of climate changes on animal production and sustainability of livestock systems. *Livestock Science;, 130, (1–3)*, 57-69.

Nath, S., R. K. (2021). Influence of anthropocene climate change on biodiversity loss in different ecosystems. In Global Climate Change. *In Global Climate Change, Elsevier.*, 63-78.

Nelson Rohan, K. P. (2010). The vulnerability of Australian rural communities to climate variability and change: Part I—conceptualizing and measuring vulnerability. *Environmental Science and Policy; Volume 13, Issue 1*, 8-17.

NMA. (2007). Climate change national adaptation program of action (NAPA) of Ethiopia. Ministry of Water Resources, Addis Ababa. Addis Ababa.

McCarthy, J,, O. F. (2001). Adaptation to climate change in the context of sustainable development and equity. Third Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, UK: Cambridge University Press.

Borana Zone. (2018). PHYSICAL AND SOCIO-ECONOMIC PROFILE OF BORANA ZONE. Borana Zone Office, Yabello Borena .

Omondi, P. E. (2014). Change in temperature and precipitation extremes over the greater Horn of Africa region from 1961 to 2010. *International Journal of Climatology 34*, 1262–1277.

Oppenheimer, M, C. M. (2014). Emergent risks and key vulnerabilities Climate Change 2014: Impacts, Adaptation, and Vulnerability Part A: Global and Sectoral Aspects

Contribution of Working Group II. Cambridge, United Kingdom: Cambridge University Press.

Oppenheimer M, C. M. (2014). *E*mergent risks and key vulnerabilities Climate Change 2014: Impacts, Adaptation, and Vulnerability Part A: Global and Sectoral Aspects Contribution of Working Group IIto the Fifth Assessment Report of the Intergovernmental Panel on Climate Change eds C B. Cambridge, United Kingdom: Cambridge University Press.

Osima, S. , V. S. (2018). Projected climate over the Greater Horn of Africa under 1.5 °C and 2 °C global warming. *Environmental Research Letters, Volume 13, Number 6*.

OXAM. (2011). Briefing on the Horn of Africa Drought 2011: Disaster Risk Reduction – fundamental to saving lives and reducing poverty.

Pagot, J. (1993). Influence of climate and weather on cattle production in tropics

Parry, M.L., O. C. (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. United Kingdom and New York, NY, USA.: Cambridge University Press, Cambridge .

Peace, N. (2020). Impact of climate change on insect, pest, disease, and animal biodiversity. *International journal Environmental science & natural resources Review article, 23(5)*.

Pedro, F, A.M. (2013) Unpacking multilevel adaptation to climate change in the Great Barrier Reef, Australia. *Global Environmental Change, 23 (4)* , 800-812.

Riché B., H. E. (2009). Climate-related vulnerability and adaptive-capacity in Ethiopia's Borana and Somali communities. Addis Ababa, Ethiopia: IISD and IUCN.

Rummukainen, M. (1997). Methods for statistical downscaling of GCM simulations. Climate research - Rossby Centre.

Schipper, C. A. (2011). Adaptation to climate change in Africa: Challenges and opportunities identified from Ethiopia. *Global Environmental Change 21* , 227–237.

Schneider, S. S. (2007). *A*ssessing key vulnerabilities and the risk from climate change. 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. Cambridge, UK: Cambridge University Press, 779-810.

Schreck, C. A. (2004). Variability of the recent climate of Eastern Africa. *International Journal of Climatology 24:*, 681–701.

Seleshi, Y. A. (2006). Seleshi, Y. and Camberlin, P. 2006. Recent changes in dry spell and extreme rainfall events in Ethiopia. *Theoretical and Applied Climatology 83*, 181–192.

Shibru, M. (2001). Pastoralism and Cattle Marketing: *A Case Study of the Borana of Southern.* Egerton University, Kenya.

Smit, B, J. W. (2006). Adaptation, adaptive capacity and vulnerability . *Global Environmental Change-Human and Policy Dimensions, 16* , 282-292.

Smit, B, M. S. (2002). Adaptation options in agriculture to climate change: a typology . *Mitigation and Adaptation Strategies for Global Change, 7* , 85-114.

Subrahmanyam, V. P. (1967). Incidence and spread of continental drought, WMO/IHD Report No. 2. Geneva.

SWALIM. (2009). *Combined drought Index methodology. FAO UN managed Somalia Water and Land Information Management (SWALIM) project.*

T.R. Carter, M. H. (1994). Intergovernmental Panel on Climate Change Technical Guidelines for Assessing Climate Change Impacts and Adaptation. University College London and Center for Global Envrionmental Research, London.

Thornton, P. K. (2002). Mapping Poverty and Livestock in the Developing World . Nairobi, Kenya. : International Livestock Research Institute .

Tierney, K. L. (2001). Facing the Unexpected: Disaster Preparedness and Response in the United States. Washington, D.C, Joseph Henry Press.

Toulmin, C. (1987). Drought and the farming sector: Loss of farm animals and post-drought rehabilitation. *Dev. Policy Rev., 5, 125–148.*

Allen S.K., B.-C. J. (2018). Translating the concept of climate risk into an assessment framework to inform adaptation planning: Insights from a pilot study of flood risk in Himachal Pradesh, Northern India. *Environmental Science & Policy, 87*, 1-10.

Tsadik, Z. S. (n.d.). Water resources for livestock in Ethiopia: Implications for research and development .

Tsakiris G., P. D. (2007). Regional Drought Assessment Based on the Reconnaissance Drought Index (RDI). *Water Resources Management, 21(5):,* 821-833.

UNCCD. (2022). DROUGHT IN NUMBERS 2022 - restoration for readiness and resilience. UN Conventions for Combating Desertification.

UNDRR. (2021). GAR Special Report on Drought 2021. https://www.undrr.org/media/49386/download

UN EMG. (2011). Global Drylands: A UN system-wide response. United Nations Environment Management Group (UN EMG).

UNEP. (2009). Millennium Ecosystem Assessments (MEA) Report. United Nations Environment Programme (UNEP).

UNFCCC. (2007). Climate Change: Impacts, Vulnerabilities and Adaptation in Developing Countries. Bonn, Germany: United Nations Framework Convention on Climate Change (UNFCCC).

Unganai, L., & Kogan, F. (1998). Drought monitoring and corn yield estimation in Southern Africa from AVHRR.

UN-OCHA. (2016). Weekly Humanitarian Bulletin: Ethiopia. UN Office of the Coordination of Humanitarian Affairs (UN-OCHA).

USAID. (2011). *USAID. (2011).* Climate change and conflict in pastoralist regions of Ethiopia: Mounting challenges, emerging responses, CMM Discussion Paper No. 4. Washington, DC: USAID.

Verduzco, R. B. (2013). A comprehensive review of climate adaptation in the United States: more than before, but less than needed. *Mitig Adapt Strateg Glob Change, 18*, 361–406.

Vishwakarma, A., Choudhary, M. K., & Chauhan, M. S. (2022). Assessment of CMIP5 and CORDEX-SA experiments in representing multiscale temperature climatology over central India. *Water Practice and Technology (2022) 17 (9)*, 1923–1936.

Wade, R. D. (2015). A Definition of Systems Thinking: A Systems Approach: 2015 Conference on Systems Engineering Research. . *Procedia Computer Science 44, 669 – 678*.

Wallemacq, P. S. (2015). The Human Cost of Natural Disasters - A global perspective.

Wilbanks, T. K. (1999). Global change in local places: how scale matters. *Climatic Change, 43* , 601-628.

Wilhite, D. I. (2000). Chapter 1 Drought as a NaturalHazard: Concepts and Definitions. In Drought: A Global Assessment; Wilhite, D.A., Ed.;. Routledge: London, UK, 2000; pp. 3–18.

Wilhite, D., & Glantz, M. (1985). Understanding the drought phenomenon: The role of definitions. *Water International, 10*, 111–120.

WMO. (2021a). Drought report calls for new management approach. https://public.wmo.int/en/media/news/drought-report-calls-new-management-approach WMO.

WMO. (2021b). WMO Atlas of Mortality and Economic Losses from Weather, Climate and Water Extremes 1970–2019. https://library.wmo.int/doc_num.php?explnum_id=10902

Yilma, Z. H. (2009). Effect of climate change on livestock production and livelihood of pastoralists in selected pastoral areas of Borana, Ethiopia. ESAP Proceedings.

Zhang, X. F. (2005). Monitoring the response of vegetation phenology to precipitation in Africa by coupling MODIS and TRMM instruments. . *Journal of Geophysical Research*, 110.

Zhao, T., & Dai, A. (2015). The Magnitude and Causes of Global Drought Changes in the Twenty-First Century under a Low–Moderate Emissions Scenario. *Journal of Climate, 28 (11)*, 4490–4512.

Zinash Sileshi, A. T. (n.d.). Water resources for livestock in Ethiopia: Implications for research and development.

ANNEXES

Annex 1: Basic information of weather stations in Borana

Name of the station	Location (GPS) coordinate		Elevation	Class	Observational element	Data availability
	long	Lat				
Alewaya (Elewaya)	4.58	38	1376	3	Precipitation / temperature (Min-Max)	2007-active
Arero	4.73	38.82	1785	4	Precipitation	1999-active
Chewbet	4.18	38.38	1472	4	Precipitation	1989-active
Dadim	5.03	38.58	1579	4	Precipitation	1990-active
Dibuluk (Dubuluk)	4.1	38.26	1488	3	Precipitation / temperature (Min-Max)	2008-active
Finch wuha	5.38	38.27	1634	4	Precipitation	1987-active
Mega	4.07	38.32	1820	3	Precipitation / temperature (Min-Max)	1988-active
Moyale	3.55	39.03	1166	1&2	Precipitation / temperature (Min-Max)	1986-active
Tuka	3.66	38.81	1259	4	Precipitation	1987-active
Teletel	5.05	37.37	1449	4	Precipitation / temperature (Min-Max)	1997-active
Yabello	4.88	38.1	1729		Precipitation / temperature (Min-Max)	1986- active

Source : www.ethionet.gov.et

Annex 2: Household Survey Questionnaire

SECTION A: HOUSEHOLD INTRERVIWE CONSENT AND BASIC INFROMATION

My name is ______________________ administering this interview on behalf of Mr. Mulugeta Shibru from the Institute for Climate Change and Adaptation, University of Nairobi, Kenya who are currently carrying out the research on **drought, vulnerability and adaptation related to food and Livelihoods Insecurity for Borana Pastoralists in Southern Ethiopia**. The research intends to assess the risk faced by Borana pastoralist system in southern Ethiopia because of climate change, particularly drought and provide actionable knowledge and information to facilitate adaptation measures. The information generated from this study will inform pastoralist, practitioners and decision makers on measures of reducing risk to the system. All the information collected from the respondents will be confidentially kept and used for the research purpose only.

Date	________________________	District	_____________________
Enumerator's name	________________________	Dheda	_____________________
Supervisor name	________________________	Pastoral Association	____________________
Interview Start time	________________________	Reera/ zoni	____________________
Interview End time	________________________		
	_________________________	Village (olla)	_____________________

District code		Pastoral Association (PA) code				
		1	**2**	**3**	**4**	**5**
1	Arero	Guto	Hirmaye	Fulduwa		
2	Dhas	Gorile				
3	Dilo	Arbale	Hoboki			
4	Dire	Haralo	Madacho	Magado		
5	Dubluk	Anole				
6	Elewoya	Ade Galchat	Dhedhertu	Horbate		
7	Gomole	Buyya	Dandala saden	Tula Wayu		
8	Miyo	Kuro Kantala	Mexi	Grincho	Chari turura	Hida Babo
9	Teletele	Bila	Hoboki	El-kune	Bule Danbi	Fulo Tole
10	Wachile	Nine	Web			
11	Yabello	Dida Yabelo	Yubdo	Haro Waxu		

SECTION B: DEMOGRAPHIC CHARACTERISTICS OF HOUSEHOLD

1. Please specify the member of your household (including head) that regularly live and eat in the household? N.B. a household is defined as a person or a group of people who usually live and eat together.

Name	Relationship to HH Head (code a)	Gender (0= male 1= female)	Age (years)	Highest level of education (code b)	Primary activity (code c)
a. Relationship to Head (code)		b. Highest level of education (code)		c. Primary activity (code)	

1. Head 2. Spouse 3. Child 4. Sibling (sister or brother) 5. Parent 6. Grandchild 7. Other relative 8. Non- relative (including employee who live in the house 9. Other specify	0. No formal and illiterate 1. No formal but literate 2. Primary school 3. High /secondary school 4. College 5. University 6. Other (specify)	1. crop farming 2. Livestock keeping (incl. sales 3. Trading in livestock and livestock products (not own 4. Trading in agricultural products (excluding livestock!) (not own produce) 5. Formal salaried employee (e.g. civil servant, domestic work 6. Business- trade / service (non-agric.) 7. Not working / unemployed 8. Old / retired 9. Infant (< 6 years) 10. Student / pupil 11. Disabled 12. Other (specify)

2. What is your marital status [ ]		
Code 1. Single 2. Married	3. Divorced (widowed) 4. Separated	5. Other (specify)

3. What is your ethnic group [ ]		
Code 1. Borana 2. Gabara	3. Garre 4. Konso	5. Burji 6. Other (specify)

4. What is your Borana kinship groups (moieties) if not Borana skip this and next two questions [ ]	Code 1. Sabbo 2. Gonna	
5. What is your sub clan if you are Sabbo [ ]	Code 1. Karayu	2. Digalu. 3. Matari

6. What is your sub clan if you are Gonna specify? [ ]
Code

1. Arslii	5. Maliyyuu	8. Daacituu	12. Banchituu
2. Hawaxuu	6. Dambituu	9. Macituu	13. Konnituu.
3. Warrajidaa	7. Noonituu	10. Galantuu	14. Oditu
4. Qarcabduu		11. Sirayyuu	

SECTION C: LIVELIHOODS ASSETS OF HOUSEHOLD

7. What are the sources of water for your household domestic and livestock use in normal year and drought year correspondingly?

Sources of water	Normal year	Drought year
Traditional deep wells “Tullas”	[ ]	[ ]
Traditional well “Ela”	[ ]	[ ]
Perennial spring “Mado”	[ ]	[ ]
Seasonal spring “Mado”	[ ]	[ ]
Open surface ponds “*Harros*”	[ ]	[ ]
scoop wells / sandy riverbeds “Hadho”	[ ]	[ ]

Shallow / hand dug wells ("*Addadis*").	[ ]	[ ]
Boreholes "Motori"	[ ]	[ ]
Hand pump "Motor Harka"	[ ]	[ ]
Cisterns " Ela Simento"	[ ]	[ ]
Roof top rain harvesting	[ ]	[ ]
Capped springs with gravity distribution.	[ ]	[ ]
Other (Specify)		
Code	(0 = No, 1 = Yes)	(0 = No, 1 = Yes)

8. What are the sources of pasture / fodder for the livestock of your household in normal and drought year correspondingly?

Sources of pasture / fodder	Normal year	Drought year
Warra grazing	[ ]	[ ]
Forra grazing	[ ]	[ ]
Enclosure (Kallo)	[ ]	[ ]
dry season grazing reserve ("Miritti")	[ ]	[ ]
Cut-and-carry	[ ]	[ ]
Crop residue	[ ]	[ ]
Hay (bailed or stacked by household	[ ]	[ ]
Supplementary mineral salt	[ ]	[ ]
Concentrate feed	[ ]	[ ]
Hay distributed by government and relief agencies	[ ]	[ ]
Other (Specify)	[ ]	[ ]
Code	(0 = No, 1 = Yes)	(0 = No, 1 = Yes)

9. Indicate the list of farms and domestic (physical assets) owned by household!

Name of the assets	Ownership
House (iron-sheet) in rural and urban area	
Radio	[ ]
Television	[ ]
Mobile	[ ]
Car / truck	[ ]
Motorcycle	[ ]
Bicycle	[ ]
Hoes	[ ]
Spades/ shovel	[ ]
Plough	[ ]
Other (specify)	[ ]
Code	(0 = No, 1 = Yes)

10. Indicate if your household either provided or received) any of the following social support from clan / kinship in recent time (last 5 years) when you or others are in need because of the adverse impact on your /other l livelihoods

Category of social capital	provided	Received	Not applicable
Busa Gonoffa (restocking)	[ ]	[ ]	
Borrowing milking animals (Dabaree)	[ ]	[ ]	
Borrowing of oxen for ploughing	[ ]	[ ]	
Gift / transfer of animals	[ ]	[ ]	
Cash gift	[ ]	[ ]	
Sharing of food (grain, relief food, milk, meat)	[ ]	[ ]	
Not applicable			
Code	(0 = No, 1 = Yes)	(0 = No, 1 = Yes)	

11. Does your household have any livestock (0 = No, 1 = Yes)? [ ]

Livestock species	Total number owned by household	Number of livestock managed by / for others households
Cattle- oxen / bulls		
Cattle- cows		
Cattle- Heifers		
Cattle-immature male		
Cattle-calves		
Sheep/ goats		
Camels		
Donkeys/ Mule		
Poultry		

12. What are the main cash income sources for your household?

To the Interviewer: Please tick income sources that apply to households. After this, ask the respondent to indicate the contribution of each income sources in EB to the total cash income of the household. Use the past 12 months (one year) as reference period for each income source. In addition, ask respondent to rank the most important income source for their household.

Income source	Total HH income in past 12 months from this source	Rank of the source
Sale of livestock		
Sale of crop produce		
Sale of livestock products own product		
Sale of hind and skin		
Livestock broker business		
Trading in livestock and livestock products (not own produced)		
Trading in agricultural products (excluding livestock! (not own produced)		
Shop-keeping		
Providing transport service using motorbike		
Self-employed (handicraft, carpentry, masonry)		
Working on other farms (herding, farming)		
Trekking livestock of traders to up country or border town		
Sale of products of natural resources (forest, sea / rivers products- fire wood and charcoal, salt /gold mining		
Pensions		
Rent out land / share cropping (cash value of share crops)		
Remittances / gifts		
NB: Most important source= rank 1 Use Ethiopian Birr (EB) throughout the survey		

13. Do your household have access to functioning market where you sell and buy your products (0 = No, 1= Yes)? [ ]

14. What is/ are name(s) of the market your household often uses for selling your product and buying necessary goods for your households. Please indicate the distance of the market (estimate) in km from your village

	Name of the Market	Distance from the village (KM)
Buying goods		
Selling goods (livestock, livestock product)		
Buying goods and Selling goods (livestock, livestock product)		

15. Please provide answer to questions related to your household access to financial assets /services

Household access to financial services		Code
Saving account	|__|	1. Yes 2. No 3. Not Applicable
Remittances	|__|	
Membership of saving and credit association	|__|	
Membership to self-help group	|__|	
Formal / informal credit	|__|	
beneficiaries of productive SafetyNet program or any form of humanitarian assistance	|__|	
Not Applicable	|__|	

SECTION D: CLIMATE RISK -DROUGH EXPOSURE, VULNERABILITY AND IMPACTS

1. How many years since your household stated lived in this area (in years): ----------------------------

2. Did you household migrated from other area If you have lived in this area for less than 10 years. In dictate the original PA you migrated from --- and reason(s) for migrating to this new location

	Reason for Migration
1.	
2.	
3.	
4.	

3. Do you plan to reside in this area (pastoral association /olla) for many years to come? (0 = No, 1 = Yes)? [ ]

4. Please rank each of the following common risk(s) that affect the livelihoods of your household in order of importance, from the most to the least important risk.

Category of risk	Rank
Erratic rainfall and distribution including drought / dry spell	|__|
Flood	|__|
Livestock diseases	|__|
Human diseases	|__|
Conflict and insecurity	|__|
Livestock market / price fluctuation	|__|
Degradation of range land resources	|__|
Bush encroachment	|__|
Deforestation	|__|

5. Did you notice some change in the environment or climate in your area as compared to the past (10 years)?

Climate parameters	Increase	Decreases	No change	Don't know
Frequency of drought / dry spell occurrence				
Drought severity				
Frequency of flood				
Rainfall amount				
Number of rainy days (in Genna season				
Number of rainy days (Hagaya season				
Temperature				
Altered/ extreme temperature				
	Late	Early	No change	Don't know
Timing rainfall (on set)				

Timing rainfall (cessation)				
Distribution of rainfall	Erratic	Even / regular	No change	Don't know

6. Indicate the significance of the following drought impacts on livelihoods of your households

Description	Significance of climate change impact on livelihoods of your households				
Higher rate of livestock mortalities					
Increase in still birth and abortion					
Decline in livestock production and productivity (milk, meat, fertility)					
Depletion of rangeland resources (pasture, forage feed) in quantity and quality					
Decline in crop yield including crop failure					
Depletion of water for livestock and domestic use in quantity and quality					
Increased distress sale of livestock					
Sale of breeding animals					
Outmigration mostly young adult					
Abnormal (long distance) migration of livestock					
Reduction in spending on festivals					
Withdrawing children out of school					
Drought caused hopelessness and sense of loss					
Increase competition and conflict to rangeland and water resources					
Food insecurity					
Livestock diseases outbreak					
Increase dependence on humanitarian assistance					
Other (specify)					
Code 1) Very low	2) Low 3) Medium		4) High 5) Very high		

7. Considering the recent drought that prevailed in 2016/2017 in your area and provide the estimated number of livestock died, sold, slaughtered during the drought of your household

Livestock species	Livestock # before drought	Mortalities	Sales	Slaughter	Losses (theft)	Livestock # after drought
Cattle- oxen / bulls						
Cattle- cows						
Cattle- Heifers						
Cattle-immature male						
Cattle-calves						
Sheep						
Goats						
Camels						
Donkeys/ Mule						

SECTION E: RISK MANAGEMENT STRATEGIES

1. How do your household cope up with water shortage during drought?

Coping strategies	Yes	No	Not applicable

Increasing watering cycle of animals			
Collecting water from distant sources by women / draft animals			
Migrating with livestock to permanent water sources			
Water tankers provided by aid agencies			
Providing succulent plat (e.g. cactus and another desert plant (e.g. Archa, Chaki)			
Other (specify)			
N.B Tick and multiple response possible			

2. Please provide if your households engaged in any of the following change(s) in livestock production practice over the last 10 years and **reasons.**

Type of changes practiced by HH	No	Yes	
Introduce new type of animals into herd			
Introduce new type of bred into herd			
Reduce the herd size (increase off take)			
Increased in herd size (buying, exchange, gift and etc)			
Increased marketing of livestock or livestock produces (especially milk)			
Alternative income-generation options (bush products, urban-based activities, agricultural labour)			
Introduction/ expansion of enclosure / fencing for calves and weak animals			
collect cut-and-carry			
Growing fodder crops			
Improved pasture / rangeland			
Fodder storage such as hay, crop residue and stall keeping			
Construction of water tank for water storage			

3. Do your household involved in crop production (0 = No, 1 = Yes)? [ ] * if no Please skip the questions 5-11 related to crop production

4. How long since your household started involvement in crop production [ ]	
Code 1) Last five-year	2) last 10 years 3) more than 10 years

5	If yes, what crops did you grow and what is the main use of these crops?		Use codes 1. Mainly consumption 2. Mainly selling 3. Both consumption and selling
		1. Maize |__|	|__|
		2. Sorghum |__|	|__|
		3. Haricot beans |__|	|__|
		4. Teff |__|	|__|
		5. Wheat |__|	|__|
		6. Other 1 (specify)	|__|

6. Please specify the type crop planted, area planted in timad and yield (in quintals) over the last two years (N.B. ***Timad***: A local unit of land measurement. 6 *timad* equals 1 hectare.)

Type of crop	Genna 2016		Hagaya 2016		Genna 2017		Hagaya 2017	
	Area planted	Yield	Area planted	Yield	Area planted	Yield	Area planted	Yield
Maize								
Sorghum								
Teff								
Haricot beans								
Wheat								

7. Do your households changes in the cropping pattern, farming practices since you have started engaged in crop cultivation/ farming (0 = No, 1 = Yes)? [ ]

8. Please specify if your households engaged in any of the below listed change in cropping pattern and farming practice

Type of change	No	Yes
Introduce new variety (ies)		
Introduced intercropping		
Stopped growing crop in one season		
Planting a better-quality variety (ies)		
Introduce a new crop		
Stopped growing crop totally		
Expand area		
Expanding / Shift farming to bottom valley land		
Switched to a shorter cycle variety		
Switched to a drought tolerant variety		
Earlier land preparation		
Earlier planting		
Introduced rotations		
Water management changes (irrigation, micro catchments)		
Soil fertility management (fertilizers, manure and compost)		

9. What are the reasons for reported changing crop production pattern and practices?

Reasons	No	Yes
Market price		
Climate /weather condition		
Overcome crop yield reduction including crop failure		
Pest / diseases		
Introduced by the government / NGOs project		
Shortage of labour		
Suitability to agro-ecological zone		

10. What are the detail reasons related weather / climate related reasons for reported changing crop production pattern and practices?

Weather / climate -related reasons	No	Yes
More erratic rainfall		
Less overall rainfall		
More overall rainfall		
More frequent drought		
More frequent floods		
Late start (on set) of rains		
Early end (cessation) of rains		
Higher temperature		

Other (specify)		

11. Considering the recent drought that prevailed in your area in 2016/2017 and provide the different type of assistance your household acquired from external assistance (government / non-government (for the duration of the drought period)

Type of assistance	Provision of assistance	
	Yes	No
Food assistance		
Cash assistance		
Fodder / feed		
Water		
Agricultural input		
Destocking		
Not applicable		

12. Were your household among the beneficiaries of productive Safety-Net program or any form of humanitarian assistance (0 = No, 1 = Yes)? [ ] for how long ---

SECTION E: HOUSEHOLD FOOD SECURITY INDICATORS, COPING AND LIVELIHOODS STRATEGIES

1. Could you please tell me if your household has eaten the following foods (write 0 for items not eaten over the last 24 hours or 7 days; Number of days if your household has eaten the food item

Food item	In the last 24 hours, have your household consumed (1=yes, 0=No)	In the last 7 days, how many **times** have you consumed these	How was the item obtained	
Maize, Sorghum				Main Food Source codes 1. Purchase (on cash) 2. On Credit 3. Own production 4. Traded food against goods or services 5. Borrowed 6. Received as gift 7. Food assistance 8. Other, **Specify:**
Wheat flour and wheat products (Bread)				
Rice				
Pasta				
White roots and tubers (e.g. potatoes, cassava				
Pules and nuts (e.g. beans, peas, groundnuts, wild nuts				
Meat (sheep / goat/ beef/ camel / poultry				
Fish (fresh or canned)				
Organ meat (liver, kidney, heart)				
Egg				
Milk and milk products (fermented milk, sour milk, cheese, yogurt) (*NO milk powder*				
Vitamin A rich vegetables and tubers (pumpkins, carrots, yellow cassava)				
Dark green leafy vegetables (kale, amaranth, spinach, cassava leaves)				
Other vegetables (tomato, cabbage, lettuce, radish)				
Vitamin A rich fruits (ripe mangos, pawpaw, gob,)				

Other fruits (banana, orange, apple, coconut, dates)				
Vegetable oil and animal fats				
Sweets (sugar, honey, soda, soft drinks, biscuits, cakes, candies)				
Any other foods, such as condiments, coffee, tea including milk in tea?				

2. In the past 7 days have there been days when your household did not have enough food or money to buy food? 0. No |__| 1. Yes |__| if no Skip to next questions.

In the past 7 days, if there have been times when you did not have enough food or money to buy food, how often has your household had to:		Number of days (0 to 7)
a.	Rely on less preferred and less expensive foods?	|__|
b.	Borrow food, or rely on help from a friend or relative?	|__|
c.	Limit portion size at mealtimes?	|__|
d.	Restrict consumption by adults in order for small children to eat?	|__|
e.	Reduce number of meals eaten in a day?	|__|

3. In the past month (30 days) did anyone in your household have to engage in any following behaviours due to lack of food or a lack of money to buy food? *If no ask why and chose from the options (codes in the right)*	1= Yes 2=No because I did not face shortage of food 3= No, because I do not have or already sold those assets or have engaged in this activity and cannot continue to do it
Sold household assets/goods (radio, furniture, refrigerator, TV)	|__|
Reduce non- food expenses on health (including medicines) and education	|__|
Sold productive assets or means of transport (sewing machine, wheelbarrow, bicycle, car)	|__|
Spent savings or sell jewelers	|__|
Borrowed money from a lender (informal or formal)	|__|
Withdrew children from school	|__|
Sold last female animals	|__|
Begging for money	|__|
Engaged in a second job	|__|
Sold more animals (non-productive) than usual	|__|
Sent an adult household member away to seek work (beyond usual migration)	|__|
Sent children to seek work	|__|

4. Household hunger score questions

1	Was there **ever no food to eat of any kind in your house because of lack of resources to get food?**	(No or Yes)? [ ] if Yes
1.a	How often did this happen in the past 30 days?	
2	Did you or any household member **go to sleep at night hungry** because there was not enough food?	(No or Yes)? [ ] if yes
2.a	How often did this happen in the past 30 days?	

3	Did you or any household member **go a whole day and night without eating anything** because there was not enough food?	(0 = No, 1 = Yes)? [ ] if yes
3.a	How often did this happen in the past 30 days?	
0= Never 1= Rarely (once or twice in the past 4 weeks) 2= Sometimes (once every week) 3= Often more than once a week		

SECTION G: ADPATATION STRATEGIES (CAPACITIES AND CHALLENGES) [18]

1. What are the key activities your households often engaged during normal year to reduce the impact of drought? Please prompt the respondent to list the activities they practice and tick the appropriate responses from the list.

Do nothing	|__|	Migration for employment	|__|
Follow up indigenous early warning forecast	|__|	Sell some livestock (unproductive one) to buy food reserve	|__|
Store crop harvest	|__|	Seek alternative source of income	|__|
Store crop residues, hay for livestock	|__|	Use less water consuming crops	|__|
Save money	|__|	Adjust cropping calendar based on weather forecast	|__|
Disperse the livestock to other area	|__|	Provide appropriate animal health care (vaccination, treatment, deworming)	|__|
Other (specify)	|__|		

2. What are some of the challenges for your households to practice some of the adaptation strategies in the future?

Challenges	
Lack/ Limitation of financial resources	
Lack/ Limitation of knowledge of some of strategies	
Decline in availability and quality of the natural resources for my household	
Restricted access to the common dry season grazing area due to insecurity and conflict	
Limited access reciprocal resource sharing and social support net work	
access to market and financial service	
Weakening of indigenous climate forecast	
Weakening of traditional resource management and governance system	
Other (Specify)	
Code 1. Yes	2. No 3. don't know

4. What is the source of weather forecast information for your household [ ]	
Code 1) No information 2) Radio and TV 3) Newspaper	4) Word of mouth (friends and neighbours 5) Self-judgment 6) Traditional knowledge sources (weather forecast)

[18] The questions in risk management section contribute to the current adaptation and coping strategies. The question in this section furthermore deals with the future and planned adaptation strategies.

Annex 3: Number of Households planned and Surveyed per Cluster

District	PSU (PA/ cluster)	# of HHs planned to be surveyed / cluster	Actual # of HHs surveyed	Response Rate	Total # of HHs to surveyed / district
Arero	Guto	19	14	**74%**	41
	Hirmaye	19	13	**68%**	
	Fulduwa	19	14	**74%**	
Dhas	Gorile	19	20	**105%**	20
Dilo	Arbale	19	16	**84%**	16
	Hoboki	19	0	**0**	
Dire	Haralo	19	18	**95%**	56
	Madacho	19	19	**100%**	
	Magado	19	19	**100%**	
Dubluk	Anole	19	18	**95%**	18
Elewoya	Ade Galchat	19	19	**100%**	56
	Dhedhertu	19	19	**100%**	
	Horbate	19	18	**95%**	
Gomole	Buyya	19	19	**100%**	54
	Dandala saden	19	17	**89%**	
	Tula Wayu	19	18	**95%**	
Miyo	Kuro Kantala	19	18	**95%**	101
	Mexi	19	17	**89%**	
	Grincho	34	34	**89%**	
	Chari turura	19	15	**79%**	
	Hida Babo	19	17	**89%**	
Teletele	Bila	19	18	**95%**	74
	Hoboki	19	0	**0**	
	El-kune	19	19	**100%**	
	Bule Danbi	19	19	**100%**	
	Kalo	19	0	**0**	
	Fulo Tole	19	18	**95%**	
Wachile	Nine	19	17	**89%**	36
	Web	19	19	**100%**	
Yabello	Dida Yabelo	19	19	**100%**	57
	Yubdo	19	19	**100%**	
	Haro Waxu	19	19	**100%**	
Total # of HH		**627**	**529**	**84%**	**529**
Total # of cluster		**32**	**29**	**91%**	

Annex 4: Focus Group Discussion (FGD) guiding questions.

SECTION A: CONSENT PROCESS AND BASIC INFORMATION

The facilitators will be seeking the consent of FGD participants. The focus group organizers and facilitators will the below summary of the information to make sure participants understand the information in seeking their consent.

Dear focus group participants,

Thank you for agreeing to participate. We are very interested to hear your valuable opinion on drought, vulnerability and adaptation related to food and Livelihoods Insecurity for Borana Pastoralists in Southern Ethiopia.

- The information you give us is completely confidential, and we will not associate your name with anything you say in the focus group.
- We would like to tape the focus groups so that we can make sure to capture the thoughts, opinions, and ideas we hear from the group. No names will be attached to the focus groups and the tapes will be destroyed as soon as they are transcribed.
- Please indicate your name and role you have in the community (traditional and administrative) for purpose of record

Date	________________________	Facilitators Names	_____________________
District	________________________		_____________________
Cluster (PA)	________________________		_____________________
Reera/ zoni	________________________		_____________________
Village (olla)	_________________________		______________________
GPS Coor	_________________________		
Interview Beginning & end time	_________________________	Note-Takers	__________________________

SECTION B: DEMOGRAPHIC INFORMATION OF FGD

Name	Sex	Age	Education level	Role in the community

N.B. use this sheet to register the demographic information of the FGD participants.

SECTION C: SKETCH AND NATURAL RESOURCE MAP

1. Develop community sketch map through brainstorming and discussion. Please include the neighbouring PAs/ woredas and physical landscape[19] using different materials for ground mapping, depending on the availability of local materials (e.g. soil, pebbles, sticks, leaves). Do not forget to translate the ground map to flip chart for documentation purpose

2. Identify key natural resource of the community depend for their livelihoods and facilitate mapping of these resources on the sketch map. The process helps you to understand living environment of the community and associated natural resources distribution, access and constraints.

3. Discuss the different wealth groups that exist in your community and the criteria that define each group using wealth ranking techniques. N.B. to determine the proportion of each group (percentage) in the community using pebbles or any other locally available materials

SECTION D: CLIMATE RISK -DROUGH EXPOSURE AND IMPACTS

4. What are the most common risk(s) that affect the livelihoods of households in your area in order of importance from the most to the least important risk? N.B. use the attached pair-wise ranking to ensure consensus among the participants.

5. Did you notice some change climate of your area in the last four Gada (30 years)?

Climate parameters	Increase	Decreases	No change	Don't know
Frequency of drought / dry spell occurrence				
Drought severity				
Duration / intensity of drought				
Frequency of flood				
Rainfall amount				
Number of rainy days in Genna season				
Number of rainy days in Hagaya season				
	Late	Early	No change	Don't know
Timing rainfall (on set)				
Timing rainfall (cessation)				
Distribution of rainfall	Erratic	Even / regular	No change	Don't know
Temperature				

6. Discuss impact of above discussed climate change observed in your area on the various livelihoods assets of the people and community. Please probe the participants to provide example(s) from their area.

Impact domain	Impact observed	example from the area
Feed and rangeland resources (availability and availability)		
Water resources (availability and availability)		
Livestock and human diseases		
Livestock numbers		

[19] Physical landscape refers to topographic and natural features. Topographic features include hills, valleys, plains and shores. Natural features include soils, water (e.g. rivers, lakes), plants and animals.

Livestock production and productivity		
Food security		
Biodiversity		

SECTION E: RISK MANAGEMENT STRATEGIES

7. Discuss coping strategies to water / pasture scarcity during drought practiced in your area?

8. Are there any traditional early warning mechanism in which this community predict droughts, other natural and man-made disaster that affect livelihoods of community in your area? If so, discuss the mechanisms and how it works?

9. Discuss who provide such prediction in your community. How was/is this information shared within the community prior to an event? How does this community relay critical information among members in the absence of critical infrastructure (communication network)?

10. Are these traditional early waring mechanisms actively practiced today? Is it effective?

11. What are some of the challenges mechanism encountered to promote early warning

12. How do you prepare as community for droughts, and other climate-induced disasters? What actions do community take to reduce loss from these events?

13. In what ways have community in your area changed behaviour / practice based on past experiences with disasters to prepare for subsequent droughts, etc.?

14. Discuss any activities / projects implemented by pastoralist and supporting institution (government and non-governmental that promote adaptation to climate change including drought

15. Discuss the decision (muurti) Raba Gada that will contribute in enhancing effectiveness of the adaptation to climate change

Category of risk	drought	Flood	Livestock diseases	Human diseases	Conflict & insecurity	Livestock market / price fluctuation	Degradation of range land	Bush encroach ment	Defores tation	**T**otal score	Rank
Drought											
Flood											
Livestock diseases											
Human diseases											
Conflict and insecurity											
Livestock market / price fluctuation											
Degradation of range land											
Bush encroachment											
Deforestation											

Annex 5: Key informant Interview (KII) guiding questions.

SECTION A: CONSENT PROCESS AND BASIC INFORMATION

The facilitators will be seeking the consent of key informant interviewers. The organizers and facilitators will share the below information to make sure participants understand the information in seeking their consent.

Dear participants,

Thank you for agreeing to participate. We are very interested to hear your valuable opinion on drought, vulnerability and adaptation related to food and Livelihoods Insecurity for Borana Pastoralists in Southern Ethiopia.

- The information you give us is completely confidential, and we will not associate your name with anything you say during the interview.
- We would like to tape the interview so that we can make sure to capture the thoughts, opinions, and ideas we hear from the group. No names will be attached to the focus groups and the tapes will be destroyed as soon as they are transcribed.
- Please indicate your name and role you have in the community (traditional and administrative) for recording

Date	___________________________	Facilitators Names	_______________________
District	___________________________		______________________
Cluster (PA)	___________________________		______________________
Reera/ zoni	___________________________		______________________
Village (olla)	____________________________		_______________________
GPS Coor	____________________________		
Interview Beginning & end time	____________________________	Note-Takers	____________________________

SECTION B: DEMOGRAPHIC INFORMATION OF KII

Name	Sex	Age	Education level	Role in the community

SECTION C: CLIMATE RISK -DROUGH EXPOSURE AND IMPACTS

1) What are the most common risk(s) that affect the livelihoods of pastoralists in your area in order of importance, from the most to the least important risk?

Category of risk	Rank
Drought	|__|
Flood	|__|
Livestock diseases	|__|
Human diseases	|__|

Conflict and insecurity |__|
Livestock market / price fluctuation |__|
Degradation of range land resources |__|
Bush encroachment |__|
Deforestation |__|

2) Do you believe the climate of Borana is changing as compared to the past? If yes when do you think the change has started? What are some of the signs you have observed regarding the changes?

3) Please discuss major events that has happened in your area that you remember or learned from your fathers / forefathers that have contributed for change of climate in Borana. Discuss when major events occurred and how they impacted the climate.

- Major drought and their effects,
- Changes in land use (crops cultivation, water development, forest cover, houses etc.)
- changes in land tenure
- changes in food security and nutrition
- changes in administration and organization
- changes in coping with diseases and prevention
- major political events

4) Did you notice some particular change climate of your area in the last four Gada (30 years)?

Climate parameters	Increase	Decreases	No change	Don't know
Frequency of drought / dry spell occurrence				
Drought severity				
Duration / intensity of drought				
Frequency of flood				
Rainfall amount				
Number of rainy days in Genna season				
Number of rainy days in Hagaya season				
	Late	Early	No change	Don't know
Timing rainfall (on set)				
Timing rainfall (cessation)				
Distribution of rainfall	Erratic	Even / regular	No change	Don't know
Temperature				

5. Discuss impact of above discussed climate change observed in your area on the various livelihoods assets of the people and community. Please probe the participants to provide example(s) from their area.

Impact domain	Impact observed	example from the area
Feed and rangeland resources (availability and availability)		
Water resources (availability and availability)		
Livestock and human diseases		
Livestock numbers		
Livestock production and productivity		
Food security		
Biodiversity		

6. Discuss the major drought events your community has experienced in the last 7-8 Gada. Can you describe them in terms of duration, scope (no of people affected), severity of the event (impact on livelihoods) using local calendar[20] and associated local name of the drought event?

Major drought	Local name of the drought	Description of duration, scope, severity	Impact

7. What are the factors that aggravated pastoralist's vulnerability to drought in your area? Please rank them in order of importance #1 being the most important factor to # 8 being the least important object and indicate its trends in future

Vulnerability aggravating factors	Rank	Trends
Increase in human and livestock population	|__|	
Increase in cultivation in valuable grazing area (bottom valley land)	|__|	
Losses of key grazing land /water due to different reasons	|__|	
Decline in mobility of herd	|__|	
Overgrazing	|__|	
Land degradation	|__|	
Increased sedentarisation and the proliferation of water points, which promote settlement	|__|	
Bush encroachment	|__|	
Weakening of customary institutions and traditional resources management	|__|	
Increase competition and conflict to rangeland and water resources	|__|	
Code (trends) 1. Increasing	**2. Decreasing** **3. No change**	

SECTION D: RISK MANAGEMENT STRATEGIES

8. Discuss coping strategies to water / pasture scarcity during drought practiced in your area?

9. Are there any traditional early warning mechanism in which this community predict droughts, other natural and man-made disaster that affect livelihoods of community in your area? If so, discuss the mechanisms and how it works?

[20] Please refer the facilitators note for calendar of each Gada.

10. Discuss who provide such prediction in your community. How was/is this information shared within the community prior to an event? How does this community relay critical information among members in the absence of critical infrastructure (communication network)?

11. Are these traditional early waring mechanisms actively practiced today? Is it effective?

12. What are some of the challenges mechanisms encountered to promote early warning?

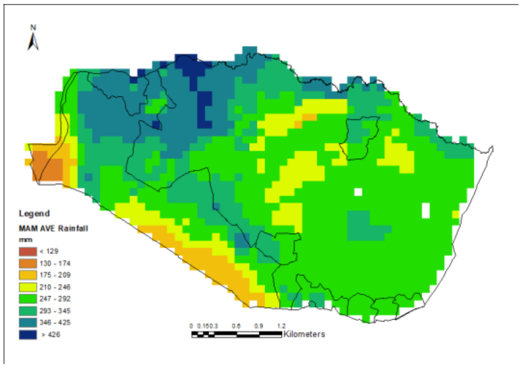
13. How do you prepare as community for droughts, and other climate-induced disasters? What actions do community take to reduce loss from these events?

14. In what ways have community in your area changed behaviour / practice based on past experiences with disasters to prepare for subsequent droughts, etc.?

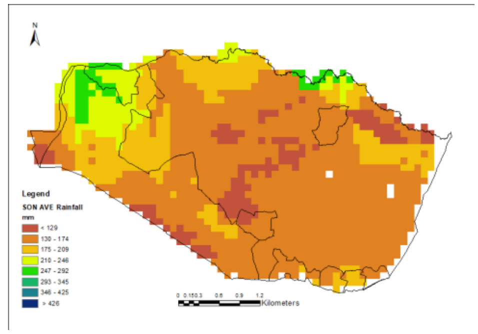
15. Discuss any activities / projects promoted by pastoralist and supporting institution (government and non-governmental that promote adaptation to climate change including drought

16. Discuss the decision (muurti) Raba Gada that will contribute to enhancing effectiveness of the adaptation to climate change.

Annex 6*:* Mean Seasonal Rainfall in Borana Zone from 1983-2013

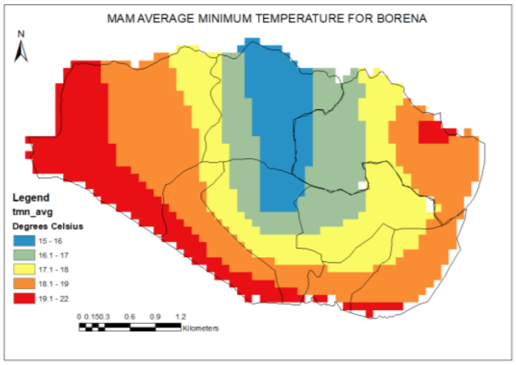


Main rainy season (MAM) average rainfall

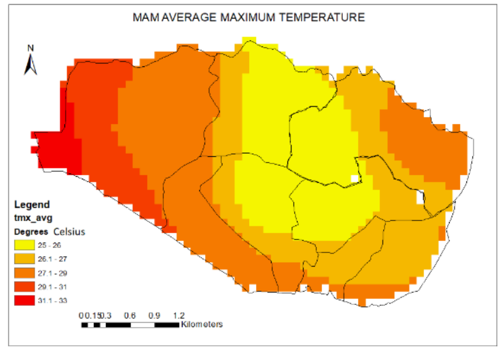


Short rainy season (SON) average rainfall

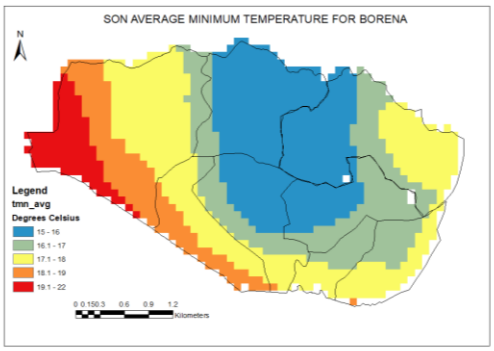
Annex 7: Average Seasonal Temperature (Min and Max) in Borana Zone from 1983-2013



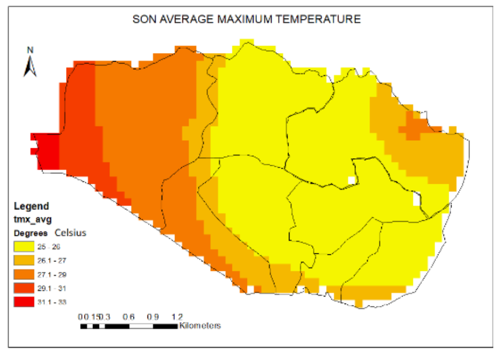
Main rainy season (MAM) average MIN temperature



Main rainy season (MAM) average MAX temperature

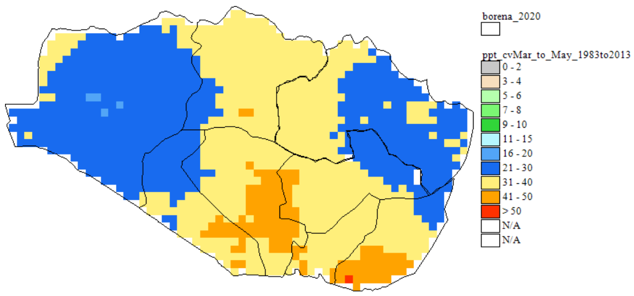


Short rainy season (SON) average MIN temperature

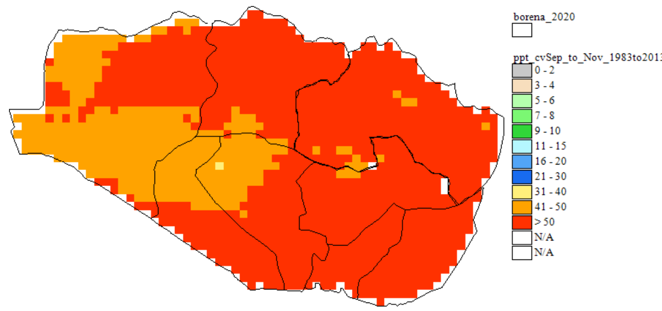


Short rainy season (SON) average MAX temperature

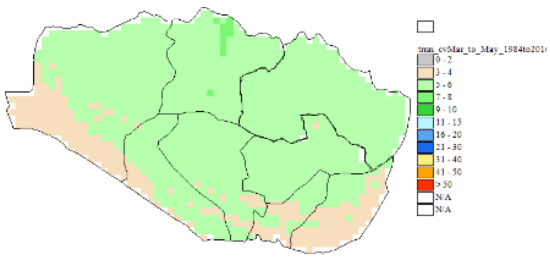
Annex 8: CV for Seasonal rainfall and Temperature (Min and Max) in Borana Zone from 1983-2013



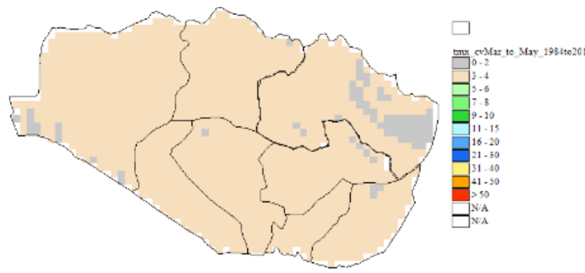
CV for main season rainfall in %



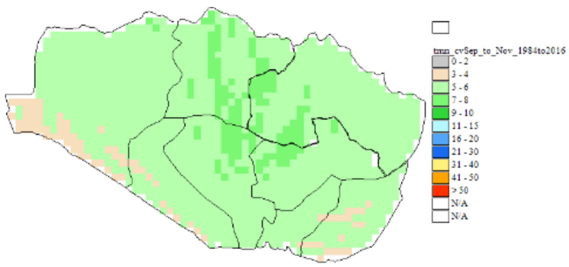
CV for short season rainfall in %



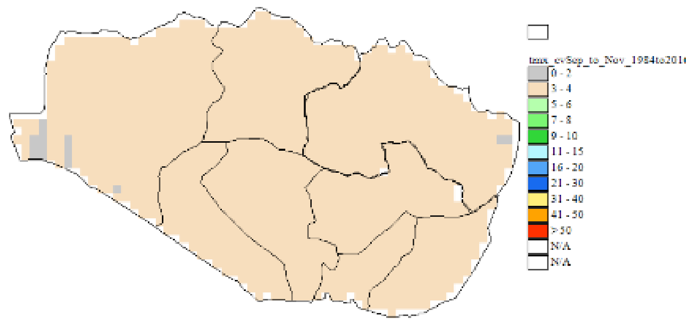
CV of main season MIN temperature in %



CV of main season average MAX temperature in %

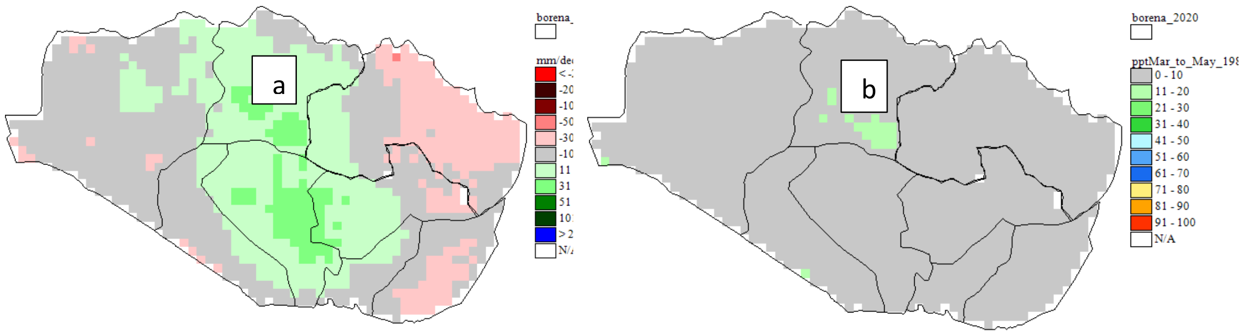


CV of short rain season MIN temperature in %

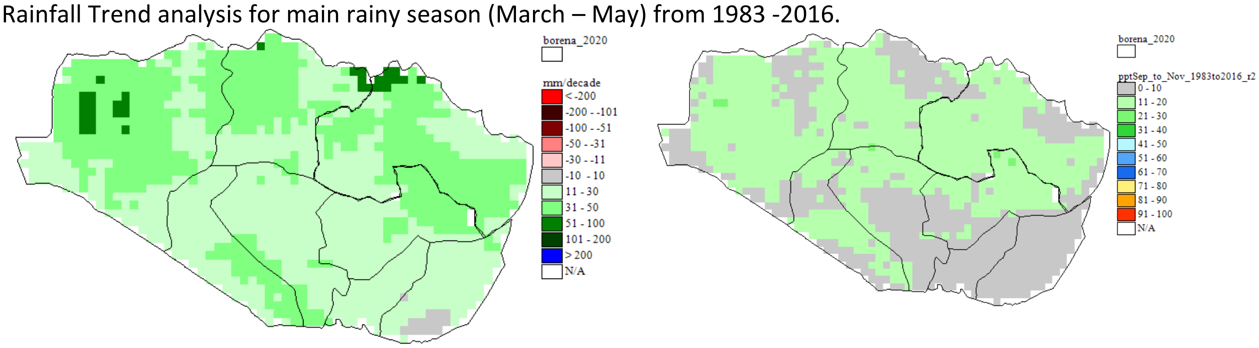


CV of short rain season MAX temperature in %

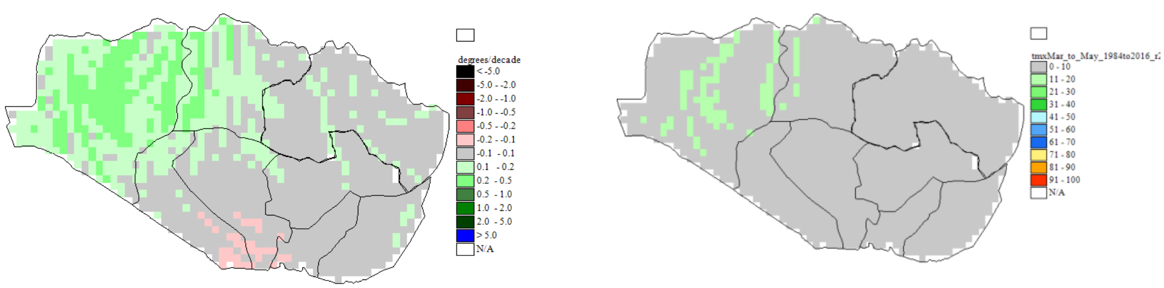
Annex 9*:* Trend analysis of seasonal rainfall and Temperature (Min and Max) in Borana zone from 1983-2016



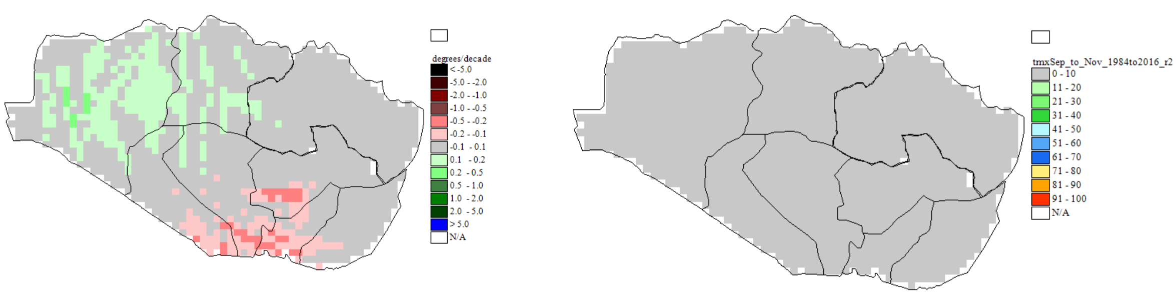
Rainfall Trend analysis for main rainy season (March – May) from 1983 -2016.



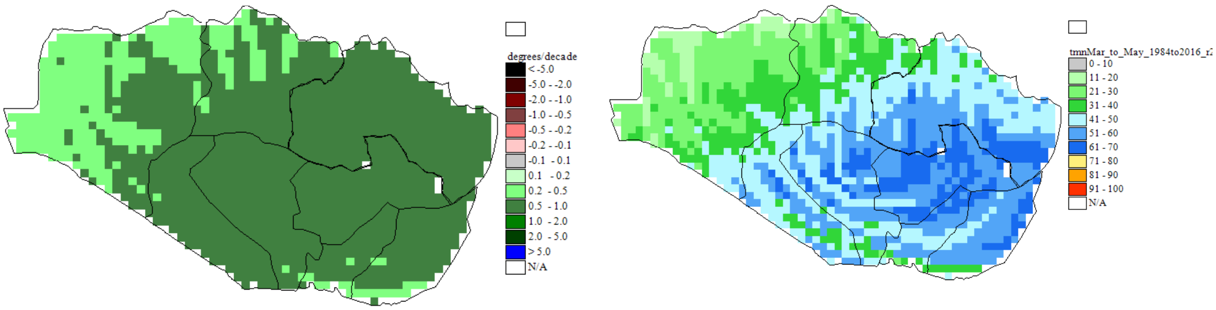
Rainfall Trend for short rainy season (Sep – Nov) from 1983 -2016



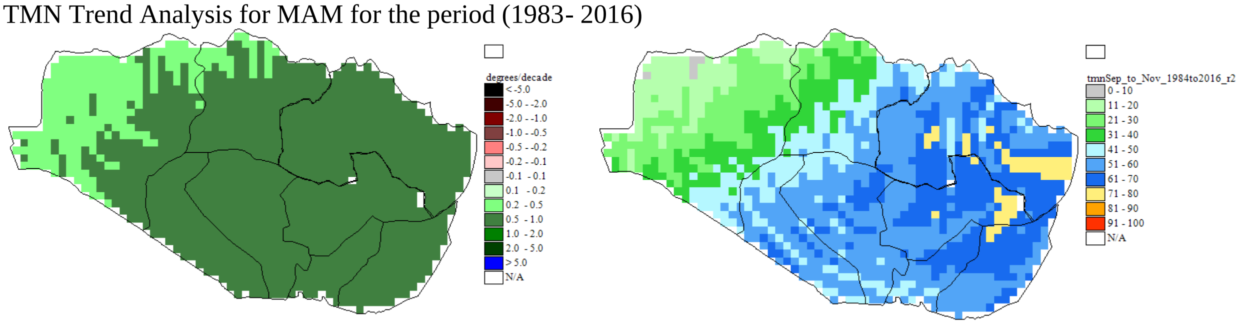
TMX Trend Analysis for MAM for the period (1983- 2016)



TMX Trend Analysis for SON for the period (1983- 2016)

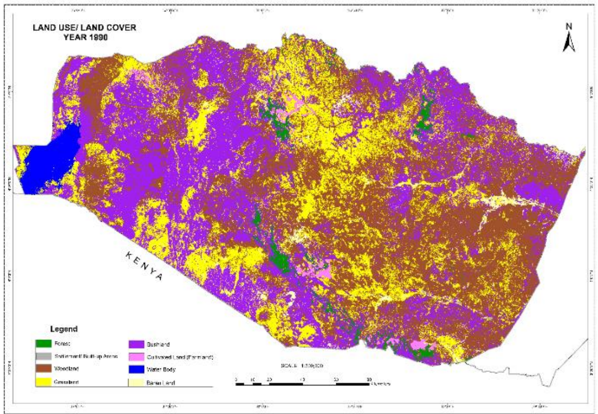


TMN Trend Analysis for MAM for the period (1983- 2016)

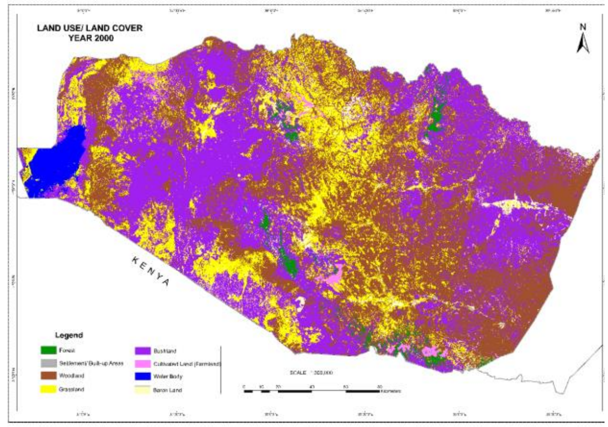


TMN Trend Analysis for SON for the period (1983- 2016)

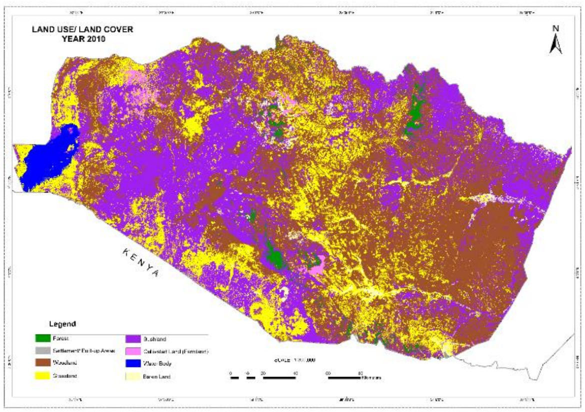
Annex 10: LULC maps of the study area of Borana Zone for 1990, 2000 and 2010 reference year



1990



2000



2010

Annex 11: Demographic characteristics of sample households

	Male	Female	Overall
Number of respondents	392 (74%)	137 (26%)	529
	Ethnicity		
Borana (Oromo)	313 (59%)	121 (23%)	435 (82.2%
Guji (Oromo)	35 (7%)	5 (1%)	40 (7.6%)
Konso	24 (5%)	2 (0%)	26 (4.9%)
Gabara	14 (3%)	5 (1%)	19 (3.6%)
Shewa (Oromo)	3 (1%)	2 (0%)	5 (0.9%)
Burji	3 (1%)	1 (0%)	4 (0.8%)
Mean age of head (years)	43.9±0.8	47.5±1.3	44.8±0.7
	Households % with		
0-14 age	54%	51%	50.1%
15-64 age	43%	44%	44.6%
>64 age	3%	5%	5.3%
	Marital status		
Single	0%	0.2%	0%
Married	71%	9.3%	80%
Divorced (widowed)	2%	14.2%	16%
Separated	1%	2.1%	3%
	Education		
No formal and illiterate	59%	26%	85%
No formal but literate	1%	0%	1%
Primary school	10%	0%	11%
High /secondary school	3%	0%	3%
College/ University	1%	0%	1%
Average family size (mean)	5.56±0.1	4.73±0.2	5.35±0.1
	Households in % with of family size		
1-5	51%	66%	55%
6-10	48%	34%	44%
>10	1%	1%	1%

Annex 12*:* Traditional weather and drought forecast.

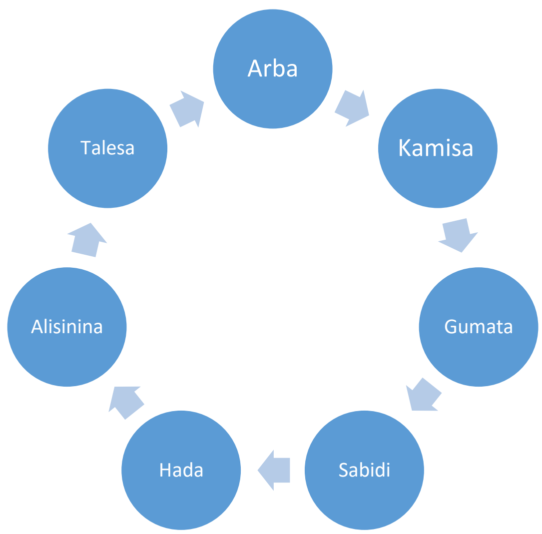
Livestock behaviours/ behaviourist: Animal behaviourist locally called as *"Waragu*" foretell upcoming events related to drought, conflict, and rainfall by closely observing livestock behaviours including any abnormality. Animal behaviourist usually observe / understand behaviours of cattle such as feeding habit (deviation from normal), the ways they leave and return from the grazing field (Boba *and Galchuma*), physical appearance and proactive ness in the grazing field to foretell about the future (indication of the problem or promising/favourable reproduction) ahead. Cattle often resist returning to the corral when they sensed problem ahead of them and herding boys must push them (forcefully) to the corral. On the contrary, if the future will be promising they run and eager to get back to the base *"Hirmanani"* and flow smoothly. Likewise, during the Boba time they are not keen to leave corral, disinterested from grazing, and simply lay down. When they anticipate promising time ahead after they return from the field, they spread widely into the corral, lay down, and stay the night. The usual concentrate / squeeze in the middle of the corral (avoid peripheral area) provides you an indication the time ahead is not good. The cow's behaviour (interests / apathy) towards the bull for reproduction also provide you indication of about the near future and likely success of fertility. For example, when cows run away from the bull indication of unfavourable time ahead. On the other hand, cows / Heifers show interest towards bull for mating expect promising time ahead.

Watering of cattle also tells you if the time ahead will bring rain or drought. Cattle watered from well if they quenched their thirsty quickly and leave watering point an indication that very soon, they will be receiving rain and access surface water (not returning water points). In addition, if they resist leaving watering points after watering tells you otherwise. The ways of cattle excrete and urinate tell you about drought. Cattle excrete at the laying position as opposed to natural way provide you hint that severe drought situation will be at the horizon. When livestock licking one another, it will also show possibility of rain, (even if a shower)

Dika wako Jilo one of the known Animal behaviourists (Waragu) in Borana specialized in understanding the livestock behaviours, performance and foretell about the weather forecast. During the interview process, he forecasted the upcoming Short rainy (Hagaya) season to be favourable based on his own assessment as waragu and information he complemented from the uuchuu. He fussed the two sources of information and concluded about the upcoming Hagaya (SON 2019), which turn out to be true. The FEWS NET CHIRPS rainfall data and NDVI anomaly to confirm his claim retrospectively.

Forecasting can also be associated with bird/ plant behavior or performance, which can signal the probability of bad or good happening ahead.

Knowledgeable about cyclical calendar of Borana (Mara): Golicha Guyo Sarite one of the knowledgeable personalities about cyclical calendar “Mara” in Borana. The elder highlights his prediction based seven years of cyclical calendar of Borana. Each of the year has its own name and presented in the below circular flow diagram.



Cyclical calendar (Mara)

The informant’s uses this cyclical calendar to predict whether a given year will be a favourable or not. According to the informants, both Genna and Hagaya seasons taken into consideration when predicating a given year. During the interview, the informants for example characterized the upcoming year, as “Kamisa” and predicted to be favourable year, no major / dry spell except the normal dry season, which turn out to be accurate prediction based on climate data analysis presented above retrospectively. However, informant indicated his worriedness about next cycle Gumata that predicted to be unfavourable year (bad year). The previous cycle was Araba of (Bad year) now would turn to be in Gumata. The next favourable year come in Sabidi. Every year depending on the cycle, have its favourable /unfavourable year alternatively.

Entrails of the livestock (uuchuu): Uuchuu usually look at intestine of slaughter animals to tell what they can see. Intestine reading is like palm reading (palmistry). Some of these "Uuchuu" these days were very cautious of their forecast information given the probability (uncertainty) the "usa" might show the distant future as if closer. If the Uuchuu provide the information as such and the forecasted event will not be materialized, their credibility will be at stake.