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Centre for Food Security Studies College *of Development Studies*

ADAPTATION OF PASTORAL LIVESTOCK PRODUCTION TO CLIMATE CHANGE AND VARIABILITY: A CASE OF HARSHIN DISTRICT, SOMALI REGION, ETHIOPIA

BY

THEODROS ESHETU TEFFERA

A THESIS SUBMITTED TO CENTER FOR FOOD SECURITY STUDIES, COLLEGE OF DEVELOPMENT STUDIES, ADDIS ABABA UNIVERSITY IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN FOOD SECURITY AND DEVELOPMENT

ADDIS ABABA, ETHIOPIA

OCTOBER 2020

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GSE /8455/10

PRINCIPAL ADVISOR: DR. DESALEGN YAYEH AYAL (PHD)

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Declaration

I, **Theodros Eshetu Teffera**, hereby declare that this thesis is my original research work and findings. It has not been submitted to any other university for any academic degree. Materials and information other than my own are duly acknowledged and a reference list has been attached. In presenting this thesis in partial fulfillment of the requirements for the degree of MSc. in Food Security and Development studies, I grant to Addis Ababa University the non-exclusive royalty free right to archive, reproduce, distribute, and display in any forms including electronic format, via any digital library mechanisms maintained by the University.

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As Advisors/ co-advisors of the thesis, we certify that we have read and evaluated the thesis prepared by **Theodros Eshetu Teffera** entitled "*Adaptation of Pastoral Livestock Production to Climate Change and Variability: A Case of Harshin District, Somali Region, Ethiopia*" and recommend for open defense as fulfilling the requirement for the degree of Master of Science in Food Security and Development Studies.

Desalegn Yayeh (PhD)	**_____**	**_____**
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Advisors	**Signature**	**Date**

As members of the examining board of the thesis open defense, we certify that we have read and evaluated the thesis prepared by **Theodros Eshetu Teffera** entitled "*Adaptation of Pastoral Livestock Production to Climate Change and Variability: A Case of Harshin District, Somali Region, Ethiopia*" and recommend that it is acceptable as a thesis required for the degree of Master of Science in Food Security and Development Studies.

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Final approval and acceptance of this thesis is contingent upon the candidate's submission of the final copy of the thesis, incorporating all the comments by examining board, to the Council of Graduate studies (CGS) through the Center Academic Committee (CAC) of the center.

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Acronyms

IPCC	The intergovernmental Panel on Climate Change
FAO	Food and Agriculture Organization
FGD	Focus Group Discussion
HS	Household Survey
KI	Key informant Interview
NGO	Non-Governmental Organization
SPSS	Statistical Package for Social Sciences
SSA	Sub-Saharan Africa
UNDP	United Nation Development Program
WB	World Bank
GHGs	Greenhouse Gases
OIE	World Organization for Animal Health
OCHA	United Nations Office for the Coordination of Humanitarian Affairs
ODI	Overseas Development Institute
GDP	Gross Domestic Product
CO2	Carbon Dioxide
CH4	Methane
N2O	Nitrous Oxide
CFCs	Chlorofluorocarbons
NAPA	National Adaptation Program of Action
PASDEP	Plan for Accelerated and Sustained Development to End Poverty
WDRMP	Woreda Disaster Risk Management Profile
SST	Oceanic Sea Surface Temperature
IRI	International Research Institute for Climate Society
CRGE	Climate Resilient Green Economy
OLS	Ordinary least squares

CF	Climatic variables to climate change
NCF	Non-climatic variables
PCCI	pastoralists' perceived impact of climate chang
CCADPT	Climate change adaptation
VIF	Variance Inflation Factor
TLUs	Tropical livestock units
PSNP	Productive Safety Net Program
CV	Coefficients of variation
PCI	Precipitation concentration index
CanESM2	Canadian Earth System Model
SDSM	Statistical Down-Scaling Model
CCCma	Canadian Centre for Climate Modelling and Analysis
SST	Sea surface temperatures
IRI	International Research Institute for Climate Society
NCEP	National Centers for Environmental Prediction
NOAA	National Oceanic and Atmospheric Administration
NMA	National Meteorological Agency of Ethiopian
TAMSAT	Tropical Applications of Meteorology using Satellite data and ground-based observations

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Abstract

Climate change and variability poses a major threat to pastoral livestock production in Ethiopia. Thus, pastoral communities positive coping and adaptation strategies need holistic support to safeguard their livestock based primary livelihood option. The purpose of this study was to determine the trends & variability of temperature and rainfall, describe climate change impact on livestock production, explore the adaptation strategies practiced and perceived success of the adaptation strategies, and determine the factors that influence the adaptation strategies. The study was conducted in Harshin Woreda, Fafan Zone, Somali region. In this study a mixed research design was applied. A total of 356 sample households were selected using systematic sampling method. Qualitative data were collected from 10 key informants and 4 focus groups discussions. Descriptive statistics, mann-kendal trend test, standardized precipitation index (SPI), precipitation concentration index (PCI), likert rating scale, and multivariate logistic regression were used to achieve the stated objectives. Pastoralist's perceptions were examined in correspondence with climate data recorded at meteorological stations in Harshin Woreda. The climate trend and variability analysis findings over the last three decades revealed that generally there is an increasing trend of rainfall and temperature, but the rainfall pattern is irregular even within the same season. This presents difficulty for the pastoral communities to pursue their two main livelihoods; livestock keeping and farming. The prominent impact of climate change and variability in the study area is reduced livestock number and productivity, degraded pasture and browse, depleted watering points, reduced terms of trade, reduced community risk sharing practice and proliferation of livestock diseases. The principal adaptation and coping mechanisms employed to mitigate the impact of climate change are herd management; changing herd composition, increased herd mobility and herd splitting followed by rotational grazing, increased veterinary service use, destocking, feed preservation, and combing livestock production with crop production. The study portrayed the most perceived success of climate change adaptation strategy relates with herd management; changing herd composition, herd splitting, and increase mobility of livestock. The perceived success of rotational grazing, purchase of livestock feed, storage/preservation of livestock feed climate change adaptation strategies are prominent as well. As per the analysis of the socio-economic (non- climatic

factors), climatic factors, and perception of climate change and variability variables against the climate change adaptation strategy revealed that household sex, livestock holding, income level, educational status, access to veterinary service, access to credit, flooding, livestock disease outbreak are statistically significant in two or more climate change adaptation strategies practiced by the pastoral communities in the study area. From the study findings, it is evident that the impact of climate change and variability is massively felt in the pastoral communities of the study area affecting their means of living, social dynamics, environment at large. However, as per the findings of the study showed, the pastoral communities never fail from trying to cope and adapt to the prevailing challenging situation resulted from climate change and variability through herd management, rotational grazing, feed preservation and diversification of livelihood options. Nevertheless, effective livestock adaptation strategies are seriously constrained by lack of institutions that governs climate issue at the grassroots level, poor service and facilities that support the adaptation strategies such veterinary and credit services and lack of basic infrastructure. Therefore, as recommendations sensitization of pastoral communities on reality of climate change and variability and its impact and to strengthen the positive coping and adaptation strategies is paramount. On top of dealing on the immediate climate related problems, it is paramount for government and any development actor to work on factors to address the barriers to climate change adaptation in the study area to deal with the root causes to find lasting solution. Policy and support program should focus on strengthening community based early warning and early action and institutionalization of climate and climate change issues.

Keywords: Climate Change; Climate change/ variability; adaptation strategy; Policy

CHAPTER ONE

1. Introduction

1.1 Background and Justification

Global average surface temperature has risen since 1900 by 0.76°C (IPCC, 2007; Deeb et al., 2011). Continents such as Africa, continent that has contributed almost nothing to anthropogenic climate change, the impact is believed to be enhanced. This is attributed to the continent's low adaptive capacity, over-dependence on agricultural sector, marginal climate and existence of many other stressors. Change in climate and climate extremes are acknowledged as a vital challenge to pastoral production systems (Collier *et al.*, 2008; McCarthy, 2001). Ethiopia's climate is naturally both highly diverse and highly variable. However, the climate is dramatically changing in recent years (Umer, 2010; Eshetu, 2011; Mokria et al., 2017). The temperature (maximum, minimum, mean) is increasing, but the rainfall does not show any definite trend– it shows high variability (NMSA, 2007; Addisu et al., 2015; Mokria et al., 2017). Since 1950, the annual average maximum and minimum temperatures of the country have been increasing every decade by about 1°C and 0.25°C, respectively (NMSA, 2001). The mean annual temperature for the period 1960-2006 increased by 1.3°C, an average rate of 0.28°C per decade (McSweeney et al., 2008). The decadal increase is above the global mean value of 0.2°C per decade (Hansen et al., 2006).

Adaptation is one of the key policy responses related to climate change. In its simplest form, IPCC (2014) defined adaptation to climate change as ''… the process of adjustment to actual or expected climate and its effects in order to moderate harm or exploit beneficial opportunities.'' Despite worldwide coverage of climate change impact, there is intra-sectoral and intersectoral variation in vulnerability depending on location, adaptive capacity and other socioeconomic and environmental factors (Rahman et al., 2007). The frequency of droughts in Ethiopia, particularly in the recent decades, is an indication of the prevalence of the variation in climate. Since 1876, about 22 droughts have occurred in Ethiopia with an average cycle of every 6 years, which has narrowed to 2 to 3 years occurring in Ethiopia. The frequency and magnitude of droughts in

Ethiopia have been increasing in space and time (Eshetu et al., 2010; Catley, *et al.,* 2016). Somali pastoralist in Ethiopia, whose livelihood is dependent upon on livestock, is one of the major victims of climate change and variabilities. Shortage of rainfall, land gradation, shortage of food and feed security are amongst the most highly observed phenomena in the Somali pastoralist areas of Ethiopia (Ayal and Muluneh, 2014). The degradation and shrinkage of rangelands decline of livestock assets and inappropriate governmental intervention forced herders to leave pastoralism and see other livelihood options such as charcoal making, crop farming and other economic activities (Beyene & Korf, 2008; Lambin et al., 2003).

The pastoral communities in Somali region of Ethiopia is not an exception to this paradigm shift to atypical pastoral livelihoods options as coping mechanisms and adaptation strategies triggered by the recurrent and severe drought, which is one of the main manifestations of climate change and variabilities. Thus, this study is inspired to understand better the paradigm shift of pastoralism in Somali region realized with various adaptation strategies the pastoral communities have undertaken due to the effect of recurrent drought caused by climate change and variability. Therefore, this study will examine the situations, perceptions, impacts and responses of pastoralists to climate.

1.2 Statement of the Problem

Ethiopia is experiencing the impacts of both climate variability and Climate change, which contributed to recurrent droughts and famines, flooding, expansion of desertification, loss of wetlands, loss of biodiversity, decline in agricultural production and productivity, scarcity of water, and increased incidence of pests and diseases. Climate change aggravates environmental degradation, food insecurity, water scarcity, disease epidemics and poverty in Ethiopia (Zegeye, 2018). Climate change increases the frequency and intensity of extreme weather events (droughts, floods, heat waves, heavy rainstorms, strong winds, etc.). The magnitude of droughts has been increasing in space and time. Recurrent droughts have resulted in loss of human and livestock life and property as well as migration of people (Eshetu, 2011; Zerga and Gebeyehu, 2016). Though drought may occur all over the globe, in general its harm is not as intense as in Africa, particularly in Ethiopia (Funk *et al*., 2008; Seleshi & Sanke, 2004; Williams & Funk, 2011).

It is of reality that many of the pastoral communities in Ethiopia are abandoning the pastoral production system as it fails to serve as the principal source of food and income as it used to be and most importantly as it fails to adopt and recover so far (Aklilu and Cately, 2010). According to Yared et al. (2018) a study conducted in Jigjiga district; Somali region had found that the causes of food security in the district are associated with climate change. In response to the above problems, respondents have adopted various strategies including sale of animals, soil and water conservation practices, use of crop residue, changing herd composition, hay making and the use of cut and carry system.

The major effects of climate change on livestock production in the pastoral areas in the country include feed shortage, shortage of water, livestock genetic resources loss, reduced productivity, and decreased mature weight and/or longer time to reach mature weight in their order of importance. Different adaptation options are followed by livestock owners, such as conservation of feed, out-migration of some household members to earn additional income, destocking, settlement and intensification of livestock production, undertaking supplementary income-generating activities and awareness creation on the factors affecting climate change (Tiruneh and Tegene, 2018). According to Birhanu and Beyene (2014) pastoralist adaptation response strategies broadly involve adjustments in pastoral practices and shifts to non-pastoral livelihoods. Results of the estimated models confirm that pastoral mobility is still quite essential in the present context of climate-induced household vulnerabilities. Increased mobility and diversification of pastoral herd portfolios in favor of a drought-tolerant species (camel) are found to have highly significant positive impact on pastoral productivity.

Thus, there is a gap of more systematic inquiry into the perceived success of the adaptation by the pastoral communities in the context of pastoralism and determining the factors affecting positively and negatively climate change adaptation. Not all individual adaptation measures to climate variability and public actions in pastoral areas are constructive and sustainable. Some can be destructive to the extent that they may increase pastoralist vulnerability. Therefore, there is a need for critical and systematic appraisal of current individual adaptation strategies practiced in study area, and the perceived success of the adaptation strategies by pastoral communities in the face of climate change. The study will explore the need as well to inform policies and innovative practices that can enhance pastoralist adaptive capacities for the success of the adaptation strategies. Nevertheless, the focus of this paper is on the analysis of individual household

adaptation strategies and the implied impacts of embraced adaptation strategies on pastoral production in Harshin Woreda, Fafan Zone of Somali region of Ethiopia.

The poor and most vulnerable pastoralists are already feeling the twin effects of climate induced shocks and stresses and rangeland degradation. Rangeland degradation is another disaster risk for the sustainability of pastoral livelihoods (Abate et al., 2010). In pastoral communities of Ethiopia, climate-induced shocks and stresses such as droughts, rising temperature and irregular rainfall-reduced pasture and water availability and lead to animal loss through hunger and disease (Conway, 2000). The weather-related natural disasters frequently occurred in pastoral areas of Ethiopia, which has been further exacerbated by the depletion of the natural resources and destruction of ecosystems due to anthropogenic activities (Tadege, 2007). Although drought may occur all over the globe, in general its harm is not as intense as in Africa, particularly in Ethiopia (Funk *et al*., 2008; Seleshi & Sanke, 2004; Williams & Funk, 2011). Ethiopia is particularly very susceptible to drought, making drought the utmost significant disaster influencing the country over time (Seleshi & Sanke, 2004). Rainfall anomalies and the delayed onset of the rainy season, along with rising temperatures, lead to impoverishment of grassland, lack of livestock feed and water and heat stress to livestock. This has, in turn, increased the mortality rate of herds, susceptibility of livestock to disease and emaciation as a result of the long distances they travel in search of pasture and water (Muluneh & Demeke, 2011).

A number of studies have been conducted in various part of the country at different times on climate change and variability and the adaptation strategies (Ayal and Muluneh, 2017; Flintan et al. 2011; Leulseged, 2010; Yesuf et al. 2008; Zelalem et al., 2009; Woldeamlak, 2015; Miftah, 2014; Muluneh & Demeke, 2011; Aklilu Y and Cately A (2010; Seleshi & Sanke, 2004; Conway, 2000). Nevertheless, few were conducted in Somali region, the study area of this research, on climate change & variability and the adaptation strategies (Yared et al., 2018; Tiruneh and Tegene, 2018; Birhanu and Beyene, 2014; Kadir, 2012). Thus, perception to climate change and variability, adaptation strategies to climate change & variability and their perceived successes, the determinant factors and barriers to adaptation strategies were not sufficiently and systematically researched. To cement the existing research gap, this study, therefore, set out to analyze the adaptation strategies practiced in the face of climate change to

sustain livestock keeping livelihood option, the perceived success of the adaptation strategies and the major determinants of adaptation strategies in Harshin district, Fafan Zone, Somali region. The study also aims at examining the impact of climate change adaptations strategies on livestock keeping, in the study area. Knowing the climate change adaptation strategies for livestock keeping, their perceived success and the major determinant factors will help for designing policies that can tackle major problems associated with adaptation activities to climate change.

1.3 Objectives of the Study

1.3.1 General/Main Objective

- Analyze the adaptation of pastoral livestock production to climate change and variability in Harshin District, Somali Region, Ethiopia.

1.3.2 Specific Objectives

The specific this research was designed to:

- analyse the past temperature and rainfall trends and variability
- describe the impact of climate change and variability on pastoral livestock production in Somali region of Ethiopia
- explore the adaptation strategies and perceived success of pastoral communities to climate change and variability for livestock production
- identify determinant factors of adaptation to climate change for livestock production

1.4 Research Questions

- What are the past climate trends and variabilities in Somali region of Ethiopia for the last 30 years (1990 - 2019) and the upcoming 30 years?
- What is the impact of climate change and variability on livestock production?

- What are the adaptation strategies of pastoral communities to climate change and variability for livestock production?
- What is the perception of pastoralists on the adaptation strategies' success in the face of climate change and variability for livestock production?
- What are determinant factors of adaptation strategies to climate change and variabilities for livestock production?

1.5 Significance of the Study

This study will determine the factors that influence positively and negatively the perceived success of adaptation strategies to climate change and the degree of association. The research findings will also contribute to the knowledge how livestock production adapts to climate change and continue to be viable source of livelihoods in pastoral setting, which will be of use to public policy formulation and research and development arena. The study will use as well different emission scenarios to predict the future climate for the upcoming 30 years to inform the stakeholders concerned including the agrarian and pastoral communities. Thus, it has methodological significance in the use of the different emission scenarios to predict future climate pattern, which not included in many of the researches. Therefore, this study was designed to reduce the information gap that exists on the impact of climate change on pastoral communities, the adaption strategies practiced, the perceived success of the adaptation strategies by the pastoral communities and the factors that determine the perceived success of adaptation strategies.

The output of this research is vital for socio-economic development planners, livestock professionals, policy makers, environmentalists, development agents and the concerned communities at large in order to have tailored programming that will improve the pastoral livestock production.

1.6 Scope of the study

The research focuses on pastoral communities and their main livelihood option, livestock keeping, related to the theme of the study. The scope of the study is described in terms of spatial, methodology, thematic and time dimensions. The spatial scope is study is in Harshin district, Fafan Zone of Somali region due to hosting the higher number of pastoralists in the zone, experienced adverse impact of climate change and variability and existence of various climate change and variability adaptation practice from 2nd information analysis. Methodologically the scope of the study ranges from climate trend analysis (retrospective) of rainfall and temperature data sourced from National Meteorological Agency (NMA), perception analysis of the impact of climate change and variability and analysis of climate change and variability adaptation practiced, and the perceived adaptation success of the pastoral communities through descriptive and inferential statistics Multivariant Logistics Regression analysis to establish the determinant factors for climate change and variability. Thematically the scope of the study is limited to the livestock production livelihoods, since it is the predominant livelihood option of the pastoral communities that was severely affected by climate change and variability and undergone various adaption strategies. The temporal scope of the study would be for 30 years (retrospective) to analyze the past temperature and rainfall trends and 15 years for the socio-economic analysis of the target communities to be informed on the impact of climate change and variability, climate change and variability adaptation strategies and the perceived success of the pastoral communities of the adaptation strategies and determinant factors of climate change and variability.

1.7 Limitation of the study

This spatial scope of the study is limited in one district and two kebeles due to financial constraint, since the study was carried out in one of the most remote part of the country characterized by poor infrastructure and services. In addition, lack of organized climate data from the Woreda Pastoral Development office was limiting factors for data acquisition.

1.8. Organization of the Thesis

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

CHAPTER TWO

2. LITERATURE REVIEW

2.1 Theoretical Related Literature

Pastoralism

Pastoralism is a livelihood system and a way of life made up of three distinct components, which are the Natural Resources, the Herd and the Family and their institutions. These components interact with each other to drive and sustain the system. System a unified whole of regularly interacting and interdependent components or units Pastoralism is a rational use of the drylands. Pastoralists respond to and use, even choose and profit from, variability. This allows for a vibrant and productive livelihood system in some of the harshest landscapes in the world (Aklilu and Conway, 2010). Pastoralists use mobility to respond quickly to fluctuations in resource availability, dictated by the drylands' scarce and unpredictable rainfall. They also employ a number of highly specialized risk spreading strategies to safeguard their herds against drought, floods, disease and social unrest. These strategies – including building up herd sizes as insurance against times of hardship, splitting herds across different locations to spread risk, keeping different species and breeds and loaning surplus animals to family and friends – ensure the rational use of the natural resource base and also develop and strengthen social relations as a form of social capital (ODI, 2009).

Pastoralists and agro-pastoralists are one of the most climate-change-vulnerable groups on the planet. It is necessary to increase their resilience to protect their livelihoods in the short term. Increased climate variability could decrease herd sizes as a result of increased mortality and poorer reproductive performance of the animals. This decrease in animal numbers would affect food security and would compromise the sole dependence of pastoralists on livestock and their products, as well as the additional benefits they confer (Thornton *et al*., 2009). Under increased

climate variability, the need for diversification of income, a strategy often (and increasingly) employed in pastoral areas, becomes ever more important. Climate change and, increasingly, climate variability will have substantial impacts on environmental security as well, as the conflicts over livestock assets often observed in these regions are likely to escalate in the future as a result of changes in environmental conditions (Herrero et al., 2016).

Climate Change and Variability

Climate change refers to any significant change in measures of climate (such as temperature, precipitation, or wind) lasting for an extended period of greater than three (3) decades or longer. Climate change is resulted from: natural factors, such as changes in the sun's intensity or slow changes in the Earth's orbit around the sun; natural processes within the climate system and, human activities that change the atmosphere's composition and the land surface (IPCC, 2007). Climate changes are expected to have an impact across many sectors of the Earth including increased occurrence of extreme weather events, damage to vulnerable populations, human health and wellbeing, infrastructure, water quality and supply, and disruptions and changes to agricultural and traditional cropping systems (Melillo *et al*., 2014).

Climate change is considered as posing the greatest threat to agriculture and food security in the 21st century, particularly in many of the poor, agriculture-based countries of sub-Saharan Africa (SSA) with their low capacity to effectively cope (Eva, 2009). Ethiopia is among developing countries least contributor but most vulnerable to climate change. Ethiopia's high vulnerability derives in large measure from the country's heavy dependence on agriculture and natural resource exploitation for its economic survival. Agricultural production is highly vulnerable as it is dependent on rainfall. In Ethiopia, the impact of climate change is felt in almost all economic and social sectors, including agriculture, pastoralism and or livestock, water, energy and health sector. Major consequence of climate change is recurrence of drought and other natural hazards (Miftah, 2014). Recurrent droughts occurring in different parts of the country have caused loss of human, animal lives and productive assets and have had a considerable effect on the national economy (NAPA, 2007). These projections of future climate in pastoral areas have led to a polarized discussion of impacts on pastoralists. On the one hand there is a fear, that pastoralist livelihoods, especially in East Africa, are fast becoming unsustainable: pastoralists are in danger

of becoming "the first climate refugees". On the other hand, there is a view, presented by NGOs and scholars that pastoralists are by their nature adapters, and if left to themselves will adapt, quite possibly more successfully than dry land crop-farmers (Little, 2010; IIRR, 2003; Brooks, 2006).

According to (IPCC, 2001) reports Climate variability is the differences in the mean state and other statistics (such as standard deviations, the incidence of extremes, etc.) of the climate on all temporal and spatial scales beyond that of individual weather events. On the other hand, Variability may be happened due to natural internal processes within the climate system (internal variability), or to differences in natural or anthropogenic external forcing (external variability) (IPCC, 2001). While the climate tends to change quite slowly, that doesn't mean we don't experience shorter-term fluctuations on seasonal or multi-seasonal time scales. There are many things that can cause temperature, for example, to fluctuate around the average without causing the long-term average itself to change. This phenomenon is climate variability, and when scientists talk about it, they are usually referring to time periods ranging from months to as many as 30 years (Rob, 2017).

Climate Change Trend

Average global temperature has risen by 1. 3°F to 1. 9°F since 1895, with the highest increase occurring since 1970, with projected rises in temperature of another 2°F to 4°F over the next few decades. The mean annual temperature in Ethiopia has increased by 1.3°C between 1960 and 2006, at an average rate of 0.28°C per decade. The temperature increase has been most rapid from July to September (0.32°C per decade). It is reported that the average number of hot days per year has increased by 73 (an additional 20% of days) and the number of hot nights has increased by 137 (an additional 37.5% of nights) between 1960 and 2006. The rate of increase is seen most strongly in June, July and August. Over the same period, the average number of cold days and night decreased by 21 (5.8% of days) and 41 (11.2% of nights), respectively (Melillo *et al*., 2014).

Impacts of Climate Change and Variability on Livelihood

Climate change and variability is considered the worst threat to sustainable development and livelihoods globally. Studies have shown that about 90% of all-natural disasters facing the world today are related to severe weather and extreme climate change events (GOK, 2010). Both pastoralism and agriculture are highly climate-sensitive sectors. Pastoral and agricultural systems are impacted by changes in rainfall patterns, extreme events, ecology of pests and diseases, temperature, and carbon dioxide concentrations. Vulnerability to these changes varies with time, geographic location, and economic, social, and environmental conditions. Climate change impacts on pastoralism and agriculture are therefore highly region, livestock and crop-specific, determining whether they result in net benefits or losses. For example, while elevated atmospheric CO levels may augment crop productivity, higher temperatures may offset such benefits by increasing pest and disease outbreaks (Fischer *et al.,* 2002). In countries like Ethiopia, however, where dryland pastoralism and rain-fed agriculture predominate, the productivity of livestock, pasture and crop species, which are already near their maximum temperature and drought tolerance, is expected to decrease, even with minimal increases in temperature (IPCC, 2001).

Climate Change Adaptation and Mitigation

Mitigation and adaptation are the two principal strategies to minimize negative impacts of climate change on humans and ecosystems. Mitigation is reducing greenhouse gas (GHG) emissions and increasing GHG sinks, while adaptation deals with enhancing the adaptive capacity and/or reducing vulnerability to climate change impacts while also taking advantage of the positive opportunities resulting from climate change. The adaptation and mitigation potential of developing countries to climate change are weakened because of poor building designs, agriculture, food in security, and low income, deforestation, and conventional solid waste management system, in general (Alefu, 2015). Specifically, Pastoralists are on the frontlines of climate change and are currently the most affected population in the Horn of Africa. The intensity, frequency and magnitude of weather-related changes are proving a challenge to pastoralist communities. The efficacy of their coping and adaptation strategies is compromised by climate extremes and associated risks. There is a need for a new and deeper understanding of

the impact of climate extremes in pastoralist regions for an accurate appreciation of their environmental and socio-economic trajectories (Hurst *et al.,* 2012; Aklilu *et al.,* 2009).

Adaptation – adapting to life in a changing climate – involves adjusting to actual or expected future climate. The goal is to reduce our vulnerability to the harmful effects of climate change (like sea-level encroachment, more intense extreme weather events or food insecurity). It also encompasses making the most of any potential beneficial opportunities associated with climate change (for example, longer growing seasons or increased yields in some regions). Throughout history, people and societies have adjusted to and coped with changes in climate and extremes with varying degrees of success. Climate change (drought in particular) has been at least partly responsible for the rise and fall of civilizations. Earth's climate has been relatively stable for the past 12,000 years and this stability has been crucial for the development of our modern civilization and life as we know it. Modern life is tailored to the stable climate we have become accustomed to (IPCC, 2014).

Adaptation measures are also employed at different levels of the country. For example, the Ethiopians, who live in the high lands, are engaged in mass actively in the combat against climate change. This fight against climate change is indicated by the people's involvement in soil and water conservation practices, which helps to maintain the existing climate as well as to accommodate favorable climate to the country, intending on minimizing the negative impacts of it (Flintan *et al*. 2011). While, the most common coping strategies in agricultural, agro-pastoral and pastoral site of the Oromia and Somali regions are pastoral migration, asset diversification, food aid, and supply side and demand side interventions with regard to water. There are a number of coping mechanisms, adopted especially by the poor and middle wealth groups, including forced labor migration, sale of assets, killing calves and travelling far distances to collect water that won't facilitate adaptation (Leulseged, 2010).

Pastoralist Adaptation Strategies to Climate Change

Pastoralists that perceived the existence of climate change had suitably adapted one or more adaptation strategies as means to tackle against the adverse effects of the climate change. In the study area four comprehensive adaptation strategies were identified and practiced by those who

perceived the climate change namely: Herd composition diversification, herd and pasture management improvement, water harvesting and extended mobility patterns strategies. There are pastoralists that have no adaptation strategy for the alleviation of the adverse effects of climate change due to different barriers. Detailed of the strategies and their barriers are discussed below.

In parallel, in Borana pastoralists, southern Ethiopia two major categories of adaptation choices, adjustment in pastoral practices, and shifts to non-pastoral livelihoods are recently embraced. The adjustment responses are increased mobility, more adoption of drought-tolerant livestock species, increasing resort to purchased hay, competitive individual household land grabs for strategic private range enclosures for the double purpose of cereal cultivation, and fodder production. While, the most non-pastoral adaptation strategy embraced by Borana pastoralists in the last two decades of the 20th century is cereal cultivation. The pastoralist massive rush to the act of having private enclosures for cereal cultivation largely began in the mid-1990s and perhaps culminated in the first decade of this century. Farming was originally adopted by shock victims and the destitute. Climate-induced recurrent pressures later made it a common experiment among Borana pastoralists primarily to avoid livestock selling required for supplementary cereal purchases in the widely pressing circumstances of declining milk yields (Birhanu and Beyene, 2014).

Adaptive capacity

Mortimore & Manvell (2011) defined adaptive capacity as the potential or capability of a system to adjust to climate change, including climate variability and extremes, to moderate potential damages, to take advantage of opportunities, or to cope with consequences. Therefore, the adaptive capacity of any society or system in the environment invariably describes its knowledge of the events, ability to modify or reduce its characteristics or behavior in order to cope better with the changes in external conditions. Smallholder farmers coping, and adaptation practices is the function of their objective and subjective adaptive capacity. In turn the scope of their adaptive capacity is the reflection of social, economic and demographic factors as well as institutional settings and services. Therefore, varied adaptive capacity of smallholder farmers is the cumulative effect of environmental, socio-cultural and institutional factors. The practical challenges poor smallholder farmers face in securing agricultural inputs, credit & extension

services and other constraints (see table 10:4) implies that objective adaptive capacity limitations strongly undermine their perceived adaptive capacity (Ayal et al., 2017). As Puri (2007) social network plays important role in alleviating individual members' problems and hence enhances objective and subjective adaptive capacity.

Policies and Strategies Relevant to Adaptation Strategies

Climate change is causing major social and economic development setbacks in Ethiopia and urged the need to pay attention to the problem. Indeed, the Ethiopian government has recognized climate change as a threat to its national development aspirations. There are also a number of environmentally oriented policies, strategies and action plans that can directly or indirectly contribute to the objectives enshrined in the UNFCCC. Ethiopia has signed and ratified many of the international conventions and protocols related to climate change and adaptation including the united-nations framework convention on climate change (UNFCCC) in May 1994, the convention on biological diversity (CBD) and the united-nations convention to combat desertification (UNCCD) in June 1997 and Kyoto Protocol (February 2005). Within these frameworks, Ethiopia prepared National Adaptation Programs of Action (NAPA) against the impacts of climate change and desertification. Such policies are expected to contribute to fight against climate change and desertification in the country. However, climate change impact-mitigation was not translated into the policies and programs of the country. In particular, the national policies and programs give limited attention to vulnerable societies in climate sensitive, drought and flood prone areas of the country (IPCC, 2007). Nevertheless, there was some initiative by the Federal Democratic Republic of Ethiopia that put in place some policies, strategies and programs that enhance the adaptive capacity and reduce the vulnerability of the country to climate variability.

In Ethiopia there are policies and strategies relevant to Climate Change Adaptation includes the climate resilient green economy strategy (CRGES), national adaptation program of action (NAPA), Ethiopian program of adaptation to climate change (EPACC), nationally appropriate mitigation actions (NAMA), rural development policy and strategies (RDPS), growth and transformation plan (GTP), Ethiopia's Agricultural Sector Policy and Investment Framework

(PIF), Environmental Impact Assessment Proclamation (EIA), Environmental Policy of Ethiopia (EPE) (Melaku *et al.*, 2016).

2.2 Empirical Literature Review

Climate and climate related factors are of great concern to the agro-pastoralists in the study area, Fafan Zone, Somali region of Ethiopia. Climate and climate change related factors were rated as the topmost important causes of food insecurity. According to their order of importance; drought, low annual rainfall, high temperature, and water shortage are the four most important causes of food insecurity. In response to the changing climatic situation of the area, agro-pastoral households have developed various adaptation and coping strategies to minimize the risks posed by climate change and extreme events. As an agro-pastoralist, households in the study area implemented a combination of techniques that minimize crop failure and shortage of pasture due to drought and/or any other climate related hazards. Herd mobility and livestock sale are the major adaptation and coping strategies, respectively, whereas use of short season crop varieties was the least adaptation practice used by sample households in response to crop failure (Yared *et al.*, 2014).

A study by Yesuf *et al.* (2008) identified use of different crop varieties, tree planting, soil conservation, early and late planting, and irrigation as the major methods used by farmers to adapt to climate change in the Nile Basin of Ethiopia. Findings of the study portrayed level of education, gender, age, and wealth of the head as well of household; access to extension and credit; information on climate, social capital, agro-ecological settings, and temperature all influence climate change adaptation. The main barriers to climate change adaptation include lack of information on adaptation methods and financial constraints. Moreover, the analysis reveals that age of the household head, wealth, information on climate change, social capital, and agro-ecological settings have significant effects on farmers' perceptions to climate change. According to Kadir (2012), the factors including age, sex, climate change information, distance to water, total livestock income, access to livestock extension, access to credit, total non-livestock income and social asset redistribution system are affecting the adaptation strategies significantly. Whereas explanatory

variables like family size, education, distance to grazing, distance to market, total enclosure land and food aid did not affect the adaptations strategies significantly.

The most important kind of asset owned by the pastoralists is their livestock. The fact of being a pastoralist coincides with the fact of being owner and herder of livestock. However, the cumulative effect of the drastic cut in the size of grazing lands and the loss of strategic pasture and watering points has led to a severe decline in the size of the individual livestock holding and eventual destitution. In this study, it was found that the livestock herd size is not only declining over time but more importantly, a sizeable portion of the Borena (7%) and Karrayu (5%) households have owned no animals at all. The data averaged for wealth categories shows that the number of animals owned by an individual household is only a tenth of what it was in the past.. It is not only the decline in livestock numbers but equally their productivity has diminished with deprivation and deterioration of the rangelands (Eyasu, 2014).

Climate change is expected to result in fall in productivity, livestock productivity may be lower that by 50% in 2050s compared to without climate change scenario. Agricultural GDP with climate change may be lower by 3% to 30% than without climate change agricultural GDP in 2050. Climate change may increase the number of people looking for food aid by 30%, increase drought expenses by 72% in 2050s. Increasing temperatures and decreasing rainfall reduce yields of rangelands and contribute to their degradation. Higher temperatures tend to reduce animal feed intake and lower feed conversion rates (Rowlinson, 2008). Pastoralists in Borana area indicated that climate change had its effect on their livelihoods through various mechanisms. As prioritized by pastoralists, the four major effects of climate change on livestock production include feed shortage, shortage of water, reduced productivity, and decreased mature weight and/or longer time to reach mature weight in their order of importance (Zelalem et al., 2009).

On the other study reported by, smallholder farmers and pastoralists across Ethiopia have made adjustments in livestock production in response to climate change and variability that includes: increased use of crop residues as animal feed; diversification of animal feeds with “Kinchib” (Euphorbia tirucalli) for goats and camels, cactus (Ficuscarica) for camels, elephant grass and

even using Prosopis and parthenium weeds as ingredients for livestock feed; changing herd composition (reducing cattle number and increasing camels and goats no). Camels and goats have better feeding habits, and the shorter life cycle of goats is good for marketing mainly in the lowland pastoral areas (Woldeamlak, 2015).

Measures and practices with potential for enhancing adaptive capacity of communities in pastoral areas were: Reducing livestock numbers to match carrying capacity of grazing lands through increased commercial off-take rates; forage development such as elephant grass and fodder trees (e.g., Leucaena and Sesbania); building on existing traditional mutual support systems and organizing communities into savings and credit associations; supporting inter-regional state collaboration in development and management of natural resources; strengthening traditional conflict resolution mechanisms; supporting cultivation of cactus to be used as feed; and developing alternative livelihood sources, especially for the younger generation. The vulnerability of pastoralists to the effects of climate change will be highly differentiated across geography, income levels, and governance arrangements, amongst other things (O'Brien *et al*., 2007).

Increased climate variability is predicted to increase severe child stunting by 62% in South Asia and 55% in East and southern Africa by 2050, although many other variables may affect undernutrition too (ANRS, 2010). Historically, pastoralists have had relatively high adaptive capacity in inhabiting arid and semi-arid areas. Climate variability more strongly stimulates adaptation than changes in climate. The high levels of climatic variability that characterize the global rangelands suggest that pastoralists should be well able to adapt to a changing climate, but the current envelope of adaptive practices may not be sufficient. In some contexts, transformational adaptation may be needed. Several analyses of pastoralist sensitivity to climatic shocks have indicated entry points by which pastoralist livelihoods can be better supported in response to a changing climate (Morton, 2007). Nevertheless, many pastoralists see climate change as just one of many important factors affecting their livelihoods; others include human and livestock population growth, globalization, conflict, competition for land, changes in land

tenure and land use, intensification of production, voluntary and government-facilitated sedentarisation of nomadic pastoralists, and institutional changes (Galvin, 2009).

About 99.8% of pastoral communities perceived the ill effects of climate change. To cope with the effects, households pursue livestock mobility as their prime strategy. Perception of pastoral, semi-pastoral, agro-pastoral and mixed-farming communities towards the importance of livestock destocking accounted for 42.5, 36, 33 and 41%, respectively. Cropping was also extensively perceived as a pathway to cope with a multitude threats of climate change, upon which semi-pastoral (95.5%), agro-pastoral (96.6%) and mixed-farming (99.8%) communities were highly dependent on to supplement their subsistence living. Considering the strategy to reverse unexpected future climate shocks and uncertainties, agro-pastoral (44.9%) and mixed-farming (51.3%) communities used animal feed storage. This might be because livestock feed storage applied by the mixed-farming communities is associated with their long-term experience in cropping. Their involvement in cropping during good seasons (non-erratic rain season) allows them to harvest a sufficient amount of straw and hay, which would also enable them to keep stocking for unprecedented future feed crises. Key informants and group discussions further confirmed that feed stocking is possible, either through their own production, purchasing or both (Melaku et al., 2017).

2.3 Conceptual Framework

The conceptual framework illustrated in Figure 1 below is suited to examine the implication of climate change and variability and the adaptation strategies applied in the context of multiple hazards and stressors by the pastoral communities Harshin Woreda, Fafan Zone, Somali region. The conceptual framework indicates the various aspects involved as a cause and effect of climate change and variability on adaptation of pastoral livestock production to withstand, and cope better to the situation. The framework serves, in part, as a ‘‘checklist’’ of relevant climatic, non-climatic, dependent and independent variables to consider in the analysis. In reference to secondary data reviewed, the vulnerability contexts such as climate variability, shocks, trends

and stresses affect household's livelihoods asset portfolio such as natural (e.g. land, water), physical (e.g. crop livestock and environmental services) asset base. Pastoralists' resource and cultural asset background determines the nature and magnitude of their vulnerability to climate change and variability. Therefore, smallholder pastoralists' climate change and variability impact perception, adaptive capacity and adaptive response are the function of their resource and cognition. In the pastoral society, the resource background and cognition have a causal relationship. Pastoralists are sensitive to climate change and variability and are adaptive to the changes in their livelihood. Hence, pastoralists modify their livestock production in the face of climate and non-climate related stresses, which could minimize the effect of climate change and variability. Therefore, pastoralists' adaptation intention and adaptive response measures stems from their exposure and perception.

Pastoralists' skill and knowledge could offer valuable insights into designing effective policies and strategies that attempt to mitigate the effect of climate change and variability. Moreover, the way how they respond to the effect has implications for household behavior and livelihood strategies and hence on the overall household livelihood outcomes (income, food security). Household livelihood outcomes (livestock production i.e. objective capability) in turn determine their adaptive perception (subjective capability) and adaptation strategies as well as access to the institutions. Policies and strategies designed by taking into consideration the vulnerability context, that is, climate change and variability. Moreover, pastoralists adaptive capacity and nature of livelihoods are basic sources for polices and strategies.

Climate change affects livestock production both in terms of quantity as well as quality (Salinger, Sivakumar & Motha, 2005). This affects the psychological wellbeing and resource base of households. The extent and severity of climate change impact on livestock production as perceived by the pastoral communities, and the adaptive capacity as well as their responses to climate change & variability and allied extremes (for example, drought, flood) influence may depend on climatic and non-climatic factors. The climatic and non-climatic factors such as resources base, asset complimentarily, family characteristics (sex, age, family size, and educational background), efficiency of policies and strategies, institutions, and livelihood

strategy beliefs, norms and social identity are key to pastoral adaptation to livestock production. Pastoralists perception to climate risk, and perception about their own ability to execute action and their perception about the effectiveness of the response to climate shock are vital determinant factors of adaptation (Frank, Eakin & Lo ´pez-Carr, 2011).

Climatic variables; drought, flooding, rangeland degradation and rainfall variability, livelihoods degradation, water scarcity, production decline, livestock disease outbreak and non-climatic variables (sex, age, livestock holding, income level, education status, access to veterinary services, marginalization etc…) were identified, which all independent variables. The perception of the pastoral communities to the impact of climate change and variability (probability, magnitude and severity) influence positively and negatively success of adaptation of livestock production to climate change and variability. The adaptation strategies practiced; livelihood diversification, herd diversification, livestock mobility, labour migration, commercialized livestock production, feed preservation, livestock sale and soil and water conversation and the adaptive capacity are presented as independent variable to livestock production. Therefore, successful adaptation to livestock production is a function of climatic and non-climatic variables, adaptation strategies, perception of the impact of climate change, policies & strategies, adaptative capacity and perceived adaptation success.

The framework indicates key networks and interactions involved on the impacts of climate change and variability on pastoral communities and adaptation strategies practiced related to the adaptive capacity in view of the country policy and strategies, which in turn leads to successful adaptation of livestock production that is well adapted, resilient and sustainable. The conceptual framework was designed on the assumption that there are various driving factors behind the pastoral communities' decisions to choose adaptation strategies to climate change and variability. Thus, the contribution of this conceptual modeling is, therefore, putting a set of components together to get a broader picture instrumental for adapting pastoral livestock production to climate hazards.

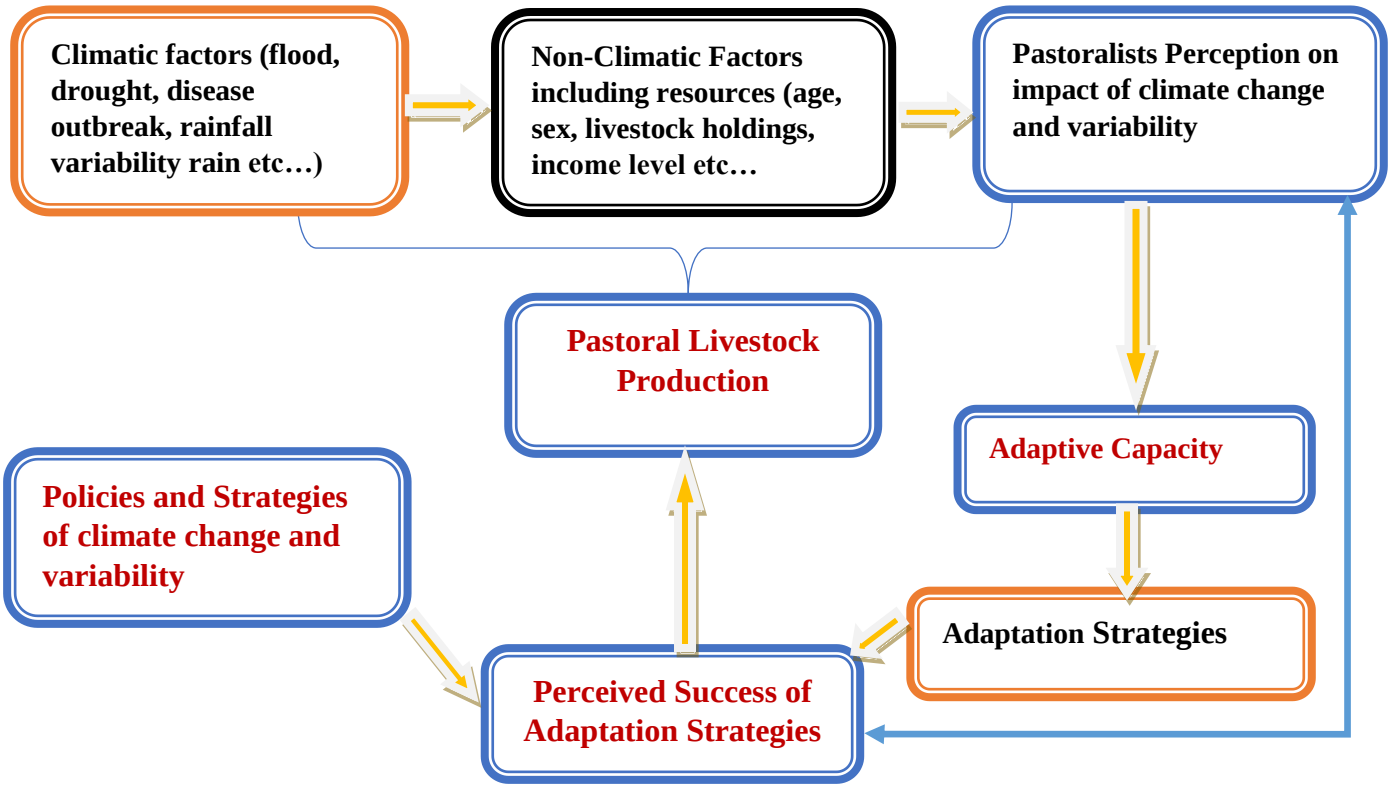

Figure 1. Conceptual framework of Climate Change and Adaptation

Source: Authors Conceptualization 2020

CHAPTER THREE

3. STUDY AREA AND METHODOLOGY

3.1 Introduction

This chapter presents a background to the study area, research design, data collection and analysis techniques, with a comprehensive discussion on how to analyze trends of climate change and variability, adaptation strategies to climate change, perceived success of adaptation strategies and determinant factors to climate change adaptation. The study incorporated both qualitative and quantitative research based on collecting primary and secondary data.

3.2. Description of the Study Area

Somali Region is one of Ethiopia's largest regions with latitude 7° 26' 19.43" N and longitude 44° 17' 48.75" E. It borders Djibouti the north, Somali to the east and north-east and Kenya to the south. To the west it borders Oromiya Region, to the North West Afar Region. There are nine administrative zones: Fafan, Jarar, Sitti, Nogob, Doollo, Shabelle, Korahea, Afder and Liban. The region has a combination of hilly, browse-rich (thick, thorny bush) areas good for Camel and Goats; shrub (grassland) plains with grazing for sheep and Cattles; and where crops may be grown. Some areas are rich in trees that produce gums and resins. The altitude of the region ranges from 200m in the southern/central parts, to 1800m in Jijiga zone; medium altitudes consisting of hilly terrain and plateaux are found in parts of Liban, Degahour, Fik and Shinile Zones. Harshin Woreda which is one of the 8 woredas in Faafan Zone, has been data collected for resource mapping using GIS tool. The development of woreda Atlas/profile provides detail information on physical, social and economic aspects of the particular woreda (Mustafa, 2014).

Harshin Woreda is located and bounded between 946,205 to 1,042,205 UTM north and 332,841 to 428,841 UTM east (see Map below). The woreda is found in Faafan zone of the Somali Regional State covering a total area of 5,120.12 square Km. It is easternmost woreda of the Jijiga Zone, bordered on the south by the Jarar Zone, on the west by Kebri Beyah woreda, and on the

northeast by Somalia. The major town in Harshin woreda is called Harshin. Harshin town, which is the woreda capital, 128Km far from the regional capital Jijiga towards the east direction. The existing administrative division of the woreda is composed of 14 Kebele. Based on figures published by the Central Statistical Agency in 2011, this woreda has an estimated total population of 92,901 of whom 51,096 are men and 41,805 are women. The 1997 national census reported a total population for this woreda of 66,488, of whom 35,145 were men and 31,343 were female; 6,409 or 9.64% of its population were unbans dwellers. Whereas the 2007 national census reported a total population for this woreda of 80,244, of whom 43,869 were men and 36,375 were female; 8,226 or 10.25% of its population were urban dwellers (Ibid).

Livestock rearing is the dominant economic activity in the woreda, followed by crop production. Much of populations in the woreda derive their food and income predominantly from selling livestock (i.e., pastoralists). Some households that live around the towns also practice crop production to supplement their household consumption and income (i.e., agro-pastoralists). This feature of the woreda enabled the sampling to be conducted in both pastoralist and agro-pastoralist kebeles. Most of the kebeles in the Harshin woreda are crippled by poor infrastructure including roads, electricity, and animal health services. According to the Woreda Disaster Risk Management Profile (WDRMP) report, access to veterinary services is poor and the existing services are not availed by large numbers of the local population due to financial constraints and/or religious beliefs (Girma, 2011). Farmers grow a variety of crops in the region. The cropping pattern in the woreda is dominated by Sorghum and Maize. Livestock is an important component of farming system in the region. The total livestock population of woreda consists of 1,174,807 out of these 573,515 (48.82%) are Sheep, 399,815 (34.03%) are Goat, 134,090 (11.41%) are Camel, 48,645 (4.14%) are Cattle, 17,343(1.48%) are Donkey. The remaining 1,399 are Mule, Horse, Beehives and Poultry. As it can be seen in the numbers, the great share of the livestock population goes to sheep which is 48.82% (Mustafa, 2014).

Harshin woreda falls within Jijiga Agro-pastoral Livelihood Zone (LZ15), which is characterized by two distinct agro ecological areas - valleys and mountains in the west and vast plains in the north-east and south, no permanent rivers running through the zone and soil is mainly black clay

(fertile) except in Babile District, where there is sandy soil (used for groundnut cultivation). The Livelihoods are rain-fed sorghum and maize production, and livestock - mainly sheep/goats (shoats) and cattle. Food, income and expenditure: food: mainly own crops, some livestock production, purchase, some food aid and gifts (poor households). Income: mainly crops/livestock production, also bush products for poor households, and remittance for poor households. Poor households can only afford to buy food and non-food essentials; middle and better-off households can afford schooling, and better-off households have savings. Vulnerabilities and responses: high reliance on rain-fed agriculture and pasture means that this population is particularly vulnerable to drought, *Hamaday* frost (October/November), crop pests and market price fluctuations. Main risk-minimizing strategies include cultivation of higher-yielding crops (poor households), selling fodder and crops when prices are higher (middle and better-off households) and selling cattle (better-off households) (Ibid).

The main determinants of wealth are livestock and area of land cultivated for crop production. Better-off and middle households own some camel while the poor have none. Cattle ownership determines the number of oxen that the household owns and hence the area of land that they are able to cultivate. Wealth in this zone is a direct result of agricultural activities and subsequent production. The predominant livestock owned by all the wealth categories in the livelihood zone including Harshin woreda are shoats (sheep and goats). Harshin woreda, Fafan Zone of Somali region is selected to conduct the research, since it a woreda having the highest pastoral communities in Fafan zone and experience various adaptation strategies as a result of the impact of climate change and variability (Ibid).

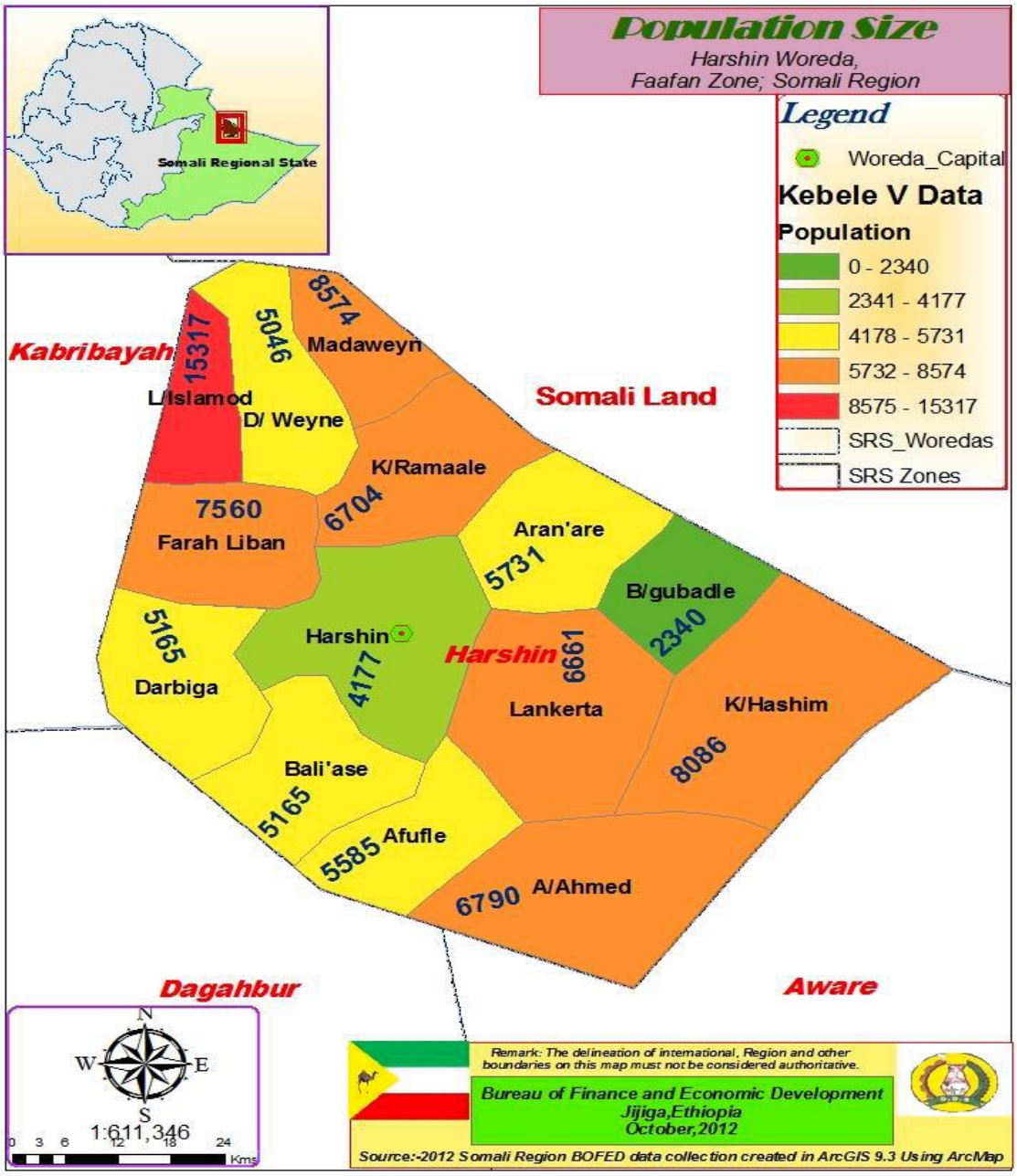

Figure 2: Map of Harsin Woreda, Somali Region

Source: Somali Region Bureau of Finance and Economic Development (BoFED)

3.3 Research Design

Triangulation mixed research method design, which gives equal emphasis to the quantitative and qualitative data was employed in this study. The study used mixed methods (qualitative and quantitative) to collect primary information from different sources identified and help answer the research questions. The data nature in this research encompasses both longitudinal and cross-sectional data types. The earlier data used to determine past and future trends and variability of climate and the later used to understand the socioeconomic and demographic characterized of respondents, their perceptions, adaptation responses and determinant factors to cope with the changing climate. To examine the climate variability and change, its impact on livelihood and pastoral way of lives, this research used combination of both quantitative and qualitative data collection and analysis techniques. Triangulation methodology was used to cross check and verify information received from different sources, such as observations, documentations and interviews. It has helped to harnesses diverse ideas about the same issue and assist in cross-checking the results, and therefore it helped to increase the validity, reliability of the findings and eases data analysis (Bryman, 2008).

Sampling Methods

Sample Size and Sampling Technique

This research was restricted to the pastoralist in two kebeles of Harshin District of Fafan Zone, Somali region. From the two kebeles a total 339 HHs were targeted with 5% error. However, considering 5% of non-response rate, the total sample size was 356 HHs. This study used Kothari (2004) systematic Random Sampling as systematic sample is spread more evenly over entire population to determine the required sample size at 95% confidence level, degree of variability=0.5 and level of precision= 5% (0.05). The statically sample size decision making formula to a population size (N) that is greater than or equal to 10000, as to Kothari is:

$$n= (z^2pq)/d^2$$

$$fn=n/(1+n/N) \text{ if N is less than 10,000}$$

Whereas n=the desire sample size; Z= Standard normal variable at the required level of confidence; P=the population proportion (assumed to be 0.50 since this would provide the maximum); q=1-p, and d= the degree of accuracy expressed as a proportion (0.05)

Finite Population Correction

The above sample size formula is valid if the calculated sample size is smaller than or equal to 5% of the population size (n/N ≤0.05) (Daniel, 1999). If this proportion is larger than 5% (n/N>0.05), we need to use the formula with finite population correction (Ibid) as follows.

$$n' = \frac{NZ^2P(1-P)}{d^2(N-1)+Z^2P(1-P)}$$

Thus, the sample size with 5% non-response rate is 356 HHs.

Confidence Level tells you how sure you can be of your results. Since it is very rare that relief and development surveys would use anything other than a 95% confidence level,

Margin of Error (also called confidence interval) is the amount of error that your survey's findings can tolerate.

The research uses purposive sampling to target district/woreda and kebele. Harshin woreda from Fafan Zone was selected for the study, since it is having the highest pastoral communities in the zone and many climate change adaptation strategies were undergoing as per the grassroots level information though it is not substantiated by research. The kebeles/Sampling frame was selected from Harshin woreda/district as the study sites, since they represent the pastoral communities in the woreda; target communities' groups, which the research is going to be conducted. In addition to sampling households for questionnaire, the researcher selected some respondents for key informant interview and focused group discussion using purposive sampling technique as they should be old enough to witness the climate change over time.

With regard to qualitative data collection, the sample size was determined to a large extent by time and resource limitation hence purposive sampling method was used. Four (4) focus group discussions covering issues of communities' perception of changes, coping and adaptation mechanisms, effect of the change on social aspects, resource, access, and control and activities

profile were conducted following COVID-19 protocol. A total of ten (10) key informant interviews were carried out with a number of stakeholders and key informants, such as government officials and nongovernmental organizations working in the area, both before, during and after fieldwork in the case study area.

Furthermore, two climate variables, rainfall and temperature blended datasets of satellite information (TAMSAT 4*4 KM) and station (NMA manual) were collected from the Ethiopian National Meteorology Agency (NMA) to determine the trend of temperature and rainfall in the study area. NMA didn't have data calibrated beyond 2016, so it has provided what it has; temperature 33 years data from 1984 to 2016 and rainfall 34 years from 1983 to 2016. According to the IPCC (2007), the classical period of time to take data of temperature and rainfall for analyzing the pattern and trend of climate change and variability is thirty years. On the other hand, field observations and household interviews were employed to analyze the trends of land use/ land-cover changes of the study area and its impacts on the livelihood of pastoralists.

3.4 Data Type, Source and Data Collection Tools

Reconnaissance

An initial reconnaissance survey of the study area was conducted prior to commencement of the actual study. The objective was to meet relevant stakeholders and to introduce the study objectives and discuss its relevance to decision-making processes. The stakeholders involved in the introductory meeting were local administrators, extension officers and local elders. The pre-study session was very useful as it helped in building local community trust as well as providing more insights into areas that the stakeholders prioritized for the study assessment. This enabled a better understanding of the peculiarities of the study area, the size of the sample frame that was considered and identification of the local enumerator for the household's interview.

Data type

Quantitative data collection was conducted through a survey questions administered to heads of households from pastoralist/agro-pastoralist of the target kebele. . The survey conducted pre-test/ pilot study in the target kebele to enable us pretesting survey questions for validity, veracity and

consistency. Mobenzi mobile application/platform was used for household data collection. Likert-scale was used to summarize household perception of the effect of climate change, and perceived success of the adaptation strategies.

The qualitative method takes the form of focus group discussion and key interviews to get trends in rainfall, temperature, drought frequency, rangeland cover, water availability and livestock. The metrological data of the study area will get both from national and international climate centers. The observe and grid (4km x 4km) rainfall data and surface air temperatures data (covering 1983-2016) at stations level were obtain from National Meteorological Agency of Ethiopian (NMA) stations. Similarly, oceanic sea surface temperatures (SST) data used for the study extract from NOAA/NCEP and International Research Institute for Climate Society (IRI) website as well as other international forecast centers.

The study was depending on merged gauge–satellite recorded rainfall and minimum and maximum temperature time series data on a ten-daily time scale which was obtained from the Ethiopian NMA for the period 1983–2016 for rainfall and 1984–2016 temperature. Staff members of NMA who had been qualified on satellite rainfall and temperature retrievals, data quality control, as well as merging gauge and satellite data did most of the work at NMA. Historically, weather stations measurements have been the major sources of climate data managed by NMA. However, in Somali region, rain gauge measurements suffered from a number of limitations. There were few stations over the study areas. The stations frequently suffered from data gaps and poor-quality data availability. Thus, to solve this problem, the NMA was offering merged gauge–satellite recorded rainfall and temperature data since 1983- up to the present time over Ethiopia at a spatial resolution of 10km and a ten-daily time scale.

Merged-satellite rainfall and temperature data are extensively employed in various hydro climatological analyses in Ethiopia (Dinku et al, 2011; Wagesho et al., 2013) and other different parts of the world (Baigorria et al. 2007; Ghosh et al. 2009; Mair & Fares 2009; Rajeevan et al. 2006; Tazalika, 2004) and are promoted as appropriate for climate variability studies.

Data Collection methods

Training of local field assistants

In total, 5 enumerators were employed locally with the assistance of the district extension officer based on their previous research experiences, knowledge of the local language and qualifications. Training was conducted for enumerators for two days before starting the survey the household interviews to reduce biases and errors in data collection and familiarize them enumerators with the objectives of the survey, interactive ways to ask questions and tools to be used.

Focus group discussions

Four focus group discussions were conducted separately with gender equality (2 men and 2 women). During the focus group discussions, we included clan leaders and elders who had long experience about the region's climate, vegetation, politics and other situations. The discussions held with different groups of the community aimed at capturing the local knowledge on climate change and variability and its impacts on local communities, adaptation and coping strategies, the main drivers of the land-use/land-cover changes and its impacts on their livelihood. A total of 4 FGDs were carried out in two target kebeles, 2 per each Kebele. FGDs were used to complement the information obtained from the key informant interviews. FGD approach offered the opportunity of allowing people to probe each other's reason for holding a certain view and it was used to validate and triangulate the responses that came out of household survey Field observations will made on the impacts of climate variability and change on livestock sources. The FGDs were conducted following COVID-19 protocol. Observation were carried out in respondent's homes, grazing fields and surrounding environments. Observation techniques were utilized to triangulate the information gather from other sources.

Key Informant Interview

Interviewing key informants and local residents in Fafan Zone Harshin district was the other important investigation technique applied during the field study, and findings from informant interviews carried out with local people in Kebele in Harshin district constitute the bearing data and have been the main engine behind the development of this thesis. Key informant interview was conducted to get in-depth information about the subject of the study from village elders and

personnel from government, Community Based institutions and community leaders. Key informant interviews will appropriate for generating information and ideas in situations when general descriptive information will need, and when understanding of the underlying motivations and attitudes of a target population was require. The interview focused on climate pattern, prospect of pastoralists, impact of climate variability and change, indigenous knowledge and coping and adaptation strategies. A total of 10 key informant interviews were conducted throughout the study.

Questionnaire pre-testing

A pilot test-run was undertaken with local enumerators and key informants before the beginning of the household interviews, and the final questionnaire were revised and rewritten accordingly. The questionnaire used for the pre-test was excluded from the final data entry and analysis. The piloting was done to check the suitability of the tools and also whether the field assistants could manage the questionnaire without difficulty.

Questionnaire interviews

A structured questionnaire with multiple-response and dichotomous questions were employed during data collection (see Appendix 1). It was administered through individual interviews with the heads of the households within two kebeles of Harshin district named Aran'are and Lankeyrta from 20th to the 31st of May 2020. The survey addressed information about household characteristics, household access to basic services, livelihood assets and their trends, income per household, and sources of income, climate change information, climate impacts, adaptation and coping strategies, constraints to the household's coping and adaptation strategies, perceived success to climate change, determinants of climate change and impacts on pastoralist's livelihood. To avoid misunderstanding, the household interviews were undertaken in the local language by the local field assistants. In addition, secondary data were obtained from national and regional offices, online sources and existing literature, including published reports from relevant sources, journal papers. This household data was collected through mobile phone using mobenzi mobile application, which codes data right from the onset. Likert-scale was used to

summarize household perception of the effect of climate change, and perceived success of adaptation strategies.

Likert Scale

In Likert scale method, a sample household indicates his or her degree of agreement or disagreement for a variety of statements related to the perceived changes of a given variable over time. Total score can then be calculated by summing up the values for all statements to see the significance of each variable. An important assumption of this scaling method is that each of the statement measures some aspect of a single variable so as to legitimately apply summation. In addition, the relative importance of subcategories of statements can be measured, by relating its score with the household's total score (Bunce et al., 2009). For this study a 5-point Likert scale method was used.

3.5 Data Analysis

Two types of statistical methods were used to analyze the collected quantitative data; descriptive and inferential statistics. The qualitative data was analyzed using descriptive statistics together with the quantitative data. In this study, seasonal rainfall analysis was based on three seasons, namely: (i) Gu (spring season) and Hagaa (summer season) are long rainy seasons, which occur from July to September and April to June respectively; (ii) Dyre (Autumn) season, a short rainy season, which occurs from October to December.

Descriptive statistics were used to analyze data obtained from the household survey such as frequencies distribution, and percentages. Climatic data are analyzed to show annual maximum, minimum and average temperatures, the warmest and coolest years in the analysis period. The highest and lowest annual ranges in a year were manifested in the analysis. Similarly, the rainfall data was analyzed to show annual maximum, minimum and average rainfall score, the highest and lowest years in the analysis period. Anomaly of temperature were estimated by: $X - \bar{x} / \sigma$. Standardized Precipitation Index (SPI) was used to assess or quantify the precipitation deficit for multiple timescales and reflects the impact of drought on the availability of the different water resources; thus, three months SPI and annual SPI was computed. A 3-month SPI reflects short-

and medium-term moisture conditions and provides a seasonal estimation of precipitation. The SPI at these timescales reflects long-term precipitation patterns. A 12-month SPI is a comparison of the precipitation for 12 consecutive months that recorded in the same 12 consecutive months in all previous years of available data. The precipitation concentration index (PCI) is used as well to analyze the temporal precipitation distributon and assessment of seasonal precipitation changes. PCI indicates the distribution of monthly rainfall and can be used as an indicator of hydrological hazard risks such as floods and droughts (Gocic et al. 2016).

The qualitative data was coded, collated, compiled, and analyzed together with the quantitative data. Interpretation and discussion were given after triangulation of the results of the analysis with the existing reality and other similar literatures. This is to make sure that the results are representative, and not to manipulate findings of the study. The qualitative data are mainly collected through FGD and KKI to triangulate information collected through household survey and some specific information about the perception of the communities about climate change, the vulnerability of their livelihoods in the face of climate change, the different adaption strategies used to withstand and cope better the impact of climate change and inquire the perceived success of adaptation strategies as per their effectiveness.. Mann-Kendall test as described by Sneyers (1990) was used to detect trends. The significance level of the slope was estimated using Sen's method. Mann-Kendall test and Sen's method are less affected by outliers (salmi et al., 2002). The Mann-Kendall test method were employed for climate data, which are not normally distributed. Similarly, the test is a non-parametric statistical procedure that is well-suited for analyzing trends in data over time. A non-parametric test is preferred over the parametric in view of its ability for analysis of data that is not normally distributed (Babar & Ramesh, 2013; Hamed, 2008; Mondal *et al.*, 2012). The basic principle of Mann-Kendall (Mann, 1945; Kendall, 1975) test for trend involves the examination of the sign of all pair-wise differences of observed values. The Mann-Kendall test is based on the statistic S. Each pair of observed values x_j, x_k ($k > j$) of the random variable is inspected to find out whether $x_k > x_j$ or $x_k < x_j$. The test statistic for the Mann-Kendall test is given as:

$$S = \sum_{k-1}^{n-1} \sum_{j=k+1}^{n} \operatorname{sign}(x_i - x_k) \qquad \textbf{(1)}$$

Where x_j and x_k are the sequential data values and j <k, n is the length of the data set and

$$\text{sign}(x_j - x_k) = \begin{cases} 1 & \text{if} x_j - x_k > 0 \\ 0 & \text{if} x_j - x_k = 0 \\ -1 & \text{if} x_j - x_k < 0 \end{cases} \quad (2)$$

The Mann-Kendall test has two parameters that are important for trend detection. These parameters are the significance level that indicates the test strength and the slope magnitude estimates that indicates the direction as well as the magnitude of the trend. Given the null hypothesis that xj are independent and randomly ordered, the statistic S is approximately normally distributed when $n \geq 8$, with zero mean and variance (Capodici et al., 2008).

The Mann-Kendall test allows inquiring on the presence of tendency of long period without having to make an assumption about the distributional properties. Moreover, the non-parametric methods are less influenced by the presence of outliers in the data compared with other methods (Capodici et al., 2008).

Econometric Analysis

In this study, the dependent variable is binary, that is, either the household adapt or not to climate change. A relevant statistical model when the dependent variable is binary is the logistic regression model. Following Uchezumba et al. (2009), the choice of binary logistic regression techniques was based on two reasons that is the technique can be employed to analyze the relationship between a categorical response variable and a set of both continuous and categorical variables. Furthermore, the technique is best suited for modelling non-linear distribution, which is not appropriate with ordinary least squares (OLS).

To evaluate the determinants of adaptation to climate change, the following general logistic regression model was used:

$$Logit\ (P_i) = \ln (P_i / 1 - P_i) = \beta_0 + \beta_i X_i + \cdots + \beta_n X_n$$

Where ($P_i/1 - P_i$) is the logit for adaptation to climate change choices; P_i represents adaptation to climate change; $1 - P_i$ is no adaptation to climate change, and the X_i's represents covariates. The empirical model, with the explanatory variables selected based on theory, is presented as:

Ln $(Pi/1 - Pi) = \beta_0 + 1CF_i + 2\ NCF_i + 3PCCI_i$

The explanatory variables are grouped into four broad categories namely: climatic variables to climate change (CF), **Socio-economic (**non-climatic variables) (NCF) for climate change, and pastoralists' perceived impact of climate change (PCCI). The explanatory variables and their hypothesized signs are shown in Table 1 and are subsequently discussed. The dependent variable is Climate Change Adaptation – whether the respondents successfully adapted to climate change or not.

The logistics (Logit) regression model were used for econometric analysis to determine the explanatory variables of adaptation to climate change and variability in pastoral communities of Harshin Woreda, Fafan Zone, Somali Region and understand the degree of association. The generalized version of the model also reduces heteroskedastic errors. The model equation was estimated using a logit model. Parameter estimates of a logit model and marginal effects of determinants were assessed for climate change adaptation. The functional form of logit model is specified as Prob (Y = 1 | X) = F (Xi, β)

Where Y is a function of explanatory variables (Xki), and expressed as:

$Y = \alpha 0 + \beta 1X1i + \beta 2X2i + \beta 3X3i + \beta 4X4i + \ldots \beta kXni + \sum$

Where $\sum$= error term.

$$= \frac{e^{Z_i}}{1 + e^{Z_i}} = \frac{e^{Z_i}}{1 + e^{Z_i}}$$

Climate Change Adaptation (CCADPT) = β0+ β1 famsz, + β2 hhsex, + β3 hhage + β4 edust, + β5 lvhl + β6 drght + β7 fld + β8 rnfvr + β9 vetsr + β10 lvdsob + β 11 hndio + β 12 incoml+ β 13 weinfo + β 14 crdt + β 15 prefccvr + β 16 perefcc + β 17 rebscft + β 18 ckadtst + β 19 cciimp

The model can thus be estimated as follows; the first step of understanding whether there is livelihood change or not can be specified as:

Where change is denoted by 1 and no change is denoted by 0. β0 is a constant, β1, . . ., βn are parameters to be estimated, X1, . . ., Xn are the vector of explanatory variables, and εi is an error term.

Climate adaptation in pastoral settings may not be only brought about by climatic factors but the non-climatic factors, since pastoralism is complex and influenced by many policy, governance and environmental factors. There might be linkage between the climatic factor and non-climatic factors as the climatic factors might be influenced positively or negatively by the non-climatic factors and the vice versa. The co-occurrence of both the climatic and non-climatic factors in pastoral settings might bring about noticeable climate change adaptation that might affect the pastoralists socioeconomic status. The probabilistic analysis, logit model used to assess the degree of the effect of the different independent variable listed below on dependent variable named climate change adaptation (CCADPT). The independent variables of the study were identified from theoretical and empirical literature reviews and hypothetical testing using pair wise comparison correlation.

Table 1. Description of Explanatory Variables.

S/No	Explanatory Variables	Short Version of Variables	Expected Sign
I	**Socio-economic (Non-Climatic Variables)**		
1	Family size (counts)	famsz	+
2	Sex of the household head - (1 if male, 0 female),	hhsex	+
3	Age of the household head	hhage	-
4	Livestock holding (counts)	lvhl	+
5	Income level (counts)	incoml	+
6	Education Status	Edust	+
7	Access to Veterinary Services	vetsr	+
8	Access to Credit	crdt	+

9	Access to information about climate change impact	cciimp	+
10	Access to weather information	weinfo	+
11	Knowledge and skill on adaptation strategies	ksadptst	+
II	**Climate Change/Climate Variability (Climatic Variables)**		
12	Drought Occurrence (1 yes, 0 otherwise)	drght	-
13	Floods Occurrence (1 yes, 0 otherwise)	fld	-
14	Rainfall variability (1 yes, 0 otherwise)	rnfvr	-
15	Livestock disease Outbreak (1 yes, 0 otherwise)	lvdso	-
16	Human disease Outbreak (1 yes, 0 otherwise)	hndio	-
17	Resource based conflict (1 yes, 0 otherwise)	rebscft	-
III	**Perception of Climate Change Impact**		
18	Perception on climate change/variability (rainfall and temperature pattern)	prefccvr	+
19	Perception of climate change impact (1 if yes, 0 otherwise)	Preffcctimp	+

Source. Authors conceptualization 2020

Methods of Estimation

STATA version 14 was used for analysis of the surveyed data. Variables were inspected for missing values, zeros and negative values. Each variable was examined not only for outliers but also for normality. In the analysis, the dependent variable is Climate change Adaptation, while the independent variables are the 19 variables stated above, which was chosen as per the literature review and preliminary assessment in study area said to influence climate change adaptation strategies. Multivariate logistic regression modeling was applied to analyze both continues and dumpy variables. To check the quality of the data different tests were run such as multicollinearity, correlation matrix and Variance Inflation Factor (VIF), Heteroscedasticity and Normality Test.

The multivariate logit regression (MANOVA) model was used to analyze the determinants of farmers' choice of adaptation strategies. The parameter estimates of the MANOVA model provide only the direction of the effect of the independent variables on the dependent (response) variable, but estimates do not represent either the actual magnitude of change or probabilities. The marginal effects or marginal probabilities are functions of the probability itself and measure the expected change in probability of a particular choice being made with respect to a unit change in an independent variable from the mean (Green, 2000). In a regression model, "multiple" denotes several predictors/independent variables. On the other hand, "multivariate" is used to mean several (2 or more) responses/ dependent variables. To this end, multivariate logistic regression is a logistic regression with more than one binary outcome. Thus, the study used multivariate logistic model, since it has more than one dependent and independent variables. Adaptation decision is unsurprisingly multivariate and attempting a univariate modelling masks the convenient economic information found in the interdependent adaptation choices. As a result, MVP model is proper to model simultaneously the effects of explanatory variables on each choice outcome variables, while permitting unmeasured factors to correlate spontaneously (Piya, et al., 2012a).

3.7 Ethical Consideration

In case of data collection, ethical considerations were seriously taken into account to ensure the protection, integrity, anonymity, consents and other human elements of the informants. The respondents were identified by names and their consent were assured prior to the interview and discussions.

CHAPTER FOUR

4. RESULT AND DISCUSSION

4.1. Demographic and Socio-Economic Characteristics

Understand the socioeconomic and demographic characteristic of the pastoral community included in the study is vital to draw a conclusion how they perceive and respond to the changing climate and its impact on their livelihood. The empirical data at micro level helps to evaluate the validity of previous studies about the difference between the literate and the illiterate, male-headed households and female-headed households, old and young, rich and poor etc. in perceiving the manifestations climate variability and its impact on the livestock sector. The table 2 below illustrates socio-economic and demographic features of survey participants. About 82% and 18% of respondents were male-headed and female-headed households respectively. The mean age of sample household heads is 44 years, while the dependency ratio, the proportion of dependent household members (household members aged less than 18 years and those older than 64 years) is to that of the active age group (15-64), was close to (98%). A livelihood study conducted among selected pastoral and agro-pastoral areas of Ethiopia found similar result with regard to dependency ratio but less literacy rate of only 13.7% (Devereux, 2006).

Education

The FGDs and KKIs informants perceived that education is a path to alternative livelihoods. They further asserted that the productivity and sustainability of pastoralism in the Somali Region is under question due to increasing trends of droughts and deterioration of rangelands. The population pressure is an issue as well, thus pastoralism couldn't accommodate all the people contained in the region and, hence, livelihood diversification is the paramount to adapt to the prevailing situation. One of the main instruments for livelihood diversification is education, which included training, coaching ad mentoring. Though, the literacy level was very low (18%) in the study area as in many other pastoral areas in the country, the attitude of pastoralists to send their children to school has increased significantly in the last two to three decades. The key

informants asserted that those people, who managed to send their children earlier, have realized their educated children have higher chance of job opportunities and support their parents in mobile cash transfer and other technologies. In contrast, those households having a negative attitude to send their children to school with the pretext of having as enough labor as possible to pursue and sustain their pastoral livelihoods. In general, the illiteracy level in the adult category is very high with 82% of the head of the household being illiterate, whereas 26% of them attend formal and informal education. Illiteracy particularly among female headed households (86%) appears very high in the study sites. However, the FGDs and KIIs confirmed most of them are sending their children to school, which is believed to be a game changer for the pastoral communities to modernize and adapt pastoralism in the near future. Education or literacy was seen not to affect as such the adaptation strategies with significant impact as illustrated in the table 2 below except combing livestock with crop production and livestock mobility impacting positively and negatively respectively. A unit increase in educational status would result in 8% increase in the probability of combing livestock with crop production to adapt to climate change with significant impact. However, with its negative effect adaptation, a unit increase in educational status would result in (-6%) decrease in the probability of having livestock mobility with significant impact.

Table 2. Respondents' Socio-Economic and Demographic Characteristics

Demographics Characteristics		**Male Headed HH**	**Female Headed HH**	**Total**	**%**
Sex		292	64	356	100%
Age	20 – 40	122	28	150	42%
	40 – 60	142	32	174	49%
	> 60	28	4	32	9%
	Total	**292**	**64**	**356**	**100%**
Educ. Level	Illiterate	237	55	292	82%
	Cycle 1 (1 to 4 years)	42	3	45	13%
	Cycle 2 (5 to 8 years)	7	5	12	3%
	High School (9 to 10 years)	2	0	2	1%
	Preparatory (11 to 12	1	1	2	1%

	years)				
	Higher Education	3	0	3	1%
	Total	**292**	**64**	**356**	**100%**
Annual Income ETB	6,000 to 10,000	9	8	17	5%
	10,000 to 20,000	42	21	63	18%
	20,000 to 30,000	96	19	115	32%
	30,000 to 40,000	88	10	98	28%
	40,000 to 50,000	31	5	36	10%
	> 50,000	26	1	27	8%
	Total	**292**	**64**	**356**	**100%**
Annual Income ETB		**Female Headed HH**	**% Female Headed HH**		
	6,000 to 10,000	4	6%		
	10,000 to 20,000	25	39%		
	20,000 to 30,000	19	30%		
	30,000 to 40,000	10	16%		
	40,000 to 50,000	5	8%		
	> 50,000	1	2%		
		64	**100%**		

Source. Authors Household Survey 2020.

Livestock Production

In pastoral communities, livestock serve as the main financial and social asset. The herd composition of sample households shows that sheep comprise significantly large proportion (about 50%) followed by goats (35%), camels (10%) and cattle (3%). Thus, it can be seen the majority of the livestock (85%) are shoats, sheep and goats. The average livestock holding calculated using tropical livestock units (TLUs) reveals that mean livestock ownership for the total sample equals 13.66 (51 heads of livestock). As shown in the table 2 below number of livestock is positively related to most of the adaptation strategies practiced by the pastoral

communities in Harshin Woreda, which signifies the higher the livestock number a household own the better adapted it would adapt to the climate change and variability.

Cash Income

The average yearly income of sample households was 30, 017 ETB. Income from livestock and livestock product appears to constitute nearly all amount of the total household income (69%). On the other hand, income from non-livestock sources notably petty trade, humanitarian aid/Productive Safety Net Program (PSNP) and remittance accounts only to 31%. Average per person per annum income of $185 (ETB 6,253.62 Ethiopian birr) in the study sites, which is below the poverty line of the country, ETB 7,184 per year (World Bank, 2020). The income of female headed households is far below that of male headed ones since more than 45% of female headed household respondents earn between $176 and $588 respectively. As reported by UNDP (2011); Alebachew (2011); Morrow (2008); Enarson (2007) illiteracy, poverty and poor infrastructure compromise adaptive capacity and worsen climate change vulnerability. The level of income is positively linked to most of the adaptation strategies practiced as illustrated in the table 19 by the pastoral communities in Harshin Woreda, which signifies the higher the household income the better adapted it would adapt to the climate change and variability.

Table 3. Respondents' Cash Income Source Versus Mean Income

Variable	Mean	%	Std. Err.	[95% Conf. Interval]	
Livestock sale	15,950.35	53%	318.571	15323.8	16576.9
Livestock Product Sale	4,658.18	16%	271.354	4124.52	5191.84
Skilled labor	584.2697	2%	126.112	336.25	832.29
Unskilled labor	721.2921	2%	118.417	488.405	954.179
Employment	234.3258	1%	83.5623	69.9864	398.665
Remittance	2,864.107	10%	364.881	2146.51	3581.71
Forest product sale	1,077.837	4%	229.972	625.558	1530.12
Petty Trade	1,741.638	6%	303.05	1145.64	2337.64
Loan	11.23596	0%	6.86442	-2.2641	24.736
Humanitarian Aid/PSNP	2,174.157	7%	213.716	1753.85	2594.47

Source: Authors household survey 2020

The FGDs and KIIs strengthen the household survey findings that drought, rainfall variability and livestock disease outbreaks are the prominent hydro-metrological hazards affecting their Woreda that threatened their livelihoods most importantly livestock keeping and farming.

Livelihood Assets

Pastoralists' resilience depends on the livelihood assets accessible to make a living, such as access to natural resources, public services, infrastructures and affordable credits (Alinovi et al., 2010; DFID, 2011). Access to these assets and the environment governs the overall livelihood strategies of societies in which these assets are merged for production and consumption functions (Ellis, 2000; Rass, 2006). The main livelihood assets that were portrayed by the households interviewed and confirmed by FGDs and KIIs are described in the following sections.

Livelihoods Trends

Pastoralism is way of life and source of livelihoods in Harshin woreda. As depicted in the table below more than 94 of the communities are relying on livestock keeping this year, which is the main stay of pastoralists. It can be seen from the table below there is transition of pastoralist from sole livestock keeping livelihood practice to other livelihood options in the last 15 years notably farming, petty trade and unskilled labor. According to the FGD and KIIs this transition is instigated, since the livestock number the pastoral communities had, couldn't sustain the household food and income need for living. It is interesting to note farming has doubled itself in the last 15 years, which could be a good complement to the livestock keeping livelihood.

Table 4. Livelihood Trend now and Last 15 Years

Livelihoods	Now	Last 15 Yrs
[1] Livestock Keeping	94%	99%
[2] Farming	53%	27%
[3] Petty Trading	15%	5%
[4] Employment/Salaried Work	1%	1%
[5] Skilled Labor	4%	1%
[6 Unskilled Labor	12%	4%

Source: Authors household survey 2020

The study depicts the livestock ownership at household level is decreasing through time mainly due to unfavorable weather condition (91% response rate), shortage of feed (78% response rate), loss of market value (67% response rate) and high prevalence of livestock diseases (64%).

Pastoral Communities Livestock Preference

It can be seen from the table below clearly the preference of the pastoral communities in Harshin woreda is moving more to the drought tolerant species more of to the browsers, goats and camels instead of grazers, cattle and sheep. This is in line to findings of the climate change adaptation strategies, changing herd composition, which is the 2nd strategy getting the highest response rate practiced by 94% of the respondents.

Table 5. Livestock Preference of Pastoral Communities in Harshin Woreda

Livestock Preference		
Species	**Number**	**Percent**
Cattle	119	33%
Goats	344	97%
Sheep	319	90%
Camel	329	92%
Equine	24	7%
Poultry	18	5%

Source: authors household survey 2020

As illustrated in the table below 100% of the respondents asserted their preference of livestock is due to drought tolerant trait of the preferred livestock species followed the high birth rate (97%), higher economic value (62%) and disease resistant (53%).

Table 6. Reasons for Livestock Species Preference in Harshin Woreda

Reason for Livestock Preference		
Reasons	**Number**	**Percent**
Higher economic value	222	62%
Drought tolerant	356	100%
Disease resistant	188	53%
Need low input	55	15%
More productive	122	34%
Give birth in short period	344	97%

Source: authors household survey 2020

Livestock assets

In the study area, the major animals kept by the respondents are sheep (50%), goats (35%) followed by camel (10%). The predominant livestock species, cattle, in the 1980s and before, now only constitutes 3%. As the household survey findings revealed, and confirmed with the FGDs and KIIs, livestock are still the primary source of pastoral income, with live animal sale and its products constituting 72% of the household income as per the household survey finding. Markets are important very important for pastoralists, as they use it to sale their livestock and its products to buy food items notably grain, processed food items and other household essentials, since most of them don't practice farming. Thus, pastoralists are extremely sensitive to the effect on markets, since they are heavily dependent to sustain their livelihoods and assure their food security. The tendency of pastoralists rearing more of small ruminants such as sheep and goats is for their ease in marketability. It is often referred as a "purse of pastoralists". The interviewed households, the FGDs and KIIs confirmed the lion share of the live animal sale attribute to shoats.

Besides, the respondents stated that pasturelands were increasingly replaced by bushes and shrubs due to bush encroachment and prolonged and recurrent droughts. Consequently, there is strong tendency from pastoralists to rear more goats and camels than cattle and sheep in response to this ecological change as goats and camels can survive on browsing trees and bushes. Due to the loss of pasturelands, the number of cattle per household has significantly declined, and currently most pastoralists in the study area are dependent on camels for milk consumption as camels yield more milk than cows and can better survive on browsing trees and bushes. The respondents further stated that the changing emphasis from grazers to more browsers was not only in response to ecological changes (loss of grasslands and drought-related hazards), but also in response to the increasing demand for purchasing grain and processed food and other households' essentials. Therefore, the transition of livestock holdings from grazers to browsers indicates the flexibility and adaptive response of pastoralists to the ecological, & climate

changes, and economic demands as asserted by 90% of the households that change in herd composition is the predominant adaptation strategies.

Social Assets

Social capital is the social resources upon which people make in pursuit of their livelihood activities. The rangeland, farmland, water resources, and livestock assets are basic components for the sustenance of livelihoods. However, the livelihood is more than getting an income and it involves intangible assets as well as social institutions such as family, village and social relations which are important to support and sustain a living. Therefore, social capital, which involves informal transfers, social support networks and participation in social institutions, is a key asset for the sustenance of pastoral livelihood (Muluken, 2017).

The respondents asserted that the mutual support in the Somali community were degraded due to the declining of livestock numbers and increasing price of grains and manufactured goods. Due to poverty in the community, most households were dependent on government and non-government aid, while their informal social support system had been degraded. On the other hand, the households' access to credit was very poor in the study area. The results showed that only 5% of households had access to credit. Therefore, there is a need to provide affordable credit access, detailed orientation on credit and business management plus market information to the pastoral communities and strengthen institutions working on credit access and capacity building to the pastoral community and incorporate it into the development strategies of the government in order to enhance the adaptative capacity of the pastoralists towards shocks and stresses.

Human Assets

Human capital refers to the skills, knowledge, capability to labor and well-being that together support household to practice various livelihood activities and attain their livelihood intentions (Carney, 1999). Pastoralism is a highly skilled practice that requires a high degree of labor input, and human capital is the most important productive input in the system. Human health obviously impacts importantly on this exhausting livelihood, particularly in times of stress when labor

demand increases (for example, during a drought when migrations can increase and bringing of water from a distance is more challenging). In the Somali community, mobility and herd splitting based on the type of animal (whether browser or grazer), physiological status (whether milking cows, dry cows or pregnant cows), age and productivity of the animal, were the most important strategies of pastoralists to utilize the spatial and temporal variable resources of a rangeland and to cope with climate-related hazards such as droughts. The success of these strategies was highly dependent on the availability of labor, skills and health status of the household.

The results also indicated that the average size of the family in the study area is seven (7). This was relatively higher than the national average rural household size 6.2. Such large family size in the study areas might be associated with the polygamy culture that is commonly practiced in the Somali region. The average age of the household heads of the respondents is 44 years and mainly patriarchal (72%). A considerable number of the respondents (82%) were found to be illiterate, which means that only 18% of the respondents could read and write with a formal education. Furthermore, the results revealed that only 28.8% of households had access to veterinary services, indicating that access to veterinary services Harshin Woreda was very poor.

Labor is critical for pastoral communities to manage their livestock and the assorted rangelands. As a prominent livestock production adaptation strategy, the pastoral communities practice rearing of different livestock species with different feeding habit and requirements. The different livestock species should be managed differently in different types of rangelands– cattle and sheep in grassland camels and goats in bush and shrub vegetation cover. Thus, such arrangements require adequate availability of labor for livestock production in the pastoral community

According to the FGDs participants, labor was sufficient in the pastoral communities two to three decades back, as it could be get readily available from the different family members or even from their neighbors or clan members in the community but now there is limited labor available as youths increasingly became involved in non-pastoral activities such as seasonal labor employment, petty and livestock trade, or in an urban business. Although these non-

pastoral activities were an important source of livelihood to accommodate the increasing population pressure in the region, it has significantly affected the labor input of pastoralism.

According to a woreda livestock expert,

Lack of labor for the livestock, the people's main livelihood, is said one of the major issues hindering people to adapt the climate change. Urbanization and youth migrating to the towns and cities is a prevalent issue in Harshin woreda. Though relatives working in the major cities are source of help during the harsh times, herding and caring of livestock is one of the areas affected by the youth migration.

4.2 Climate Trend and Variability

This section of the thesis paper presents the findings of climate trends variables (rainfall and temperature) analysis in Somali region, Fafan Zone, Harshin Woreda, which were analyzed based on the data obtained from the Ethiopian National Meteorological Agency (NMA) for the period 1983 - 2016 for rainfall and 1884 – 2016 for temperature. The impacts of increasing temperature and rainfall variability and anomalies on livelihoods are discussed. The south eastern part of Somali region has four seasons; from January to March, locally called Jilal; from April to June, locally called Gu, July to September, locally called Hagaa and October to December, locally called Dyre. The south eastern part of the region has bimodal rainfall pattern; the long rainy season from April to June, locally called Gu and short rainy season from October to December, locally called Dyre.

4.2.1 Rainfall and Temperature Trends and Variability

Monthly rainfall trends

In the analysis period from 1983 to 2016, the maximum monthly rainfall (126.9 mm) was observed in Harshin district during the month of Oct (1999). The basic characteristics of monthly rainfall time series in the study areas for the analysis period are summarized in Table 6.

Table 7. Average monthly aggregated rainfall data in the Harshin district: Descriptive statistics for 1983–2016 (mm)

Rainfall level	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Minimum	0.0	0.0	0.0	0.0	12.0	0.0	5.0	0.0	0.0	0.0	0.0	0.0
Maximum	13.0	23.0	43.0	109.0	53.0	19.0	48.0	86.0	70.0	104.0	13.0	41.0
Average	2.3	1.6	9.1	32.9	32.3	6.6	19.2	16.9	23.9	32.6	1.8	3.8
SD	3.7	4.7	11.3	21.4	10.8	5.3	12.9	21.8	14.2	24.4	3.2	9.6
CV (%)	164	298	125	65	33	80	67	129	59	75	182	254

CV = Coefficient of Variation; SD = Standard deviation

Source. National Meteorological Agency, 2020.

The highest rainfall was recorded in a month of Apr, May and Oct, which is, contributed 53.4 % to the mean annual rainfall totals in Harshin district. The rainfall extremes exhibited in the month of April, May and October have indeed influenced the seasonal rainfall, since the season they are falling showed significant increasing trend as illustrated in the table 6 below.

Seasonal rainfall trend and variability

The results indicated that in the Harshin district, the GU, Hagaa and and Dyre seasons contributed 39%, 33% and 21% to the annual rainfall totals, respectively.

Coefficients of variation (CV) have been computed for Harshin district in order to investigate the inter-seasonal rainfall variability. According to Hare (1983), CV is used to classify the degree of variability of rainfall events as less (CV < 20), moderate (20 < CV < 30), and high (CV > 30). In this study, the CV ranged from 64.6 % (Dyre season) to 33.9 % (Gu season) (Table 8).

Table 8. Descriptive statistics of seasonal rainfall in the Harshin district for the period 1983–2016 (mm)

Rainfall Level	Gu	Hagaa	Dyre
Minimum	33.0	15.0	0.0
Maximum	150.0	132.0	104.0
Average	71.8	60.0	38.2
SD	24.3	32.7	24.7
CV (%)	33.9	54.4	64.6
PCI	10.5	8.5	18.6

SD = Standard deviation, CV = Coefficient of Variation, PCI = Rainfall concentration index

Source: National Meteorological Agency, 2020.

The coefficient of variation for Dyre rainfall was extremely high (CV > 60) indicating very high variability among Dyre rainfall seasons for the observation periods. This indicated that since pastoralists are highly dependent on bio-modal rainfall, the high rainfall variability during Dyre rainfall seasons could jeopardize their livelihoods security through its direct effect on pasture and browse availability and farming practice. Key informants described that due to seasonal rainfall variability, pastoralists in the Somali region were obliged to move long distances during the dry season, which in turn caused their livestock to be physically emaciated and exposed to diseases, resulting in loss of livestock in loss of livestock body condition and subsequent low market price that will hamper access to food and income of the pastoralist households. On similar note, when pastoralists move long distances in searching for feed and water for their livestock, education, health services and other public services, which could affect the sustainability and modernization of their livelihoods.

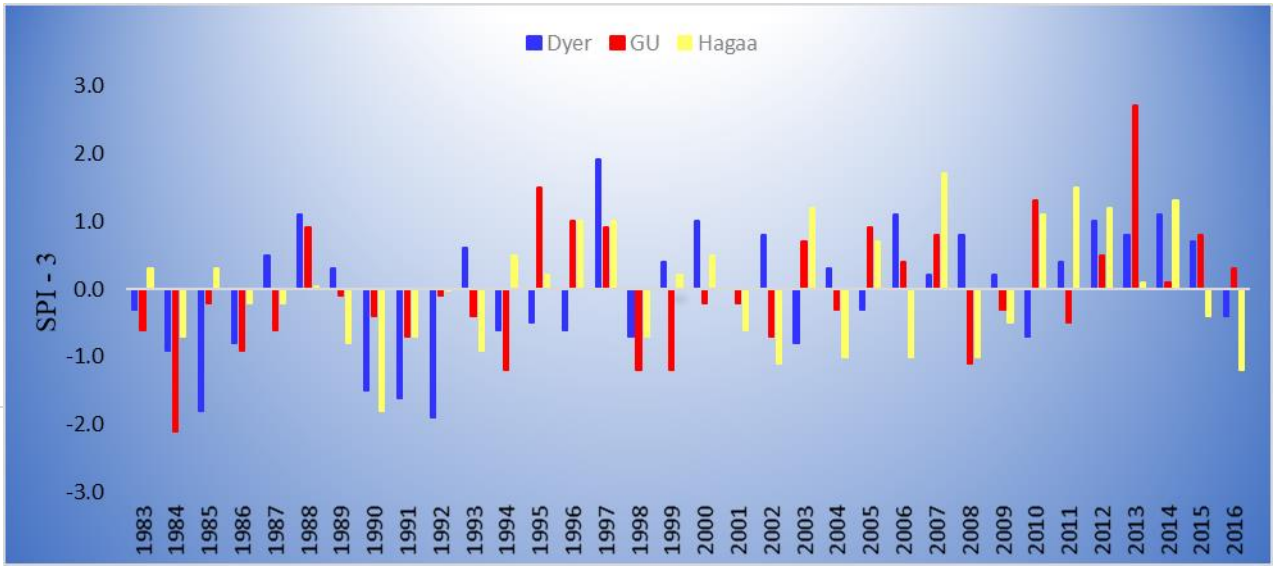

Figure 3. Three months SPI for the study sites for Dyre, Gu and Hagaa rainy seasons

Source: National Meteorological Agency, 2020. The seasonal rainfall distribution was analyzed following Oliver's (1980) precipitation concentration index (PCI). According to Oliver (1980), the rainfall is uniformly distributed if the PCI value is less than 10. If the PCI values are in the range of 11−20, then it indicates the irregular distribution of rainfall, and values above 21 indicate a very irregular rainfall distribution. Accordingly, the result showed that PCI values were 10.5 and 18.5 for *Gu* and *Dyre* rainfall, respectively, indicating (irregular distribution of rainfall for both *Gu* and Dyre rainy seasons but the irregularity is very in the Dyre season, however the PCI value for Hagaa rain is 8.5% indicating uniform distribution of rain. (Table 8). Thus, the PCI values obviously indicate that rainfall distribution was more irregular in Dyre season. Furthermore, the SPI for seasonal rainfall is presented graphically to identify seasonal rainfall standard anomalies in the study areas for the period 1983–2016 (see Figure 4 and Figure 5). Rainfall analysis at annual level may not indicate rainfall deficits in pastoralist areas where rainfall is an erratic and large share of the total rainfall over a few days and lost rapidly through runoff and evaporation. Therefore, seasonal rainfall distribution and amount is the better indicator of rainfall shortages than the total annual rainfall in arid and semi-arid areas (Ellis & Galvin, 1994).

Analysis of SPI indicated that the total percentage of dry Dyre season (negative anomalies of Summer/Dyre rainfalls) is at 50% (Figure 4). This indicates that pastoralism in the study area appears to be a risky enterprise as the bimodal rainfall pattern in the region has changed and concentrated towards two months of the Gu/spring season, mostly on the months of April and May, while for Dyre/Autumn season only in October leaving with no sufficient regeneration of the rangeland; pasture/browse and watering points. This, subsequently, could result in a shortage of feed and water for livestock. Ellis and Swift (1988) indicated that a lengthier bimodal pattern favors' grasses, browses and pastoralism in Africa. In the dry lands of Eastern Africa, there is a long history of specialized pastoralism and limited agro-pastoralism, since the bimodal rainfall regime prevails (Ellis & Galvin, 1994). From the present study, it was observed that the bimodal rainfall regime is changing, and rainfall is more concentrated towards the few months of the rainy season; hence pastoralism in the South Eastern Somali region is at great risk to continue

making livestock keeping as predominant source of livelihoods.The **Mann-Kendall test** on seasonal rainfall data is indicated in Table 9. The results showed a significant increasing trend of *0.372* rainfall (at α=0.05) and 0.24 in the Harshin district.

The **Sens slope estimator** indicated that the Gu, Dyre and Hagaa rainfall seasons had significant increase by 0.372, 0.242 and 0.164 in the Harshin district, respectively.

Table 9. Mann-Kendall-derived trend values for seasonal rainfall estimates: 1983–2016

Variable	Dyre	Gu	Hagaa
Seasonal rainfall trend (Mann-Kendall* Test stat)	0.242*	0.372*	0.164 ns

**Significant trend at α = 0.05, ns=non-significant*

Source: National Meteorological Agency, 2020. *Positive numbers indicate an increasing trend of seasonal rainfall, while negative numbers reveal a decreasing trend.*

Although the *Dyre and Gu* rainfall seasons showed a significant increasing trend, the rainfall amount appears have high variability with very high CV and PCI. This implies an uneven distribution of rainfall, late onset and early cessation dates of rainfall. Overall, the anomaly observed in the rainy seasons could have disastrous effects on the seasonal availability of pasture and water for livestock which may impact on food and livelihood security of the communities in the study area.

Trend and variability of annual rainfall

The results showed that the average total rainfall from 1983–2016 was 183.5 mm Harshin district. The mean, minimum and maximum rainfall during the observation periods are indicated in the Table 10.

Table 10. Descriptive statistics of annual rainfall in districts for 1983–2016

Number of years	Minimum (mm)	Observation year	Maximum (mm)	Observation year	Mean (mm)	SD	CV	PCI

34	89.0	1984	298.0	2013	183.5	55.3	30%	14

SD = Standard deviation, CV = Coefficient of Variation, PCI = Precipitation concentration index

Source: Authors household survey 2020.

The coefficient of variation of annual rainfall indicated variability of annual rainfall (CV < 20) as compared to seasonal rainfall variability (Table 9). Furthermore, the annual rainfall distribution was analyzed using PCI, and the result showed that PCI values was 14, highlighting the irregular distribution of annual rainfall (Table 9).

The coefficient of variation of annual rainfall indicated less variability of annual rainfall as compared to seasonal rainfall variability. Furthermore, the annual rainfall distribution was analyzed using PCI, and the result showed that PCI values was 14, highlighting the irregular distribution of annual rainfall (Table 9). However, irregular rainfall distribution was observed in seasonal rainfalls than annual rainfalls. Thus, this finding implies that the impacts of seasonal rainfall variability on pastoral communities' livelihoods in the Somali region could be more noticeable than annual rainfall variability. Hence, in order to improve the pastoral community livelihood, the local government and non-governmental organizations should engage towards systematizing the seasonal mobility of pastoralists to benefit from the seasonally available assorted rangeland resources.

The Mann-Kendall test statistic results indicated that the long-term rainfall trend was significant (Appendix 2). The findings of the present study are not in agreement with the findings reported by Funk et al. (2008), which indicated that Ethiopia, Kenya, Burundi and Tanzania revealed significant rainfall decline trends during the 1979–2005 periods. On the other hand, the studies by Woldeamlak and Conway (2007) in north-western Ethiopia, Seleshi and Sanke (2004) in central, northern and north-western Ethiopia, Conway et al. (2004) in the central Ethiopian highlands and Conway (2000) in the north-eastern Ethiopian highlands, reported non-significant and unclear trends of annual rainfall.

The findings indicated that out of 34 years analyzed fourteen of them (41%) experienced drought; mild drought (57%), moderate drought (36%) and severe drought (7%). Severe drought occurred in 1986, the historical drought seasons the country that affected the entire country with

more pronounced impact in the northern part of the country. The effect of 1986 drought was devastating, since it is a cumulative year of drought with steady increase in magnitude starting from 1984 with moderate drought, extended with moderate drought in 1985 and ended with severe drought in 1986. This is supported by Seleshi and Sanke (2004) who showed that the most devastating disaster that occurred in Ethiopia was the 1984 famine due to the failure of the long rainfall season (June to September), which caused a decline of the GDP by 97% and agricultural products by 21%. Due to its widespread coverage across the region, much has been said for the 1984 famine in Ethiopia. Another episode of drought occurred from 1990 to 1994 for solid 5 consecutive years with mild and moderate intensity, which extremely affected the pastoral community livelihoods. According to the FGDs and KIIs, the 1984 – 1986, and 1990 – 1994 drought years have extremely affected their livestock wealth and put danger immense challenge to pastoral way of life. Though it was not shown in the SPI analysis restricted due to the data provided by NMA (1983 to 2016), the FGD and KII participants asserted that the 2017 drought season was devastating as well that wiped out more than 50% of their livestock wealth and farming impossible. The participants added that unless with livelihoods diversification and modernization of their existing livelihoods especially the livestock rearing, they won't be able sustain the pastoral way of life. The SPI analysis illustrated figure 7 below showed that the 1990 and 1984 drought in Harshin district, as the 1990 drought negative anomaly was extended till 1994 (that means the rainfall was below average for 5 consecutive years); leaving the pastoral communities with no time due to recover due to drought seasons.

Table 11. Standardized Precipitation Index values and drought categories which indicates negative values in the Harshin district for 1984−2016

SPI	Year	Category
-1.2	1984	Moderate drought
-1.3	1985	Moderate drought
-1.5	1986	Severe drought
-0.9	1987	Mild drought
-0.5	1990	Mild drought
-1.4	1991	Moderate drought
-1.2	1992	Moderate drought

-0.8	1993	Mild drought
-0.6	1994	Mild drought
-1.1	1999	Moderate drought
-0.6	2002	Mild drought
-0.2	2004	Mild drought
-0.3	2009	Mild drought
-0.1	2016	Mild drought

Source: Authors household survey 2020

The drought occurred during 1984 and 1990 were also the worst in the Harshin district as they were extended from 1984-1987 and 1990–1994 (Figure 5). The results indicated that the frequency and duration of droughts has increased in the South Eastern Somali region, which could further complicated food and livelihood security in the area.

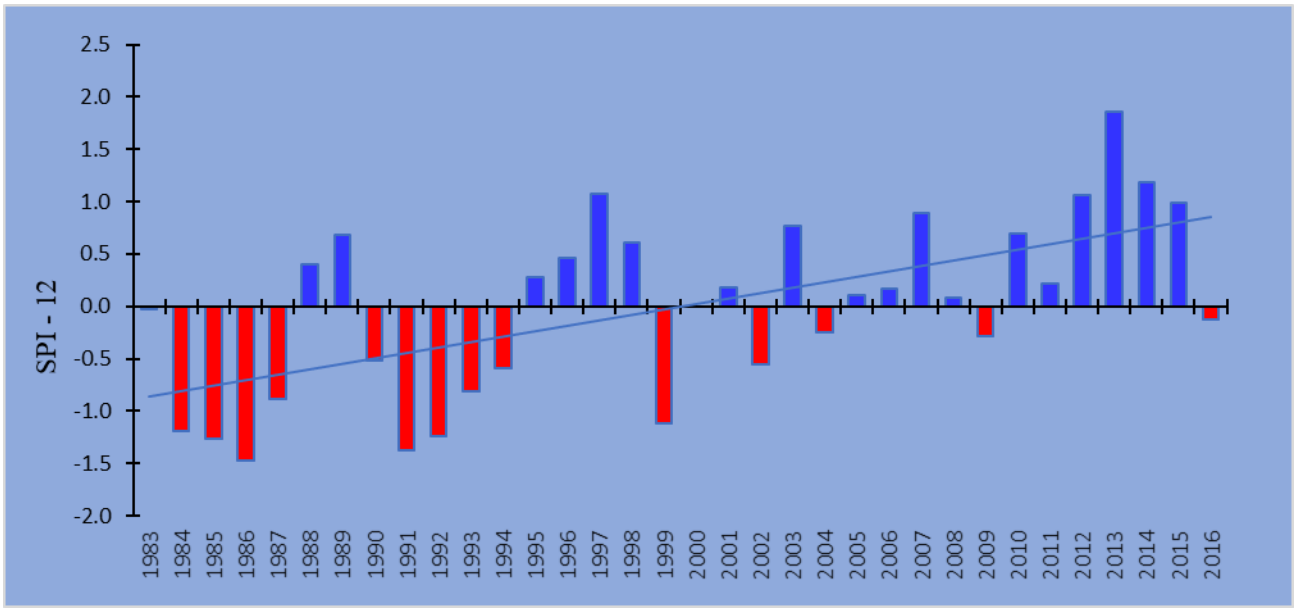

Figure 4. Twelve-months SPI in the Harshin district for 1983-2016

Source: National Meteorological Agency, 2020.

The total percentage of moderate drought years was at 36% in Harshin Woreda and the mild at 57%, while the severe/extreme drought stands at 7% an (Table 7). The frequency and intensity of drought occurrence is more in late 1990 (71%) as compared to years in 2000 as illustrated in the

table above. The total percentage of drought years is at 41% indicating more and more drought affecting South Easter Somali Region. This is supported by Conway (2000), Conway and Schipper (2011), Demeke *et al.* (2011), Hulme *et al.* (2001), Roselle *et al.* (2011), Seleshi and Sanke (2004), Tadege (2007) and Muluken (2017), who reported that rainfall anomaly, especially droughts, have been increasing and were the main reason for food insecurity and famine in Ethiopia.

All in all, the timeline analysis of normalized annual rainfall data indicated the episodic fluctuation of rainfall, which could be a great risk to pastoral livelihoods in Harshin woreda to practice their livelihoods that is heavily dependent on rainfall. This unpredictable situation has left the food and livelihood security of the pastoral communities' in Harshin Woreda at stake. Devereux and Edward (2004) reported that East African countries are already among the most food insecure as compared to the rest of the countries on the globe and climate-induced shocks and stresses could exacerbate loss of agricultural outputs.

In general, the temporal and spatial rainfall variability was consistent over the past 34 years. The region is increasingly receiving irregular and insufficient annual rainfall, although the long-term rainfall intensity has not decreased significantly. The question is: Why have pastoralists of the region suffered from shortage of forage and water when there has been no significant declining in long-term rainfall? Although there are other reasons that led to shortage of pastures in the area, such as problems associated with rainfall pattern, since the rains are often characterized by high intensity within short period of time that could not support rangeland regeneration as confirmed by FGD and KII participants. The first outlook is associated with significant changing of the bimodal rainfall regime in the Somali region, which is more critical in determining rangeland productivity than long-term rainfall. As was discussed above on the seasonal rainfall trend analysis, *Dyre* rainfall has declined significantly and rainfall was more concentrated towards the few months of the Gu *season*, indicating significant changing of the bimodal rainfall regime.

The second outlook is inconsistency in the duration, beginning, and end of the rainy season. For a seasonal and monthly rainfall analysis, it can be seen that during *Dyre* rainfall, the rainfall started early in October and ceased early, leaving November and December with scanty rainfall, while during *Gu* rainfall, the rainfall started late in April and ceased early, leaving May and June with insufficient rainfall. The FGD and KII participants confirmed that the delay or early onset of rainfall has become a common phenomenon in the area years. This irregular rainfall pattern resulted in the shortage of pasture and water for their livestock, forcing the pastoralists of the area to either stay for a long time until the next rainy season comes or move a long distance in search of forage and water. In the Somali region, it is sad to observe the large part of the rainwater that falls during the rainy season was allowed to flow without concreted and large scale attempt to retain or harvest, and then start looking for water in the dry season travelling long distance even crossing borders.

The third perspective is ascribed to increasing temperature, which is deliberated below in the section below. The region is increasingly becoming hotter and receiving irregular annual rainfall. It is apparent that with increasing temperature and irregular rainfall pattern, the degradation of pasture//browse and water resources is apparent. Evaporation from water bodies, soil surfaces and transpiration from plants will increase due to the increasing temperature. This, in turn, leads to water stress and droughts (Bruhn, 2002).

Temperature Trends Analysis

In the present study, four seasonal calendars were identified to analyze the seasonal temperature trends. According to the local calendar; January to March is locally called Jilal, April to June is locally called Gu, July to September is locally called Hagaa and Oct to Dec is locally called Dyre. Accordingly, the temperature series was investigated for monthly, seasonal and annual temporal trends to provide a micro-scenario for temperature variability and change in Harshin districts between 1984 and 2016.

Monthly temperature trends

The statistical description of minimum, maximum and mean temperature of the study area is indicated in Table 12. Results showed that the mean monthly highest and lowest temperatures were observed in month Dec (17 °C) and June (24.6 °C), respectively, in Harshin district.

Table 12. Monthly, seasonal and annual temperatures distribution characteristics

Sits	Harshin district Temp (°C) 1984-2016								
	Mini			Max			Mean		
	Mean	SD	CV (%)	Mean	SD	CV (%)	Mean	SD	CV (%)
Monthly	14.3	2.20	15.37	28.7	1.20	4.19	21.5	1.64	7.61
Seasonal									
Jilaal	12.3	0.95	7.72	28.4	0.81	2.87	20.3	0.70	3.45
Gu	16.4	0.66	4.40	29.9	1.00	3.33	23.2	0.56	2.43
Hagaa	16.2	0.62	3.84	29.1	0.81	2.80	22.6	0.51	2.26
Dyre	12.3	0.88	7.20	27.6	0.64	2.31	20.0	0.52	2.61
Annual	14.3	0.50	3.52	28.7	0.68	2.37	21.5	0.41	1.91

SD = Standard deviation, CV = Coefficient of Variation

Source: National Meteorological Agency, 2020.

The results further indicated that highest variations of mean monthly temperatures were observed in the months of December in Harshin. (Table 9). The lowest of the maximum temperatures and the highest of the minimum temperatures were recorded in December (28.2°C) and May (18.9°C), respectively, in the Harshin district. The highest variation in the monthly maximum temperature was observed during the months of March (CV =4) and April (CV =4) in Harshin woreda. Variations in the monthly minimum temperatures were very high as compared to variations in the monthly maximum temperatures (Table 10).

Seasonal temperature trends

The descriptive statistics of seasonal mean temperatures are summarized in Table 14. According to the local calendar, normally the year is classified into four seasons; *Jilaal* (Jan to March), *Hagaa (*July to September*)* and *Gu* season (April to June) and *Dyre* season (October to December).

Table 13. Seasonal trends of minimum and maximum temperature

	Maximum temperature			**Minimum temperature**			**Mean temperature**		
Season	Test Z	Sig.	Q	Test Z	Sig.	Q	Test Z	Sig.	Q
Jilaal	0.083		0.011	-0.125		-0.019	-0.030		0.011
Gu	0.462	***	0.044	-0.220		-0.021	0.133		0.044
Hagaa	0.432	***	0.036	0.011		0.003	0.258	*	0.036
Dyre	0.280	*	0.023	0.049		0.007	0.189		0.023

**** = 0.001 significance level, ** = 0.01 significance level, * = 0.05 significance level*

Source: National Meteorological Agency, 2020.

The Mann-Kendall test results showed that all seasons Harshin district depicted increased trends of maximum and minimum temperatures (Table 14). Therefore, it is obvious that with increasing temperature, the consequence on water resources, agricultural yields and income of the pastoralists and agro pastoralists could be devastating in the study area.

The significant warming trend in the seasonal maximum temperature was in the range of -0.011 °C during the *Jilal* season in the Harshin district to 0.044 °C during the *Hagaa* season (Table 16). On the other hand, the seasonal minimum temperatures also varied from -0.021 °C during *Gu* in Harshin to 0.007°C during *Dyre* (Table 15). The seasonal mean temperature series also showed a significant warming trend in all seasons of the year during the observation periods, which ranged from -0.005 °C during the *Jilal* season in the Harshin district to 0.018 °C during the *Hagaa* season (Table 14).

Annual temperature trends

The mean annual temperatures were 21.5°C. The annual mean minimum and maximum temperatures were 19.6°C and 22.8°C, respectively, for Harshin district. The annual time series of minimum and maximum temperature for the period 1984–2016 is shown in Figure 6. In general, the annual maximum temperature increased in Harshin district from about the mid-2000s to present. The Mann-Kendall test statistic results indicated that the long-term temperature trend was significant (Appendix 3) and showing increasing trend.

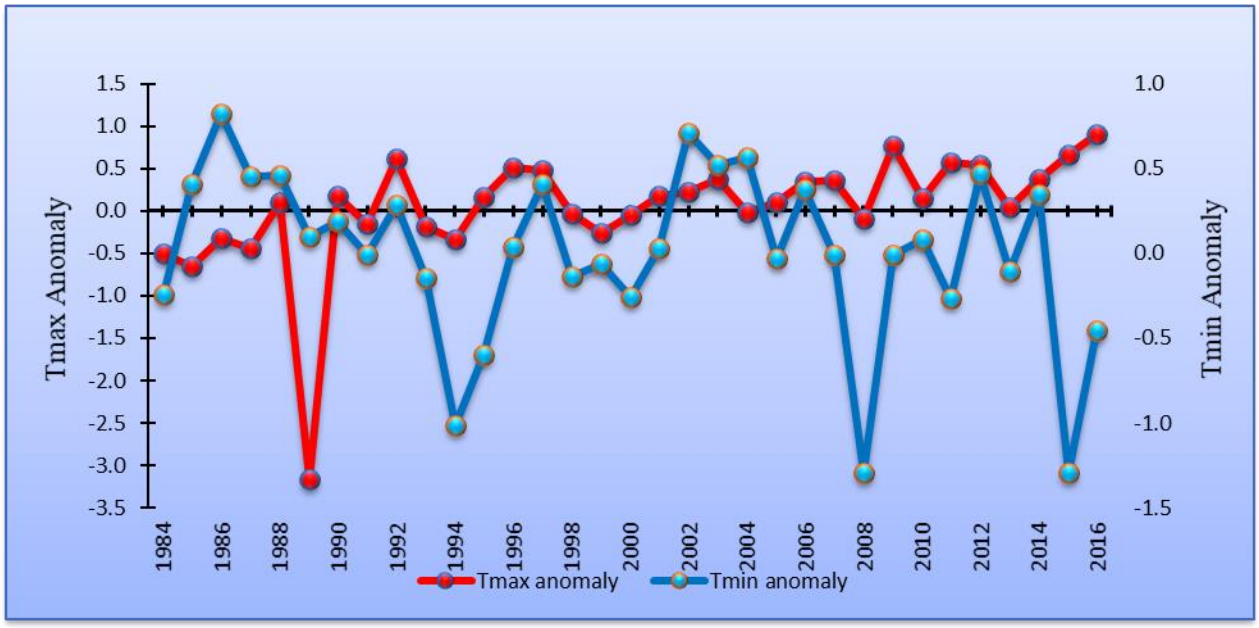

Figure 5. Time series of annual maximum and minimum temperature anomaly of Harshin district (1984 - 2016)
Source: National Meteorological Agency, 2020.

A rise in mean annual minimum temperature showed that the heat interchange between the atmosphere and the earth has been declined. Even though both the mean annual maximum and minimum temperatures showed an increasing trend, it was observed that the maximum temperature have risen at a faster rate than the minimum temperature; hence, an increasing trend of diurnal temperature range (DTR) was observed during the observational periods.

4.3 Local Communities Perception of Climate Change and Variability

Introduction

Pastoralism is the main livelihood strategy of Harshin Woreda households that seek to sustain an optimal equilibrium between livestock, pasture and the society in unreliable and variable environments. However, climate variability and extremes has posed a great challenge for sustainability of pastoralism in the region. The temporal and spatial variability of natural resources such as pasture, water, and the quantity and quality of forages are mostly controlled by rainfall. The results from meteorological data showed a significant seasonal and annual rainfall variability and decreasing trends of seasonal rainfall. In this part, the hydrometeorological hazards prevalent in the study areas, the main livelihood assets and its trends, the consequences of climate variability and extremes on pastoralists' livelihood, perception of pastoral communities on climate indicators, constraints to climate change adaptation and coping strategies, perceived success to climate change adaptation and coping strategies and determinant factors of climate change adaptation and coping strategies.

Perceived Hydro-Metrological Hazards in Harshin Woreda.

According to the FGDs and KIIs, the onset and cessation of rainfall pattern, for the last two or three decades became more and more unpredictable with high intensity and erratic nature that often resulted in drought situation or prolonged dry spell. The endemic livestock diseases were also changed to epidemics mainly due to rainfall variability, and recurrent & prolonged droughts. The household survey findings indicated that drought was the frequent hazard in the study areas as reported by 99% (n=353) of the respondents, followed by rainfall variability by 96% (n=342), livestock disease outbreak by 48% (n=172) as shown in table 16.

Table 14. Perceived Hyrdo-Metrological Hazards

Types of Hazards	**No Replied/Frequency**	**%**
Drought	353	99
Flooding	12	3
Rainfall Variability	342	96
Livestock Disease Outbreak	172	48
Human Disease Outbreak	30	8
Crop Pest & Disease Outbreak	94	26
Resource Based Conflict	50	14

Source: Author's Household Survey (2020).

Overall, that majority of the pastoral communities interviewed perceive that there is climate variability in their localities over the last 15 years with a total grand mean score of 3.9 as illustrated in the Table 17. This finding complements the previous climate variability and change perception studies in the pastoral area of the country for instance (Limantol et al., 2016 and Feleke et al., 2016). The aggregated mean score values confirmed that pastoral communities observed the change of each climate variability indicator over the last 15 years. The most perceived aspects of climate variability in decreasing order are: i) drought frequency increased ii) Number of rainy days decreased iii) number of hot days increased iv) erratic onset and cessation rainfall increased v) Number of warm nights increased vi) rainfall intensity increased, vii) untimely rainfall increase viii) flooding frequency increased ix) the degree of coldness of cold season increased. The climate variability stated above denotes that the main challenges of climate variability in the study areas are related temperature and extremes increase, increment of erratic rainfall and untimely rainfall increase. The perception of the pastoral community can be described as water deficiency, which can be better understood, if one sees it from the point of 'agricultural drought' rather than absolute decrease the amount of rainfall. The main problem is rising temperature and bad rainfall distribution that affects pastoral livelihoods be it be livestock keeping or farming.

What really matters to perception is not total lack of rainfall, but lack of sufficient precipitation required for the normal agricultural activity and pasture growth (Speranza, 2010). Therefore, pastoral communities' rainfall amount perception implies recognition of the existence and effect of adequate rainfall on the right time (Sene et al., 2006). From a pragmatic point of view, one could understand the pastoral communities' climate variability perception could be influenced by their assessment of changes regarding impacts on their livelihood. Since the livelihood of pastoral communities in the study areas is directly influenced by climate situation, they are likely to be sensitive of factors that challenge more of their major livelihood strategies. As rainfall temporal and special distribution performance had a more pronounced negative effects on crop and livestock production, it is natural that the respondents would emphasize the existence and effects against meteorological analysis. The result reinforces the contention that the livelihood nature influence pastoral communities' perceptions of climate change (ATPS, 2013). All in all, the respondents' perception of rising temperature, occurrence of frequent and prolonged droughts, decline and seasonal variability of rainfall is in line with the results of the recorded meteorological data analysis of the present study, which was described in prevision of this paper. The principal concern of the local households was about seasonal changes and variability of the rainfall, which impeded their capacity to envisage rainfall patterns and plan their grazing and planting managements accordingly.

Table 15. Mean score of pastoral communities s perception of climate indicators

Climate Indicators	Mean
Perception of Temperature Variability Indicators	
Number of Hot Days Increased	4.6
Number of warm nights increased	4.2
Degree of Coldness of cold seasons increased	2.2
Perception of Rainfall Variability Indicators	
Onset of Rainfall Becomes More Unpredictable	4.4
Cessation of Rainfall Becomes More Unpredictable	4.2
Number of Rainy Days Decreased	4.6

Intensity of Rainfall Increased	4.0
Occurrence of Untimely Rainfall Increased	3.8
Drought Occurrence Frequency Increased	4.8
Flood Occurrence Frequency Increased	2.3
Grand Mean	**3.9**

Source: Author's Household Survey (2020).

Further analysis of the household survey finding on perception of climate indicators depicts majority of the respondents perceived increasing trend of temperature indicators, increased daily temperature (96%) and increased night temperature (93%), in the last 15 years. During FGD and key informant interview sessions, the respondents underlined the increase in temperature in all seasons, day and night. The result is consistent with annual and seasonal minimum and maximum temperature meteorological data analysis illustrated in figures 12. Actually, the pastoralists perception of the increasing trend of annual and seasonal temperatures are supported by researchers (Ayal and Muluneh, 2014; Alebachew, 2011; Woldeamlak, 2012). With regard to the rainfall pattern in the last 15 years, the majority of respondents perceived decreasing trend of rainfall indicators; the number of rainy days decreased (97%), and onset (87%) and cessation (83%) of rainfall becomes unpredictable and erratic in its nature. However, the perceived reduction of seasonal and annual rainfall volume contradicts with the instrumental findings as depicted in figure 5. Ayal et al. (2017) indicated overwhelmingly highest perceptions of trends in climatic variables; large share of households perceive temperature has been increasing overtime (83%), that rainfall has been decreasing (84%) and that irregularity of rainfall has been increasing (86%).

Furthermore, the household survey results revealed that there have been frequent and prolonged droughts in the study areas as reported by majority of the respondents (99%). More than 30% of respondents of also reported the occurrence of flood hazards in the study areas increased, which is consistent with the households who reported the increased in intensity of rainfall (68%). The sampled households' perceptions about the frequency and timing of rainfall, and the increasing temperatures trend and drought and flooding frequency are consistent with FGD and key informants' observation. Thus, in general, the majority of respondents interviewed using the

different methods, are conscious about the existence of climate variability. They explained their experience on climate variability using the rising of seasonal and annual temperature, reduction of the volume of annual and seasonal rainfall, increment of drought frequency and severity. FGD and key informants underscored the changing climatic conditions in their localities particularly in the last 15 years. Table 17 above illustrates the mean perceptions of the pastoral communities on the different indicators of climate variability and change in their localities. The total mean score illustrates the degree with which the pastoral communities have perceived different indicators of climate variability, allowing the most and least perceived aspects of climate variability to be identified. The grand mean reveals the respondents' perception about their local climate situation.

Perception about Temperature Situation

The majority of respondents perceived the increasing trend of temperature, hot days and warm nights and decreases in the number of cold nights from time to time in their localities as illustrated in the table 17 above. Their perceptions of increasing temperature match with the meteorological records presented in the table 12 above that maximum and minimum monthly, seasonal and annual temperature showing increasing trend. Moreover, the pastoral communities' perception is consistent with scientific claims about the increasing trend of temperature in Ethiopia and globally (Nyanga et al., 2011; Woldeamlak, 2012 and Ogalleh et al., 2012). The communities' perception of the increasing trend of hot days and warm nights and decreases in the number of cold nights are in line with instrumental record of previous local and country level studies (UNDP, 2007/2008; McSweeney et al., 2008; Woldeamlak, 2012). The pastoralist perceptions of increased temperature, 89.23%, are in line with the meteorological data of increased temperature record from 1989-2008 of Harshin Woreda, Fafan Zone, Somali region (Kader, 2012).

Perceptions about Rainfall Situations

Table 17 reveals that the majority of the pastoral communities perceived rainfall onset and cessation as becoming more erratic with increased rainfall intensity and decreased number of rainy days. The respondents also realized increased occurrence of untimely rainfall and drought

frequency. Hence, rainfall distribution performance, timing and volume are major problems to the pastoral communities for grazing and planting management. According to Kadir (2012), a study conducted in Harshin district, Somali region, 97.7% of the pastoralists perceived that raining times had reduced and only 3% believed as constant over the years. Overall, as to the average precipitation, 99.2% of the pastoralist in the study area perceived a declining and only 0.8% perceived as constant annual average rainfall across these years. Woldeamlak (2007), as his meteorological data analysis in the study sites indicated that rainfall intensity is increasing, supports the pastoral communities' observations. FGDs and key informants observed that the main rainy season (Gu rain falling between April and June) and the short rainy season (Dyre falling between Oct to Dec) starting late and ending earlier.

According to FGDs and KIIs, in the last 15 years the amount and number of rainy days varied significantly, which corresponds to the surveyed households' responses about the shortening of rainy days, with a mean score of 4.6. The perceived erratic behavior of rainfall matches with both Gu and Dyre rainfall season of the instrumental record as illustrated in the Table 8 above with CV and PCI at (64.6%, 18.5) and (33.9%, 10.5) for Dyre and Gu seasons respectively. According to NMSA (1996), a rainfall amount with CV of less than 0.20 is less variable, CV between 0.20 and 0.30 is moderately variable and CV greater than 0.30 is highly variable. As Table 8 shows long-term annual rainfall and main rainy season rainfall were unevenly distributed in Harshin Woreda with CV < 30% and PC at 14%. Unlike the perception of pastoral communities', which portrays that rainfall amount reduced, meteorological analysis proves increase of rainfall especially from the year 2000 onwards with statistically significant for Gu and Dyre rainy seasons.

Fatuase and Ajibefun (2013) observed that if the perception of respondents' tallies with short-term analysis of instrumental records, it is because they are psychologically influenced by the latest phenomenon. As a result, by way of regression, they tend to believe the unique characteristics of rainfall observed over the last five years are true for the years before, since the entire Somali region was suffering from prolonged drought from the year 2015 to 2018. According to NMSA (1996), a negative anomaly of rainfall at 25% and 50% refers to dry and

very dry conditions respectively. The annual rainfall drought assessment meteorological result showed that over the last thirty-four years, there were 11 very dry years and 2 dry years in Harshin woreda. The rainfall distribution performance of the woreda proves most years with rainfall amount below normal had very dry conditions. In this regard, the respondents' perceptions coincide with meteorological assessment result.

4.4 Climate Change Perceived Impacts and Adaptation Strategies

Impacts of Climate Change and Variability

Climate shocks and stresses notably drought and rainfall variability impacts are multifaceted Harshin Woreda, Somali region per the findings of the household survey, FGDs and KIIs. According to respondents, the impacts of climate change and variability included: (i) reduced livestock number and productivity, (ii) reduced pasture and browse availability, (iii) depleted watering points, (iv) reduced terms of trade (livestock/grains) (v) reduced community risk sharing practice (iv) proliferation of livestock diseases. FGD participants and key informants in lowland sites reported that their coping and adaptation strategies are threatened by increased frequency of drought and other climate extremes. They recall that during 2011 drought, their asset base is heavily eroded. Due to frequent drought, over the past 15–20 years, every household lost remarkable livestock asset. Sometimes there are drought events that cost some households their total livestock. They also believe that their social bond is weakened due to the effects of recurrent drought (Ayal et al., 2017).

Reduced Livestock Number and Productivity

The respondents described the impacts of climate shocks and stresses on livestock in terms of drought and floods and unreliability and the erratic nature of rainfall. The majority of the respondents (95%) asserted that the recurrent and prolonged droughts reduced livestock numbers and productivity through increasing mortality and morbidity rate, falling of fertility rate and increasing weaning time of different animals. Amsalu and Adem (2009); Muluken (2017), reported similar findings, who indicated that livestock productivity and reproduction rates have been decreasing from time to time in pastoral communities, due to the adverse impacts of climate

extremes, notably drought. Death of animals in the study areas was also caused by disease outbreaks and raiding, which all exacerbated the impact of recurrent droughts. Respondents also reported that farming could be productive as such and has become increasing difficult due to reduced rainfall and unpredictability.

The respondents asserted that the prominent effect of the drought has been realized by reducing the livestock holding per household. According to the respondents, 15 years ago, the average number camel, cattle, sheep and goats per household on average was 30, 20, 60 and 90 respectively, however, now, the findings indicated on average, the number of camel, cattle, sheep and goats per household are 5, 2, 18 , 25 and 1 respectively. Therefore, the findings revealed that the overall livestock holding has decreased by 71% mainly due to the effect of the recurrent and prolonged drought. The reduction in the cattle is the highest, since it was difficult for this livestock species to withstand the drought attributed to their grazing trait. The livestock holdings per household for each livestock species now and 15 years ago are indicated in Table 18. This study is supported by the findings of Bekele and Amsalu (2012) and Muluken (2017), who have indicated that the number of livestock owned by a household has been declining over time linked with climate-induced shock, mainly droughts.

Table 16. Average Livestock Holdings per household Now and in the Last 15 years

Livestock Species	Now	In the last 15 years	Reduction
Camel	5	30	25
Cattle	2	10	8
Goats	18	60	42
Sheep	25	90	65
Equines	1	2	1
Total	**51**	**192**	**141**

Source: Authors household survey 2020.

According to Sanford and Habtu (2000), a 5% – 15% decline of livestock assets happened in Afar due to the drought of 1999/2000. In these areas, field reports suggest pastoral households have lost up to 60 percent of their livestock since mid-2016 due to drought-related deaths and

excess sales. (FEWSNET, 2017). Likewise, Hazell et al. (2003) indicated that droughts caused significant loss of livestock and push many herders into poverty. On the other hand, the percentage of livestock loss reported in the UNDP field report (2012) by Karrayu pastoralists was 45% of their livestock due to drought. On the other hand, the recurrent drought also reduced the amount of yield per animal. Apart from the impacts of the drought, as reported by 30% of the respondents, pastoralists were also negatively affected by floods, accordingly to the 68% of the respondents associated with the intensity of rain increase.

Degraded Pasture and Browse

The findings of household survey as well the FGDs and KIIs regretfully explained about the abundance of pastures about 15 years ago that their livestock won't travel long distance to enjoy the plentiful pasture and browse. The majority of the respondents (80%) reported that since the drought has become severe and recurrent, the palatable and nutritious grass and browse species have recently been disappearing from the rangelands, while the non-palatable and less nutritious bushes and shrubs were expanding. The respondents also noted that recurrence of the drought within a short period of time couldn't give enough time for the pasture and browse to recover, which has resulted in complete loss of some pastures and browse from the rangelands. Similar findings were reported by Bekele and Amsalu (2012), who indicated that the increased incidence and prolonged nature of the drought adversely affected the growth and development of pastures, leading to loss of palatable forages. The authors further noted that the seasonal, annual and spatial variability of rainfall also caused deterioration of natural forages. According to the FAO (2008), the productivity of arid and semi-arid rangelands of Ethiopia decreased and has failed to support the existing livestock. FGDs and KIIs have also reported that the grazing and browsing areas deteriorated due to recurrent droughts and unreliable and erratic rains, herders concentrate around water points such as along the sides of perennial water sources, which in turn led to overgrazing of the existing forage resources and resource-based conflict. On the other hand, informants noted that the widespread occurrence of drought throughout the Somali region restricted mobility of the pastoral people and Internally Displaced People Settlement Sites (IDPs). Settlement, in turn, caused the further depletion of the grazing areas and cutting of trees for fuel. Successive poor/failed rains in 2016 and 2017 in the South and Southeastern part of the

country have impacted on pasture and water availability, causing abnormal migrations, deteriorating livestock body conditions and weakened immune systems among livestock, resulting in increasing cases of opportunistic diseases and internal and external parasites among animals and further pushing up mortality rates (FAO, 2017).

Depleted water points

All the respondents of the study noted that water is key to sustain their pastoral way of life, since most of the areas they are residing is moisture stressed areas. In other words, productivity of the rangelands is highly correlated with water availability. Studies conducted by Opiyo et al. (2011) indicated that water is a critical factor in pastoral production systems. More than 85% of the respondents reported that watering points have either dried up or their yield have reduced due to recurrent and prolonged droughts over the last 15 years. The shallow wells, ponds and birkads were the key sources of water for pastoral communities. These seasonal water points are extremely prone to drought effect and most of them vanished from the area due to the frequent and prolonged droughts. The respondents asserted that most of them has to travel long distances to fetch potable water, which is almost exclusively the burden of women. Therefore, water scarcity has become a serious and chronic problem for Somali pastoralists due to the drying up of many water points associated with recurrent droughts. In one-woman KII respondents in Harshin district noted: When there is sufficient rain, the ponds and birkads are full and enough for us; however, during the drought season, most water points dried up and we have to travel long distance fetch water.

Declined Terms of Trade

As discussed above in section above, some like 15 years back, the major sources of food for pastoral households were milk, meat and butter. They used milk to drink instead of water and ate meat and butter as food. Recently, livestock assets and their outputs have significantly declined due to environmental changes and, hence, the grains became the major source of food for pastoral households in the study area. Most of the respondents complained that they sold their livestock not by preference, but they were obligated to sell as a result of shortages of food or cash at households to meet essential needs. More than 80% of percent of the respondents

confirmed that during droughts, pastoral households had been forced to sell their livestock, but demands were very low due to poor body conditions of animals and oversupply. All the respondents noted that the 15 years ago, drought cycles were relatively long and, hence, they had enough time to recover from the impacts of the previous drought. As per the household survey findings, 75% of the respondents, depicts decline in terms of trade, decrease in livestock and livestock product sale, while price of grain increase over the last 15 years, which constraint household access to food. The price of inputs and outputs were also fair as pastoralists started to get a sufficient amount for animal products. In recent years, drought cycles were shorter, droughts occurred every two to three years and pastoralists had no time to recover from the impacts of the previous drought and, hence, the price of livestock continued to decline, while the food grain price experience steady increase. The respondents both in FGDs and KIIs noted that during normal seasons of the year (when there is no drought), the rainfall starts late and stops early and/or it would rain for a few days with high intensity and then disappear, which is not sufficient for the growth of pastures and, hence, livestock assets still continue to decline, while the price of grains is rising. Overall, climate change and variability in terms of recurrent drought, short rainy days, changes in the timing of rainfall and erratic nature of rainfall and increased temperature resulted in negative terms of trade and threats their food security.

As per the response of the household survey, milk production has declined by as 80%, raising serious concerns over already high malnutrition rates given the close link between milk availability and human nutrition in pastoral communities. Preliminary estimates indicate that between November 2016 and April 2017, more than 1.5 million livestock perished in southern and southeastern areas, representing an economic loss of over USD 350 million. With low livestock production and unfavorable terms of trade, extreme coping mechanisms – such as reducing the number and size of meals, selling remaining productive assets and, in increasing numbers of cases, destitution and displacement owing to the complete loss of livestock assets – have been observed throughout affected areas (FAO, 2017).

Impacts on Community Risk Sharing Practice

In response to climate-related shocks and stresses, pastoralists in the Somali region were largely reliant on the reciprocal links that tie them together. More than 25% of the respondents reported that pastoralists relied on a community risk sharing practice system in response to shocks, seasonal food deficiencies and droughts for centuries. However, recently, changes rainfall variability and recurrent and prolonged drought decreased the livestock wealth of the Somali pastoralists and increased the price of food grain and other household essentials including processed foods items. Hence, most pastoral households had no surplus food, livestock and cash to transfer to others thus reduces the community risk sharing practice as reported by 50% of the household interviewed. Therefore, according to Muluken (2017), recently, individualism is replacing the mutual support system in pastoral communities, and larger part of the community are dependent on formal support systems such governmental or NGO food aids.

4.5 Adaptation and Coping Strategies for Livestock Production

Adaptation strategies

Adaptation refers to the long-term changes in livelihood strategies, while the short-term adjustment in reaction to shocks and stresses on livelihood of people refers to coping (Migosi et al., 2012). The coping and adaptation strategies of pastoralists to climate variability and ecological changes have been studied over decades (McCabe, 2006). These studies indicated that through the course of hundreds of years, pastoral households have deployed different strategies to adapt and cope with unreliable and variable environments such as livestock mobility to grazing areas less influenced by drought, changing planting dates and mixed livestock–crop farming (Thornton & Gerber, 2010).

However, recently, pastoral communities in Africa are faced with socio-economic, political and environmental marginalization while the drought cycles have been decreasing (Schilling et al., 2012). According to Notenbaert et al. (2012), shocks and stresses posed by climate variability and change, particularly climate extremes such as droughts and floods, are becoming beyond

their indigenous coping and adaptation strategies to sustain their livelihood. Similarly, like in other African countries, the intensity and frequency of droughts have been increasing since the 1980s in pastoral communities of the Somali region. Therefore, it is essential to understand how pastoralists respond to adapt or cope with shocks and stresses in order to design appropriate strategies or development interventions to support the communities' initiatives. In the study areas, pastoralists have been using many adaptive and coping mechanisms to escape negative influences of climate induced hazards. The strategies that Somali pastoralists in Harshin Woreda deployed against climate-induced hazards are discussed below.

As illustrated in the Table 19 different adaptation and coping mechanisms are employed to mitigate the challenges posed by climate variability and change on livestock production. Herd management; herd composition change (94%), increased herd mobility (94%) and herd splitting (93%) and being the prominent one followed by rotational grazing (84%), increased veterinary service use (75%), destocking (74%), feed preservation (69%), combing livestock production with crop production (55%) and increased water harvesting (47%). It is important to note as well some pastoralists though not many started area closures (27%) and bush clearing (22%) for pasture regeneration and purchase of livestock feed (13%), which will contribute its part to sustain the pastoral livestock production. It is commendable as well to see some pastoralist as well started to practice livestock commercialization (16%) mainly with small ruminants, which will excel the quality livestock production. The findings of the FGDs and KII have confirmed feeding livestock during dry season, becomes increasingly common in the study areas. The FGDs and KII in additional revealed that animal feed mainly sorghum straws are bought from the neighboring woredas and preserved and kept in an enclosed site. The widely common owned pastureland is now turned to personally owned. The local communities fence wide area of rangeland and preserve it for pasture regeneration for dry season grazing.

Table 17. Adaptation and Coping strategies for livestock production

Coping and Adaptation Strategies for Livestock Production	Harshin Woreda N= 356	
	No. replied	%
Increased herd mobility	336	94
Change of Herd Composition	333	94
Herd Splitting	330	93
Increased Rotational Grazing	299	84
Increased Use of Veterinary Service	267	75
Destocking	262	74
Increased Preservation of Livestock feed	244	69
Combing Livestock with Crop Production	195	55
Increased Water Harvesting	166	47
Forage development	124	35
Area Closure	95	27
Bush Clearing	77	22
Commercialization of Livestock Production	56	16
Purchase of Livestock Feed	45	13

Source: Authors' household survey, 2020.

This study confirms the validity a claim that successful adaptation requires diversifying livestock, destocking and providing professional veterinary services (Nyanga *et al.*, 2011). FGD and the KII findings revealed that their coping and adaptation strategies are extremely challenged by the recurrent and prolonged drought and other climate extremes. For instance, the prolonged drought from 2015 to 2017, their livestock asset base is heavily eroded that made them to lose more than half of their livestock, which was already exhausted by the recurrent drought. Some households have lost their entire livestock assets due to the recurrent drought, the prominent and the recent one being the prolonged 3 years consecutive drought from 2015 to 2017. The FGD and KII participants further noted that their community risk sharing practice and reciprocity is weakened due to the effects of recurrent drought. According to Kadir (2012), a study conducted in Harshin district of Somali region, four comprehensive adaptation strategies were identified and practiced by those who perceived the climate change namely: Herd composition

diversification, herd and pasture management improvement, water harvesting and extended mobility patterns strategies.

Herd Management - Changing and Splitting of Herd

Changing herd composition or diversification were key strategies to adapt to the changing environment and recurrent and prolonged drought. Herd splitting among the different age category and livestock species is paramount for effective livestock feeding and utilization of the scarce resources available. According to the respondents, some 3 decades ago the dominant number of the herd kept was cattle during the past times, when there was plenty of pasture available for grazing. But now, the cattle ownership of the interviewed households is at its least. Sheep and goats (shoats) were the dominant population in the herd, followed by camels. The respondents noted that the reason for there is increasing trend within the pastoral community of keeping goats and camels as they are drought tolerant species for their browsing feeding habit. It is becoming extremely difficult to keep the grazers especially cattle, since palatable pasture species are diminishing through time due to frequent and prolonged droughts as well as bush encroachment. At the same time the pastoralists still continued in keeping diverse livestock species in order to reduce the disaster risks and use the assorted resources of rangelands. Informants further reported that if grass availability was abundant, pastoral households preferred to keep cattle rather than camels. The reason for this was that in the Somali culture, cow milk can be processed into butter, yogurt and other milk products, while milk from camels is not processed and is used for drinking only.

Combining livestock production with crop farming

As the livestock productivity declines over time, some households started rainfed farming. The crops types mainly cultivated in the area is Sorghum, since it has dual purpose, the straw as feed for livestock and grain for human consumption. There were also other crops produced in the area such as maize and vegetables. The results indicated that out of 356 households, 48% started practicing using rainfed agriculture. The respondents asserted that they are practicing crop farming to complement pastoralism rather than to substitute livestock production. The respondents also stated that total shifting to crop farming is risky as since rain is becoming

extremely unpredictable, since the last 15 years and more. On the other hand, livestock production as the sole livelihood is also becoming a risky strategy associated with recurrent and prolonged drought and high seasonal, annual and spatial variability of rainfall. In this study, the annual income of households was calculated and the results revealed that the minimum, maximum and average annual income of pastoral households were 7600 ETB, 94,000 ETB and 31723 ETB respectively, while the minimum, maximum and average annual income for agro-pastoral households was 6000 ETB, 72, 800 ETB and 28,511 respectively. The income of the agro-pastoral community being lower reveals that they are in transition from pure pastoralists, since livestock keeping can't sustain their livelihoods and couldn't be effective as such earning income from their farming livelihoods apart from being own food source, which is attested as well through the FGDs and KIIs.

Furthermore, the average livestock holding of pastoralists and agro-pastoralists was 65 and 42, respectively, which showed a significant difference between the two livelihood groups in terms of livestock holdings. The low livestock holdings of agro-pastoralists explain the rationale of the need for livelihood diversification, since the they can't bear to remain only being pastoralist with the few livestock number they own. The income analysis supports it as well is the pastoral households, who have the higher livestock number, who have the higher income than the agro-pastoralists households, who have less livestock number.

Herd mobility

Herd mobility was a well-known strategy pursued by pastoralists in the Somali region in response to feed and water shortage. The elders noted that pasture availability was highly variable, both temporally and spatially, and because of their experience they knew where and when the pastures were available. The respondents reported that forages were temporally available and especially the grasses were short-lived in arid and semi-arid areas of the Somali region. Therefore, before the forages disappear, the local people would move their livestock on time and on the right place to utilize these short-lived forages. This indicated that mobility was a key strategy for pastoralists in response to the seasonal, annual and spatial variability of rangeland resources. Recently, mobility was highly restricted due to the uniform occurrence of

the recurrent droughts in the Somali region, shrinkage of rangelands due to expansion of commercial farms and bush encroachment such as P. juliflora. The respondents complained that since forage was not available in the immediate environment and most regions of Somali, the local people were forced to travel long distances into neighboring regions of Somali such as in highland regions of Oromia. Although herd mobility was challenged by the aforementioned factors, the majority of the respondents (94%) were still using it as a strategy to reduce risks and for other economic purposes such as to access livestock markets and urban centres.

Development of water points

In Harshin, accordingly the respondents, water scarcity in the study area, local people practice water harvest methods such as Birkads and ponds. Birkas, a water harvesting method, which is constructed around water catchment sites with a cemented wall and sometimes roofed with Iron sheets. The birkad water are kept till the dry season starts, when the surface water and streams dry. Some of the birkads serve up to three months depending on the capacity and it use. Most of the birkads in the area are individually owned though some communal are also available. Some of the owners sell the birkads water to the pastoralist for animal and human consumption during dry season. According to the household survey, some 47% of the respondents practice water harvesting.

Coping strategies

In the study area, households were pursuing some form of coping strategies to cope with the negative influences of climate-induced hazards. The most important coping mechanisms employed by the local people are discussed as follows:

Purchase of Livestock Feed

The results of the household survey revealed that the pastoral households in the study area do cope the shortage of feed in the dry season with the purchase of livestock feed mainly the sorghum straw from neighboring woredas, which practice lots of farming. They preserve it as a “hay” for dry season to feed the core breeding stock. The KII and FGDs participants confirmed

that purchase of livestock feed is becoming increasing common in Harshin Woreda and the purchase feed is bought during harvest season from neighboring woredas and stored at the backyard as “hay” for dry season feeding of the core breeding livestock.

Destocking

It is interesting to realize pastoralists are now practicing destocking as coping strategy as reported by 74% of the respondents, since destocking reduces stress on available scarce resources, while creating opportunity for quality livestock production. The KII interviewed findings indicated that the prolonged three consecutive years of drought (2015 to 2017) resulted in more than 80% of the pastoral households engaged in abnormal livestock selling for dual reason; 1) to meet households ends meet including livestock needs such as feed and treatment services 2) reduce the number of livestock to mitigate the limited feed availability and the other required resources such as water. In destocking situation, the FGD and KII participants noted that pastoral community first sold their older large animals in particular cattle that they believe won’t survive the drought and the younger ones followed by sheep and goats. Some of the pastoral communities are forced to sale their core breeding cows and camels, a last option, when the drought escalate and got at its worst.

4.6 Barriers to Coping and Adaptation Strategies

The pastoral community in the Somali region had their own indigenous adaptation and coping strategies against climate-related shocks and stresses as discussed in the previous section. However, they had various constraints to adapt/cope with climate variability and climate extremes such as droughts. Drought (91%) and Rainfall variability (91%) are prominent constraints noted by respondents followed by low livestock holding (86%), livestock disease (85%), low access to livestock feed (78%), lack of knowledge on climate variability (77%), lack of access to weather information (70%), less livestock value in the market (67%), low access to income (60%) and livestock water (60%) as illustrated in table 20 below. The respondents also asserted that low access to veterinary services (58%), low access to credit (58%), low education level (57%), old age (53%), Lack of knowledge on current climate change adaptation methods

(53%), Less value to livestock product market (51%) are the notable constraints that hindered their coping and adaptation strategies against climate related shocks and stresses. Thus, Sewmehon, (2013) argued that shortage of water, feed, veterinary services, money and unequal entitlement to natural resources are major challenges for the livestock sector.

Table 18. Constraints of Adaptation to Climate Change

Constraints to Adaptation Strategies	No of Replies /Frequency	%
Rainfall Variability	325	91%
Drought	324	91%
Low Livestock Holding	305	86%
Livestock Disease	303	85%
Low Access Livestock feed	278	78%
Lack of Knowledge on Climate Change and Variability (Rainfall and Temperature)	273	77%
Lack of Weather Information	248	70%
Less livestock value market	238	67%
Low income	215	60%
Low Access to livestock water	215	60%
Low access to veterinary and extension service	208	58%
Lack of access to credit	208	58%
Low level of education	203	57%
Old Age	189	53%
Lack of knowledge on adaptation methods	187	53%
Lack of access to information on climate change impact	181	51%
Less livestock product value market	87	24%
Young age	62	17%
Less family size	58	16%
Resource based conflict	58	16%
Lack of knowledge and skill to practice on other livelihoods	53	15%

Lack of resource to practice other livelihoods	32	9%
High family size	31	9%
Flooding	5	1%

Source: Authors household survey 2020.

The respondents stressed that crop farming based on rainfall patter in Harshin Woreda and South Eastern Somali region is difficult due to the unreliable and erratic nature of rainfall and the occurrence of recurrent and prolonged droughts and, hence, the households emphasized on the need of small-scale irrigation farming for to be productive in farming. The equipment for irrigation needed greater investment, which was beyond the capacity of the pastoral households, thus the FGD and KII participants underlined on the need of government or other developmental actors on this regard.

As Harshin Woreda is located at the border from Somalia coupled with the pastoral communities' marginalization socially, economically and politically access to credit is very low as reported by 58% of the respondents and confirmed by FGDs and KII participants. The respondents asserted that if they could have access to credit, they could recover with faster rate from the frequent natural disaster hitting their woreda and practice other livelihoods to diversify their income sources. The respondents further emphasized that access to credit would assist them during times of drought, which could have enabled them to meet household needs as well as livestock requirements such as feed and veterinary services. Therefore, poor credit access in the woreda inhibited pastoralists from diversifying their livelihood and boosting up their income level. Restocking of livestock after droughts was also becoming difficult in the woreda due to lack of credit access.

Respondents also asserted that illiteracy and lack knowledge on climate change adaptation methods constrained pastoral households to diversify their livelihood. As reported by many of the participants of the FGDs and KIIs, the pastoral households lack even the basic skill of farming, which is hindrance to be productive in this livelihood option coupled inadequate agricultural extension service delivery. Muluken (2017) have similar findings in Southern Afar

Region that households were constrained due less technical skills on how to practice crop farming; plough the farmland, manage and harvest the crop that made them to be less productive on this livelihood option. As Di Falco, Bezabih & Yesuf, (2010) observed, lack of information, shortages of labor and money are critical factors that prevent smallholder farmers/livestock keepers from employing adaptation measures to climate related shocks. As Ayal et al., (2017), both in highlands and lowlands, problems of climate & market information, finance, prejudice towards some occupations cost of technologies and cultural barriers determine farmers/livestock keeper's selection of coping strategies to climate related problems. The majority of the FGD and KII participants the findings of the household survey that reported majority of the households having less access to weather information, impact of climate change, and climate change adaptation strategies, which they consider as one of the areas they would like to receive support from government and other local development actors. To persuade smallholder farmers/livestock keepers to take adaptive measures to climate change, they should be provided with access to information, credit and extension services (McDowell et al., 2010). This could help farmers/livestock keepers intensify and diversify agricultural production and enjoy a better and stable market, as experienced in Tanzania (Paavola, 2008) and recommended for Ethiopian smallholder farmers/livestock keepers (Temesgen et al., 2009). According to Kadir (2012), a study conducted in the same assessment area, Harshin woreda, Somali region, a total of ; 55.4% faced lack of money, 42.3% lack of access to water, 17% lack of knowledge, 12.3% resource conflict, 11.5% shortage of labor, 5.4% lack of information and 4% lack of market access; an assessment finding, which is similar to the present study finding.

4.7 Perceived Success of Coping and Adaptation Strategies

The respondents of the household survey revealed that their most perceived success goes towards herd management; changing herd composition, herd splitting, increase mobility of livestock and destocking with the mean score of 4.3, 4.2, 4.1 and 4.0 respectively as illustrated in Table 21 below. The success of rotational grazing, purchase of livestock feed, storage/preservation of livestock feed adaptation strategies are prominent as well with mean score of 3.5, 3.3 and 3.2 respectively. It is interesting to note as well commercialization of livestock production, combing

crop production with livestock production, increase use of veterinary services adaptation strategies and area closure showed perceived success with mean score of 3, 3, 3, and 2.9 respectively. Bush clearing shows marginal success in adaptation with mean score of 2.7. The respondents didn't perceive employing more water harvesting is successful adaptation strategies.

Table 19. Perceived Success to Climate Change

Mean estimation	**Mean**	**Std. Err.**	**[95% Conf. Interval]**	
Herd Composition Change	4.3	0.0281638	4.292942	4.403719
Herd Splitting	4.2	0.034519	4.134376	4.27015
Increased Livestock Mobility	4.1	0.031865	4.055203	4.180537
Destocking	4.0	0.0385285	3.893242	4.044786
Rotational Grazing Pattern	3.5	0.0592953	3.360457	3.593684
Purchase of Livestock Feed	3.3	0.062965	3.199563	3.447223
Fodder Storage or Preservation	3.2	0.0592812	3.09164	3.32481
Commercialization of Livestock production	3.0	0.066729	2.885909	3.148374
Combing Livestock Production with Crop Production	3.0	0.0714525	2.839845	3.120889
Increased Use of Veterinary Service	3.0	0.0697629	2.826609	3.101008
Area Closure	2.9	0.0545357	2.839539	3.054044
Bush Clearing	2.7	0.057887	2.546267	2.773954
Employing more water harvesting	2.4	0.0549676	2.338863	2.555067

Source: Authors household survey 2020

4.8 Determinants of adaptation to climate change for livestock production

Logistic regression model describes the relationship between a dichotomous response variable (adaptation to climate change) and a set of explanatory variables that aimed to reduce the adverse impact of climate change and variability. The logistic model is special case of generalized linear model where the assumptions of normality and constant variance of residuals are not satisfied.

The problem of multicollinearity among the explanatory variables was tested using variance inflation factor and contingency coefficient for continuous and dummy explanatory variables respectively. Specifically, in analyzing the farmers'/livestock keepers' adaptation strategy to climate change in Harshin Woreda, the cross-sectional data collected through questionnaire was used. Moreover, to analyze the determinants of pastoral communities' decision to take climate change adaptation strategies, the logit regression model was employed with 19 explanatory variables, which are hypothesized to influence the probability of engaging with the adaptation strategies either positively or negatively.

Model Specification Test for Multivariate Logit Model

In the estimation, 19 hypothesized variables were included but perception of climate change effect variable was dropped due to multicollinearity. Eight (8) adaptation strategies that were found to be practiced by more than 50% of interviewed households were analyzed to establish the determinants factor of the main adaptation strategies. The overall significance of the explanatory variables in explaining the 8 models of adaptation strategies with R-square ranging from 0.1402 to 0.4307 showing 14% to 43% of the models were explained by the included regressors. In addition, the estimated probability greater than chi-square value (Prob > chi-square = 0.0000), suggests that all the model parameters are jointly significant in explaining the dependent variable.

Correlation matrix

A Pearson pair-wise correlation matrix was generated in STATA 14 (see Appendix 3). According to Gujarati (2007), if the pair-wise correlation is in excess of 0.8, then the data has a serious problem of multicollinearity. From the correlation matrix, **no variables had a pair-wise correlation above 0.6, which shows that the data was free from multicollinearity.**

Multicollinearity

Multicollinearity exists in the data when variables in a model are highly correlated. It affects cross-section data and if not addressed, the confidence intervals tend to be artificially wide

leading to accepting the null hypothesis even when it is not true. In addition, it causes the ordinary least squares (OLS) estimates and standard errors to be sensitive to small changes in the data (Gujarati, 2007). Two tests were used to test for multicollinearity in this study; correlation matrix and Variance Inflation Factor (VIF).

Variance Inflation Factor (VIF)

The Variance Inflation Factor (VIF) shows how the variance of an estimator is inflated by the presence of multicollinearity. With increased multicollinearity, the VIF approaches infinity and in the absence of multicollinearity, VIF will be equal to 1 (Gujarati, 2007). The VIF is given as:

$VIF=1/(1-r^2)$

where:

= the artificial regression with the i^{th} as a dependable variable.

According to literature, VIF should be less than 10 indicate absence of multicollinearity. The results showed that all the dependent variables computed against the independent variables **had VIF values of less than 10 and the mean VIF is 1.6**, which indicates absence of multicollinearity.

Heteroscedasticity

Heteroscedasticity refers to the absence of constant variance of each disturbance term conditional on the chosen value of the explanatory variables. If present in the data the estimates will not be the Best Linear Unbiased Estimates (BLUE) (Gujarati, 2007). The data were tested for heteroscedasticity using the Breusch-Pagan test (Wooldridge, 2009). The Breusch-Pagan test evaluates the null hypothesis of a constant variance in the data.

The null hypothesis of a constant variance depicts there is no heteroscedasticity in the dataset since the p-value is insignificant. The result of the Breusch-Pagan test (Wooldridge, 2009) for the 8 models analyzed.

Linktest was checked as well and the t-test for hatsq is insignificant, indicating that the model is okay, since the p-value is significant. Thus, it passes the link test. The result of the Linktest for the 8 models analyzed.

Akaike's information criterion and bayesian information criterion - IC Test

The maximum likelihood models for our models' selection is good as well in estat ic testing as AIC is lower than BIC. The result of the IC test for the 8 models analyzed.

Finally, the model was run and tested for the validity of the independence of the irrelevant alternatives (IIA) assumptions by using both the Hausman test for IIA. The test failed to reject the null hypothesis of independence of the climate change adaptation options, suggesting that the multivariate logit (MANOVA) specification is appropriate to model climate change adaptation.

Out of the 14 adaptation strategies stated by the communities; 8 of them, which were practiced by more than 50% of the respondents were considered in the determinants of adaptation strategies. Thus, the effect of the socio-economic variables, climate variables and perception of climate change variables were analyzed with the main adaptation strategies stated by more than 50% of the community member interviewed. To facilitate interpretation of the estimation results, the marginal effects of multivariate logistic regression of each explanatory variable on the predicted probability of adaptation strategies of livestock production, are presented in table 22 below. The marginal effects report of the logit regression provides the probability estimation for the likelihood of effects of exercising climate change adaptation strategies for livestock production given the explanatory socio-economic, climate and climate change impact variables: family size (famsz), head of household sex (hhhsex), Age of household head (agehhh), livestock holdings (ttlvhl), household income (tlinc), household education status (hheducst), access to veterinary service (acvtsv), access to credit service (accrtsv), access to information on climate change impact (accinfccipct), access to weather information (acwthinf), knowledge and skill on adaptation strategies (kdskadpt), drought (drought), flooding (Fldg), rainfall variability (Rfvr), livestock disease outbreak (Lvdsob), human disease outbreak (hmdsob), crop pest & disease and pest (crppsds), resource based conflict (rsbscf), perception of climate change variability (perccvr) and perception of climate change (percceft). The ability to adapt to climate change is determined by predictor variables, which are demographic, socioeconomic and institutional in nature (Juana, Kahaka, & Okurut, 2013).

Table 20. Marginal effects from the multinomial logit climate change adaptation model.

	Changing Herd Composition		Herd Spliting		Increased Use of Veterinary Service		Destocking		Rotational Grazing		Feed Preservation		Increased Mobility of Livestock		Combining Livestock with Crop Production	
Explanatory variables	Coefficient dy/dx	P>z	Coefficient dy/dx	P>z	Coefficient dy/dx	P>z	Coefficient dy/dx	P>z	Coefficient dy/dx	P>z	Coefficient dy/dx	P>z	Coefficient dy/dx	P>|z|	Coefficient dy/dx	P>z
Famsz	0.0086858	0.132	-0.0012393	0.843	0.0098583	0.334	0.0134909	0.217	0.0106209	0.222	0.0096476	0.26	0.0075097	0.179	-0.0132602	0.262
HHHSex*	0.0085772	0.803	0.0914216	0.014	0.0197946	0.745	0.0320948	0.622	-0.0348113	0.502	0.0390543	0.445	-0.0800683	0.016	0.1160252	0.099
AgeHHH	-0.0011699	0.281	-0.0004862	0.679	-0.0026407	0.169	-0.001039	0.614	0.0036959	0.024	-0.000232	0.886	0.0006373	0.545	-0.0006728	0.762
Ttlvhl	0.0002443	0.539	0.0007958	0.064	0.0008829	0.209	0.0001009	0.893	-0.0020345	0.001	0.0009999	0.091	0.0009882	0.01	-0.0020657	0.011
tlinc	5.80E-06	0.000	3.07E-06	0.013	-1.54E-06	0.444	2.26E-06	0.296	-1.01E-06	0.556	0.0000251	0.000	2.54E-06	0.021	-6.43E-06	0.006
Hheduc	2 .0169258	0.336	-0.017341	0.363	-0.001014	0.974	2 .0042565	0.899	-0.0176689	0.506	0.0120961	0.644	-0.0400173	0.019	0.084712	0.019
AcVtSv*	0.0112388	0.692	0.0136777	0.656	0.301199	0.000	0.0370788	0.491	0.0534202	0.212	0.0844516	0.045	0.0563561	0.04	-0.0130082	0.823
AcCrts*	0.0765286	0.041	0.1254777	0.002	0.0558076	0.398	-0.0076783	0.914	-0.0675579	0.231	0.3466439	0.000	0.0083645	0.817	-0.1277939	0.095
Acinfc*	-0.0062684	0.875	0.0133058	0.758	-0.0022385	0.975	0.0405669	0.592	0.1619688	0.007	-0.069199	0.244	0.0604781	0.119	0.0270447	0.741
Acwthi*	0.0737824	0.148	-0.0294226	0.594	0.0251884	0.78	0.0259958	0.788	0.0810675	0.292	0.052953	0.485	0.0483115	0.329	0.1190652	0.254
kdskadpt*	0.0089271	0.861	0.0765677	0.166	-0.1396238	0.122	0.1270872	0.189	0.0067136	0.93	-0.0282817	0.709	-0.0615324	0.213	-0.0840005	0.421
Drght*	0.5020076	0.000	0.087023	0.569	-0.1431628	0.566	0.1091683	0.683	-0.0389075	0.855	0.302879	0.149	0.0771428	0.573	0.234351	0.418
Fldg*	0.0548262	0.441	-0.0613271	0.426	-0.0132286	0.916	0.2490428	0.065	0.0155357	0.885	0.2252326	0.033	-0.129375	0.061	0.3564161	0.014
Rfvr*	0.0199732	0.766	-0.0252044	0.729	0.2175951	0.067	0.1147179	0.368	0.0949119	0.349	-0.0183844	0.854	0.0703245	0.28	-0.1409515	0.306
Lvdsob*	0.0078827	0.791	-0.0331929	0.304	0.0012335	0.981	0.1700492	0.003	0.1091467	0.015	0.0355959	0.422	0.031386	0.278	0.0446954	0.464
Hmdsob*	0.0435144	0.352	-0.0427566	0.399	0.00343	0.967	0.1577516	0.076	-0.023572	0.738	0.0114331	0.869	0.0077275	0.865	0.0959737	0.317
Crppsds*	0.0727926	0.054	-0.0006106	0.988	-0.0431169	0.519	0.0219528	0.76	0.0976476	0.087	0.0200568	0.721	-0.0395459	0.281	0.0763065	0.325
Rsbscf*	-0.0425715	0.247	0.0079804	0.841	-0.0355584	0.585	-0.0651771	0.35	0.1178675	0.034	-0.0262731	0.631	0.0139752	0.695	0.1937598	0.01
Perccvr*	0.0225109	0.709	0.0439705	0.501	0.0048187	0.964	0.0924454	0.419	0.2851405	0.002	0.0282004	0.753	0.171591	0.003	0.2404071	0.052

Source: Authors household survey 2020.

Household size

Increased household size appears not to significantly affect adaptation strategies for livestock production, though most of the coefficients except for herd splitting and combing livestock with crop production have a positive sign/association. Even though it is not significant, it can be inferred that the larger the size of the household, the better the chance of adapting to climate change. As family size increased, adaptation to various options will also increase, since farming activities are obviously labor intensive and household's labor is the main source in Ethiopian context (Tazeze et al., 2012). However, according Tizale (2007), there was a possibility that households with large families enforced to divert part of their labor to non-farm activities to earn income to ease the consumption pressure imposed by large family. Therefore, family size here hypothesized to affect diverse adaptation choices both positively and negatively.

Sex household head

The results indicate that male-headed households adapt more readily to climate change. Male-headed households were 9% more likely to do herd splitting, and 8% more likely to practice increased livestock mobility with significant relation. Female headed farmers had less exposure to adaptation measures since they are culturally assigned for activities, which are domestic in nature and even had limited access to critical resources (land, cash and labor), which often undercuts the ability to carry out labor-intensive agricultural activities (Temesgen et al., 2009). Male-headed farmers on the other hand, had better access to information on climate as they exposed for varied socio-political contacts in the community.

Age of the household head

Age of the household head, which represents often experience, was seen to affect adaptation to climate change. For instance, a unit increases in age of the household head results in a 0.36% increase in the probability of having increased rotational grazing. Juana et al. (2013) - farmers' age had a positive effect on the diverse adaptation choices. The assumption is that as age

increases, the farmers are likely to acquire experience in weather forecasting there by increases the likelihood of practicing different adaptation options. However, according to Belayneh et al. (2012), age negatively influenced the decision to adapt options related to technology because older farmers are more risk-averse and less likely to be flexible. Therefore, age of the farmer here hypothesized to have both positive and negative influence on adaptation choice decisions to climate change. Nonetheless, a study in South Africa, found that female-headed farmers were more likely to take up adaptation means (Nhemachena & Hassan, 2007). Therefore, male-headed farmers hypothesized to have more likely positive kin with adaptation choice decisions to climate change.

Education

Education of the head of household appears to have both positive and negative effect on the probability of adapting to climate change. As can be observed in Table 5, education significantly increases combing of livestock with crop production, which is mainly associated with agriculture extension at confirmed by the KII and FGDs. A unit increase in educational status would result in 8% increase in the probability of combing livestock with crop production to adapt to climate change with significant impact. However, with its negative effect adaptation, a unit increase in educational status would result in (-6%) decrease in the probability of having livestock mobility with significant impact. Studies showed that as the higher the education level, the better would be the knowledge on climate change and its adaptation choices. Literate farmers were likely to respond to climate change through making best adaptation choices of his/her preference (Evengelista, Young, & Burnett, 2013). In this study, hence farmers with better education expected to understand climate change; thus, assumed to influence the adaptation choice decisions positively.

Livestock holding

The livestock holding is also positively related to most of the adaptation options, even though the marginal impacts are not significant. It is positively related to the adoption of adaptation methods such as change of herd composition, herd splitting, and increased use of veterinary services,

rotational grazing, and increased livestock mobility. Livestock ownership is negatively related to combing livestock with crop production, with a unit increase in livestock ownership would result in 2% decrease in the probability of combing livestock with crop production with significant impact. Livestock ownership and goat flock size seems to be proxy but in the study area there were farmers engaged in goat production solely as well as in the mixture of livestock types. Accordingly, the investigators pursue to see the relation between goat flock size and the dependent variables since being a small animal, compared to large animals keeping goats is less risky and even restoration of the flock size is easy (Philip et al., 2013). On contrary, larger goat flock, size is associated with greater demand for feed and water. Hence, goat flock size of the farmers hypothesized to have positive influence on adaptation choice decisions to climate change.

Income

The household income of the households surveyed has a positive and significant impact on change of herd composition, herd splitting, feed preservation, and livestock mobility. A unit increase in income increases the probabilities of the above-mentioned adaptation strategies by less than 0.01%. Household income has a negative and significant impact on combing livestock production with crop production with one unit increase in income would result in decrease of the probability by less than 0.01%. This shows the pastoral communities in Harshin district would tend to combine livestock with crop production as their income decreases. Increased annual income of the household from different farming activities mainly of selling livestock and crop products expected to increase the opportunity to look alternative climate change adaptation options (Kassaye, 2010). Therefore, farm income was hypothesized to have a positive influence on farmers' adaptation choice decisions to climate change. The non-farm income obtained from sources like transfers, labor wages, and production assets, thus non-farm employment provides constraint to climate change adaptation due to the pressure on the farm managerial time (Zelalem et al., 2009). As a result, non-farm income was hypothesized to have a negative influence on adaptation choice decisions to climate change.

Access to Veterinary Service

Access to livestock veterinary service has a positive and significant impact on use of livestock services, feed preservation and livestock mobility. A unit increase in access to livestock veterinary service increases the probability of using veterinary service, feed preservation and livestock mobility by 30%, 8% and 5% respectively. Increased contacts with support services such as extension agents and climate information providers are supposed to increase farmers' perception of climate change and its associated risks, there by rises their adaptation decisions (Amdu et al., 2012). Ethiopian Agricultural Extension manual dictates every farmer has the right to get advice and technical support at least once a month via the assigned agents (MoA [Ministry of Agriculture], 2010). According to the guide, farmers who get technical advice and support at least six times a year named as "extension accessed". Thus, increased extension contact was hypothesized to have positive influence on farmers' adaptation choice decisions to climate change.

Access to credit

Access to credit has a positive and significant impact on the likelihood of change of herd composition, herd splitting and feed preservation. A unit increase in getting to access to credit would result by 8%, 13% and 35% for change of herd composition, herd splitting and feed preservation respectively. This result implies the important role of increased institutional support in promoting the use of adaptation options to reduce the negative impact of climate change. Access to affordable credit also increased the financial sources of farmers then their capacity to meet transaction costs associated with adaptation options that they might want to take (Nhemachena & Hassan, 2007). Farmers who had access to credit do take more adaptation chances as any investment requires the use of owned/borrowed finance. Accordingly, access to credit was hypothesized to have positive influence on adaptation choice decisions to climate change. Access to affordable credit increases the financial resources of farmers and then their ability to come across transaction costs associated with various adaptation options that they might want to take (Berman, 2014). According to the Kadir (2012), access to credit services

increases the probability of adapting herd and pasture management improvement, and extended mobility patterns by 42.23% and 34.95% at less than 5% significance level. This might be associated with the limited financial resources required for the choice of water harvesting and extended mobility patterns strategies. Studies indicate of Temesgen et al., 2008; Taddesse, 2011 and; Dawit and Habtamu, 2011 indicate that access to credit allows higher chances of adapting to changing climatic conditions, increases financial resources of farmers and their ability to meet transaction costs associated with adaptation strategies.

Information on climate change

Information on temperature and rainfall has positive impact on the likelihood of using most of the adaptation strategies though is not significant. But it has significant and positive impact on rotational grazing with a unit increase in information on climate change would result in increase of 16% increase in rotational grazing. Accessing climatic information increased the probability of adapting diversified choices since better information helps farmers to make comparative decision among choices to cope effectively with the changes (Tazeze et al., 2012). Therefore, accessing climate information was hypothesized to have a positive influence on farmers' adaptation choice decisions to climate change. Access to climate change information increases the probability to opt for herd and pasture management improvement, and extended mobility patterns by 20.36% and 1.9% at less than 5% and 10% significance level respectively. Ordered logit results also showed that climate change information significantly affects the pastoralist perception level. Temesgen et al. (2009) found that climate change information increases the probability to use different technologies. Dawit and Habtamu (2011) also confirmed that climate change information is a significant factor for use of water harvesting schemes, rearing of sheep and goats rather than cattle, and herd diversification.

Drought

Though not significant, drought has positive impact on many of the adaptation strategies to be practiced by the pastoral households in Harshin district. However, it has significant and positive on changing of herd composition with unit increase in drought occurrence would result in

increase of change of herd composition by 50%. This is clear indication of the drought impact on the use of the adaptation strategies notably changing of herd composition.

Flooding

Though not significant, flooding as well has positive impact on many of the adaptation strategies to be practiced by the pastoral households in Harshin district. However, it has significant and positive on feed preservation and combing of livestock with crop production with unit increase in flooding occurrence would result in increase of feed preservation and combing of livestock with crop production by 23% and 36% respectively. This is clear indication of the flooding impact on the use of the adaptation strategies notably feed preservation and combing of livestock with crop production.

Livestock disease outbreak

Similarity, though not significant, livestock disease outbreak has positive impact on many of the adaptation strategies to be practiced by the pastoral households in Harshin district. However, it has significant and positive on destocking and rotation grazing with unit increase in livestock disease outbreak occurrence would result in increase of destocking and rotational grazing by 17% and 2% respectively.

Resource Based Conflict

Resource Based Conflict has a positive and significant impact on the likelihood of rotational grazing and combing livestock with crop production. A unit increase in resource-based conflict would result by 12%, and 19% rotational grazing and combining livestock with crop production respectively.

Perception of Climate Change and Variability

Perception of climate change and variability of households surveyed has a positive to all the adaptation strategies though it is significant to rotational grazing and livestock mobility. A perception of climate change and variability would result in increase of rotational grazing and livestock mobility by 29% and 17% respectively. This shows the crucial role perception would play in the practice of adaptation strategies. Perception strongly affects how farmers deal with climate induced risks, thus the nature of their interactive responses to perception shapes adaptation choices. Misconception about climate change and its associated risk may result in no adaptation or maladaptation in turn increased the adverse effects of climate change (Pauw, 2013). This variable was therefore, assumed to have a positive influence on climate change adaptation choices.

CHAPTER 5

5.1 Summary

This study examined perception of climate change indicators, impact of climate change and variability on pastoral livestock production, adaptation strategies to the pastoral livestock production, perceived success of the adaptation strategies, determinants of the adaptation strategies together with the past and future temperature and rainfall trends and variabilities.

The prominent hydro metrological hazard observed in the study area indicated that drought was the frequent hazard in the study areas as reported by 99% (n=353) of the respondents, followed by rainfall variability by 96% (n=342), livestock disease outbreak by 48% (n=172), which matches with the metrological records, since the findings depicts that out of 34 years analysed 14 of them (41%) experienced various intensity of drought; mild drought (57%), moderate drought (36%) and severe drought (7%).

Climate shocks and stresses notably drought and rainfall variability impacts are multifaceted Harshin Woreda, Somali region per the findings of the household survey, FGDs and KIIs. The conspicuous impacts of climate change and variability as reported by the household interviewed (i) reduced livestock number and productivity (95% response rate), (ii) reduced pasture and browse availability (84% response rate), (iii) depleted watering points (88% response rate), (iv) reduced terms of trade (livestock/grains) (72% response rate) (v) reduced community risk sharing practice (40% response rate) (iv) proliferation of livestock diseases (78% response rate).

Perception of climate indicators depicts majority of the respondents perceived increasing trend of temperature indicators, increased daily temperature (96%) and increased night temperature (93%), in the last 15 years. The result is consistent with annual and seasonal minimum and maximum temperature meteorological data analysis. With regard to the rainfall pattern in the last 15 years, the majority of respondents perceived decreasing trend of rainfall indicators; the number of rainy days decreased (97%), and onset unpredictability (87%) and cessation unpredictability (83%) of rainfall becomes unpredictable and erratic in its nature. However, the

perceived reduction of seasonal and annual rainfall volume contradicts with the instrumental findings of this study. Furthermore, the household survey results revealed that there have been frequent and prolonged droughts in the study areas as reported by majority of the respondents (99%).

The perceived erratic behavior of rainfall matches with both Gu and Dyre rainfall season of the instrumental record with CV and PCI at (64.6%, 18.5) and (33.9%, 10.5) for Dyre and Gu seasons respectively. The long-term annual rainfall and main rainy season rainfall were unevenly distributed in Harshin Woreda with CV < 30% and PC at 14%). Unlike the perception of pastoral communities', which portrays that rainfall amount reduced, meteorological analysis proves increase of rainfall especially from the year 2000 onwards with statistically significant Gu, Dyre and annual rainy seasons.

Mann-Kendall Test Stat analysis of seasonal and annual rainfall trend from 34 years of NMA data depicted that Dyre (0.242*), Gu (0.372*) and annual (0.342**) significant increase in the total amount of rainfall. Similarly, the seasonal and annual temperature trend analysis of 33 years with Mann-Kendall Stat revealed temperature is on the increasing trend annually and in most of the seasons.

The study findings depict different adaptation and coping mechanisms are employed as per the findings of the household survey to mitigate the challenges posed by climate change and variability on livestock production. Herd management (94%); herd composition change (94%), increased herd mobility (94%) and herd splitting (93%) being the prominent ones followed by rotational grazing (84%), increased veterinary service use (75%), destocking (74%), feed preservation (69%), combing livestock production with crop production (55%) and increased water harvesting (47%). Various constraints were raised by the respondents of the study to adapt/cope with climate variability and climate extremes; drought (91%) and rainfall variability (91%) are main ones followed by low livestock holding (86%), livestock disease (85%), low access to livestock feed (78%), lack of knowledge on climate variability (77%), lack of access to weather information (70%), less livestock value in the market (67%), low access to income

(60%) and livestock water (60%). The respondents also asserted that low access to veterinary services (58%), low access to credit (58%), low education level (57%), old age (53%), Lack of knowledge on current climate change adaptation methods (53%), less value to livestock product market (51%) are the notable constraints that hindered their coping and adaptation strategies against climate related shocks and stresses.

Analysis of the perceived success of the adaptation strategies as per the response of the household survey revealed that the most perceived success goes towards herd management; changing herd composition, herd splitting, increase mobility of livestock and destocking with the mean score of 4.3, 4.2, 4.1 and 4 respectively. The success of rotational grazing, purchase of livestock feed, storage/preservation of livestock feed adaptation strategies are prominent as well with mean score of 3.5, 3.3 and 3.2 respectively.

The effect of the socio-economic variables, climate variables and perception of climate change variables were analyzed with the main adaptation strategies practiced by more than 50% of the community member interviewed. Out of the 18 variables computed to analyze the determinants explanatory variables 11 variables; household sex, livestock holding, income level, educational status, access to veterinary service, access to credit, flooding, livestock disease outbreak, resource based conflict and perception of climate change and variability, appear to have significant impact on two or more adaptational strategies.

5.2 Conclusion

The pastoralist adaptation response mechanisms have generally involved the strategies of adjustment in pastoral practices and shifts to non-pastoral livelihoods. Despite the existing restrictive pressures, increased pastoral mobility still remains to be a viable strategy of sustainable pastoralism in the present context of climate-induced risks and pastoral livelihood vulnerability. In a related front, the Somali pastoralists appear to have gradually moving to practice farming and other non-pastoral livelihoods such as skilled and unskilled labor as a result of the increasing need to generate own food source and income at household level. It was been

realized as well the pastoral communities in the study area are coming to rear more browsers livestock species, goats and camels as oppose to grazers, cattle and sheep to diversify their herd portfolios in favor of drought-tolerant species. These adjustments in pastoral practices are apparently quite helpful in the sense that they are found to exhibit significant positive implications for increased pastoral production.

Somali pastoralists have long years of experience in terms of responding to the impacts of climate change with various adaptation and coping strategies through analysis and evaluation of the local situations, their resource and potential with regard to issues central to their livelihood. However, their efforts were not supported for long with inappropriate pastoral development policies practices that left them marginalized for generation. Somali pastoral communities have found it difficult to sustain their livestock-based livelihood, since the climate change impact degraded rangelands, increases the prevalence and severity of livestock diseases and hamper mobility. Impact of climate change and variability on livestock production is multifaceted in its nature notably: reduced livestock number and productivity, reduced pasture and browse availability, depleted watering points, reduced terms of trade (livestock/grains), reduced community risk sharing practice and proliferation of livestock diseases. However, effective livestock adaptation strategies are seriously constrained by lack of institutions that steers or governs climate issue at the grassroots level, poor service and facilities that support adaptation such veterinary and credit services and lack of infrastructure. Even though, pastoralists were not passive victims, currently practiced climate change adaptation strategies are found far from materialization to of the desired outcome, fast economic growth and development.

The recorded trend and variability of temperature in the last three decades was found to correspond with pastoralist perception of climate change in the region but rainfall. The temperature fairly following a general upward trend in the last three decades matches with the pastoralist perception, while the rainfall records increase in all the rainy season Harshin Woreda received doesn't associate with the pastoralist's perception of climate change, since they perceive rainfall for having declining trend. The inconsistency between meteorological record and pastoral community's rainfall observations, since farmers/livestock keepers focus associate

the climate patterns with extreme events such as drought in relative to the climate phenomena they observed during that event and interpret qualitatively, while in scientific records, changes are explained using temperature and rainfall in statistical averages and in absolute terms.

It is quite naive to attribute the crisis in pastoral communities of Ethiopian, and the subsequent pastoralist adaptation response mechanisms, entirely to a factor of climate variability and change, since there are various non-climate factors associated. However, as per the findings various studies including this study in pastoral communities the influences of climate-induced recurrent shocks have been profoundly sharp to affect their habits, way of living and livelihood strategies at large.

This study confirmed livestock are still the main stay and primary source of pastoral income, with live animal sale and its products constituting 69% of the household income as per the household. The study attested the pastoral communities are extremely sensitive to the effect on markets, since they sale they do marketing of their livestock to buy grains and other food and non-food items. The pastoral communities in the woreda rear more of sheep and goats for their ease in marketability. It is often referred as a "purse of pastoralists". As the pasturelands were increasingly replaced by bushes and shrubs due to bush encroachment and prolonged and recurrent droughts, there is strong tendency from pastoralists to rear browsers, goats and camels than grazers, cattle and sheep. Thus, currently goats are the best preferred livestock species in Harshin Woreda as well the goats are reared more and more by pastoralists for ease in marketability and their browse feeding habits.

5.3 Recommendation and Policy Implication

As per the findings of this study and conclusion drawn, the following recommendations were forwarded that would enhance the pastoral livestock production in Somali region and the country at large and improve their wellbeing.

In addition, it is recommended the pastoral communities should also focus and strengthen forage development and preservation, which is not practiced as such currently in study area.

It is indeed paramount to strengthen the pastoral adaptive capacity to climate change through timely provision of climate forecast for preparedness and early action. To this effect, local institutions dealing with early warning, which meaningfully participate the communities, is highly recommended for quick dissemination information and action at the grassroots level. It is crucial as well to blend the metrological agency information with local traditional forecasting, since experience shows the traditional forecasting matches and at times supersede the instrumental. As part of developing the objective adaptive capacity, government and development actors should promote the use of drought tolerant/resistant livestock and crop species for use by the pastoral communities, since the natural hazards notably rainfall variability, and drought would continue at large scale in relation to the projected rainfall and temperature.

On top of dealing in addressing the climate related problems, it is paramount for government and development counterparts to work on factors to that address the barriers to climate change adaptation in the study area. These include provision of the necessary capital inputs at affordable price, increase access to credit and capacity building with robust agricultural extension services including veterinary services.

Commercialization of livestock production should be supported in the woreda and equally promoting pasture development, and services such as veterinary and credit, which are paramount to the commercialization initiative.

In the study area, literacy level is very low in the adult category from the study that shows the household head 18% literacy rate, which depicts low level of education. Thus, government as well as development actors should work on promoting education customized to the pastoral way of life and norm such as pastoral school model.

Besides, the policy program which is intended at reducing the climate related problems should also focus on accessing improved inputs such as improved seeds, improved livestock breeds and fertilizer to farmers/livestock keepers with reasonable price. Nevertheless, it is paramount that government or any development actors should first understand the pastoral communities' preferences for climate change adaptation in designing and implementing appropriate policy response to reduce the impacts of climate change and variability in the study area. Therefore, the pastoral community's climate change adaptation effort should be supported by government and other development actors in the country through rigorous capacity building, institutionalizing of the climate issues at the grassroots level and input provision support.

The findings of the study have significant implications in terms of informing local level pastoral development and policy directions that helps the pastoral community to be resilient to the effect of climate change and assure sustainable development through effective capacity building, creation and strengthening of services and support service or facilities. Thus, it is highly recommended for appropriate interventions ensuring management of rangeland and water availability so as to improve livestock productivity.

Moreover, creating opportunities for non-pastoral own production and income sources are important as these helps them to engage on those activities that are less sensitive to climate change. Furthermore, providing climate change information, extension services, and creating access to markets are crucial. Therefore, including these activities in the existing formal extension channels of the Ministry of Agriculture and other line ministries is indispensable. Policy and support program should focus on strengthening community based early warning and early action and institutionalization of climate and climate change issues. Additionally, provision

of livelihood insurance notably livestock insurance has very crucial role in supporting the smallholder farmers/livestock keepers to recover from risks against climate related problems.

Climate foresight must be integrated into planning for pastoralist development. Better awareness of how to access and use climate projections is required at different levels of planning and implementation.

Climate change adaptation should be mainstreamed into pastoral development plans and strategies at national and local/district level and at sectoral levels, including disaster risk reduction, livestock development and agriculture.

Effective public information campaigns are needed to help people understand and respond to the climate change challenges faced in different regions and districts.

Context specific action research is paramount to build and share knowledge on climate adaptation by pastoralists and to share and disseminate learning to key regional and national institutions.

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Appendices

Appendix 1. **Household Questionnaire**

Adaptation to Climate Change - Somali Pastoralist in Harshin Woreda, Fafan Zone

Unique Survey Questionnaire Code: _____

INTRODUCTION AND INFORMED CONSENT

My name is _____. This research aims to investigate climate variability effects on livestock husbandry and adaptation mechanism of pastoralist to climate variability's by exploring how people

perceive climate change, how vulnerable they are, and what they do to adapt to climate change. Your responses will be treated as confidential and will be used for research purposes. The results of the questionnaire will not be used in any way other than for conducting this research. If you accept to participate in this research, you will be doing so voluntarily and there will not be any monetary returns. You are also free to refuse to respond to any questions you do not feel comfortable answering or to withdraw from the research all together. This interview will take about an hour of your time to respond to the questions.

Thank you in advance for your willingness to discuss with me.

SECTION 1: HOUSEHOLD BACKGROUND INFORMATION

Location: Somali Region, Fafan zone, Harshin District

No.	Questions	Answers			
1.1	Kebele of resident	1=Aran'are		2=Lankerta	
1.2	Sex of Head of HH	1= Male		2=Female	
1.3	Marital status of the HH	1=Married	2=Single	3=Divorced	4=Widow
1.4	How old is the head of household? **[ONLY ONE RESPONSE]**				

1.5	Household Size and characteristics	1.4.1	Children under 5 years old		
		1.4.2	Children from 5 to 18 years old		
		1.4.3	Adults from 18 to 60 years old		
		1.4.4	Adult over 60 years old		
		Grand Total			
		1.4.5	Person with disability	1=Yes	2=No
		1.4.6	Pregnant/lactating woman	1=Yes	2=No

1.6	What is the household head's **highest level of education?**	1=Illiterate	2= Cycle 1 (1-4)	3=Cycle 2 (5-8)
		4=High School (9-10)	5= Preparatory (11,12)	5=Higher Education
1.7	Access to Veterinary Services	1=Yes	2. No, skip to Qtn__	
1.8	Access to Credit from financial services institutes (owned by government or private such banks, MF)	1=Yes	2. No, skip to Qtn__	

SECTION 1: HOUSEHOLD BACKGROUND INFORMATION				
1.9	Access to weather information	1=Yes	2. No, skip to Qtn__	
1.10	Access to information about climate change impact	1=Yes	2. No, skip to Qtn__	

SECTION 2: HOUSEHOLD ASSETS AND SOURCE OF INCOME			BEFORE	NOW
2.1	What is/are the main **livelihoods of** your household **now and before 15 years?** **[MULTIPLE RESPONSE IS POSSIBLE]** **[PUT THEM IN RANKS]**	[1] Livestock Keeping		
		[2] Farming		
		[3] Petty Trading		
		[4] Employment/Salaried Work		
		[5] Skilled Labour		
		[6 Unskilled Labour		
		[8] Others, specify_____		
2.2	If livestock rearing is mentioned as one of the livelihoods; please indicate no of livestock, you own now and 15 years back? **[MULTIPLE RESPONSE QUESTION]**		Before	Now
		[1] Cattle		
		[2] Goats		
		[3] Sheep		
		[4] Camel		
		[5] Donkey		
		[6] Horse		
		[7] Mule		
		[8] If others, pls specify _____		

SECTION 3: HOUSEHOLD CASH INCOME		
No.	Questions	Answers

3.1	What is your source of cash income for your household in the last 12 months (in year)? Circle the answers. **Enquire the amount of income from each source of income?**	Source of Livelihoods	Amount (ETB)
		1. Sale of livestock (cattle, goat, cheep, chickens)	
		2. Sale of livestock products (milk/butter/yoghurt)	
		3. Casual Labour (Skilled)	
		4. Casual Labour (Unskilled)	
		5. Employment (salary)	
		6. Remittance	
		7. Sale of forest products (charcoal/grass/ poles/firewood/etc…)	
		8. Petty Trade	
		9. Loan	
		10. Sale of relief items	
		11. Cash from NGOs	
		12 Other (specify)_____	

SECTION 4: HOUSEHOLD LIVELIHOODS CHARACTERISTICS

4.1	Within the last 15 years, is there any change in the trend of **livestock production?**	1=Yes	2. No, skip to Qtn__	3=Don't know, skip to Qtn__
4.1.1	If yes, what is the trend?	1= Increase		
		2= Decrease		
4.1.2	If increase, what do you think is the cause for the increase in your opinion? **[MULTIPLE RESPONSE**	1= Increased availability of water		
		2= Increased availability of livestock feed		
		3=Favorable weather condition		
		4= Less livestock disease occurrence		
		5=High Market Value		

	POSSIBLE - CIRCLE ALL THAT APPLY]	6= Other/s (Specify)_____	
4.1.3	If decrease, what do you think is the cause for the decrease in your opinion? **[MULPTILE RESPONSE POSSIBLE - CIRCLE ALL THAT APPLY]**	1= Loss of market value	
		2= Shortage of feed for livestock	
		3= High Occurrence of Livestock Diseases	
		4=Shortage of livestock water	
		5=Unfavorable weather	
		6= Other (Specify)_____	

SECTION 5: HAZARD OCCURRENCE

5.1	Have you encountered any hazard in your kebele for the last 15 years?	1=Yes	2. No, skip to Qtn__	3=Don't know, skip to Qtn__	
5.1.1	What are the most important hydrometeorological hazards in your kebele for the last 15 years? ***(Circle the responses and put them in ranks as the frequency, and scale of occurrence and extent of damage)***	1=Drought			
		2=Flooding			
		3= Livestock disease outbreak			
		4= Human disease epidemics			
		5=Crop pests' infestation or crop diseases epidemics (standing and/or Harvested crops			
		6=Resource based conflict			
		7=Other, specify _____			
5.1.2	What are the main impacts of the hydrometeorological hazards in your kebele for the last 15 years? ***(Circle the responses and put them in ranks as the frequency, and scale of occurrence and extent of damage)***	1=Reduced livestock number and productivity			
		2=Reduced pasture and browse			
		3=Depleted watering points			
		4=Reduced terms of trade (livestock/grains)			
		5=Reduced community risk sharing practice			
		6=Proliferation of livestock species			
		7=Other, specify _____			
5.1.3	Which livestock do you prefer to raise most in current situation? (PUT THEM IN RANKS)	1=Cattle			
		2=Goat			
		3=Sheep			
		4=Shoats			
		5=Camel			
		6=Poultry			
		7=Equine			
		8=Other, specify _____			
5.1.4	Why do you prefer the one at the first rank above all?	1=Higher economic value			
		2=Drought resistant			

	(MULTIPLE ANSWER POSSIBLE)	3=Disease resistant	
		4=Need low input	
		5=More productive	
		6=Give birth in short period	
		7=Other, specify_____	

SECTION 6: PASTORALISTS' PERCEPTION ON CLIMATE CHANGE

6.1	Pastoralists perceptions on temperature, rainfall and Natural Hazard (drought and rainfall). Accordingly, some possible statements are listed in the table below. Please read each item separately and indicate your opinion by putting a tick (√) mark under one of these alternatives. Your response could range from strongly disagree (1) to strongly agree (5). 1. Strongly disagree 2. Disagree 3. Neutral (undecided) 4. Agree 5. Strongly agree (ATTEMPT EACH QUESTION)	**Climate Outcomes**	
		Perception of Temperature dynamics	
		Number of hot days increased	
		Number of warm nights increased	
		The degree of coldness of cold seasons increased	
		Perception of Rainfall Variability Indicators	
		The onset of rainfall becomes more unpredictable	
		The cessation of rainfall become more unpredictable	
		Number of rainy days decreased	
		The intensity of rainfall increased	
		The occurrence of untimely rainfall increased	
		Perception on Natural Hazard (Drought and Flooding)	
		Drought occurrence frequency increase	
		Flooding Occurrence frequency increases	

SECTION 7: ADAPTATION TO CLIMATE CHANGE

7.1	Do you apply any strategies to safeguard your livestock assets from climate change	1=Yes	2. No, skip to Qtn__	3=Don't know

7.1.1	If, yes, what are the adaptation strategies you apply to reduce the impact imposed on your livestock production by the climate change? **(CIRCLE ALL THAT APPLY)**	1=Change of herd composition	
		2=Herd splitting	
		3= Increased use of veterinary services	
		4= Destocking	
		5= Labour migration	
		6=Commercialization of livestock production	
		7=Feed Preservation (e.g. hay, silage)	
		8=Forage development	
		9=Bush Clearing	
		10=Area Closure	
		11=Purchase of livestock feed	
		12=Employing water harvesting technology	
		13=Shift from livestock to crop production	
		14=Shift from livestock to non-farm activities	
		15=Rotational grazing pattern (between dry and wet season)	
		16=Increased mobility of livestock herd	
		17=No adaptation method used	
		18=Others (specify)	
7.1.2	Do you have the necessary knowledge and skill for the adaptation strategies you are undertaking against the effect of climate change on livestock production?	1= Yes	2=No
7.1.3	Do you think you will adapt your livestock production to suit to the changing context brought about by climate change?	1= Yes	2=No
7.1.4	Which livestock do you prefer to raise most in current situation?	1=Cattle	
		2=Goat	
		3=Sheep	
		4=Shoats	
		5=Camel	
		6=Poultry	
		7=Equine	
		8=Other, specify _____	
7.1.5	Why do you prefer the one at the first rank above all?	1=Higher economic value	
		2=Drought resistant	

		3=Disease resistant		
		4=Need low input		
		5=More productive		
		6=Give birth in short period		
		7=Other, specify_____		
7.1.6	Did you encounter any constraints to pursue the adaptation strategies effectively to safeguard the livestock assets at household level?		1= Yes	2=No
7.1.6	If yes, what is/are the constraint/s?	1= Young Age		
		2= Old Age		
		3= Less Family Size		
		4=High Family size		
		5=Low Level of education		
		6= Low livestock holding		
		7= Low Income level		
		8= Low Access to livestock water		
		9= Lack of access to credit		
		10= Less livestock value in the market		
		11=Less livestock product value in the market		
		12=Low Access to livestock feed		
		13=Lack of knowledge and skill to practice other livelihoods		
		14=Lack of resources both financial and materials to practice other livelihoods		
		15= Livestock Disease Occurrence		
		16= Lack of access to veterinary and extension services		
		18=Drought Occurrence		
		19= Floods Occurrence		
		20=Rainfall variability		
		21=Lack of weather information		
		22=Lack of knowledge on climate change/variability (rainfall &temperature)		

		23= Lack of current knowledge on adaptation methods	
		24= Lack of access to information about climate change impact	
		25=Resource based conflict	
		26=There is no hindrance to adaptation	
		27=Other specify _____	

SECTION 8: PERCEIVED SUCCESS TO CLIMATE CHANGE ADAPTATION STRATEGIES PRACTICED ON LIVESTOCK PRODUCTION

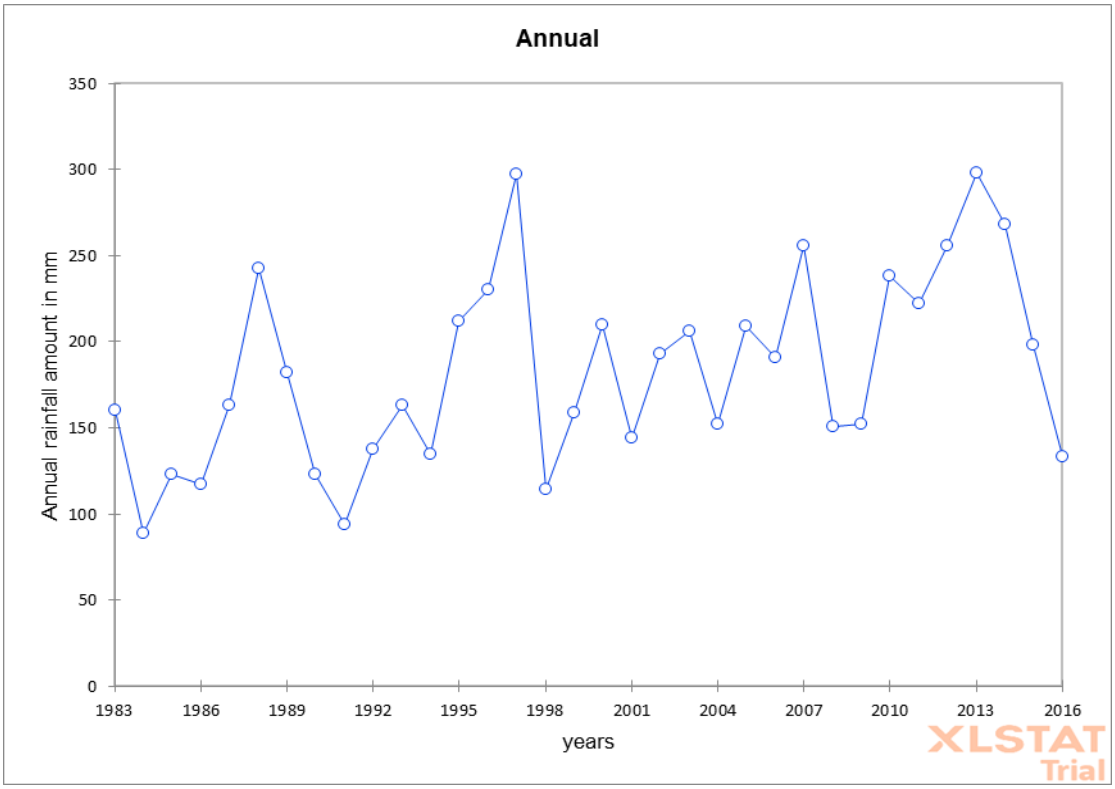
8.1	I think you are successful on the different adaptation strategies you are practicing for livestock production. **(CIRCLE ALL THAT APPLY)**	**Climate Outcomes**	Success Measure 1. Strongly disagree 2. Disagree 3. Neutral (undecided) 4. Agree 5. Strongly agree
		1=Change of herd composition	
		2=Herd Splitting	
		3=Destocking	
		4=Increased use of veterinary Services	
		5=Commercialization of livestock production	
		6= Labour migration	
		7=Shift from livestock to crop Production	
		8=Shift from livestock to non-farm activities	
		9=Fodder storage (e.g. hay, silage)	
		10=Forage development	

		11=Increased mobility of livestock Herd	
		12= Rotational grazing pattern (between dry and wet season)	
		13=Employing Water harvesting for livestock production	
		14=Area Closure	
		15= Bush Clearing	
		16= Purchase of livestock feed	
		17=Others (specify)	

THANK YOU VERY MUCH

END OF QUESTIONNAIRE

Appendix 2: Long-term rainfall trend, Mann-Kendall test statistic results



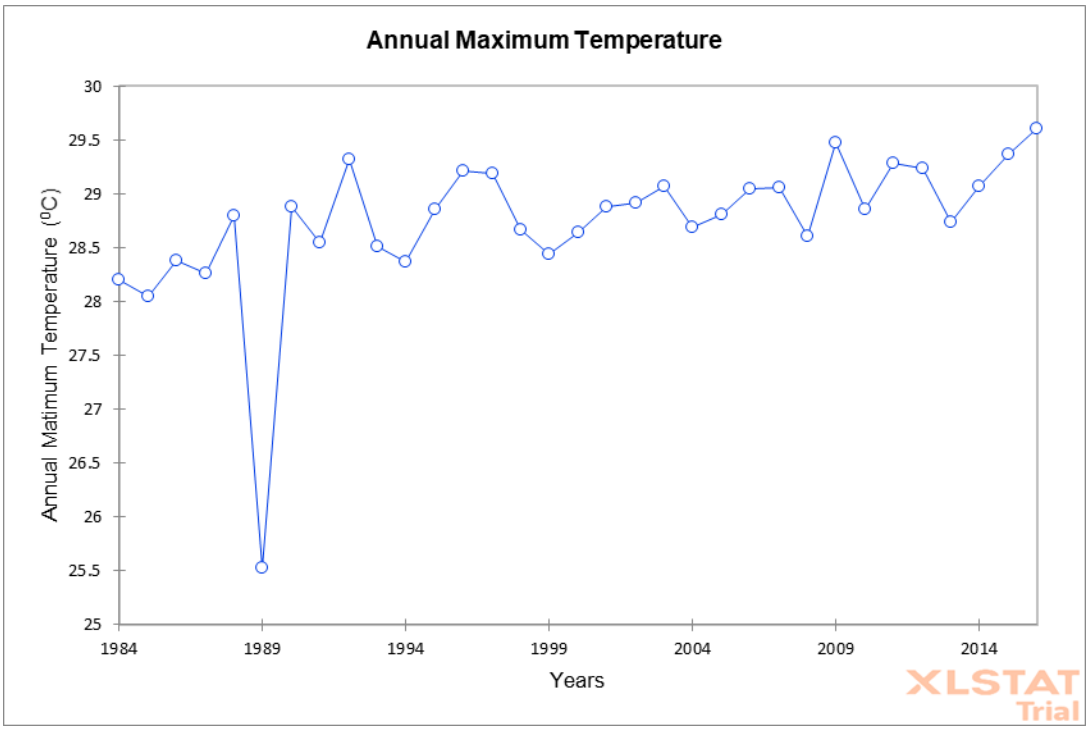
	p_value	significance level Alpha_value	Kendall's tau	Sen's slope estimates
Annual	0.005	0.001	0.342	3.000
	0.005	0.01	0.342*	3.000
	0.005	0.05	0.342*	3.000

*Significant trend at α = 0.05, ** Significant trend at α = 0.01, *** Significant trend at α = 0.001 and ns=non-significant.

As the computed p-value 0.005 is lower than the significance level alpha=0.01, and alpha=0.05 so, annual Rainfall of Harshin district is significant trend at α = 0.05 and significant trend at α = 0.01.

Variable	Annual
Annual rainfall trend (Mann-Kendall* Test stat)	0.342**

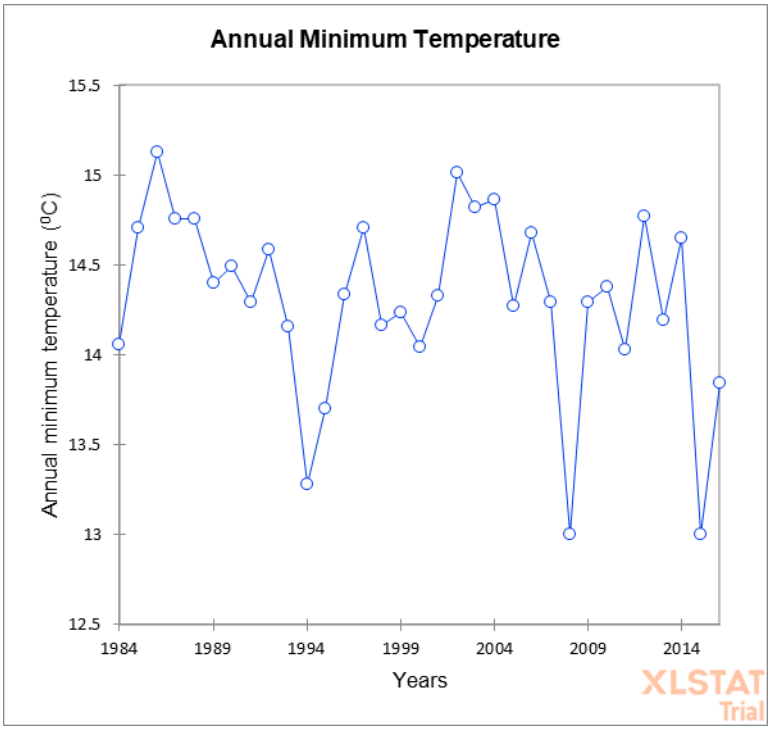
Appendix 3: Long-term Temperature trend, Mann-Kendall test statistic results



Annual	p_value	significance level Alpha_value	Kendall's tau	Sen's slope estimates
Tmax	< 0.0001	0.001	0.492*	0.032
	< 0.0001	0.01	0.492*	0.032
	< 0.0001	0.05	0.492*	0.032

*Significant trend at α = 0.05, ** Significant trend at α = 0.01, *** Significant trend at α = 0.001 and ns=non-significant.

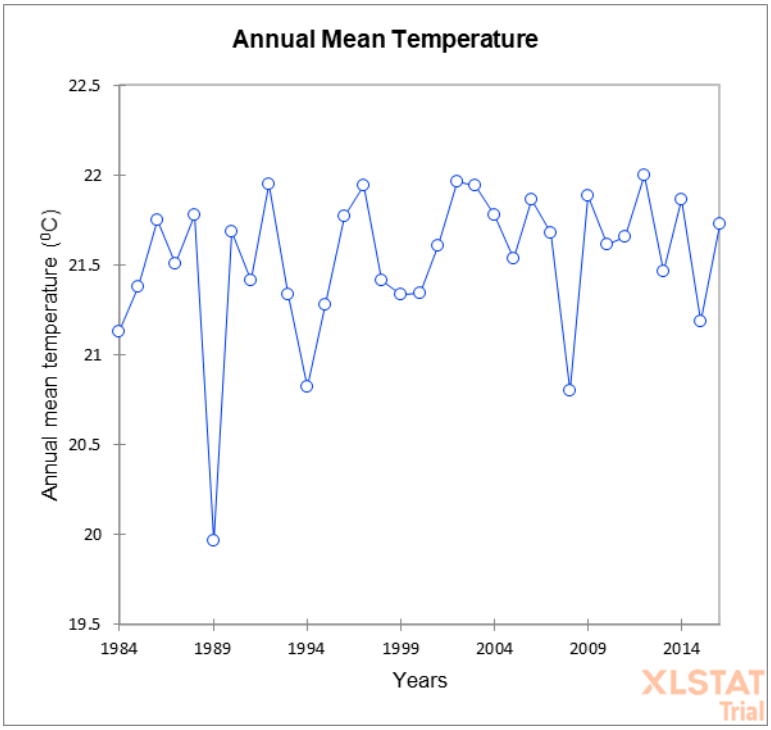
As the computed result of Annual Tmax **p-value = <0.0001** is **Lower than** the significance level **alpha value = 0.001**, the significance level **alpha = 0.01** and the significance level **alpha value = 0.05** so, Annual Maximum Temperature of Harshin district is significant trend at α = 0.001, 0.01 and 0.5.



Annual	p_value	significance level Alpha_value	Kendall's tau	Sen's slope estimates
Tmin	0.150	0.001	-0.178	-0.013
	0.150	0.01	-0.178	-0.013
	0.150	0.05	-0.178	-0.013

*Significant trend at α = 0.05, ** Significant trend at α = 0.01, *** Significant trend at α = 0.001 and ns=non-significant.

As the computed result of Tmin **p-value = 0.150** is **greater than** the significance level **alpha value = 0.001**, the significance level **alpha=0.01** and the significance level **alpha = 0.05** so, Minimum Temperature of Harshin district is not significant trend at α = 0.001, 0.01 and 0.05.



Annual	p_value	significance level Alpha_value	Kendall's tau	Sen's slope estimates
Tmean	0.178	0.001	0.167	0.009
	0.178	0.01	0.167	0.009
	0.178	0.05	0.167	0.009

*Significant trend at α = 0.05, ** Significant trend at α = 0.01, *** Significant trend at α = 0.001 and ns=non-significant.

As the computed result of Tmean **p-value = 0.178** is **greater than** the significance level **alpha value = 0.001**, the significance level **alpha=0.01** and the significance level **alpha = 0.05** so, Minimum Temperature of Harshin district is not significant trend at α = 0.001, 0.01 and 0.05.

Appendix 4. Pearson pair-wise correlation matrix was generated in STATA 14

```
pwcorr ccadplvpr Famsz HHHSex AgeHHH Ttlvhl tlinc HHeducSt AcVtSv AcCrtsv Acinfccipct Acwthinf
kdskadpt Drght Fldg Rfvr Lvdsob Hmdsob Crppsds Rs > bscf Perccvr Percceft , sig
```

	ccadplvpr	Famsz	HHHSex	AgeHHH	Ttlvhl	tlinc	Hheduc
ccadplvpr	.						
Famsz	.	1					
HHHSex	.	0.0405	1				
AgeHHH	.	0.3619	0.0348	1			
Ttlvhl	.	0.1029	0.0402	-0.0089	1		
tlinc	.	0.0089	0.2581	-0.0289	0.1557	1	
HHeducSt1i~2	.	-0.0613	-0.0057	-0.0225	-0.0943	-0.0311	1
AcVtSv	.	0.1358	0.0387	0.0844	0.0153	0.0989	0.1168
AcCrtsv	.	0.1177	0.1009	0.0576	0.1106	-0.208	0.066
Acinfccipc	.	-0.1132	0.1092	-0.003	-0.1109	0.1323	0.0574
Acwthinf	.	0.0637	-0.0223	0.0393	-0.0755	-0.054	-0.0145
kdskadpt	.	-0.0212	0.0145	0.0323	-0.0776	0.0919	-0.0029
Drght	.	0.0707	0.1969	0.0002	0.0232	0.0956	0.0351
Fldg	.	0.0252	-0.0747	0.0264	0.1147	-0.0827	-0.0059
Rfvr	.	-0.0958	0.0182	-0.0529	-0.0007	0.082	0.077
Lvdsob	.	0.0507	-0.0012	0.0114	0.0129	-0.038	-0.046
Hmdsob	.	0.0226	-0.016	-0.0431	0.0066	-0.0582	-0.0166
Crppsds	.	-0.3481	0.1145	-0.1349	-0.1792	0.1063	0.0924
Rsbscf	.	0.0831	-0.0423	0.0242	0.0478	0.0448	-0.0748
Perccvr	.	-0.1291	-0.0159	-0.0744	0.0853	-0.0152	-0.0221
Percceft	.	0.1132	-0.1092	0.003	0.1109	-0.1323	-0.0574
	AcVtSv	AcCrtsr	Acinfccipct	Acwthinf	kdskadpt	Drght	Fldg
AcVtSv	1						
AcCrtsv	-0.013	1					
Acinfccipct	0.2992	0.0172	1				
Acwthinf	0.3547	-0.0241	0.4196	1			
kdskadpt	0.0534	0.0131	0.0943	0.0633	1		
Drght	-0.0469	0.05	0.0292	-0.0054	0.0949	1	
Fldg	-0.0628	-0.0569	-0.0903	-0.0903	-0.1923	0.0172	1
Rfvr	0.0241	-0.0002	0.0255	0.103	0.2272	-0.0187	0.0378
Lvdsob	-0.1997	0.0263	-0.5234	-0.313	-0.0643	-0.0953	0.0063
Hmdsob	-0.0507	0.0086	-0.0151	0.1056	-0.0353	-0.0827	-0.0567
Crppsds	-0.1562	-0.0461	0.367	-0.2043	0.0649	0.0552	-0.0766
Rsbscf	-0.0457	0.0038	-0.1872	-0.1457	-0.0155	0.0373	0.0141

Perccvr	-0.3706	0.0021	-0.5608	-0.7	-0.0735	-0.0508	0.103
Percceft	-0.2992	-0.0172	-1	-0.4196	-0.0943	-0.0292	0.0903
	Rfvr	Lvdsob	Hmdsob	Crppsds	Rsbscf	Perccvr	Percceft
Rfvr	1						
Lvdsob	0.0221	1					
Hmdsob	-0.0427	0.0709	1				
Crppsds	0.0884	-0.1838	0.1165	1			
Rsbscf	-0.0846	0.1269	0.1102	-0.0954	1		
Perccvr	-0.0774	0.3071	-0.0719	0.1344	0.1655	1	
Percceft	-0.0255	0.5234	0.0151	-0.367	0.1872	0.5608	1