INDIRA GANDHI NATIONAL OPEN UNIVERSITY, SCHOOL OF CONTINUING EDUCATION

CLIMATE CHANGE INDUCED DROUGHT IMPACTS ON LIVESTOCK SECTOR AND COMMUNITIES ADAPTATION ACTIONS IN THE CASE OF HAMMER WOREDA, SOUTH OMO ZONE, SOUTHERN NATIONS NATIONALITIES AND PEOPLES REGION, ETHIOPIA.

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DECLARATION

I hereby declare that this thesis which is entitled as **"CLIMATE CHANGE INDUCED DROUGHT IMPACTS ON LIVESTOCK SECTOR AND COMMUNITIES ADAPTATION ACTIONS IN THE CASE OF HAMMER WOREDA, SOUTH OMO ZONE, SOUTHERN NATIONS NATIONALITIES AND PEOPLES REGION, ETHIOPIA."** Submitted for partial fulfilment of the requirements for the Masters of Arts in Rural Development to Indira Gandhi National Open University, (IGNOU) is the original work done by me under the supervision of Dr. Mulugeta Taye and this thesis has not been published or submitted elsewhere for the requirement of any course of study to the best of my knowledge and belief. Materials or ideas of other authors used in this thesis have been duly acknowledged and references are listed at the end of the main text.

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CERTIFICATE

This is to certify that, Mandefro Aynalem (DVM), a student of Master of Arts in Rural Development from Indira Gandhi National Open University, was working under my supervision and guidance for his project work for the course of MRDP 001. His project is entitled " **CLIMATE CHANGE INDUCED DROUGHT IMPACTS ON LIVESTOCK SECTOR AND COMMUNITIES ADAPTATION ACTIONS IN THE CASE OF HAMMER WOREDA, SOUTH OMO ZONE, SOUTHERN NATIONS NATIONALITIES AND PEOPLES REGION, ETHIOPIA."** which he is submitting, is his genuine and original work.

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ACRONYMS

CSA	Central Statistics Authority
CWD	Consecutive Wet Days
CDD	Consecutive Dry Days
DRM-ATF	Disaster Risk Management Agricultural Task Force
ETCCDI	Expert Team on Climate Change Detection and Indices
FAO	Food and Agricultural Organisation
FFP	Food for Peace
FEWS NET	Famine Early Warning Systems Network
FGD	Focus Group Discussion
GDP	Gross Domestic Products
HRD	Humanitarian Response Document
IONS	Institute of Noetic Science
IPCC	Intergovernmental Panel for Climate Change
ITCZ	Inter Tropical Convergence Zone
KII	Key Informant Interview
MEA	Millennium Ecosystem Assessment
NMA	National Meteorological Agency
NRC	National Research Council
NDD	Number of Dry Days

NWD	Number of Wet Days
SSA	Sub Saharan Africa
SST	Sea Surface Temperature
SNNPR	Southern Nations Nationalities and Peoples Region
SPSS	Statistical Package for Social Science
SRS	Simple Random Sampling
UNISDR	United Nation International Strategy for Disaster risk
UNOCHA	United Nation Office for Humanitarian Affair
USAID	United State Agency for International development
USGS	United States Geological Survey
USD	United State Dollar
WMO	World Metrological Organisation
WB	World Bank
WFP	World Food Programme

ABSTRACT

Climate change is predicted to have the main impact on agriculture dominated economy particularly in livestock based livelihood economy of the pastoral populations dwell in under-developed world and largely in Sub-Saharan Africa. To improve the knowledge in this respect and guide policy making for adequate and relevant adaptation strategies, 154 pastoralists were interviewed in three kebeles of Hammer Woreda, South Omo Zone, and SNNP Region. Pastoralists were asked both closed and open-ended questions about climate knowledge, perceived climate change, perceptions about temperature changes and variability in precipitation, coping strategy, adaptation strategies, loss and damage and the impact trend of climate change on their livelihood. According to the FGD and KII results, the rainfall in Hammer has become more erratic than before. Likewise, regardless of age groups, all the surveyed households (100%) have experienced changes in the climate and have characterised this change by late rain onset (97.4%, increased dry spell frequency (96.755), total amount of rain decrease (96.1%), early rain cessation (95.45%), decreased wet season duration (87.66), 97.4% felt increased number of hot days, and again 95.45% of respondents has said number of cold days has also decreased. On top of this, the Metrological Data it is apparent that both precipitation and temperature data computed at both station shown variable rainfall trend and for areal average, highest monthly rainfall variability (103.32%) and the lowest monthly rainfall variability (39.78%) was observed on July and April month, respectively. The highest rainfall variability has been observed in the month of July. Most of the observed extreme trends in temperature and precipitation did not show spatial coherence among stations within eco-environments and varied within stations with some showing opposite trends. As a result of increased weather variability of the study area, which matches with the communities' perception on the changing climate, the pastoralists faced significant loss and damage on their financial, natural and social capitals. To avert this, at risk communities have employed collective and individual adaptation and coping strategies. However, some of vital social coping capacity being eroded and at the same time the adaptation actions were seen marginally helping hard hit and disadvantaged communities group to the level it has been expected.

Key Words: Climate Change, Pastoralist Perceptions, Adaptation, Copping Strategy, Precipitation, and Temperature.

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CHAPTER ONE: INTRODUCTION

1.1. Background of the study

According to IPCC 2007 definition, climate change is a complex biophysical process and often hard to predict precisely the future climate conditions. Albeit this, the scientific consensus is the global land and sea temperatures are warming under the influence of greenhouse gases, and so expected to continue to warm regardless of human intervention at least for the next two decades (IPCC, 2007). Besides, widely it is recognized that the earth has been experiencing anthropogenic induced climate change and climate change induced extreme weather events for several years now (IPCC, 2014a). In an absolute sense, characteristics of extreme weather event vary from place to place. When a pattern of extreme weather persists for some time, such as a season, it may be classed as an extreme climate event, especially if it yields an average or total extreme e.g., drought or heavy rainfall over a season (IPCC, 2014a).

The period from 1880 to 2012 has already been reported that Global average surface temperature increase by 0.85 °C and very likely that temperature will sustain to increase in the coming decades (IPCC, 2014). Besides, the period from 1983 to 2012 was identified as the warmest 30-year period of the last 1400 years and the global average surface temperature exhibits substantial decadal and inter-annual variability, particularly in the post 1950 (IPCC, 2014). Climate variability refers to variations in the mean state and other statistics such as standard deviations, the occurrence of extremes, etc. of the climate on all spatial and temporal scales beyond that of individual weather events (IPCC, 2014). As a result of this, many changes happened in the earth's climate system by affecting the earth's hydrological cycle and global atmospheric circulation patterns. The general consensus is that warming of the planet is very likely to enhance the hydrological cycle, and this will cause changes in rainfall amount, frequency, magnitude, intensity, duration and rainfall seasons (Groisman et al., 2005). In consequence to this, extreme events such as heat wave, flooding, drought and related human and livestock diseases are affecting many communities in the world (IPCC, 2007a) and more specifically developing nations who predominantly depends its livelihood on rain fed agriculture (FAO, 2007).

Horn and East Africa is a region infamous due to its vulnerability to associated extreme and cyclical drought events. In consequence, the world has been making substantial effort to reduce impacts of extreme events through humanitarian and development aid for decades. In the area, multifaceted poverty has been further aggravated by wars and political instability and have caused the region to be an area where population are in constant need of external assistance. Moreover, climate change induced droughts events have become more frequent and severe during the past two decades (USGS, 2011). Hence, poverty and rural vulnerability to climate induced hazards are intimately linked (World Bank, 2010).

Extreme weather events like drought, can increase vulnerability of many people but more importantly of rural population (World Bank 2013a), particularly true for the communities who leads natural resource based livelihood strategy. Again, when this combined with lack of infrastructures and facilities cum with high levels of poverty create increased vulnerability in the face of all types of environmental change. Agricultural production and the biophysical, political and social systems that determine food security in Africa are expected to be under considerable additional stress by climate change (FAO, 2007). In many parts of Africa, particularly in Sub Saharan Region, it seems that warmer climates and changes in precipitation not only destabilise agricultural production but also undermine the systems that provide food security (Gregory et al., 2005).

Like other Horn and East African countries, Ethiopia has been also affected most by climate change due to the fact that significant portion of its population ca 80% predominant livelihood system is agriculture mainly relied on rain performances that is highly impacted by climate variability (FAO 2007). In the country, irrigated agriculture constitutes only 1.1 % of the total cultivated land (Bewket and Conway 2007) and so irrigation contribute only less than 3% of the current food production (Awulachew et al., 2005).

Close to 60% of the land in Ethiopia found in pastoral dominated livelihood system wherein it constitutes most vulnerable communities for climate driven hazards. Pastoral and agro-pastoral societies in the arid and semi-arid parts of Ethiopia are enduring a downward spiral of increasing poverty, food insecurity, and escalating instability (Little et al., 2010; Fratkin 2014). The situation is exacerbated by a lack of economic development and so remained heavily dependent on an increasingly unstable base of traditional livestock production system for their survival. In recent times, due to increased frequency of extreme weather events such as drought, it has been observed that livestock die more quickly, more regularly, and in larger numbers in this environment in response to dry or drought years compared to what was experienced in previous generations. As a result, the pastoral areas in Ethiopia are one of the most drought vulnerable areas with chronic food deficiencies. Moreover pastoralists in Ethiopia are the most marginalized social groups in terms of availability and access to public services. Education and human health services are very poor (Solomon et al., 2007).

Just to mention, between 1980 and 2000 the Borana and south Omo Zone have suffered with three major droughts in which pastoralists lost 35-67% of their livestock which commensurate a monetary value of hundreds of millions of USD (Desta & Coppock, 2002). In 2001-02 another drought hit followed by the 2005-06 drought. The 2005-06 drought chief impact has been livestock mortality, though severe impacts on human water supply were mentioned in many communities. Overall livestock losses of 50-75%, higher among cattle than other species, and higher in the more southerly woredas, were reported (Morton, 2007).

In Low land of Ethiopia, rainfall exhibits notable spatial and temporal variability (Hulme *et al.*, 2005). Repeated droughts resulted from changing climates badly affect the region around East and Horn African region. Each time when it occurs, claim the lives of several hundred thousands of people, e.g., 1973–1974 and 1982–1985 in Ethiopia (Beltrando and Camberlin, 1993). This depict that climate change is already impacting populations, livelihoods and ecosystems generally in Ethiopia and particularly study area, South Omo Zone Hammer Woreda. Recently, in 2016/17, 7.9 million people is being affected due to rain fall variability (HRD, 2017) and among the area affected most, Hamer Woreda is the one.

One of the poorest and most marginalized regions in Ethiopia include the Hammer District of the South Omo Zone. The people there are mostly pastoralists1 who live off the livestock they raise and they are semi-nomadic. The hammer tribe in a semi-arid2 region and is known to have little surface water.

1.2. Statement of the problem

Grazing areas have been reduced over the years because of continuous increase of livestock. Again, due to land degradation and other factors, available pasture is of poor quality and palatable fodder is being diminished due to extensive grazing. On the other hand, as opposed to huge number of livestock population, the yield obtained is very low due to low genetic potential associated with poor livestock management and veterinary services. This is arid rangeland zone in the basin of the Omo River and frequent rain failure has rendered the

1 Pastoralism is defined by a specialization to take advantage of the characteristic instability of rangeland environments. Through strategic mobility, pastoralism finds an asset in the existence of dynamic variability in the drylands, where sedentary agriculture or mixed farming find a problem in their lack of uniformity and stability.

2 Semi-arid is typically defined as areas with between 250 and 500 millimetres of annual precipitations.

population food insecure, and all wealth groups have received annual relief food amounting to 8-14% of annual food requirement (PDO, 2011).

Due to frequently occurring severe droughts, in conjunction with degradation of range land, certain people in the woreda are attempting to increase food production via opportunistic vegetable and cereal cultivation. However, efforts to this option seen bringing marginal impact complementing existing livestock dependent livelihood. These issues are magnified by the impact of climate change. In addition to under investment and improperly analyzed and implemented strategy has also increased this community vulnerability. The frequency and impact of drought shows increased trend in the area, reducing the availability of pasture and water. Increasing aridity has also had negative impacts on range land for the livestock. Moreover, rangeland degradation, increased occurrences and impacts of drought due to climate change is also forcing people to mitigate the effects of limited pasture and water availability i.e. food insecurity and loos of livelihoods, through different coping and adaptation mechanisms. Albeit to this, different observations has depicted that existing social assistances in pastoral communities at large and so in hammer tribes, which were in use as part of coping strategy, is deteriorating further.

To mitigate the impact of such malicious phenomena-drought, several efforts has been put in by community, government and other development and humanitarian actors through different plan and programme strategies. But, the current international scientific consensus is that recent global warming conditions, that drive and escalate changing climate, indicate a fairly stable long-term trend with natural variability of local climate inducing massive losses of livelihood assets (Hansen et al., 2012). As a result, the frequency and duration of priority climate induced hazard occurrences for this specific community will continue to grow up resulting deterioration of individual, household and communities' level assets particularly of pastoralists and agro pastoralists' livelihood system. The continued variability in local climate conditions and the underlying long-term trend towards changing climate makes it difficult for local people to discern, develop and undertake appropriate strategy to lessen their vulnerability to the impact of disasters.

In light of the above background, there are abysmally low studies in similar drought prone areas focusing on copping and adaptation strategies for climate induced hazards. Likewise, in the study area, where this research focuses on shows nearly complete absence of empirical study unearthing existing facts of climate change induced drought impacts on the livestock dominated livelihood system with and through in-depth analysis well-established by scientific evidence.

1.3. General Objective and Specific Objectives

Hence, **the general objective** of this research is to analyze impact of climate change on livestock sector stemming from rainfall variability and temperature rises in the study areas. Based on this, its **specific objectives** are illustrated in the below:

- ✓ To analyze trends of extreme rainfall and temperature indices in the study area.
- ✓ To assess the perceptions of local communities to climate change induced drought,
- ✓ To assess climate change induced drought losses and damage on the livestock sector in the hammer community.
- ✓ To explore tangible adaptation actions taken to lessen impacts of climate changes induced drought on livestock sector.

1.4. Research questions

The Researchable Issues dealt under this research are illustrated below:-

- What are the trends of extreme rainfall and temperature indices in the study area?
- What are the study communities' perception to climate change?

- What are climate change induced losses and damaged in the livestock sectors in the study area?
- What climate change adaptation mechanisms do the local communities have to anticipate, respond and absorb climate change induced drought impacts?

1.5. Scope and Limitations of the study

The research was carried out in line with recommended scientific procedures and methodologies set and agreed for such empirical research. The intention of this research was to elucidate the climate variability trend, communities' perceptions, loss and damage encountered by pastoralists and then to suggest way forwards to ameliorate the already felt and anticipated impacts of climate change driven drought. Rainfall in arid and semi-arid areas is very local by nature. Local spatial dynamics will not be elaborated in this paper as current meteorological observations are too sparse for meaningful analysis. Besides, missing records of observed climate data was also the other limitation faced during the analysis. Hence, compared meteorological trends with pastoralists' perceptions and assume that verification across both indicates "correctness". Lastly, it is important to be aware of language barriers and semantics, as many nuances may be lost in translation (both between sociolects and ethnic languages).

1.6. Definition of concepts and Terms

1.6.1. Concepts of drought

For the purpose of this research drought defined as a recurrent extreme climate event that occurs over land characterized by below-normal precipitation over a period of months to years (Dai, 2011). Likewise, IPCC (2000a) is also drawn drought as a period of abnormally dry weather long enough to cause a serious hydrological imbalance. Thus, it is a hazard of nature that occurs in virtually all climate zones, although its characteristics vary significantly from one region to another. By IPCC (2014), hazard is also explained distinctly as a potential occurrence of a natural or human-induced physical event or trend or physical impact that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems and environmental resources. Drought is often classified into three types: meteorological, agricultural and hydrological. Meteorological drought is a period of months to years with below-normal precipitation. It is often accompanied with above-normal temperatures, and precedes and causes other types of droughts. Meteorological drought is caused by persistent anomalies (e.g., high pressure) in large-scale atmospheric circulation patterns, which are often triggered by anomalous tropical sea surface temperatures (SSTs) or other remote conditions. And hence, this can induce agricultural drought resulted from dry soils due to below-average precipitation, intense but less frequent rain events, or above-normal evaporation, all of which lead to reduced pasture availability and plant growth. Hydrological drought on the other hand occurs when river streamflow and water storages in aquifers, lakes, or reservoirs fall below long-term mean levels. Hydrological drought develops more slowly because it involves stored water that is depleted but not replenished (Dai, 2011). A lack of precipitation often triggers agricultural and hydrological droughts. Moreover, global warming become another driver for drought development and severity as a consequence of water loss by evaporation and transpiration (Vicente-Serrano et al., 2010; Dai 2011).

1.6.2. Terms used in the Study

- ***Climate*** in a narrow sense is usually defined as the average weather, or more rigorously, as the statistical description in terms of the mean and variability of relevant quantities over a period of time ranging from months to thousands or millions of years. The classical period for averaging these variables is 30 years, as defined by the World Meteorological Organization.

- **Climate change** refers to long term fluctuations of temperature, precipitation, wind and other elements of Earth's climate system. It is a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global and/or regional atmosphere. Natural climate variability observed over comparable time periods in the types of changes of temperature and rainfall. It occurs because of internal variability within the climate system and external factors (IPCC, 2013a).

- ***Weather***: Is a short-term phenomenon, describing atmosphere, daily air temperature, pressure, humidity, wind speed, and participation. (IPCC, 2007).

- ***Climate variability***: refers to variations in the mean state and other statistics (such as standard deviations, the occurrence of extremes, etc.) of the climate on all spatial and temporal scales beyond that of individual weather events (IPCC, 2014).

- ***Extreme Weather Event***: is an event that is rare at a particular place and time of year. Definitions of rare vary, but an extreme weather event would normally be as rare as or rarer than the 10th or 90th percentile of a probability density function estimated from observations. By definition, the characteristics of what is called extreme weather may vary from place to place in an absolute sense. When a pattern of extreme weather persists for some time, such as a season, it may be classed as an extreme climate event, especially if it yields an average or total that is itself extreme (e.g., drought or heavy rainfall over a season (IPCC, 2014a).

- ***Vulnerability***: the propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt (IPCC, 2014).

- ***Mitigation***: An anthropogenic intervention to reduce the sources or enhance the sinks of greenhouse gases (IPCC, 2001a).

- ***Disaster risk reduction***: according to UNISDR, is the concept and practice of reducing disaster risks through systematic efforts to analyze and reduce the causal factors of disasters through reducing exposure to hazards, lessening vulnerability of people and property, wise management of land and the environment, and improving preparedness and early warning for adverse events are all examples of disaster risk reduction.

- ***Adaptive Capacity***: The ability of systems, institutions, humans and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences (MEA, 2005).

- ***Resilience;*** the capacity of social, economic and environmental systems to cope with a hazardous event or trend or disturbance, responding or reorganizing in ways that maintain their essential function, identity and structure, while also maintaining the capacity for adaptation, learning and transformation (Arctic Council, 2013).

- ***Risk***: the potential for consequences where something of value is at stake and where the outcome is uncertain, recognizing the diversity of values. Risk is often represented as probability or likelihood of occurrence of hazardous events or trends multiplied by the impacts if these events or trends occur. (IPCC, 2014).

CHAPTER TWO: LITERATURE REVIEW

2.1. Global climate change: An overview

Changes in extreme weather and climate events have significant impacts and are among the most serious challenges to society in coping with a changing climate (IPCC, 2001). According to the International Panel on Climate Change (IPCC, 2007), most of the observed increase in global average temperatures since the mid-twentieth century is very likely due to the observed increase in anthropogenic greenhouse gas concentrations. Discernible human influences now extend to other aspects of climate, including ocean warming, continental-average temperatures, temperature extremes, and wind patterns (IPCC, 2007). Evidence that human influence is affecting many aspects of the hydrological cycle on global and even regional scales is now accumulating (Santer et al., 2007; Min et al., 2008; Barnett et al., 2008; Milly et al., 2008). These changes in mean state inevitably affect extremes. Moreover, the extremes themselves may be changing in such a way as to cause changes that are larger than would simply result from a shift of variability to a higher range (Hegerl et al., 2004; IPCC, 2007; Kharin et al., 2007).

The climate is becoming more variable and less predictable, and trends towards future changes are emerging. Global climate models predict changes over the longer term – increased temperature, shifts in rainy seasons, intense rains over much of East Africa – which will result in a mosaic of changing climate conditions with serious implications to pastoral livelihood system. Hence, this seriously aggravate the impacts of current challenges in the pastoral areas. Of all, the natural resource-based land uses in the drylands continue to affect more pastoralists within the context of wide rainfall variability and unpredictability (Magda et al., 2009). To deal with this, pastoralists employ various coping strategies. However, seen increasingly less able to do so, and more pastoralists are losing their livestock assets which is their main livelihood (Kinyangi et al., 2008). The substantial and unpredictable differences in total rainfall between years, within a year and even between areas, the climate of the drylands is also characterised by scarce absolute rainfall. High temperatures during rainy seasons ensure that much of the rainfall is lost in evaporation, and intense downpours ensure that water runs off in floods (Anderson et al., 2008).

IPCC (2007) reports produced based on instrumental series indicated that number of observed changes in extremes over the past several decades. In recent decades, most land areas of the world have experienced fewer cold days/nights (and frost days) and more hot days/nights (and heatwaves). Heavy precipitation events have increased over most areas, leading to a larger proportion of annual total rainfall from heavy falls. The area affected by droughts has increased in many regions since 1970. Over the same period, the intensity and lifetime of tropical cyclones have increased, with no trend in frequency. The incidence of extreme high sea level (storm surges and extreme wave heights) has increased (WMO, 2009).

2.2. Climate change in Sub Saharan Africa

The IPCC’s Fourth Assessment Report Scientific Basis has collated strong scientific evidence to show seasonal annual mean warming of Africa, though few studies actually manage to quantify significant linear trends in rainfall (Cheung et al., 2008). Outputs, such as the Intergovernmental Panel on Climate Change (IPCC) reports, show that for many parts of Africa the exposure to new climatic conditions is projected to reach beyond previously experienced extreme events (Boko et al., 2007). As more than 95% of sub-Saharan African agriculture is rain fed, the impacts are felt particularly by those who directly depend on reliable weather patterns for a livelihood, and where crop cultivation is already on the threshold, small variations will be more noticeable (Tadross et al., 2009). Climate impacts are often based on crop-model simulations run for biophysical adaptations to water and temperature stress while assuming farmers as either doing none or full adaptation (Challinor et al., 2010).

Due to climate driven calamities and others, Sub- Saharan Africa (SSA) is among the poorest places on Earth with 441 million people living below the poverty line (WB, 2013a). Many of these people live in countries where governments lack the resources-to mitigate and adapt the impacts of climate change, inexperience, political instability, or lack of institutions to effect long-term structural change to bring their people out of poverty (WB, 2013a). The World Food Programme estimates that $3.2 billion is needed per year to reach all 66 million hungry school-age children and nearly half of the deaths of children under five on a global basis are a result of poor nutrition (WFP, 2013) and the same report has indicated that climate change is a huge impediment to solving global hunger and beyond it threatens any gains made against hunger over the past two decades.

2.3. Agriculture Dominated Economy of Ethiopia

Ethiopia is among those countries most vulnerable to climate risks in Africa (IPCC, 2007). Agriculture in Ethiopia is heavily dependent on rain. Its geographical location and topography, plus a low adaptive capacity, make the country highly vulnerable to the adverse impacts of climate change. The country is one of the most food insecure nations in the world, a situation compounded by cyclical droughts and other calamities. Agriculture is the largest sector in the Ethiopian economy, accounting for about 41% of GDP and employing over 80% of the labour force (MEDaC, 1999). Pastoralism is a livelihood practiced mainly in the low land area. In Ethiopia, pastoralists and agro pastoralists compose nearly 13 percent of the population and traditionally have ranged across up to 60 percent of the land in search of pasture, water, and saltlicks for livestock. And totally, they depends on rained for pasture generation and water to their livestock dominated economy. Besides, of the 4.3 million hectares of potentially irrigable agricultural land, less than 10 percent is currently farmed. The farming or agrarian sector is dominated by smallholder farmers generating about 90 percent of agricultural output (Adenew, 2006). Ethiopian agriculture is predominantly characterized by traditional methods of farming and livestock keeping with very little change in practice over the past few centuries.

2.4. Climate Change in Pastoral Community of Ethiopia

In pastoral community of Ethiopia, climate change, as well as overgrazing and population growth, has reduced the amount of land available for pasture. The pressures on the system from high stocking rates for cattle in a shrinking geographical area have resulted in overgrazing and bush encroachment (Coppock et al. 2008; Kamara, Swallow, and Kirk 2004). Additionally, due to meteorological drought conditions caused huge livestock losses due to death and the pressure to sell animals during droughts to generate money to buy food. In 2017 South Eastern Ethiopia drought event only 384,000 and 124,867 heads of livestock has been reported dead in Borena Zone and South Omo Zone alone (PDO, 2017). Likewise, according to Disaster Risk Management Agricultural Task Force (DRM-TF) of South Omo Multi-Agency Assessment of 2017 indicated that, as of March 2017, in Hammer district 52,442 livestock have reported dead and 40,994 people has also found facing acute food insecurity. During droughts there is a high death rate for cattle estimated at over 50 percent of the total herd (Desta and Coppock 2002). The high death loss in the times of drought is not from a lack of water as much as it is from lack of forage (Coppock 1994; Hogg 1997). The pastoral system is in constant danger of overstocking and suffering a system crash when drought events occur (Brigham Forrest, 2014).

In this year, due to drought event in Ethiopia triggered by La Nina cyclical weather phenomenon, 1.259 billion $ has been requested to save lives from sufferings as well as to protect key livelihood assets of the communities through multiple assistances (HRD, 2017). The area affected by this phenomena most is livestock dominated livelihood systems i.e.

pastoralists and agro pastoralists (FAO, 2017).To lessens the impacts of hunger resulted from many confounding factors which further heightened by climate change driven recurrent droughts, Ethiopia became a country that has continued to receive a large amount of development aid over the past two decades, with a good portion of this aid coming in the form of food aid and to mention, The United States alone contributed $235 million USD in food aid to Ethiopia in 2013 through their Food for Peace (FFP) program (USAID 2013a) and this figure has never show declining trend due to countries vulnerability to recurrent drought as well as many has fall into chronic poverty.

According to FEWS Net East Africa Special report of 13 July 2017, poor belg rains affected household food security across belg-dependent woredas of Somali, Oromia and SNNP regions including study woreda i.e. Hammer. As a result, Southern and eastern Ethiopia continue to battle the impact of the Indian Ocean Dipole-induced drought, exacerbated by disease outbreaks, large scale loss of livelihood assets and displacement. The start of the March to June 2017 rains was delayed by 10 to 40 days across the region and cumulative totals of rain between March 1 and May 31 were less than 70 percent of average in much of southeastern and southern Ethiopia. To put the severity of this drought into perspective, rainfall totals between June 2016 and May 2017 were the first or second lowest in the past 36 years in many areas, including in Southern and South Eastern Ethiopia (FEWS NET, 2017).

2.5. Impact of Climate Change on Agriculture-Crop and Livestock

Nearly all the literature agrees that climate change and climate variability have already and will continue to impact global agriculture. The consensus in the literature was that the change in water availability and average temperature resulting from climate change will continue affecting agricultural production both crop and livestock and that tropical regions, where some of the poorest countries in the world exist, will be the regions most impacted (Kurukulasuriya and Rosenthal 2003). According to the IPCC's Fifth Assessment Report, changes in the climate over the last 30 years have already reduced global agricultural production by 1 – 5 % per decade relative to a baseline without climate change. In addition, recent studies indicate that even a 2 degrees increase in global temperature will affect agricultural productivity, particularly in the tropics, and this impact will rise with increases in temperature (Danish D et al., 2015). Increases in maximum temperatures can lead to severe yield reductions and reproductive failure; in a crop such as maize, for example, each degree day spent above 30 °C can reduce yield by 1.7% under drought conditions (Lobell et al., 2011).

Unlike for cropping systems, there is currently only limited evidence for recent impacts on livestock systems (Porter et al., 2014). For future impacts, projections indicate widespread negative impacts on forage quality and thus on livestock productivity in both high and low latitudes. In much of Africa, where many millions of smallholder farmers on livestock-based systems, this will have cascading impacts on incomes and food security. The negative effects of increased temperature on feed intake, reproduction and performance across the range of livestock species are reasonably well understood (Porter et al., 2014). Livestock are a critically important risk management resource; for about 170 million poor people in sub-Saharan Africa, livestock may be one of their very few assets (Robinson et al., 2010). For livestock, most species have perform best at temperatures between 10 and 30 °C, and at temperatures above 30 ºC, cattle, sheep, goats, pig and chickens all reduce their feed intake 3-5% for each 1°C increase (NRC, 1981). An increase in average temperatures was identified as only part of the problem arising from climate change. What was more concerning was the changing frequency and variability of temperature and rainfall (Brigham Forrest, 2014). Future projected changes in Aboveground Net Primary Productivity (ANPP) in Africa's rangelands during the present century are shown for two future emissions pathways: intermediate and high-end. ANPP and livestock production, productivity and profitability are closely linked (Moore and Ghahramani, 2013). The spatial distribution of percentage change in ANPP production by the 2050s for the case of high-end emissions are explored in relation to the mean value of 1971-1980. Accordingly, changes on the availability and quality of feed and water are anticipated that aggravate existing risks associated with extreme events to livestock based livelihood systems. Besides, changes in the balance between herbs and shrubs could provide important insights into changes in suitability of the rangelands for different types of animals e.g., browsers versus grazers (Thornton PK et al., 2015)

2.6. Perception on Climate Change and Observed Weather variability

Pastoralists' perception of climate change generally in the pastoral dominated region of the country and specifically in Southern part is found to be very consistent with the actually recorded trends of increased temperature and the evident secular declines in precipitation. Not only long-term declines, trends in the region's rainfall also appear to have taken a shift towards the direction of more unpredictability.

An apparent need for aligning perceptions and meteorological observations is the frequently stated indication of climate variability and/or change: the "increase in *erratic* rainfall" (Jennings and Magrath, 2009). "Erratic" seems more commonly used by practitioners (possibly citing farmers/pastoralists) and only a few scientists have attempted to quantify what is meant by "erratic" using methods such as coefficient of variation (Parida and Moalafhi, 2008), or associating erratic rainfall with periodic atmospheric phenomena such as El Niño (Tadross et al. 2009). Evidence from farmers' across Africa links the changes in climatic patterns, in particular increase in rainfall variability, with impacts on crop production, e.g. plummeting crop production in Botswana 1982-85 (Parida and Moalafhi, 2008) and teff cultivation in Ethiopia (Rosell and Holmer, 2007). Mongolian herders characterised changes in a number of rainfall markers, such as onset, droughts, patchy rainfall, timing, seasonality, frequency and intensity, not all could be verified with nearby meteorological observations (Marin, 2010).

Climate change has already altered the mean, variability and extremes of relevant weather variables, and climate models project that these changes will continue. New infrastructure and the new development strategy should be designed on the basis of both historical information on changes in extremes and projected future changes. The maximum value of a particular variable in the historical record can no longer be regarded as the normative value for design. Analogously, WMO recommends the use of operational normal values in addition to classic 30-year normal values for prediction (Trewin, 2007).

The natural variability is high, and although rainfall commonly exhibits cyclic patterns, traditional statistical models often fail to capture this within the noise of natural variability (Mongi et al., 2010). Some studies using spatially aggregated data analyses have demonstrated significant trends over recent decades, typically with trend breaks in the 1980s. For example, mapping a wide range of meteorological data (Funk et al., 2008) find that ten countries in East and Southern Africa had declining growing season rainfall between 1979 and 2005. Using 134 time-series points from meteorological stations in Ethiopia, another study finds a rainfall decline during June-September between 1960 and 2002 (Cheung et al., 2008). Similarly, there is evidence from Botswana of a decrease in rainfall since 1981 (Parida and Moalafhi, 2008) and a decrease in the number of rainy days during 1975-2005 (Batisani and Yarnal, 2009). However, changes in intensity and seasonality are more statistically significant than changes in annual total rainfall, at least in South Africa (Boko et al., 2007).

Ingram et al., (2002) found that rainfall variability in the Sahel-Sudan region of western Africa could be correlated with sea-surface temperature, while East African rainfall is associated with the movements of the Inter-Tropical Convergence Zone (ITCZ) during the “long rains” in

March-May (Mugalavai et al., 2008) and declining rainfall in East and Southern Africa has been linked with warming of the Indian Ocean (Funk et al., 2008). Using historical documents from the Nash, Kalahari and Endfield (2008) showed that droughts have been associated with post-El Niño-Southern Oscillation (ENSO) years at least since the 19th century.

Marin (2010) argues that indigenous knowledge provides a necessary complementary spatial scale of analysis of climate change to those offered by meteorological stations and general circulation models. So-called participatory methods can be used for enhancing farmers' capacities to perceive and interpret weather signs. For example, crop model simulations have shown that "false onsets" may be due to failure to distinguish local rainfall from the large-scale onsets, hence farmers could obtain higher yields by postponing planting (Marteau et al., 2011). Moreover, Patt & Gwatha (2002) find that farmers who received training and feedback are more successful in interpreting and responding to the information than those who simply received one-way weather forecasts. Their work draws attention to the need for shared interpretations of weather and tools to characterise changes (Newsham and Thomas, 2011).

2.7. Pastoralists Coping and Adaptation Mechanisms for Changing Climate

During droughts pastoralist households as a coping strategy employ forced livestock sell to meet family needs for cash income, which is used to buy food grains and to satisfy immediate non-food items like industrial products such as clothing. The pastoralists' forced supply is constrained by their inability to plan sales in accordance with market need (time and quality) (Belachew and Jemberu, 2003). Often, the livestock sold are that do not die at a higher rate than desired in order to buy grain to offset the energy loss resulting from poor milk production. The traditional pastoralist society is unable to manage the impact of the frequency of droughts as is evident by the loss of livestock, famine risk, and growing poverty that occur during droughts (Coppock, 1994). The market price of grain during droughts rises while the market price for cattle declines. As a result, during droughts the net energy derived from an animal (milk and income to purchase grain) is reduced (Coppock, 1994). Livestock marketing operations are generally small-scale family businesses. The live animals are either transported in trucks or herded over long distances to feedlot operators, export abattoirs, or major markets. These final market destinations are far away from supply sources, and the transportation costs associated with getting live animals to markets can result in significant weight loss and even death; stock routes are characterized by lack of adequate feed, water, and resting places. It can be argued that the long supply channels lead to high costs and reduce the competitiveness of live animal or meat exports (Eyob and Zewdu, 2016).

There is a wide range of possible adaption options for livestock keepers, from the genetic selection of robust animals to adaptive management of resources and diversity at farm level and income insurance and market development. Table 4 is from a recent review to evaluate the range of adaptation options for livestock systems (Thornton and Herrero, 2014). No options stand out that have high potential for enhancing food security and addressing resilience, diversification or risk management, that do not also have constraints to their adoption: their feasibility will depend on local conditions and their implementation will incur costs. Further, no options stand out that have strong impacts on increasing resilience of households, suggesting that there are limits to what can be achieved in increasing resilience through livestock management (Thornton PK et al., 2015). The importance of the policy and enabling environment with respect to adaptation is clear, but identifying the bounds of what endogenous adaptation can achieve in relation to incomes and food security in livestock systems is critical for informing national policy debates. Accordingly, the capacity of pastoralists to respond to observed and perceived drought due to changing climate is often constrained by a lack of investments and policy integration, which can exacerbate existing problems and reduce further adaptation options (Fazey et al., 2010).

Perception is a necessary prerequisite for adaptation (Madisson, 2007, p. 22), the demand for adaptation policies that acknowledge local contexts is rising (Jennings and Magrath, 2009) from both donor and local communities. These communities are becoming increasingly aware that both top-down and bottom-up approaches, each on its own, will overlook whether there is a common understanding among stakeholders of *what* aspect of climate (exposure) is changing, or *how* it is changing. This development require tools that can mix indigenous and scientific knowledge to better illustrate local perceptions of change (Newsham and Thomas, 2011).

Ethiopia provides a clear example of how droughts are only are the final trigger while structural and institutional failures are the main cause of famines (Devereux, 2009). The drivers of droughts are context-specific, often interlinked and act over different time scales.

Pastoralist communities are generally expected to be among the most affected groups, and hence will need access to resources and services that help them cope with impending catastrophic shocks, protect their livelihood assets and increase their resilience (Aklilu et al., 2008). Pastoralists are thought to be natural adaptors provided that they are free from negative external interference and are able to inhabit an enabling policy environment of suitable support services (Nori et al., 2015). Pastoral adaptations and climate-induced innovative coping mechanisms are strategically embedded in the indigenous social structures and resource management value systems (Birk et al., 2015). However, the case of global climate change, expressed in terms of increased temperature and shifts in patterns of precipitation, is a new challenge to the world of pastoralism. The possible negative welfare effect of global climate change is an added dimension to the already prevailing crisis in the pastoral livelihood system, which is substantially driven by non-climatic factors of internal and external pressures of change such as population growth, bad governance and shrinking rangeland areas lost to competing activities (Pavanello. S, 2009). Pastoralist response in this case is based on an adoption of a variety of strategies. 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 (Wassie and Fikadu, 2015). The poorest and marginalized communities are especially the most vulnerable group within developing countries due to their very limited ability to embrace adaptive choices (Thomas et al., 2015). Many livestock adaptation changes are likely to involve transformation of pastoralists' livelihood. Recent examples of such transitions include the adoption of camels and goats in addition to, or as a replacement for, cattle in drylands as a result of changing drought frequency and declining feed availability (Jones and Thornton, 2009). However, the recently increasing prohibitive cost of adoption of drought impact reduction strategies through livelihood diversification mechanisms including drought tolerant species (camel and goat) implies that it is only the wealthy households that can more productively diversify the composition of their herd species portfolios as well as relationship between local rainfall conditions and the level of household adaptation actions rather largely indicates the observed less in the pastoral community. Even their herd portfolio are predominantly characterized by small ruminant production in addition to cattle. A policy stance that ignores the detrimental impacts of the currently pervasive private rangeland enclosures or intends to hasten pastoralist sedentarization in the area is simply untenable in the present context of climate-induced drought risks and pastoral livelihood vulnerability (Wassie and Fikadu, 2015).

The expected future trend is that the prevailing long-term declines in average rainfalls in in many pastoral livelihood would generally imply the adoption of drought adaptation strategies like drought tolerant livestock species such as camel and natural resources enhancement mechanisms like range land reclamation, water harvesting as well as livelihood diversification options looks very low, albeit the increasing restrictive pressure of soaring adaptation costs. The current status in camel holding is partly influenced by the experience of past tradition and the often observed location-specific predominance of camel adoption, which, in addition to the particular case of suitability of existing range ecology, is substantially shaped by the degree of exposure to the breeding practices and experience of other adjacent camel rearing pastoral groups in the area (Desta et al., 2008).

Institutional support mechanisms such as rural credit access and regular extension visits appear to have no effect on pastoral household choice of the selected adaptation measures. This suggests, at least, the partial ineffectiveness of these institutions in southern Ethiopian rangelands. Perhaps, except for the human health programs, the existing extension services are largely less development-oriented at the household level. Consistent with the fairly observed recent recommendations by some governmental and non-governmental agents for household stockpiling of hay required to minimize the problem of feed shortages encountered during dry periods. However, private rangeland enclosures for this purpose may significantly imply negative repercussions due to the inbuilt incompatibility of this measure with the more ecologically sound broad strategy of extensive pastoralism on communal pasturelands in dryland ecosystems. The previously discussed remaining strategies of pastoralists increasingly resorting to low-return activity engagements are generally related to the tendency of dropping out of pastoralism (Berhanu et al., 2007).

CHAPTER THREE: METHODOLOGY

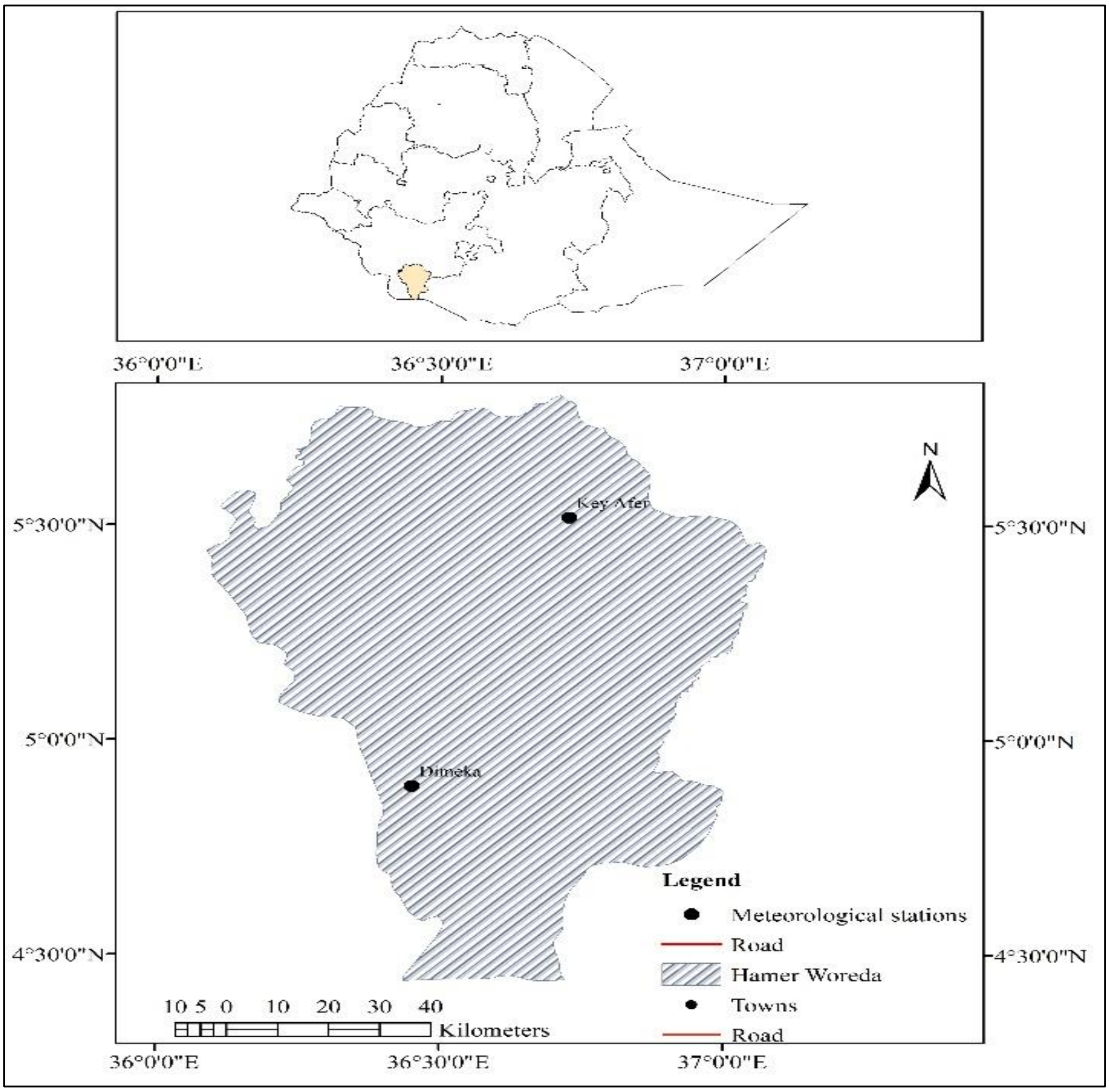
3.1. Study Area Description

Southern Nations Nationalities and Peoples Region (SNNPR) is one of the nine administrative regions of the Federal Democratic Republic of Ethiopia (FDRE). The SNNPR borders Kenya to the south (including a small part of Lake Turkana), the Ilemi Triangle to the southwest, South Sudan to the west, the Ethiopian region of Gambella to the northwest, and the Ethiopian region of Oromia to the north and east. The region has a total of 112,000 Square Kilometer which is about 10% of the total land masses of the country. It has a total of 112 woredas occupying the most part of Southwest corridors and it extends west from the Rift Valley as it runs through southern Ethiopia. The population size is assumed one-fifth of the country's population-18-20 million depending on growth assumptions for the decade since the last full census (CSA 2007). The region has both highland and low land areas. The main lowland areas stretch to the south-west and west, mainly in South Omo and Bench Maji Administrative Zones, and with relatively high temperatures and low rainfall with a particular scene of agro-pastoralism. Except the northern part of South Omo Zone which has mixed and broad leaf covered forest, the Zone is covered with open grasslands and bushes which was traditionally a grazing ground – settled agriculture is a recent phenomenon. The area is dominated with Pastoral Livelihood system, very remote and livestock-dependent, inhabited by far greatest number of ethnic and language groups and accordingly 16 ethnic tribes assumed to be there. The Hamar are the largest of five pastoral groups who inhabit the area. Rainfall pattern is bimodal and the longest season starts from Mid-March to May and the shortest rainy season also commences on September to ends on November. The lowland areas such as the Hamer rangeland receive annual rain fall equivalent to 601mm (adopted from CSA, 2007). This is a low rainfall area at the best of times, and erratic rains and periodic drought in recent years have affected both crop production and the condition of livestock. As they are pastoralist, wealth is particularly gauged by livestock ownership. Due to many socio economic factors, the pastoral communities keep large population of livestock. Grazing areas have been reduced over the years because of continuous increase of livestock. The available pasture is of poor quality and palatable fodder is being diminished due to extensive grazing. On the other hand as opposed to huge number of livestock population, the yield obtained is very low due to low genetic potential associated with poor livestock management and veterinary services. The bulk of their diet is grain purchased from market; milk, meat and blood (siphoned from live cattle) are an important element. This is arid rangeland zone in the basin of the Omo River and frequent rain failure has rendered the population food insecure, and all wealth groups have received annual relief food amounting to 8-14% of annual food requirement.

3.1.1. Biophysical Feature of Hammer Woreda

The Hamer are a tribal people in southwestern Ethiopia. They live in Hamer woreda/district, a fertile part of the Omo River valley, in the South Omo Zone of the Southern Nations, Nationalities, and Peoples Region. The hammer are largely pastoralists and place a significant value on cattle. Based on the 2007 census the Central Statistical Authority estimated the population of the Hammer language speakers at 70,816. Hamer has 35 rural and urban peasant associations/kebeles. The average density of 3-10 persons per km (CSA 2007).The average family size for the woreda is 5 persons per household. Hence, the number of household is in Hamer is estimated to be 14,163. The number of households per Kebele is nearly 404.

Figure 1: Study are Map-Hammer woreda of Southern Nations and Nationalities



3.2. Sampling and sampling procedure

For the study, Hammer woreda was selected and sampled purposefully based on the fact that the Hammer is priority one hot spot woreda[3], its inaccessibility as well as due to comprehended lack of similar researches that is empirically evidenced. Thus, used as a geographic unit for both primary and secondary data. In order to collect a robust data needed to achieve the objectives of the research, simple random sampling (SRS) was employed to select three kebeles

[3] Priority one hot spot woreda is areas or population affected by hazards which have direct impact on food security, nutrition and livelihood. The level is classified in priory one (Very Severe), two (Severe) and three (Moderate).

from pastoral livelihood system in such a way that the kebeles can represent the sampled woreda given that study kebeles has relatively similar agro-ecological and livelihood systems.

3.3. Data Sources and Collection Methods

Four sets of primary data namely: socio-economic profile of respondent household as well as climate change perception, coping and adaptation strategies, access to climate information, impact trends, encountered loss and damages on livestock due to climate change were collected. Besides, daily time scale rainfall and temperature data sets was also collected for dense network stations available in the proposed study site of long record length of 30 years were procured and obtained from National Meteorological Agency of Ethiopia. Focus Group Discussion (FGD) and Key Informant Interview (KII) to supplement the household data was also gathered from communities and experts, respectively. In addition to direct observation, the study has also employed secondary data sources from government records, policies and strategies and also from scientific and academic journals has also been revisited and used,

A household survey was conducted from late July 2017 to 5 September 2017 where 154 pastoralists were randomly sampled from the three Kebele population master list of Dimeka Zuria, Besheda and Dembaite of Hammer Woreda with latitude 4 to 5 Degree of North and longitude between 36 to 37 degree of East of the SNNPR region in Ethiopia. For determining the sample size, a given table developed by Krejcie & Morgan (1970) was used. The non-available respondents at the time of interviews had been replaced with the next neighbour households from master lists. Semi structured questionnaires were used to investigate whether pastoralists had noticed impacts of long-term changes in temperature and rainfall to the livestock dominated livelihood economy and in turn their adaptation and coping response. A total of 154 randomly sampled pastoralists were interviewed using a structured questionnaire with closed and open ended questions (Bryman, 2008). Research objectives and theory informed the kind of data collection methods used while research questions influenced the type and content of questions used in this study. Information to be collected was characterised in three categories in accordance to Newing (2011) being: basic characteristic of respondents; information on knowledge (memories and experiences regarding climate changes) and information on behaviour (adaptation and coping mechanisms). Beyond this, loss and damage encountered due to climate change induced drought has also been included in household survey. The household level information was collected with trained and hired enumerator via Kobo Collect tool which was designed collaboratively by both Harvard University and UNOCHA.

To augment information's obtained from household interview, semi structured open questions were employed to community groups discussion identified for focus group discussions and this were carried out with the help of Hammer woreda pastoral development bureau and local development agents. Accordingly, two focus group discussion were carried out per Kebele that contains 5-8 pastoralists and totally six focus groups-3 men only and 3 women only groups were undertaken. On top of this, in depth semi structured open questionnaire interview was held with key informants (KI) individuals and totally 7 KI interview (1 woreda livestock and Fishery department head, 3 elderly and 3 development agents) were carried out to explore and understand better the phenomenon in detail and in turn has been used as an input for triangulation of findings from household level interviews.

To this study, daily time scale rainfall and temperature data obtained from National Meteorological Agency of Ethiopia has been utilized which has been collected and reported from two metrological station namely Dimeka and key Afer. Hence, to analyze and understand rainfall and temperature extreme amounts and events defined by WMO, 2009 guidelines has been taken in to account. This guideline provided a list of 27 weather extremes defined based on daily rainfall and temperature data. Consequently, for this study 10 indices for rainfall and

8 indices for temperature was undertaken based on data suitability and representativeness to the climate of study area (Table 1 and 2).

Table 1: Definitions of daily rainfall indices used in the study.

Index	Definition	Unit
RX1day	Highest precipitation amount in one day	mm
RX7day	Highest precipitation amount in Seven days	mm
R20mm	Count of days where rainfall≥ 20mm	days
SDII	Mean precipitation amount in wet days	mm
PRCPTOT	Total precipitation in wet days where rainfall ≥1mm	mm
NWD	Count of wet days where rainfall ≥1mm	days
NDD	Count of dry days where rainfall <1mm	days
CDD	Maximum length of dry spell (rainfall <1mm)	days
CWD	Maximum length of wet spell (rainfall ≥1mm)	days
R95p	The 95th percentile of daily rainfall amount	mm

Note: A day with rainfall of ≥1 mm is defined as wet day, and dry day otherwise. In addition to these daily indices, this study will define and generate total rainfall amounts for annual and seasonal time scales.

Table 2: Definitions of daily temperature indices used in the study

Index	Definition	Unit
TXx	Monthly maximum value of daily maximum temperature	ºC

TXn	Monthly minimum value of daily maximum temperature	ºC
TNx	Monthly maximum value of daily minimum temperature	ºC
TNn	Monthly minimum value of daily minimum temperature	ºC
TX10p	Cool days: percentage of days when TX <10th percentile of base period (1986-2016)	Days
TN10p	Cold nights: count of days where TN < 10th percentile of the base period	Days
TX90p	Warm days: percentage of days when TX >90th percentile of base period	Days
TN90p	Warm night: percentage of days when Tn >90th percentile of base period	days
WSDI	Warm spell duration indicator: annual count of days with at least six consecutive days when TX >90th percentile of base period	Days
DTR	Diurnal temperature range: monthly mean difference between TX and TN	ºC

3.3.1. Rationale for drought indices

Many drought indices have been developed to analyze the frequency and magnitude of drought events. These include the Palmer Drought Severity Index (PDSI; Palmer, 1968), Standardized Precipitation Index (SPI_ McKee et al., 1993), the rainfall Deciles Index (Mpelasoka et al., 2008), simpler precipitation anomalies using duration and frequency of dry spells (Pandey et al., 2008), Surface Water Supply Index, Drought Area Index and Drought Severity Index (Dai, 2011). Many new drought detection and monitoring indices were also developed to detect the impacts of global warming on drought development and severity. Some of these are Reconnaissance Drought Index (RDI; Tsakiris et al., 2007), Standardized Precipitation Evapotranspiration Index (SPEI; Vicente-Serrano et al., 2010), Standardized Relative

Humidity Index (SRHI; Farahmand et al., 2015) and Standardized Vapour Pressure Deficit (SVPD; Behrangi et al., 2015). The choice of indices for drought monitoring in a specific area should eventually be based on the quantity of climate data available, computational simplicity, purpose of the study and on the ability of the index to consistently detect temporal variations during a drought event. For this study, Standardized Rainfall Anomalies (SRA) is used. This method was selected because it require only monthly rainfall and temperature data that can be accessed from dense network meteorological stations in the proposed study area. In addition to this, SRA was highly recommended by World Meteorological Organization for drought detection. Detail description on the method is presented as follows:

3.3.2. Trend Detection

The non-parametric Mann-Kendall trend test and Sen's slope estimators was applied for trend detection. Mann-Kendall's trend test has been widely used in many hydro climatological trend studies (e.g., Degefu and bewket, 2014a,) as it is distribution-free, robust against outliers, and has a higher power than many other commonly used tests like linear regression method (Kundzewicz et al., 2005). However, the Mann-Kendall trend test requires that the data to be serially independent, since the presence of serial correlation in climate time series records tended to inflate the results of trend test, making it appear as there are more statistically significant trends than were actually present (You et al., 2002). Several approaches have been suggested to remove the serial correlation from a data set prior to apply a trend test. To remove serial correlation we the test employed the prewhitening method, which has been applied in many previous studies (e.g., Petrow and Merz, 2009; Burn et al., 2010; Degefu and Bewket, 20014a). Procedures for the prewhitening method is found in You et al. (2002). Then the Mann-Kendall test was applied to the resample dataset and the number of significant trends at the local significance level of the $p<0.05$ determined. The resembling procedure will repeat 1000 times and the value of the relative frequency of local significant trends that will exceeded with probability 0.05 (the field significance levels) in these bootstrap samples selected as the critical value of the test. Trend results having a relative frequency greater than the critical value will consider field significant. The overall field significance of the trends is being tested by comparing the number of locally significant trends in the study area with that of expected from chance at 0.01 level. As used in many similar studies (e.g. Hannaford and Marsh, 2008; Burn et al., 2010) field significance can be viewed as a measure of the overall significance of the outcomes from a set of statistical tests for a the area, which can be tested by comparing the number of locally significance trends with that expected by chance for the region. Hence, in this study for a local significance level of 0.05, it is expected that 5% of the stations records anticipated to have significant trends by chance alone. Sen's slope estimator used to calculate trend magnitudes.

3.4. Data Quality Check Methods

Before any analysis, all data has passed through quality control for possible errors like inhomogeneity, outliers and missing data. Many approaches and statistical techniques have been developed for detecting in homogeneities in climatological time series, and in this study method and software (RHtestV2) which was proposed by Expert Team on Climate Change Detection and Indices (ETCCDI) for daily time series (WMO, 2009) was employed. Missed data has been filled using linear regression method and for this data from neighboring stations used. And it is applied if missed data for a given year is not more than 10%, otherwise left that year as missed. Outliers will be smooth using data from nearby stations. Besides, for the household data, quality check is made using SPSS software running homogeneity test was also employed.

3.5. Data Analysis Method

Extreme climate indices for rainfall and temperature generated using R-based software ((R DEVELOPMENT CORE TEAM, 2007) developed by Expert Team on Climate Change Detection and Indices (ETCCDI) for daily time series (WMO, 2009), and this is available http://cccma.seos.uvic.ca/ETCCDI. The non-parametric Mann-Kendall trend test and Sen's slope estimators were applied for trend detection. For data collected from respondent households, various master coded sheets prepared for coding purpose, after verifying and organizing the reviewed schedule. Raw data entered to statistical software package VERSION 20 for data management and further analysis. Focus Group Discussion has also be analyzed independently as supportive information.

CHAPTER FOUR: RESULT AND DISCUSSION

4.1. Demographic characteristics of sample household

4.1.1. Sample size distribution

Proportional sample sizes have been taken from each of the three sampled [4]kebeles. The frequency and percentage distribution of interviewed households per Kebele has been illustrated in the below (Table 3).

Table 3: Sample Size Distribution among the sampled Kebele

Name of Kebele	Frequency (#)	Percentage (%)
Dimeka Zuria	53	34.42
Dembaite	51	33.12
Besheda	50	32.47
Overall Total	154	100%

Source: Household Survey

[4] a small administrative unit in Ethiopia

4.1.2. Respondent household Characteristics

The relationships between interviewees to sampled households comprise of 61.6% father, (28.57%) mother, (9.09%) eldest son and (0.65%) eldest daughter. From the respondents, 29.87% were female and 70.13% were male.

Of the overall total respondents, the majority age group was between 35-65 years old (70.78%) which is followed by between 19 to 34 year old (24.03%) and the remaining age groups were above 65 year old (5%). Pertaining to their marital status, 95.45% were married, 2.6% were single, and 1.35 % were widowed. The family size ranges from one to nine and the obtained mean were five individual per household variance of 2.6. From the respondents, (98.05%) had no any numeracy and literacy skills as a result have fallen under the illiterate groups.

Table 4: Age Category of the respondent Households

Age Category of Respondent	Frequency (#)	Percentage (%0
35-65 year old	109	70.78
19-34 year old	37	24.03
Above 65 year old	8	5

Source: household survey

4.1.3. Livestock Vs. Physical asset owned

The results indicated that all respondents' household have livestock and that the herd diversity constitutes shoats (Goat and Sheep), oxen, cows and donkeys. In addition to camels, the availability of donkeys, which used to be known as drought resistant due to their feeding habits and feed conversion efficiency, looks meagre (1.3%). Among the livestock, 99.35% of respondent household said that cattle--cow and ox are the most important livestock species for the households' food security, wellbeing, and income. In addition to these livestock assets, the households also own different types of physical assets such as corrugated iron sheet roofed houses (1.95%), thatched roofed houses (98.7%), assorted hand tools (81.17%) and mobile cell phones (5.19%).

4.1.4. Allied livelihood Means of Interviewed Household

On top of pastoral livelihood system, the respondent household has also run different livelihood options to sustain and complement existing means of livings. Consequently, 88.31% were found to be engaged in wage employment, 50.65% in petty trading, 37.66% in charcoal making, 18.18% in livestock trading, 2.6% in grain trading and 1.3% in quarrying. From these, the three priority livelihood options in the order of importance, were livestock rearing, wage labourer and petty trading. However, from in depth key informant interview (KII) and Focus Group Discussions (FGD), it is understood that these ancillary activities are very temporary and seasonal. For example, with regards to wage labourer, it is usually implemented during Public Safety Net Programme (PSNSP) period from the months of January to June of each year- again, carried out with support from Non-Governmental organisations (NGO). Although not considered as the main livelihood strategy, charcoal making has evolved as an important income sources for the poor households during lean seasons.

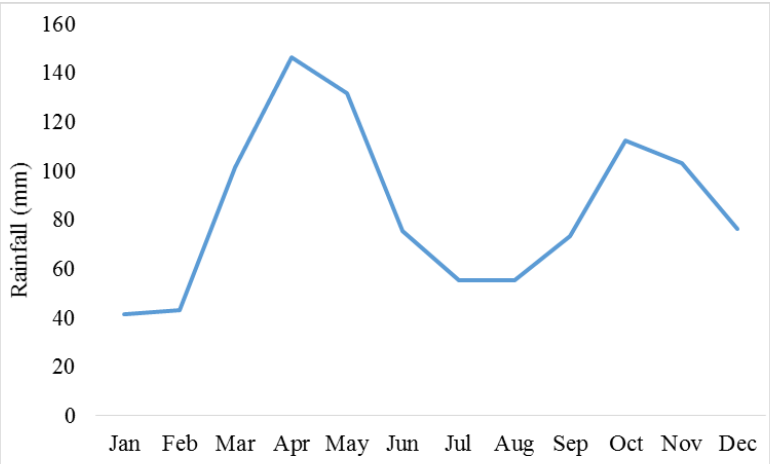
4.2. Perception of Communities in Changing Climate and Extreme Events Trends

4.2.1. Seasonal classification

The climate in Hammer district is characterised by a bimodal rainfall pattern, with the longer rainy season occurring following the first light rains in January, and this season (February, March, and April) but, according to the Focus Group Discussions and Key Informant

Interviews, nowadays the onset has been delayed by one month (March) and also the offset has been pushed to May. This, according to the National Metrological Agency (NMA) data, the findings of this research has set a longer rainy season from March to May (Fig 2). And the short rainy season after gradual and intermittent start in August but often said on (September) and so lasts between September to November. The study findings also agree with the above results and so indicated that there are two rainy seasons in Hammer. The first has been classified as a short rainy season covering September to November and the second as long rainy season from (March to May). Consequently, the study area has bimodal rain seasons with two dry season from Dec-Feb and Jun-Aug (Fig 2).

Figure 2: Annual rainfall cycles



Source: National Meteorological Data of Key Afer and Dimeka (1987 to 2016)

4.2.2. Monthly climate Variability

4.2.2.1. <u>Dimeka station</u>

The highest monthly rainfall variability has been seen on the month of July with coefficient of variation equivalent to 116.81% as well as minimum monthly rainfall variability was also seen on April with Coefficient of Variation (36.47%). The station monthly average rainfall ranges from 36.47mm to 107.96mm. In relation to monthly temperature, the coefficient of variation also found between 6.72% and to 9.19%. The highest variation was observed in June. Maximum and minimum temperature for *Dimeka* station ranges between 24.83 and 22.18 degree centigrade, respectively (Table 5).

Table 5: monthly Climate Variability of the area

Station	Climate element	Statistics	Month											
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Dimeka	Rainfall	Mean (mm)	34.99	53.28	52.85	47.43	72.98	53.18	35.28	26.88	43.44	50.54	88.61	71.46
		CV (%)	90.16	107.96	63.35	36.47	61.96	94.88	116.81	96.37	79.95	60.65	83.72	99.75
		SD (mm)	35.0	53.3	52.9	47.4	73.0	53.2	35.3	26.9	43.4	50.5	88.6	71.5
	Temperature	Mean (°C)	23.64	24.83	24.74	23.03	22.41	22.18	22.18	22.57	23.08	22.69	22.37	22.49
		CV (%)	6.68	6.91	7.35	7.68	8.33	8.99	9.19	8.91	8.64	8.81	8.04	6.72
		SD (^{0} C)	1.6	1.7	1.8	1.8	1.9	2.0	2.0	2.0	2.0	2.0	1.8	1.5

Key Afer	Rainfall	Mean (mm)	42.39	35.74	114.83	160.56	132.50	80.70	72.43	80.17	88.79	125.32	92.66	62.64
		CV (%)	131.34	96.32	56.01	55.50	60.34	73.84	97.02	71.90	74.71	81.54	89.90	121.80
		SD (mm)	55.7	34.4	64.3	89.1	79.9	59.6	70.3	57.6	66.3	102.2	83.3	76.3
	Temperature	Mean (ºC)	23.04	23.40	23.12	22.07	21.49	21.56	21.53	21.55	21.79	21.81	21.99	22.47
		CV (%)	6.61	7.28	4.36	5.62	6.49	7.88	8.25	7.25	6.29	5.57	4.23	3.63
		SD (^{0} C)	1.5	1.7	1.0	1.2	1.4	1.7	1.8	1.6	1.4	1.2	0.9	0.8
Areal average	Rainfall	Mean (mm)	41.70	43.27	101.78	146.71	131.86	75.41	55.65	55.43	73.38	112.45	103.36	76.29
		CV (%)	93.86	76.33	57.70	39.78	52.91	79.03	103.32	77.91	68.61	82.39	79.72	101.09
		SD (mm)	39.1	33.0	58.7	58.4	69.8	59.6	57.5	43.2	50.3	92.7	82.4	77.1
	Temperature	Mean (ºC)	23.30	24.15	23.96	22.67	22.14	22.07	22.06	22.25	22.60	22.30	22.24	22.54
		CV (%)	5.31	5.92	5.23	4.70	5.27	6.53	7.15	6.76	6.68	5.66	4.96	4.40
		SD (^{0} C)	1.2	1.4	1.3	1.1	1.2	1.4	1.6	1.5	1.5	1.3	1.1	1.0

Source: National Meteorological Data of Key Afer and Dimeka (1987 to 2016)

5. **<u>Key Afer station:</u>**

Maximum coefficient of variation (CV) for precipitation was 131.34% and occurred in January as well as the minimum coefficient of variation to precipitation was (55.50 %.) and was recorded in April. The minimum and maximum for temperature was CV (3.36%) and CV (8.25%), respectively. The former was revealed in December and the latter in July.

4.2.2.3 <u>Areal Average:</u>

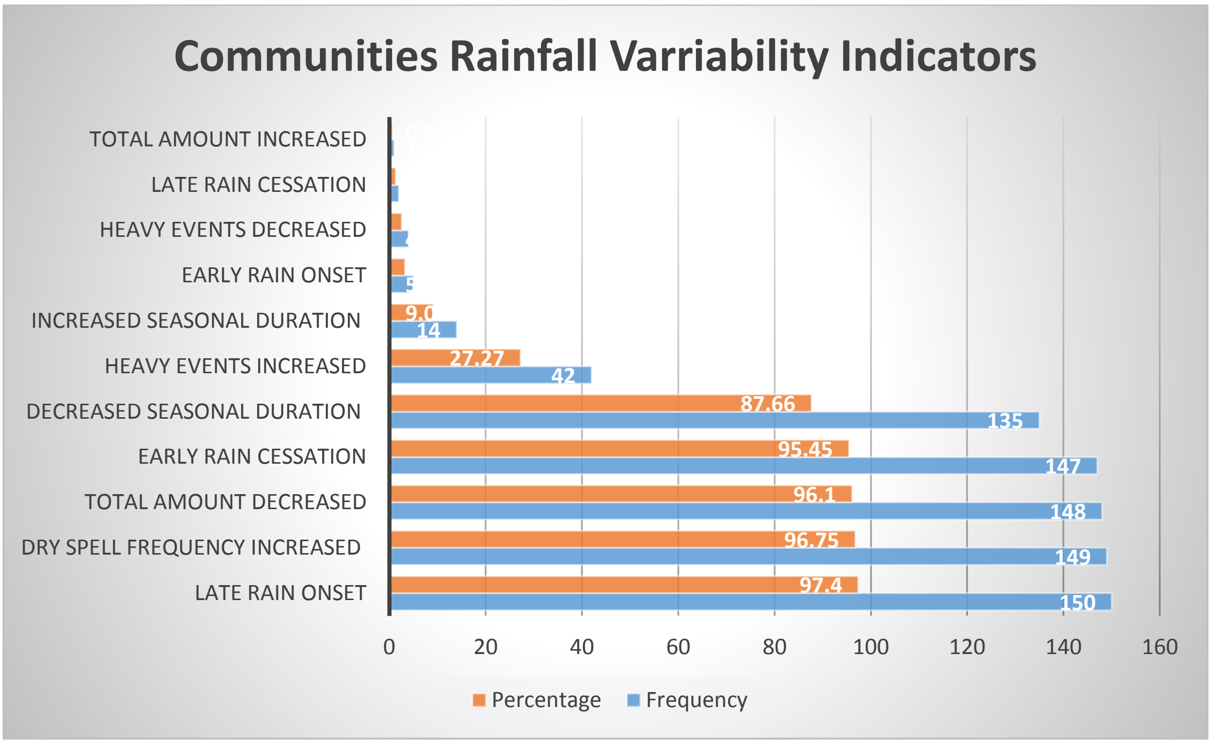
For areal average, highest monthly rainfall variability (103.32%) and the lowest monthly rainfall variability (39.78%) was observed during July and April months, respectively. Likewise, minimum and maximum monthly temperature variability for the areal were 4.4% and 7.15%, respectively and the highest was detected in July and the lowest in December.

Compared to both stations, *Key Afer* received relatively better rainfall than the *Dimeka* station. The above (Table 5) reflects irregularities both for temperature and precipitations. According to the data, the maximum rainfall, during the past 30 years, was recorded in April (146.71 mm) with low CV amounting to 39.78%. Except this month, other months have increased variability

4.2.3. Annual and seasonal climate variability

Meteorological records suggest a reduction in rainfall since the early 1990s over southern parts of Ethiopia, unlike other areas of Ethiopia where a modest increase in rainfall has been observed (Funk et al, 2008). This could be linked to warming of Indian Ocean SST, which may also have been responsible for the 1984 drought (Funk et al, 2008). According to the FGD and KII results, the rainfall in Hammer has become more erratic than before. Likewise, regardless of age groups, all the surveyed households (100%) have experienced changes in the climate and have characterised this by late rain onset (97.4%), increased dry spell frequency (96.755), total amount of rain decrease (96.1%), early rain cessation (95.45%), decreased wet season duration (87.66) (Fig 3).

Figure 3: Communities Rainfall Variability indicator



Source: household Survey

In addition to the household survey, both FGD and KII pastoralists felt that the rainy seasons start later and stop earlier in the recent past as compared to a long time ago. Respondents were more aware of climatic changes related to the rainy season than other seasons. One 67 years old pastoralist explained that, for many resident community including himself, it has been a long memory since sustained and adequate rains was received.

Table 6: Annul and seasonal climate variability

Station	Climate element	Statistics	Time scale				
			Annual	Mar-May	Sep-Nov	Dec-Feb	Jun-Aug
Dimeka	Rainfall	Mean (mm)	848.70	331.25	243.51	159.79	114.14
		CV (%)	19.91	34.78	49.30	62.45	71.48
		SD (mm)	168.9	115.2	120.1	99.8	81.6

	Temperature	Mean (ºC)	23.02	23.39	22.71	23.66	22.31
		CV (%)	6.91	7.14	8.12	5.98	8.57
		SD (^{0} C)	1.6	1.7	1.8	1.4	1.9
Key Afer	Rainfall	Mean (mm)	1088.73	407.88	306.78	140.78	233.29
		CV (%)	29.51	43.00	51.76	69.75	54.47
		SD (mm)	321.3	175.4	158.8	98.2	127.1
	Temperature	Mean (ºC)	22.15	22.23	21.86	22.97	21.54
		CV (%)	4.40	4.57	4.80	4.90	7.47
		SD (^{0} C)	1.0	1.0	1.0	1.1	1.6
Areal average	Rainfall	Mean (mm)	1017.29	380.35	289.19	161.25	186.50
		CV (%)	28.17	36.65	53.10	54.86	64.82
		SD (mm)	286.6	139.4	153.6	88.5	120.9
	Temperature	Mean (ºC)	22.69	22.92	22.38	23.33	22.13
		CV (%)	4.52	4.26	5.28	4.37	6.57
		SD (^{0} C)	1.0	1.0	1.2	1.0	1.5

Source: National Meteorological Data of Key Afer and Dimeka (1987 to 2016)

The areal average minimum rainfall seasonal variability was found to be 36.65 as well as maximum seasonal rainfall variability was 64.82%.

The annual average for both stations- *Dimeka* and *Key Afer* were 1017.29(mm) and CV (28.17%). The respective areal annual average for *Dimeka* was 848.70 (mm) and CV (19.91%). Again, for *Key Afer* it was 1088.73(mm) with CV (29.51%). Both wet seasons (long and short rainy season) have substantial variability in time and space between and within the study areas (Table 6). In line with this, temporal and spatial variability of rainfall over Ethiopia remain a major concern and recent studies have been providing scientific evidences to this effect (Williams et al., 2012; Gebrehiwot, and Veen, 2013).

Annual rainfall cycle with the long rain during March to May (accounts 37% of the annual total) and the short rains from September to November (accounts 28% of the annual total). The rainfall amount during June to August and December to February were relatively small but contributed to 16% and 18% of annual total, respectively. In terms of rainfall, the respondents felt there had been a decreasing rainfall amount and shortening duration of the rainy seasons with the majority citing a late onset and early cessation of the rainy season. It is good to note that, this area is as part of south western part of Ethiopia, so receives sporadic rains during the dry season of the year and this contributes altogether 34% of overall areal average rainfall (Table 6).

Coppock (1994) report, the southern lowland areas, particularly Borena, longer rainy season contributes 60% of annual rain as well as the short rainy season contribute 30%. In contrast to this, the study has found that both short and longer rainy season altogether contribute approximately 66% per cent of the annual rainfall and the remaining amount is usually received during dry seasons.

4.2.4. Standard Rainfall Anomalies

The Standard Rainfall Anomaly (SRA) has been computed on an annual basis during the study period (1986-2016) for the two stations namely *Dimeka* and *Key Afer*.

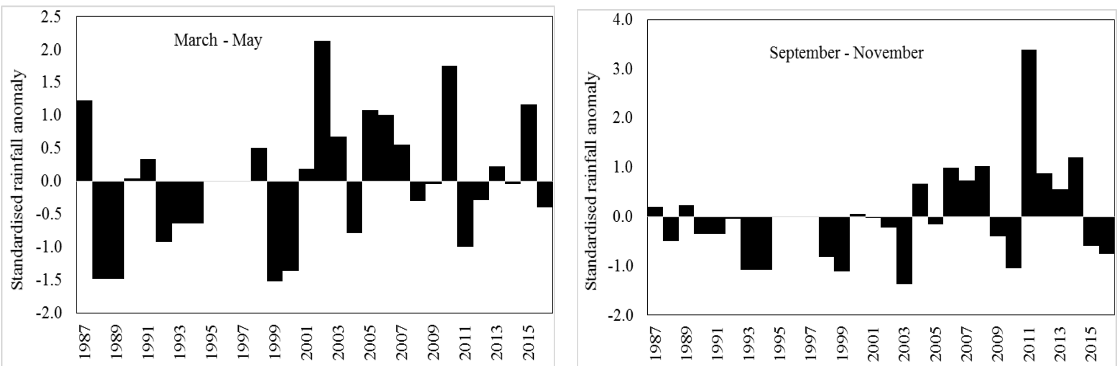
Standardised Rainfall Anomalies= $(Xi - \bar{X})$/Sx

Where 'Xi' represent individual observations in the data set; ' $\bar{X}$', 'Sx' are the mean and standard deviation of the observations. SRA in the range of – and + for normally distributed data sets. If SRA is large positive, then the rainfall is positively deviating from the mean and vice versa, whereas, if SRA is zero, then there is no rainfall variability.

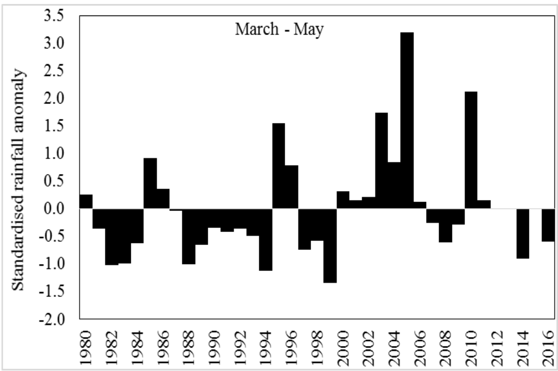
The below figure 5 (c) presents, areal inter annual rainfall variability and shows below normal precipitation in different years like in 1989 to 1995, 1999 to 2001, 2003 to 2006, 2008 to 2011, 2013 to 2016. The most severe drought has occurred in 1999 and 2000 as well as moisture stress was also observed in 2004, 2008 to 2011, 2016 and 2017. The years of occurrence of the maximum and minimum Standardised Rainfall Anomalies values in any particular year are not uniform for the two stations during the analysis window. This shows that there is high spatial rainfall variability during the study period. In this regard, FGD and KII participants indicated that the year starting from 2008 was characterized by increased anomalies. However, due to missing data, for some years the anomalies have not been analyzed. Despite this, pastoralists' reflections revealed that the climate change trend has increased in the past ten years. Likewise, Metrological data collected from National Metrological Agency also agrees with the pastoralists views hence, commencing from 2007, although the severity varies along the time series, the study area has been affected by severe below normal rainfall. Scientific evidences suggest that higher temperatures and changing precipitation levels as a result of the changing climate will further depress agricultural production in many arid and semi-arid parts of Ethiopia over the coming decades (Gebrehiwot, T. and Veen, AV.D 2015). This is also a characteristic feature of the South and Central part of Ethiopia (Funk et al., 2012; Kassie et al., 2014).

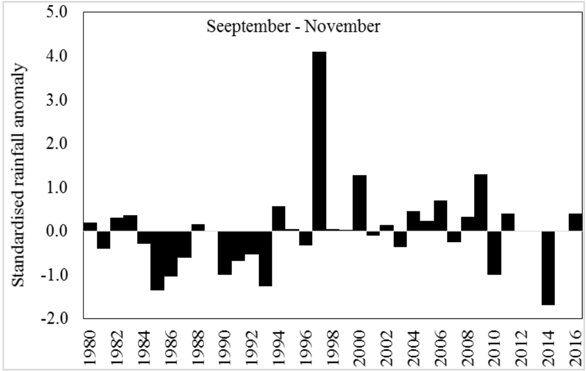
Figure 4: Standardized rainfall anomalies for the wet seasons at a) Dimeka station, b) Key Afer station and c) Areal average

a)

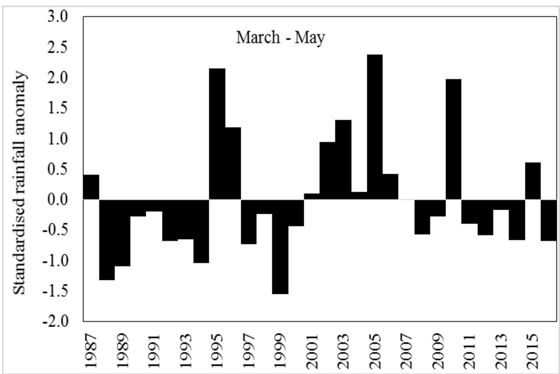


b)





c)



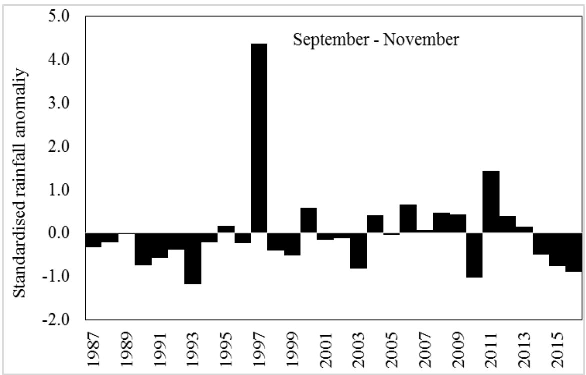
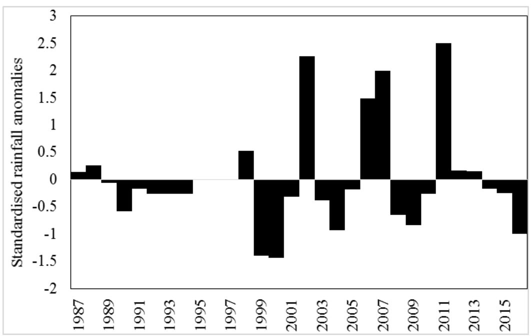
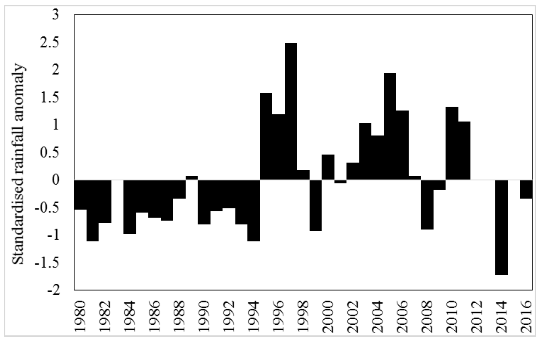


Figure 5: Standardized annual rainfall anomalies at a) Dimeka station, b) Key Afer station, and c) Areal average

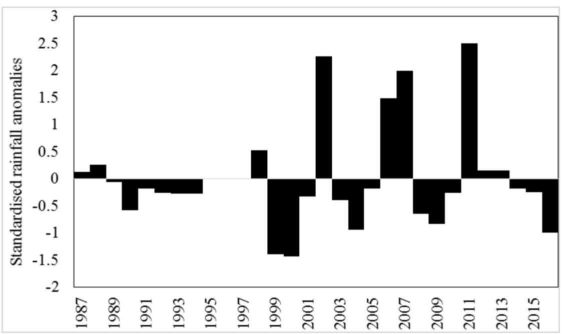
a)



b)



c)



Source: National Meteorological Data of Key Afer and Dimeka (1987 to 2016)

From above figure 5 (c) the year 2011 was the wettest year from the study period (1986 to 2016). But, this negates with the communities feedback because the year was known by its worst drought and it was also the time that the government declared an emergency for South Omo lowland areas including Hammer. The year 2000, was found as the driest year from the observations. In addition, according to figure 5 ('a' and 'b') the year 2011and 1998 were the wettest period for *Dimeka* and *Key Afer* Station, respectively. The year 2014 and 2000 were also identified as the driest year for *Key Afer* and *Dimeka*, respectively.

4.2.5. Trend Analysis

4.2.5.1. Annual and seasonal rainfall and Temperature trend analysis.

Long-term changes in the daily, seasonal and annual rainfall indices were examined using the nonparametric Mann–Kendall's test and Sen's slope estimator using MAKESENS Microsoft Excel add-in software developed by the Finnish Meteorological Institute (Salmi et al., 2002). MAKESENS uses the nonparametric Mann–Kendall test, which is most commonly used to analyse trends in rainfall, stream flow and water quality (Shahid 2009). Trend analysis using linear regression assumes normality and homogeneity of variance throughout.

In terms of changing climate trend, there is a growing concern that more stressors now coincide, in comparison with the past. As one person in a Focus Group Discussion (FGD) in Hammer Woreda[5] said, "The shocks nowadays come in multiples. Rainfall patterns are perceived to have changed over the past decade, particularly in terms of onset, offset, timing and duration". The frequency of droughts are viewed as increasing particularly over the past two decades. Within the group, some people argued that the changes have become more noticeable since the major famine in 1984.

[5] district

Table 7: Trends of annual and seasonal rainfall and temperature amounts

Station	Climate element	Statistics	Time scale				
			Annual	Mar-May	Sep-Nov	Dec-Feb	Jun-Aug
Dimeka	Rainfall	MK	-0.17	1.21	1.36	**-2.44[c]**	-0.44
		Trend (mm/decade)	-5.04	36.83	33.26	-55.85	-5.21
	Temperature	MK	0.66	0.22	0.49	1.45	-0.04
		Trend (^{0}C/decade)	0.23	0.10	0.16	0.39	-0.01
Key Afer	Rainfall	MK	**2.16[c]**	0.98	1.53	0.86	**1.72[d]**
		Trend (mm/decade)	124.77	25.67	30.54	15.57	38.44
	Temperature	MK	**1.90[d]**	0.71	**2.49[c]**	-0.39	**3.14[b]**
		Trend (^{0}C/decade)	0.37	0.15	0.34	-0.05	0.97
Areal average	Rainfall	MK	-0.25	0.89	0.82	**-2.21[c]**	-1.03
		Trend (mm/decade)	-19.04	22.57	23.50	-43.05	-15.77
	Temperature	MK	0.93	0.00	1.46	0.79	1.50
		Trend (^{0}C/decade)	0.19	0.00	0.28	0.17	0.47

Source: National Meteorological Data of Key Afer and Dimeka (1987 to 2016)

Bold figures represent trends with statistically significant changes as follows:

[a] Significant at 0.001,

[b] Significant at 0.01,

[c] Significant at 0.05,

[d] Significant at 0.1 level

Although it is not statistically significant, MA Kendal trend test shown declining trend of precipitation for areal average. For the two dry periods, from December to February and from June to August, precipitation amount has been reduced by 43.05mm/decade and 15.77mm/decade, respectively. In *Dimeka* station, the rainfall which used to be available at dry season from December to February declined significantly, at 0.05 level. Likewise, for the area, the same period also showed a statistically significant declining trend at 0.05 level. The annual temperature in *key Afer* shown increasing trend at 0.1 confidence level. Besides, September to November and June to July temperature also shown increasing trend at 0.05 and 0.01 level, respectively. In line with this, 100% of the households have responded that there is an ongoing increase in temperature.

This study findings also agree with previous studies by Seleshi and Zanke (2004), Verdin et al., (2005) and Cheung et al., (2008) that reported declining trends for the annual total precipitation amounts over this area for the period 1960s–2002. However, this result contradicts with a recent study by Kebede and Bewket (2009) that covered south-western Ethiopia and identified increasing trends in annual rainfall at six out of nine stations studied for the period 1978–2007. Similarly, other two studies that analysed areal average annual rainfalls reported tendencies toward increasing trends over the southern and south-eastern lowlands (Jury and Funk 2012) and south-western highlands (Viste et al., 2013). The findings also disagree with the results of other studies (Ayalew et al., 2012) that reported the recovery of rainfall over much of Ethiopia since the 1990s.

4.2.5.2. Variability and trends in extreme rainfall amounts

a) *Maximum 1-day (Rx1DAY) precipitations,*

The maximum rainfall amount for a day in annual time series do not show any trend for *Dimeka* station. But, for the same station, increments by 2.22mm/decadal in March to May and 3.56mm/decade for September-November season has been observed. Conversely, in *Key Afer* station, significant declining trends have been observed at 0.1 level. In line with this, although not statistically significant, at *Key Afer* both Mar-May and Sep-Nov, has shown declining trend by 5.15mm/decade and 4.17mm/decade, respectively.

b) *Maximum 7-day (Max7DAY) precipitations,*

The maximum seven consecutive day's rainfall (Max7day) indicated non-significant declining trend in *Dimeka* station and has reduced by 1.25mm/decade. And for, *Key Afer* station, non-significant incremental trends by 4.75mm/decade has been recognized.

c) R95p,

The 95th percentile of daily rainfall amount has shown insignificant incremental trend in *Dimeka*. But, in *Key Afer* these indices have indicated highly significant increasing trend at 0.05 level. Although it is not significant, the 95th percentile of daily rainfall for areal average indicated slight increment for Sep-Nov and Mar-May. .

d) PRCPTOT,

Although the total precipitation amount indicates incremental trend in Mar-May and Sep-Nov wet season by 35.85mm/decade and 34.82mm/decade, respectively in *Dimeka* station; however, the annual total for the same station has showed decreasing trend at a rate of 4mm/decade. In *Key Afer*, the MA Kendal Trend test indicated increasing trend by 122.67mm/decade, at 0.05 level. In the same station, Mar-May and Sep-Nov rain has also showed increasing trend at a rate of 26 mm/decade and 31.25mm/decade, respectively. Overall trend of annual rainfall, though not significant, indicated increasing trend.

e) *Daily intensity index (SDII)*

Mean precipitation amount in wet day's (SDII) for *Dimeka* station indicated non-significant increasing trend for annual. But, for the same indices, *Key Afer* station showed increasing trend with 0.01 significant level. In the same station, both wet seasons, Mar-May and Sep-Nov has found increasing trend at 0.001 and 0.01 level, respectively.

The table below which reflects the above discussion, shows complex trend and the overall daily rainy fall and this most consistent with Kebede and Beweket (2009) for the north-western part of the study area. The annual, long and short rainy season on the extremes daily rainfalls for *Dimeka* and *Key Afer* shows lack of consistencies and so this result concurs with previous research that reported an absence of consistent patterns of trends in the extreme daily rainfall indices in the country (Bewket and Conway 2007; Rosell and Holmer 2007; Kebede and Bewket 2009; Shang et al., 2010; Ayalew et al., 2012). For the southern and south western Ethiopia, two recent studies (Jury and Funk 2012; Viste et al., 2013) reported a contradicted trends. For the period 1948–2006, Jury and Funk (2012) reported the presence of a weak rising trend in the arid lowlands of southern and south-eastern Ethiopia and declined trends over the south western highlands and Sudan border. On the other hand, Conway (2000); Conway et al., (2004) and Meze-Hausken (2004) confirmed the absence of significant trends over the central and northern Ethiopia. For the period 1979–2008, Ayalew et al., (2012) reported the presence of a complex pattern of trends in the seasonal and annual rainfall over the north central parts of Ethiopia. Bewket and Conway (2007) showed absence of consistent systematic trends in the daily rainfall indices in the Amhara Region for the period 1975–2003. The study by Kebede and Bewket (2009) in the south-western part of Ethiopia, which is the wettest part of the country, reported a complex pattern of daily rainfall trends for the period 1978–2007.Findings from the previous studies therefore indicate that trends in the annual and seasonal rainfalls are highly sensitive to local climatic controls, and the study period considered for analysis.

Table 8: Variability and trends in extreme rainfall amounts

Station	Time scale	Statistics	RX1day	Max7day	R95p	PRCPTOT	SDII
Demeka	Annual	Mean (mm)	57.63	123.36	14.64	845.32	10.67
		MK	0.21	-0.29	0.27	-0.10	1.48
		Trend (mm/decade)	0.00	-1.25	0.16	-4.00	0.56
	Mar-May	Mean	43.73	97.12	19.52	331.05	11.17
		MK	0.63	1.57	0.48	1.21	2.09
		Trend (mm/decade)	2.22	9.00	0.75	35.85	0.82
	September-November	Mean (mm)	40.36	82.57	13.96	242.32	9.81
		MK	1.21	0.13	1.50	1.36	0.90
		Trend (mm/decade)	3.56	0.14	1.95	34.82	0.63
Key Afer	Annual	Mean (mm)	54.55	132.09	18.55	1081.17	13.05
		MK	**-1.87**[d]	0.74	**2.45**[c]	**2.19**[c]	**3.56**[a]
		Trend(mm/decade	-5.15	4.75	1.97	122.67	1.93
	Mar-May	Mean (mm)	45.62	99.07	23.25	405.70	13.41
		MK	-1.23	1.45	1.04	0.95	**3.05**[b]
		Trend (mm/decade)	-1.92	9.72	1.21	26.00	1.98
	Sep-Nov	Mean (mm)	41.03	97.72	18.17	304.39	12.40
		MK	-1.35	0.30	0.65	1.56	**1.68**[d]
		Trend (mm/decade)	-4.17	1.25	0.93	31.25	1.35

Source: National Meteorological Data of Key Afer and Dimeka (1987 to 2016)

Bold figures represent trends with statistically significant changes as follows:

[a] Significant at 0.001,

[b] Significant at 0.01,

[c] Significant at 0.05,

[d] Significant at 0.1 level

4.2.5.3. The long-term mean and trends in duration of extreme rainfall events for R20mm, NWD, NDD, CWD, CDD

a. R20mm

This parameter revealed no trend for annual rainfall for *Dimeka* Station but shown statistically non-significant trend increasing trend for both long term and short rainy season by 0.71day/decade and 0.12day/decade, respectively.

For *Key Afer* station, the same indices, shown significant increasing trend by 3.57days/decade at 0.05 level. In the same station, both short and long rainy seasons show statistically non-significant increasing trend by 1 day/decade and 0.77 day/decade, respectively.

a. Number of Wet Days (NWD)

In *Dimeka* Station, the Number of Wet Days (NWD) trend show a declining trend by 2 days/decade but for short and long rainy season indicated statistically non-significant 0 increasing trend by.91 day/decade and 2 days/decade, respectively.

The same indices for annual, in station 2 i.e. *Key Afer*, shown declining trend by 2.5 days/decade as well as for longer and shorter rainy season indicated decreasing trend by 2 days/decade and o.45days/decade, respectively. But, the trend was significant only for long rainy season at 0.05 level.

b. Number of Dry Days (NDD)

Though it is not significant, *Dimeka* station has exhibited increasing trend by 2 days/decade, for annual. Albeit this, for long and short rainy season, the trend shown decreasing by 0.91 days/decade and 2 days/decade, respectively.

NDD in *Key Afer* station has shown non-significant increasing trend by 2.5 days/decade, for the annual. Conversely, the long and short rainy season indicated incremental trend by 2 days/decade and 0.53 day/decade, respectively. For the longer rainy season, the trend is significant at 0.1 level.

c. Count of Consecutive Wet Days (CWD)

In *Dimeka* station, the annual, longer, and shorter wet season do not revealed any trend. In relation to *Key Afer* station, the maximum Consecutive Wet Day lengths (CWD) shown statistically non-significant increasing trend. But, the longer rainy season has shown no trend. The annual maximum consecutive wet days also shows non-significant declining trend by 0.30 day/decade.

d. Consecutive Dry Day (CDD)

The maximum Consecutive Dry Days at *Key Afer* shown statistically significant increasing trend, at 0.05 level. Besides, the shorter rainy season consecutive dry days has also shown increasing trend by 2.5 days/decade and it is significant at 0.05 level. But the indices, for *Dimeka* station, do not show any significant trend changes.

Table 6: The long-term mean and trends in duration of extreme rainfall events

Station	Time scale	Statistics	R20mm	NWD	NDD	CWD	CDD
Demeka	Annual	Mean (days)	11.74	79.74	285.26	6.15	44.37
		MK	0.44	-0.82	0.82	0.47	1.27
		Trend (day/decade)	0.00	-2.00	2.00	0.00	5.00
	March-May	Mean (days)	4.63	29.63	62.37	5.30	13.96
		MK	1.19	0.48	-0.48	0.60	0.75
		Trend (day/decade)	0.71	0.91	-0.91	0.00	1.07
	September-November	Mean (days)	3.26	24.11	66.89	4.15	16.37
		MK	0.88	1.24	-1.24	-0.34	-0.38
		Trend (day/decade)	0.12	2.00	-2.00	0.00	-0.45
Key Afer	Annual	Mean (days)	19.62	83.06	281.82	6.44	39.94
		MK	**2.54**[c]	-0.99	0.99	-1.21	**2.36**[c]
		Trend (day/decade)	3.57	-2.50	2.50	-0.30	5.20
	March-May	Mean (days)	7.47	29.76	62.21	4.53	12.21
		MK	1.54	**-1.70**[d]	**1.70**[d]	-0.09	0.76
		Trend (day/decade)	1.00	-2.00	2.00	0.00	0.50
	September-November	Mean (days)	5.26	24.06	66.91	4.91	16.32
		MK	1.59	-0.55	0.60	-1.12	**2.46**[c]
		Trend (day/decade)	0.77	-0.43	0.53	0.21	2.50

Source: National Meteorological Data of Key Afer and Dimeka (1987 to 2016)

Bold figures represent trends with statistically significant changes as follows:

[a]Significant at 0.001,

[b] Significant at 0.01,

[c] Significant at 0.05,

[d]Significant at 0.1 level

Seleshi and Camberlin (2006) identified statistically significant declining trends for the wet day intensity and maximum consecutive 5-day rain over the eastern, southern and south-western parts during the Kiremt and Belg seasons. Though the intensity of declining trend varies, this study has also found statistically significant declining trend for *Key Afer* station. On the other hand, Shang et al. (2010) analysed trends of extreme rainfall events based on the generalized extreme value modelling approach at Debre Markos in the north-western highlands of Ethiopia and reported the absence of significant trends at this location for the period 1953–2006. Similarly, Rosell and Holmer (2007) found no significant trends in rainy days, rainfall intensity and dry-spell length in south Wello (northeast Ethiopia) for the Belg (February to May) and Kiremt (June to October) seasons for the period 1963–2003. Overall, this study has found that non-systematic changes over the observation period for longer term climate events. The presence of complex patterns of daily rainfall trends in Ethiopia as shown by the various studies suggests that further local-scale investigations into variability and trend of extreme rainfall events are necessary to understand local-scale manifestations of climate change and accordingly design local-specific adaptation interventions.

4.2.5.4. Temperature Variability and Trends

Table 10 : Variability and trends in extreme temperature

Station	Statistics	Extreme temperature indices								
		TXx (^{0}C)	TXn (^{0}C)	TX10p (day)	TX90p (day)	DTR (^{0}C)	TNx (^{0}C)	TNn (^{0}C)	TN10p (day)	TN90p (day)
Dimeka	Mean	38.67	23.00	31.65	34.04	17.64	20.93	7.43	33.04	34.35
	MK	**1.93**[d]	-0.75	-0.93	1.32	0.79	0.27	1.33	**-2.57**[c]	-1.08
	Trend	0.63	-0.45	-6.36	4.38	0.22	0.00	0.65	-2.31	-12.73
Key Afer	Mean	32.88	21.68	35.24	29.56	11.37	20.86	10.11	32.21	32.53
	MK	**3.09**[c]	**2.36**[c]	**-3.83**[a]	**2.21**[c]	1.57	-1.12	0.98	**-2.60**[b]	-0.25
	Trend	0.70	1.06	-12.50	9.23	0.34	-0.31	0.45	-5.33	-0.80

Source: National Meteorological Data of Key Afer and Dimeka (1987 to 2016)

Bold figures represent trends with statistically significant changes as follows:

[a] Significant at 0.001,

[b] Significant at 0.01,

[c] Significant at 0.05,

[d] Significant at 0.1 level.

a) *Max Tmax (TXx) and min Tmax (TXn)*

With respect to max (TXx), increasing trend has been observed in the both station. The increment over time was significant at 0.1 level for *Dimeka* and 0.05 level at *Key Afer*. TXn values were not significantly changing downward over time at *Dimeka* station. But, in *Key Afer* station, shown significantly increasing trend at 0.05 level (table 10).

b) *Min Tmin (TNn) and Max Tmin (TNx)*

Non-significant increasing trend has been identified for TNn in both station. TNx shows no trend in *Dimeka* station but in *Key Afer,* although it is not significant, declining trend has been observed (table 10).

c) *Diurnal temperature range (DTR)*

Trend in the diurnal temperature has shown non-significant increasing trend at both station. Indicating that daily maximum and minimum temperatures are not changing in opposite direction at both of the stations studied (Table 10).

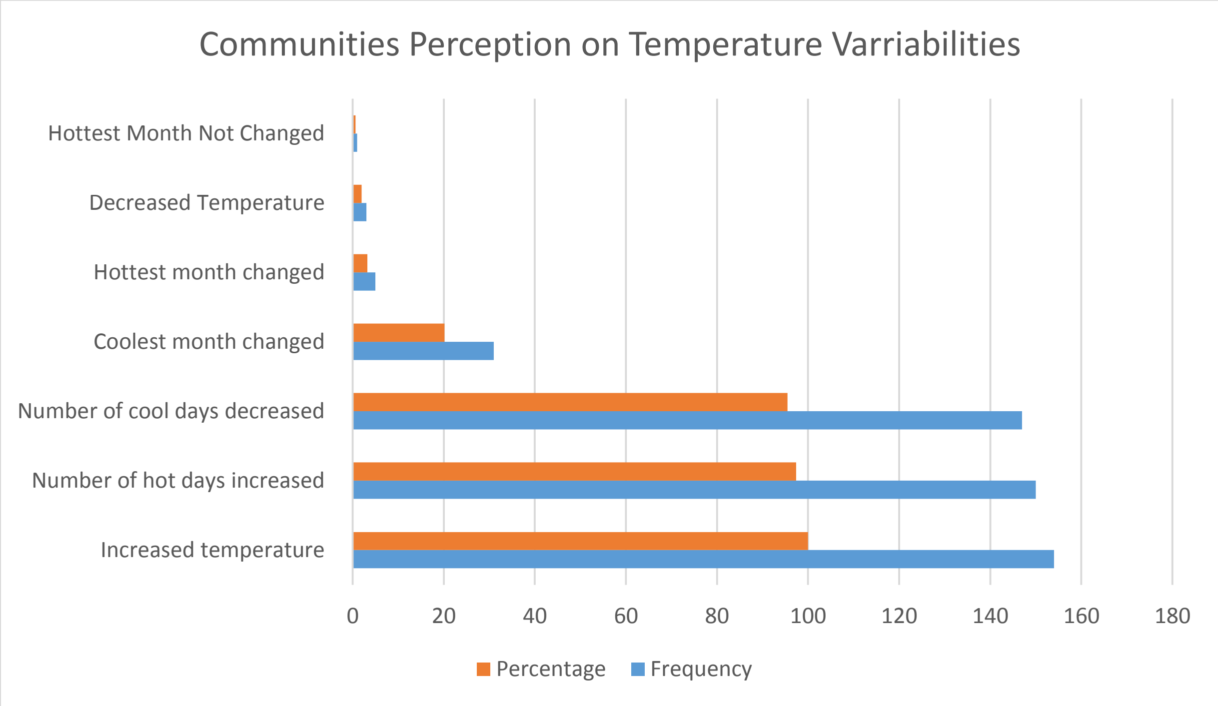
d) Warm days (TX90p) and warm nights (TN90p)

Although there is a tendency of increasing trends in TX90p at both of stations, the trends were significant in only *Key Afer* station at 0.05 level. At both stations TN90p showed non-significant decreasing trend (Table 10).

e) *Cool days (TX10p) and cool nights (TN10p)*

The TX10p showed non-significant decreasing trends at both station but is significant only at *Key Afer* station at 0.001 level (Table 9). TN10p stations had negative trends in both station and the trends were significant in *Dimeka* and *Key Afer* station at 0.05 and 0.01 level, respectively (Table 10).

Figure 6: Communities Perception on Temperature Variability



Source household Survey

With regard to temperature, 100% pastoralist has reported increased temperature, 97.4% felt increased number of hot days, and again 95.45% of respondents has said number of cold days has also decreased. Besides, according to the seasonal areal average temperature variation ranges from 4.26% to 6.57%.

As in other parts of Africa and the rest of the world and in Ethiopia, the climate have shown changes in temperature trends during recent decades (Cheung et al., 2008; Doherty *et al.*, 2009; Wong et al., 2010). Though the magnitude and trends of change reported vary with reports and locations, time series analysis of mean national maximum and minimum temperatures have shown positive trends (Gebre Michael and Kifle, 2009). In the same way, this study's findings also agree with these researches. The research has also found that, the warming is accompanied by a steady decline in precipitation in the observation series. This also agrees with study reports of (Genet and Alem, 2006; Williams and Funk, 2011) undertaken in many parts of the country. Although increases have been reported in some areas (Meze-Hausken, 2004) and no changes detected in others (Rosell and Holmer, 2007). Associated with these long-term changes in mean temperature and precipitation patterns (Lemi, 2005), like this study, changes in climatic extremes have been observed and reported by (McSweeney et al., 2010; Shang et al., 2010). Existing reports on extremes for Ethiopia indicate declining trends in frequency of heavy rains (Endalew, 2007), increase in frequency of dry extremes (Endalew, 2007) and increases in the number of warm days and nights (McSweeney et al., 2010). This study also agrees with mentioned ones.

4.3. Communities Adaptation Actions for Changing Climate

4.3.1. Access to climate information

The ability and nature of the adaptation response depends on an individual's, households, or community's access to information about climate risks and the appropriate responses. While many communities have developed their own systems for monitoring climate conditions, this information may not be adequate to inform adaptation if the climate changes in unprecedented ways. Socio-cultural changes also account for the shift away from traditional practices such as the use of bio indicators for agricultural production, even when such practices continue to provide useful information ((Dercon and Krishnan 2000). In view of this, the study community has responded yes about their access to climate information and source varies and this has been indicated in the below (Table 11).

Table 11: Climate Information Sources of the targeted community

Climate Information Sources	Frequency	Percentage
Words of Mouths	154	100.0%
Development agents/DRR committee	152	98.7%
Traditional Forecasters	152	98.7%
Radio	94	61.04%

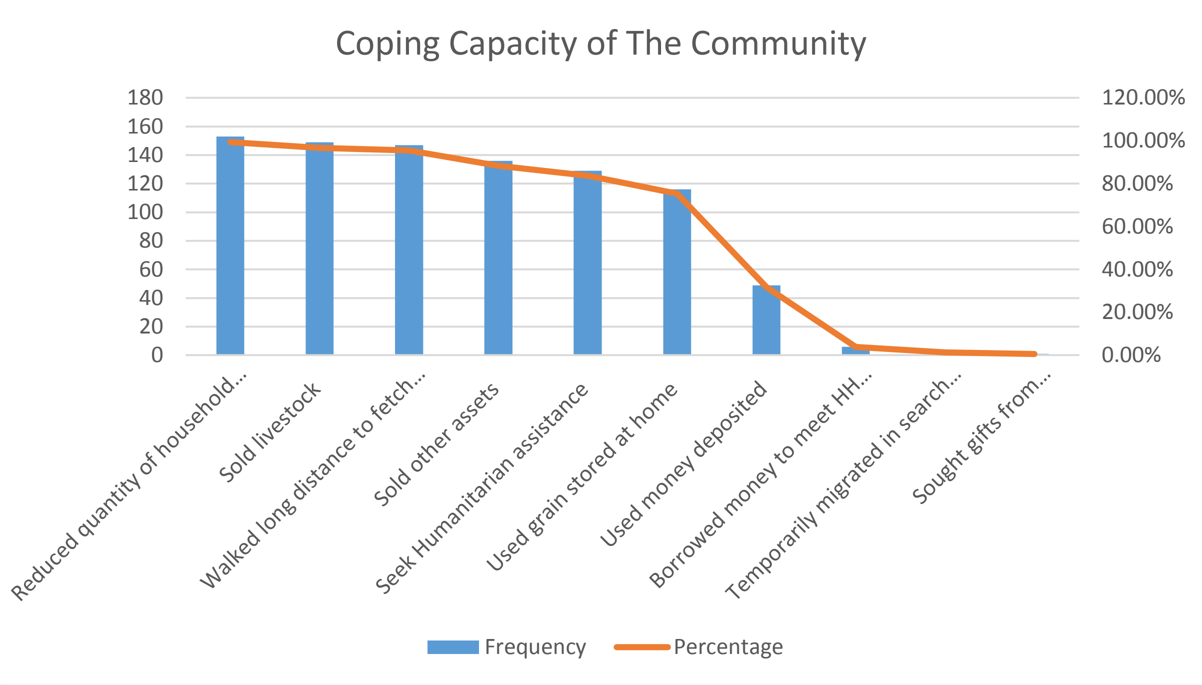
Source household Survey

According to the above (Table 11), the community had different climate information sources and 100% of the respondent said that the service has helped them a lot for early and timely decision making in relation to when to migrate (99.35%), when to sell livestock assets at better prices (98.05%), decision on water and pastures (98.05) and better management of savings (49.35%). Albeit to this, when the response compared with the recent drought impact, the actions taken seems not produced meaningful impacts. For instance, due to this year 2016/17 drought, the community has lost significant cattle herds.

4.3.2. Communities immediate actions in the faces of drought

Among the coping strategies employed by the communities, the main one has been illustrated in the below (Table 14). Accordingly, most of the copping actions taken depend on the available resources and this has been further depicted both during the FGD and KII discussions. In relation to this, among the least strategy employed, borrowing money- in hitherto known coping strategy of the community, looks now affected more because of cyclical drought and thus diminished loan repayment capacity of individual and households. Consequently, this has made the practice unproductive to traditional money lenders.

Figure 7: Coping Capacity of the community



Source household Survey

4.3.3. Adaptation action of the community for drought

The resources to which individuals, households, and communities have access to implement adaptation strategies change over time. Well-being improvements resulting from adaptation decisions taken today may reduce future vulnerability to climate change and variability and give actors more freedom to implement additional adaptation decisions in the future. On the other hand, inability to take protective measures against future climate change and extreme climate-related events may reduce well-being and increase vulnerability to future climate change, leaving actors with more limited adaptive capacity (Bryan and Behrman 2013). The observed climate variability and associated pastoralist perceptions, along with other drivers of socio-economic and political origins, are generally considered to have essentially generated a variety of local adaptation response mechanisms among the pastoralist community. A number of adaptive response strategies have been identified in the context of traditional pastoralism. Among the adaptation actions taken by the community have shown in the below (Table 12).

Table 12: Adaptation Action of the communities

Adaptation actions	Frequency	Percentage
I started to preserve grains to use them during food shortage	154	100.0%
I started to preserve fodder to be used during lean period	152	98.7%
Use veterinary services both vaccination and treatments	148	96.1%
I started non-livestock based livelihood options	130	84.42%
Involved in the communities actions to mitigate impact of drought	102	66.23%
I started to deposit/save money	67	43.51%
I reduced the number of livestock before the impact of drought occurs	33	21.43%
Employed water harvesting technologies	1	0.65%

Source household Survey

USAID Bureau for Food Security, has noted that "It is not drought, but vulnerability to drought that is eroding food security in [the drylands of Somalia, Ethiopia, and Kenya] and this vulnerability is a result of chronic underinvestment" (Tran, 2011). Besides the underinvestment, would add to the vulnerability of pastoralism is also the result of substantial investments in the wrong direction, often misguided by inadequate analysis. Basic information on the pastoralists experiences obtained through long years of practices easily match with time, location and cultural diversity of the people. This in turn helps the community to better understand the climate change implications and respond to adverse effects strategically (Martin et al., 2014). Flexible and responsive mobility is a vital strategy of livelihood sustenance in dryland pastoralism. Mobility which used to be recommended has been impacted by many shocks and Scoones (1995) reported the scale (distance) and frequency of pastoral mobility depends on spatial and temporal variations in resource availability which, in addition to the nature of range ecology, is also often influenced by accidental shocks. Likewise, in this study, migration has been impacted most and responded as 'no longer option'. This is because of the fact that, in addition to larger scale of drought in the area, the ever escalating conflict among the community where hammer bordered with has resulted in limited mobility for Hammer pastoral communities. In all cases, reducing mobility lowers the returns of dryland animal production and compromises both economic and ecological sustainability (IUCN, 2012). In addition to these, the study community has also mentioned other barriers posed challenges to their adaptation and emphasized the need for financing to invest in income-diversifying options. Furthermore, a need to improve the capacity of the community to adapt through trainings was also raised. Some of contextual factors mentioned as constraints specifically on capacity were indicated in (Table 13).

Table 13: Barrier to Communities Adaptation Action

Barrier to Adaptation	Frequency	Percentage
Lack of information	152	98.7%
Remoteness of the area	152	98.7%
Lack of Technology	151	98.05%
Lack of capital	148	96.1%
Lack of water	147	95.45%

Source household Survey

4.4. Loss and Damage encountered due to drought

According to the Household Survey, 100% of respondents said that impact associated with drought has shown increased trend particularly in the last 10 years' time. The level of impact felt was reported very negatively and negatively with response rate of 64.29% and 35.71%, respectively. In ten years' time, drought has reportedly occurred with Mean value of 3.6 and Standard deviation= 0.98; in turn, killed many livestock assets, most importantly, cattle species, (98.05%) reported as most affected one. The same has been reported by the KII and FGD participants.

Table 14: Livestock reported dead due to drought in the last 10 years

Livestock Type died in the last 10 years' time due Drought	Mean	Median	Mode	Standard deviation
Cow	26	19.0	*	20.5
Ox	3	3.0	2.0	2.5
sheep	14.0	9.0	0.0	16.6
Goat	24	18.0	9.0	21.3
Donkey	0.1	0.0	0.0	0.6

Source household Survey

In reference to above (Table 14), one household has lost in average 26 cows, 3 oxen, 14 sheep's and 24 goats due to drought or drought associated stress in the 10 years' time. And this, among the interviewed household, the losses commensurate to 4071, 472, 2163, and 3687 for cows, oxen, sheep and goats, respectively. In terms of monetary values the overall interviewed household loss estimated to be ETB 29,059,800.00 and this is equivalent to 1,320,900.00 USD. To attain this, 10 year USD to Birr conversation rate from AONDA as well as 10 years average prices of these commodities at local market prices has been collected from Hammer Woreda Pastoral development office, *Dimeka*.

CHAPTER FIVE: CONCLUSION AND RECOMMENDATION

5.1. Conclusion

The study was conducted in hammer woreda and from the survey it is apparent that both precipitation and temperature data computed at both station shown variable rainfall trend and for areal average, highest monthly rainfall variability (103.32%) and the lowest monthly rainfall variability (39.78%) was observed on July and April month, respectively. The highest rainfall variability has been observed in the month of July. Compared to long rainy season (March to May), the other season rainfall predictability is less.

The trends in precipitation extremes were much more variable and more inconsistent among both stations. Although some indices show positive (R20mm, NDD and CDD). The former doesn't show statistical significance but the latter two indicate significant trend at *Key Afer*. NWD and CWD and reveal negative trends in both stations. (Rx1DAY and Rx7DAY) show decreasing trend but (R95p, SDII and PRCPTOT) has shown positive trend and the trends were significant only at one station for some of the parameters. Similar to this results, New (2006) also reported inconsistencies and lack of statistical significance in precipitation extreme indices computed from stations in southern and western Africa regions.

The TXx, TXn, TX90p, TN90p (only at *key Afer*) and TX10p, and TN10p showed statistically significant positive trends at both station stations while the TNn, DTR revealed non-significant increasing trend at both stations. TNx has no trend in *Dimeka* station but shows statistically non-significant declining trend in *Key Afer* station. In both station, TN90P has revealed statistically non-significant negative trends. This indicated a general tendency of increasing warm extremes and a decreasing tendency of cold extremes in the study environment. This is in line with previous studies that indicated an increase in warm extremes and decrease in cold extremes in tropical environments (Manton et al., 2001; Kruger and Shongwe, 2004; McSweeney et al., 2010; Kruger and Sekele, 2013).

Most of the observed extreme trends in temperature and precipitation did not show spatial coherence among stations within eco-environments and varied within stations with some showing opposite trends. This could be due to the fact that in mountainous countries, the spatial and temporal patterns of temperature and precipitation are complex due to both regional synoptic scale and landscape scale physiographic controls of the climate system (Dobrowski *et al.*, 2009). The spatial and temporal variability observed in the trends of both precipitation and temperature extremes could thus be related to the diverse topography and relief features of the country (McSweeney *et al.*, 2010) which affects local and regional atmospheric circulations (NMSA, 1996; NMA, 2001).

As a result of increased weather variability of the study area, which matches with the communities' perception on the changing climate, the pastoralists faced significant loss and damage on their financial, natural and social capitals. To avert this, at risk communities have employed collective and individual adaptation and coping strategies. However, some of vital social coping capacity being eroded and at the same time the adaptation actions were seen marginally helping hard hit and disadvantaged communities group to the level it has been expected.

Communities experienced a number of difficulties in relation to their livelihoods and climate-related shocks and stresses. The main problem was drought/shortage of water and it consistently identified as the biggest problem across sampled locations.

All communities have reported having tried to respond to difficulties related to their livelihoods and climate-related shocks and stresses. Common responses included but not limited to (Table 13), preserving grain, preserving hays, vaccinated and treating livestock against locally important diseases, started non-livestock based livelihood options, and participated in the communities' climate adaptations and mitigation actions. Albeit to this, barriers to communities adapting or responding to climate-related shocks and stresses across the communities were lack of information, remoteness of the area, lack of technology, lack of capital and lack of water included among the mentioned backlogs.

5.2. Recommendation

Based on the above findings, the following recommendations are made:

Assessing the economic impacts of changing climatic conditions and their interactions with other driving forces of livelihoods vulnerability has remained a relatively neglected area of research in the context of pastoralist systems. The burgeoning literature on the assessment of the economic impact of climate change in agriculture has almost exclusively focused on crop agriculture and mixed farming systems. Hence, there should be a focus to elaborate and demonstrate the extreme event impacts on the livestock dominated livelihood economy.

It is a winning idea if a move is made to advocate a shift from a focus on replacing pastoralism to a focus on developing it on its own terms, namely turning instability into an asset. More than a need is anticipated to invent or discover new development tools and strategies. This seems a matter of re-qualifying existing sets of problems and solutions. In order to achieve this, the importance of policy and enabling environment with respect to mitigation and adaptation is clear. But, identifying the bounds of existing endogenous knowledge achieving household incomes and food security in livestock systems is critical for informing national policy debates. This information does not yet exist and this needs to be deliberated generally across the nation and specifically on the target woreda.

The study community has explained the unprecedented and ever growing climate and weather extremes and hence, weather forecasting is an essential component to the communities' development and resilience alongside the Ethiopia's National Meteorological Agency (NMA) to design customer need based weather forecasting for dissemination in local languages as this could help the community to make better anticipated and informed decision for the upcoming drought event. It is worthwhile if local authorities works NMA who have experience developing guidelines for Development Agents on how to interpret weather forecasts of different frequencies (predominantly fortnightly, monthly and seasonal). The choice of the best approach for providing information services on changing weather and climate extremes depends on the specific application and the availability of resources. In general, the combined use of different techniques is recommended, as this will also provide information on the uncertainties.

Capacity building of existing agricultural programmes in local broadcasters is recommended in terms of enabling for sustainability of climate information/discussion as well as to address problems that are specific to certain locations. Existing agricultural programmes could be encouraged to include regular weather forecasts followed by discussion on interpretation (for example, probability vs. certainty) and farmers' responses. Programmes would address the main problems of drought and water shortage and build on solutions already proposed by communities as well as featuring successful problem-solving communities. Programmes would endeavour to gather and share farmer experiences from across the region (language permitting, translations would increase access), through letter, calls or Short Message Service (SMS). The design and cost of capacity building is subject to further research.

Pointing to external interventions and induced adaptation strategies, which are indicated to have triggered scarcities by undermining the efficacy of traditional strategies of natural resource management and patterns of grazing/pasture land use, as significant drivers of vulnerability to catastrophic assets shocks during drought years. In line with this, it is high time to undertake more systematic inquiry into affordability of induced adaptation options vs.

endogenous one, and its relative economic impacts of adaptation practices, means to address existing barriers or challenges of local adaptive responses, and long-term welfare implications of specific adaptation options in the context of traditional pastoralism. In addition to individual adaptation options ascertained at household level, there are several public measures and scattered efforts that have been identified in the context. 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, a critical and systematic appraisal of current individual adaptive behaviour and public measures in pastoral areas is essentially justifiable in view of the need to design policies and selectively promote innovative practices that can enhance pastoralist adaptive capacities.

In addition to weather information, market information system is needed to disseminate current market information to keep all livestock market participants at the same level of access for market information (price, time specific demands, quality information etc.). This enables all market participants to make well-informed decision in making transactions. Since the market information system is not well developed in pastoral areas, information kept as secret in order to make use of the ignorance of competitors and sellers as an advantage. Access to domestic market information about livestock is very important for setting prices. To realise this, reliable source of information on the country are livestock number, export demand, annual off-take, productivity, and consumption levels to producers, traders, exporters and support giving institutions need to be established. Besides this, market infrastructure and institutions, production inputs, polices and laws, should be made available to serve best the disadvantaged community.

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ANNEXES

Annex 1: Household Interview Schedule for Household Characteristics (HC)

HC1	Woreda				
HC2	Kebele				
HC3	Respondent Code				
HC4	Respondent Name and its relationship with the HHs	A. Father B. Mother C. Elder boy D. Elder women/girl E. others			
HC5	Sex (circle one)	M		F	
HC6	Age				
HC7	Marital Status (circle one)	Married	Single	Divorced	Widow
HC8	Education (circle one)	Illiterate	1-4	5-8	Above 8
HC9	Family size (put number in the below row)	Male	Female	Total	

Annex 2: Household Interview template for Livestock Production (LP)

<table>
<tr><td>LP1</td><td colspan="5">Do you have Livestock?</td><td>yes</td><td>No</td></tr>
<tr><td rowspan="13">LP2</td><td colspan="7">If yes, Which livestock you possess and what is their money value</td></tr>
<tr><td rowspan="2">S/No</td><td rowspan="2">Type of Livestock</td><td rowspan="2">Numbe
r</td><td colspan="2">Money Value</td><td colspan="2" rowspan="2">Brief remark if any?</td></tr>
<tr><td>ETB</td><td>USD</td></tr>
<tr><td>A</td><td>Oxen</td><td></td><td></td><td></td><td colspan="2"></td></tr>
<tr><td>B</td><td>Cows</td><td></td><td></td><td></td><td colspan="2"></td></tr>
<tr><td>C</td><td>Heifers</td><td></td><td></td><td></td><td colspan="2"></td></tr>
<tr><td>D</td><td>Steers</td><td></td><td></td><td></td><td colspan="2"></td></tr>
<tr><td>E</td><td>Calves</td><td></td><td></td><td></td><td colspan="2"></td></tr>
<tr><td>F</td><td>Sheep</td><td></td><td></td><td></td><td colspan="2"></td></tr>
<tr><td>G</td><td>Goat</td><td></td><td></td><td></td><td colspan="2"></td></tr>
<tr><td>H</td><td>Donkeys</td><td></td><td></td><td></td><td colspan="2"></td></tr>
<tr><td>I</td><td>Camels</td><td></td><td></td><td></td><td colspan="2"></td></tr>
<tr><td>J</td><td>Poultry</td><td></td><td></td><td></td><td colspan="2"></td></tr>
</table>

Annex 3: Household Interview template for Physical assets (PA)

PA1	What types and quantities of physical assets (other than livestock) your household own and what is their money value?					
	S/No	Type of Physical Asset	Number	Money Value		Brief remark if any?
				ETB	USD	
	A	Sheet metal roofed house				
	B	Hut				
	C	Other Buildings such as stores				
	D	Hand tools				
	E	Spray can				
	F	Solar panels				
	G	Radio				
	G	Mobile phone				
	H	Tables and chairs				
	I	Land				
	J	Others				

Annex 4: Household survey template for type and diversity of livelihood options (DLO)

DLO1	Type of Livelihood options	Yes/No	Current money value		Remark if any?
			ETB	GBP	
A	Practicing farming and growing crops-Sorghum and maize.				
B	Rearing cattle				
C	Rearing shots				
D	Rearing Camel				
E	Rearing poultry				
F	Livestock trading				
G	Grain trading				
H	Petty trading				
I	Charcoal making/wood selling				
J	Wage based employment				
K	Quarrying				
L	Other (Specify)				

Annex 5: Household level interview to collect data on exiting level of understanding on climate change (CU-CC)

CU-CC1	Understanding about climate change			
A	How long have been in this area?			
B	Have you heard about Weather/Climate change?		Yes	No
C	If Yes, can you provide some description regarding climate and weather?			
D	Do you think that climate in hammer has changed when compared to 10 years before (circle either)?		Yes	No
E	If your answer to "D" is yes, what is your representation of climate change in Hamer district?			
	E1	Air became hot than it used to be		
	E2	More amount of Rainfall than it used to be		

	E3	Low amount of RF than it used to be	
	E4	Sometimes high and sometimes low RF than it used to be	
	E5	Late start of RF than it used to be	
	E6	Late ending of RF than it used to be	
	E7	Short Rainfall period than it used to be	
	E8	Long RF period than it used to be	
	E10	More mosquito and other disease outbreak than it used to be	
	E11	Other (Specify)	

Annex 6: Household survey template for gathering household coping strategies during drought related shocks (C-DF)

C-DF1	Has drought affected your livelihoods?	Yes	No	Since when	Additional Remark if any?
C-DF2	If yes to C-DF1, what immediate action you took to respond?				
A	Reduced quantity of household meals per day				
B	Sold livestock				
C	Sold other assets				

D	Used grain stored at home				
E	Used money deposited				
F	Walked long distance to fetch water				
J	Temporarily migrated in search of wage				
H	Borrowed money to meet HH needs				
I	Sought gifts from relatives/friends/networks				
J	Temporarily migrated in search of pasture and water for their livestock				
K	Split family members				
L	Permanently migrated				
M	Temporarily migrated in search of food				
N	Other (specify)				

Annex 7: Household survey template for gathering tangible actions for adaptation measures to Drought related shocks (A-D)

A-D1	Has drought affected your livelihoods?	Yes	No	Since when	Additional Remark if any?
A-D2	If yes to R-D1, have you/your household taken actions to adapt to drought impacts?				
A-D3	If yes to R-D2, what actions?				

A	I started to preserve fodder and use cut-and-carry method for livestock feeding				
B	I started to preserve grains to use them during food shortage				
C	I started non-livestock livelihood options				
D	I started to deposit/save money				
E	I reduce the number of livestock by selling and/or slaughtering before the impact of drought occurs				
F	I constructed shelter for livestock to reduce heat stress				
G	I am involved in community actions for drought impact reduction				
H	Vaccinate livestock before the drought				
I	Others (specify)........				

Annex 8 Household level interview for access to weather information

WI1	Access to weather information:			
WI2	Do you have access to weather information	Yes	No	

WI3	If you receive, from where did you get the information?	a. Words to Mouth b. Radio, C. Mobile D. development Agent/Government e. Traditional forecaster		
WI4	Does the climate or early warning information helped you to take appropriate adaptation action?	Yes	No	
WI5	If Yes, What decision have you made based on received information?	A. Know when to move livestock B. know when to sell asset at a better price C. Better management of savings D. Better decision over water and pasture		

Annex 9: Household Interview questionnaire to collect data for loss and damage (DD)

DD1	Year of Drought event (Ethiopian calendar for the last 10 years):				
DD5	No of Livestock died				
	S/N	Type of animals	No	Money value	
	A	Cows			
	B	Oxen			
	C	Sheep			
	D	Goat			

	E	Donkeys			
	F				

Annex 10: Secondary data collection sheet for Drought related loss and damage (DLD)

DLD1	Year of drought event (Ethiopian calendar):				
			Sex		Additional Remark if any?
			M	F	
DLD2	Number of people died				
DLD3	Number of went hungry/received food aid				
DLD4	No of people migrated				
DLD5	No of animals died				
	S. No	Type of animals	No	Money value	
	A				
	B				
	C				

	D				
	E				
	F				

Annex 11: Secondary data collection sheet for rainfall (RF) and temperature

- For Temperature (T)

Name of Woreda: ___________________________________

Year	Maximum, Minimum, and Mean monthly temperature (Degree Celsius)											
	Jan	Feb	March	April	May	June	July	Aug	Sep	Oct	Nov	Dec

- For Rainfall (RF)

Year	Monthly rainfall (mm)											
	Jan	Feb	March	April	May	June	July	Aug	Sep	Oct	Nov	Dec

Note: Both temperature and RF data sets will be easily collected from NMA and central grid point better representing the woreda will be used.

Annex 12: FGD questionnaire on Climate related Hazard, Trend Analysis and DAM

DAM1	Name of Woreda
DAM2	Name of Kebele
DAM3	Name of community/village

CR: Hazard Ranking

CR1	Hazard Name	Hazard Ranking	Frequency of event
A			
B			
C			

Trend Analysis

- Ask pastoralists to compare the general pattern of rainy season(s) nowadays with those when they were young, to determine if they perceived any change in climate.
- Rain fall: For short and long rainy season-onset, cessation, duration, distribution, and intensity,
- Temperature; increased, decreased, remain same

- In the case of a positive response (that they had perceived a change), ask to state the time of the start of the change referring to a year if possible, or to any important event known by other people.
- Ask to name the differences between the past climate and today's according to climate variables (rainfall pattern, temperature, sunshine and wind).
- Ask pastoralists to mention any other indicators of climate change in their environment.
- To access adaptation strategies, ask to list their strategies from the best to the least to adapt to climate change and to explain why they think they were worth doing.

List the gradual change observed and threatening the livelihood of your communities	Describe the trend	Impacts of the trend on human and non-human elements	Individual coping /adaptation mechanisms	Community coping /adaptation mechanism

FGD template for collecting data on the size of adaptation mechanisms by the community (DAM)

DAM1	Types of Adaptation mechanisms employed by the community				
	No	Type of mechanism	Unit of measure	Quantity	Remark

Annex 13: Key informant Interview open ended template for Climate Change Adaptation

1. What are the 3 priority climate related hazards in the woreda?
2. The frequency of priority hazard occurrences? Duration? Period of occurrences?
3. What triggers hazard to turn into disaster?
4. Elaborate the impact of disaster on the lives and livelihood of pastoral communities?
5. Enumerate loss and damage recorded in the area due to recent drought-2016/17?
6. Coping mechanisms frequently employed by the community/HHs to reduce impact of disaster?
7. Adaptation mechanisms preferred and suggested by community?
8. What are the major gaps in addressing the communities' adaptation needs?
9. System, methods and practices that you suggest most to wider actors to accelerate and advance communities' adaptive capacity?

SUBMISSION OF MARD PROPOSAL FOR APPROVAL

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NAME OF THE STUDY CENTER: ___________

NAME OF GUIDE _________

TITLE OF THE PROJECT CLIMATE CHANGE INDUCED DROUGHT IMPACTS ON LIVESTOCK SECTOR AND COMMUNITIES ADAPTATION ACTIONS IN THE CASE OF HAMMER WOREDA, SOUTH OMO ZONE, SOUTHERN NATIONS NATIONALITIES AND PEOPLES REGION, ETHIOPIA.

SIGNATURE OF THE STUDENT:

APPROVED: ________,

DATE________

1. *Introduction*

Climate change is a complex biophysical process. It is not possible to predict precise future climate conditions, but the scientific consensus is that global land and sea temperatures are warming under the influence of greenhouse gases, and will continue to warm regardless of human intervention for at least the next two decades (IPCC, 2007). Climate change is expected to present heightened risk, new combinations of risks and potentially grave consequences. This is particularly true in Africa where direct dependence on the natural environment for livelihood support combines with a lack of infrastructure and high levels of poverty create vulnerability in the face of all types of environmental change. In Africa, this vulnerability is further heightened by the large number of households that depend on the already marginalized natural resource base for their livelihoods. Agricultural production and the biophysical, political and social systems that determine food security in Africa are expected to be placed under considerable additional stress by climate change (FAO, 2007). In many parts of Africa it seems that warmer climates and changes in precipitation destabilise agricultural production. This is expected to undermine the systems that provide food security (Gregory et al., 2005).

Like many countries of Africa, Ethiopia is also affected most due to climate change because agricultural production is predominantly rain-fed which is susceptible for climate variability and irrigated agriculture constitutes only 1.1 % of the total cultivated land (Bewket and Conway 2007) as a result contribute less than 3% of the current food production in the country (Awulachew et al. 2005). In Low land of Ethiopia, agro pastoralism and Pastoralism represents about 60% of the land mass and much of the commercially valuable livestock is produced under rain fed dryland small-scale agricultural systems vulnerable to the adverse impacts of climate change (Little et al. 2010; Fratkin 2014). Rainfall exhibits notable spatial and temporal variability (e.g., Hulme et al., 2005). Rural households in sub-Saharan Africa and majority of rural population of Ethiopia are heavily reliant on their natural resource base to provide food and income for the family, and the availability of such resources is dependent on favourable seasonal weather conditions (Solomon et al. 2007).

1. Statement of the Problem and Rational for the Study

For Africa, it is commonly considered that agriculture is the primary rural activity, though the level of productivity has been in decline in recent decades (World Bank, 2000a). Using World Resources Institute data (WRI, 1994; IPCC, 1997) states that a third of Africa's land area is permanently used for agriculture, 30% of African GDP is derived from agricultural production, 75% of the population lives in rural areas and almost all of the rural labour force is engaged in agriculture including livestock, forestry and fisheries.

Ethiopia is endowed with huge number of livestock and it is the largest in Africa. The sector contributes about 30 to 35 percent to agricultural gross domestic product (GDP) (Benin, Ehui and Pender, 2006), about 85 percent farm cash income and 12–16 percent of the total GDP (Halderman, 2004). From the total livestock population in the country the pastoral areas share is estimated to be 40% (Pantuliano and Wekesa, 2008). However, pastoralist and agro-pastoralist areas supply 95% of livestock destined for export market (Getachew et al, 2008). Pastoralists constitute about 20% of Ethiopian population (PFE, 2006) and use about 60 percent of Ethiopia's land area (MoARD, 2005). The social, economic and political importance is of livestock is immense in the pastoral areas.

Repeated droughts resulted from changing climates badly affect the East and Horn African region. Each time when it occurs, claim the lives of several hundred thousands of people, e.g., 1973–1974 and 1982–1985 in Ethiopia (Beltrando and Camberlin, 1993). This depict that climate change is already impacting populations, livelihoods and ecosystems generally in Ethiopia and particularly study area, South Omo Zone Hammer Woreda. According to Ethiopia Humanitarian Requirement Document of 2016/17 shows that currently 7.9 million people is being affected due to rain fall variability. Among the area affected most, Hamer Woreda is the one. The extent to which systems are vulnerable to climate change depends on the actual exposure to climate change, their sensitivity, and their adaptive capacity (Intergovernmental Panel on Climate Change (IPCC) 2001). More recent work (Hewitt, 1983; Alexander, 2000; Pelling, 2003; Wisner et al., 2004; Lemos, 2007) advances this thinking, highlighting that disasters are the combination of hazard, poverty, and other causes of vulnerability—including an array of deficits and characteristics such as (income, age, political power, health, education, gender)— that define and shape livelihoods of those at risk. Often the poor, uneducated, very old or very young, the sick, and the oppressed, experience the worst impacts of natural hazards (Comfort et al., 1999).

To mitigate the impact of such malicious phenomena, several efforts has been put in place by community, government and other development and humanitarian actors through different plan and programme strategies. But, the current international scientific consensus is that recent global warming conditions, that drive and escalate changing climate, indicate a fairly stable long-term trend with natural variability of local climate inducing massive losses of livelihood assets (Hansen et al. 2012). As a result, the frequency and duration of priority climate induced hazard occurrences continue to grow up resulting deterioration of individual, household and communities' level assets particularly of pastoralists and agro pastoralists' livelihood system. The continued variability in local climate conditions and the underlying long-term trend towards changing climate makes it difficult for local people to discern, develop and undertake holistic strategy to lessen their vulnerability to the impact of disasters.

Against above background, there are few studies available on other similar drought prone areas, the study area where this research focuses on shows nearly complete absence of empirical study unearthing existing facts through in-depth analysis and well-established scientific evidence on the nature and extent of climate variability, impacts of climate change induced drought in the livestock sector and the likely adaptation measure employed by the community. Therefore, the study intends mainly to explore the Impact of Climate Change Induced Drought and Adaptation Action on livestock Sector of Hammer Woreda, South Omo Zone, Southern Nations and Nationalities of People Region, Ethiopia. . Further will also explore perception of study communities to climate change.

2. Significance of the Study

The study can establish pragmatic evidence and body of knowledge to the development and humanitarian actors to comprehend synthesize and employ sound Disaster Risk Reduction (DRR) and Resilience policies, programme and strategies in response to ever swelling impacts of climate change in the woreda and region to foster adaptive and mitigation capacity to extreme climate risks. Ultimately, the study will develop an analysis on impacts of climate changes on livestock production and adaptation strategies that can be used as an insight for future studies on the issue.

3. General Objectives

The overall objective of this study is to analyze impact of climate change and adaptation action on livestock sector stemming from rainfall variability and temperature rises in the study areas.

a. Specific Objectives

1. To analyze trends of extreme rainfall and temperature indices in the study area.
2. To assess the perceptions of local communities to climate change,
3. To assess climate change induced losses and damage on the livestock sector in the hammer community.
4. To explore tangible adaptation actions taken to impacts of climate changes on livestock sector.

b. Research Questions (The Researchable Issues)

- What are the trends of extreme rainfall and temperature indices in the study area?
- What are the study communities' perception to climate change?
- What are climate change induced losses and damaged in the livestock sectors in the study area?
- What climate change adaptation mechanisms do the local communities have to anticipate, respond and absorb climate change impacts?

4. Scope of the study

The study has set its boundary to focus mainly on two areas, 1.) To analyses climate variability from two climatic parameters (temperature and rainfall) perspective, 2.) To explore the impact of climate change impacts on the livestock production system in the study area. Moreover, the study will search in depth communities coping and adaptation strategies employed in response to changing climate. The information sources for this study will be both secondary data sources exist at academic and research institutions, at different level of government functionaries and primary data exist from different segments of communities' members through different participatory data collection techniques.

5. Literature Review

a. Important terms used in the project title.

- **Climate change** refers to long term fluctuations of temperature, precipitation, wind and other elements of Earth's climate system. It is a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global and/or regional atmosphere. Natural climate variability observed over comparable time periods in the types of changes of temperature and rainfall. It occurs because of internal variability within the climate system and external factors (IPCC, 2013a).

- ***Climate*** in a narrow sense is usually defined as the average weather, or more rigorously, as the statistical description in terms of the mean and variability of relevant quantities over a period of time ranging from months to thousands or millions of years. The classical period for averaging these variables is 30 years, as defined by the World Meteorological Organization.

- ***Weather***: Is a short-term phenomenon, describing atmosphere, daily air temperature, pressure, humidity, wind speed, and participation. (IPCC, 2007).

- ***Climate variability***: refers to variations in the mean state and other statistics (such as standard deviations, the occurrence of extremes, etc.) of the climate on all spatial and temporal scales beyond that of individual weather events (IPCC, 2014).

- ***Extreme Weather Event***: is an event that is rare at a particular place and time of year. Definitions of rare vary, but an extreme weather event would normally be as rare as or rarer than the 10th or 90th percentile of a probability density function estimated from observations. By definition, the characteristics of what is called extreme weather may vary from place to place in an absolute sense. When a pattern of extreme weather persists for some time, such as a season, it may be classed as an extreme climate event, especially if it yields an average or total that is itself extreme (e.g., drought or heavy rainfall over a season (IPCC, 2014a).

- ***Drought:*** a period of abnormally dry weather long enough to cause a serious hydrological imbalance (IPCC, 2000a).
- ***Hazard***: the potential occurrence of a natural or human-induced physical event or trend or physical impact that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems and environmental resources. In this report, the term hazard usually refers to climate-related physical events or trends or their physical impacts (IPCC, 2014)
- ***Vulnerability***: the propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt (IPCC, 2014).
- ***Mitigation***: An anthropogenic intervention to reduce the sources or enhance the sinks of greenhouse gases (IPCC, 2001a).
- ***Disaster risk reduction***: according to UNISDR, is the concept and practice of reducing disaster risks through systematic efforts to analyze and reduce the causal factors of disasters through reducing exposure to hazards, lessening vulnerability of people and property, wise management of land and the environment, and improving preparedness and early warning for adverse events are all examples of disaster risk reduction.
- ***Adaptive Capacity***: The ability of systems, institutions, humans and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences (MEA, 2005).

- ***Resilience;*** the capacity of social, economic and environmental systems to cope with a hazardous event or trend or disturbance, responding or reorganizing in ways that maintain their essential function, identity and structure, while also maintaining the capacity for adaptation, learning and transformation (Arctic Council, 2013).

- ***Risk***: the potential for consequences where something of value is at stake and where the outcome is uncertain, recognizing the diversity of values. Risk is often represented as probability or likelihood of occurrence of hazardous events or trends multiplied by the impacts if these events or trends occur. (IPCC, 2014).

b. Climate change and Pastoralism

The climate is becoming more variable and less predictable, and trends towards future changes are emerging. Global climate models predict changes over the longer term – increased temperature, shifts in rainy seasons, intense rains over much of East Africa – which will result in a mosaic of changing climate conditions with serious implications to pastoral livelihood system. Hence, this seriously aggravate the impacts of current challenges in the pastoral areas. Of all, the natural resource-based land uses in the drylands continue to affect more pastoralists within the context of wide rainfall variability and unpredictability (Magda et al., 2009). To deal with this, pastoralists employ various coping strategies. However, seen increasingly less able to do so, and more pastoralists are losing their livestock assets which is their main livelihood (Kinyangi et al., 2008). The substantial and unpredictable differences in total rainfall between years, within a year and even between areas, the climate of the drylands is also characterised by scarce absolute rainfall. High temperatures during rainy seasons ensure that much of the rainfall is lost in evaporation, and intense downpours ensure that water runs off in floods (Anderson et al., 2008). The variability in climate change impacts across different locations, at different times into the future, the interactions of increasing temperatures and more erratic rainfall, and soil types and landscape topography, will all result in mosaics of climate change effects across the Horn and East Africa region. This has an implications for economic productivity and poverty reduction, and so requires to better understand what the ranges of likely effects are going to be in different locations. Again, in order to appropriately inform policy, strategies and programmes, it is imperative to better understand what the ranges of likely effects are going to be for most susceptible pastoral livelihood system.

c. Agriculture dominated Ethiopian Economy

Ethiopia is among those countries most vulnerable to climate risks in Africa (IPCC, 2007). Agriculture in Ethiopia is heavily dependent on rain. Its geographical location and topography, plus a low adaptive capacity, make the country highly vulnerable to the adverse impacts of climate change. The country is one of the most food insecure nations in the world, a situation compounded by cyclical droughts and other calamities. Agriculture is the largest sector in the Ethiopian economy, accounting for about 41% of GDP and employing over 80% of the labour force (MEDaC, 1999). Pastoralism is a livelihood practiced mainly in the low land area. In Ethiopia, pastoralists and agro pastoralists compose nearly 13 percent of the population and traditionally have ranged across up to 60 percent of the land in search of pasture, water, and saltlicks for livestock. And totally, they depends on rained for pasture generation and water to their livestock dominated economy. Besides, of the 4.3 million hectares of potentially irrigable agricultural land, less than 10 percent is currently farmed. The farming or agrarian sector is dominated by smallholder farmers generating about 90 percent of agricultural output (Adenew, 2006). Ethiopian agriculture is predominantly characterized by traditional methods of farming and livestock keeping with very little change in practice over the past few centuries.

d. *Agro climatic profile and livelihood system of South Omo Zone and Hamer in particular*

Southern Nations Nationalities and Peoples Region (SNNPR) is one of the nine administrative regions of the Federal Democratic Republic of Ethiopia (FDRE). The SNNPR borders Kenya to the south (including a small part of Lake Turkana), the Ilemi Triangle to the southwest, South Sudan to the west, the Ethiopian region of Gambella to the northwest, and the Ethiopian region of Oromia to the north and east. The region has a total of 112,000 Square Kilometer which is about 10% of the total land masses of the country. It has a total of 112 woredas occupying the most part of Southwest corridors and it extends west from the Rift Valley as it runs through southern Ethiopia. The population size is assumed one-fifth of the country's population-18-20 million depending on growth assumptions for the decade since the last full census (CSA 2007). The region has both highland and low land areas. The main lowland areas stretch to the south-west and west, mainly in South Omo and Bench Maji Administrative Zones, and with relatively high temperatures and low rainfall with a particular scene of agro-pastoralism. Except the northern part of South Omo Zone which has mixed and broad leaf covered forest, the Zone is covered with open grasslands and bushes which was traditionally a grazing ground – settled agriculture is a recent phenomenon. The area is dominated with Pastoral Livelihood system, very remote and livestock-dependent, inhabited by far greatest number of ethnic and language groups and accordingly 16 ethnic tribes assumed to be there. The Hamar are the largest of five pastoral groups who inhabit the area. Rainfall pattern is bimodal and the longest season starts from Mid-March to May and the shortest rainy season also commences on September to November. The lowland areas such as the Hamer rangeland receive annual rain fall equivalent to 601mm (adopted from CSA, 2007). This is a low rainfall area at the best of times, and erratic rains and periodic drought in recent years have affected both crop production and the condition of livestock. As they are pastoralist, wealth is particularly gauged by livestock ownership. Due to many socio economic factors, the pastoral communities keep large population of livestock. Grazing areas have been reduced over the years because of continuous increase of livestock. The available pasture is of poor quality and palatable fodder is being diminished due to extensive grazing. On the other hand as opposed to huge number of livestock population, the yield obtained is very low due to low genetic potential associated with poor livestock management and veterinary services.The bulk of their diet is grain purchased from market; milk, meat and blood (siphoned from live cattle) are an important element. This is arid rangeland zone in the basin of the Omo River and frequent rain failure has rendered the population food insecure, and all wealth groups have received annual relief food amounting to 8-14% of annual food requirement. The population density in South Omo and in particular of Hammer, is very low, ranging between 3-10 persons per square kilometer (CSA 2007).

6. Sampling and sampling procedure

a. Population and livelihood System

The Hamer are a tribal people in southwestern Ethiopia. They live in Hamer woreda/district, a fertile part of the Omo River valley, in the South Omo Zone of the Southern Nations, Nationalities, and Peoples Region. The hammer are largely pastoralists and place a significant value on cattle. Based on the 2007 census the Central Statistical Authority estimated the population of the Hammer language speakers at 70,816. Hamer has 35 rural and urban peasant associations/kebeles. The average density of 3-10 persons per km (Bureau of Finance & Economic Development, regional profile, 2005). The average family size for the woreda is 5 persons per household. Hence, the number of household is in Hamer is estimated to be 14,163. The number of households per Kebele is nearly 404.

b. Sampling Design and Sample Size

Hamer woreda sampled purposefully so will be used as a geographical unit of data collection and analysis for secondary and primary data. In order to collect a robust data needed to achieve the objectives of the research, simple random sampling (SRS) will be employed to select three kebeles from pastoral livelihood system in such a way that the kebeles can represent the woreda assuming that sampled woreda has relatively similar agro-ecological and livelihood systems. From total kebeles of the woreda, 3 kebeles will be sampled for the study. Further, sample villages will also be selected from sample kebeles by simple random sampling. The selection of respondent households for survey will also be done through simple random sampling. Accordingly, the kebeles, villages and respondent HHs selection will be done through simple random sampling. Out of estimated 404 average households in each Kebele and 1212 households for the 3 kebeles altogether, 291 households will be identified and surveyed. For determining the sample size, a given table developed by Krejcie & Morgan (1970) is used. However, given the homogeneity of targeted communities' livelihood, dispersed settlement of the community expected to inflate the overall cost of the study hence inclined to take only 50% of 291 estimated households circa 145.

FGD and KII depend on the kind of information needed and diversity of respondents. Old men and women, government officials and other experienced staffs, and community leaders, religious leaders and etc. are potential key informants. At least two focus group discussions per Kebele (six in total), among which one is sole women group and the other will be male community group will be carried out.

c. Data Source and Data Collection Method

Four sets of primary data namely: ***climate*** (temperature and rainfall), ***socio-economic***, hazard trends, loss and damages and communities perception about climate change will be collected.

Daily time scale rainfall and temperature will be the data inputs to this study. These data sets will collect for dense network stations available in the proposed study site that have long record length (at least 30 years), and will obtained from National Meteorological Agency of Ethiopia. Before any analysis all data will pass through quality control for possible errors like inhomogeneity, outliers and missing data. Many approaches and statistical techniques have been developed for detecting inhomogeneity in climatological time series, and in this study we will use the method and software (RHtestV2) proposed by Expert Team on Climate Change Detection and Indices (ETCCDI) for daily time series (WMO, 2009). Missed data will be filled using linear regression method by using data from neighboring stations. This will apply if the missed data for a given year is not more than 10%, otherwise left that year as missed. Outliers will be smooth using data from nearby stations. Household level interviewees will also be undertaken to explore socio-economic profile of the targeted community, household's adaptation and coping mechanisms, loss and damage and perception of the community for climate change. For this, open and closed questionnaire has been created under Kobo Collect to collect questionnaire through digital system. In order to check the validity and appropriateness of the semi-structured questionnaire, three households will be identified and interviewed to pre-test prior to the actual interview of the total sample households. Data collectors/ enumerators and research assistants who have better knowledge of the local tradition and language will be contacted and trained before conducting the survey.

Key informants and community groups will be identified for focus group discussions and interview with the help of the woreda pastoral development bureau and local development agents. Accordingly, two focus group discussion will be carried out at Kebele level which will contain 5-8 pastoralists in a particular Kebele as well as one key informant interview will also be carried out at Kebele level to generate general information on the main research problem. The open ended question will developed to explore and understand better the phenomenon in detail and so used as an input to triangulate and discuss the finding from household level interviews.

Additionally, valuable secondary data will also be collected from various sources including previous scientific and academic studies and reports from universities, research institutions, woreda/regional level agricultural bureau and other concerned organizations. Detailed description of the data collection methods that will be used for each group of data are presented below.

Climate data; observed climate data on climate variables mainly temperature and rainfall, from 1986-2016, of the study area will be obtained from the National Metrology Agency of Ethiopia regional office.

Data on socio-economy and traditional coping mechanisms; an in-depth household survey, using a semi-structured questionnaire and in-person interview, will be employed to collect both the detailed socio-economic data, loss and damage, and the climate change adaptation and coping mechanism of the households.

Data processing and analysis

After all these quality control, extreme climate indices for rainfall and temperature will generate using R-based software (RClimDex) developed by Expert Team on Climate Change Detection and Indices (ETCCDI) for daily time series (WMO, 2009), and available http://cccma.seos.uvic.ca/ETCCDI. In addition to this, rainfall and temperature data will generate at monthly time scale to use for drought analysis and make seasonal climate analysis. Various master coded sheets will be prepared for coding purpose, after verifying and organizing the reviewed schedule for data collected from village HHs. Focus Group Discussion will be analyzed independently as supportive information. Raw data will be entered to statistical software package (SPSS) for data management and further analysis. Findings will be presented in different ways such as summary tables, matrices, graphical illustrations, narrative descriptions etc.

7. Chapter Plan

Chapter 1

This chapter will contain introduction part of the main report and will focus on the theoretical background of climate change, climate hazards, impact of climate change on the socio-economic and ecosystem etc. The review of past studies which are related to the topic will also be discussed. In addition the chapter will discuss about;

- Statement of the problem
- Significance of the study
- Scope and limitation of the study
- Important concepts used in the investigation and assessment
- Objectives of the study

Chapter 2

This chapter holds about the review of literature which is relevant to issues of climate change and its impact on the livelihood systems of pastoralism. Critical examination of the relationship among various researches will also be presented here.

Chapter 3

Under this chapter, detail socio-economic description and demographic characterization of study area, research methodologies and design used in the study, sampling method, tools and methods of data collection, data verification and encoding and data analysis will be dealt with.

Chapter 4

The findings from the study will be analyzed, interpreted and presented in different forms. In addition, loss and damages due to priority hazard, adaptation mechanisms for known climate change, strategies chosen, analysis community perception, analysis of meteorological information on rainfall, temperature will be presented under this chapter.

Chapter 5

Summary of major findings, conclusions, recommendations, comparisons of findings with literature review, remarks and recommendation for further action for field practitioners, policy makers, researchers etc will be discussed under chapter 5.

The annexes will include the interview questionnaires, KII and FGD questions.

8. Report Writing

The report will have preliminaries, main bodies with findings and conclusion and references. Each section will have its main and sub-topics and outlines in the chapter plan coupled with tables, figures, and presentations.

9. Time estimates

No	Research activities	Time required	Remark
1.	Problem Identification		Done
2.	Identification of objectives		Done

3	Formulation of research questions		Done
4	Literature review	1 months	June, 2017.
5	Writing of literature review	2 weeks	June, 2017
6	Research designs, sampling and data collection tool.	2 weeks	Mid-July, 2017
7	Submission of the report to the center	2 weeks	20th July, 2017
8	Reflection expected from the advisor	1 week	July, 2017
9	Approval of the research project		July, 2017
10	Pre-test of research questionnaires	1 week	August, 2017
11	Collection of data from research site	2 weeks	August, 2017
12	Data clearing, editing	2 weeks	September, 2017
13	Code book preparation and master chart preparation	2 weeks	September, 2015
14	Data processing	2 weeks	September, 2017
15	Report writing	2 months	October and November, 2017
16	Submission of the report		November 20th, 2017

CURRICULUM VITEA

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Academic rank

PhD, Associate Professor (Hawassa University,Ethiopia)

Trainings (diploma, certificate)

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- Horticulture production, processing and protection technology
- Participatory Rural appraisal (PRA) Training (FARM AFRICA-Ethiopia),
- International potato course: production, storage and seed technology , the Netherlands,

- Recent development in potato technology for rural development in sub-Saharan Africa ,
- Action research program on the improvement of peeper production SOS-Sahel

- Modeling: Applying Innovation System Concept in Agricultural Research for Development (Haramaya University)
- Human resource management
- Project management

Employment

-Educator, Researcher and consulting, Hawassa University (over 25 years), St Mary's University (about four years), Unity University (two years)

Skill and Expertise

Food crops production, food systems, rural development, production, processing and marketing of coffee, tea, vegetables, temperate and tropical fruits, vegetables, spices , tuber and root crops. Seed production, home gardening, post harvest handling, seed system, , honey production and marketing, biodiversity, food security and livelihood, organic farming, ecophysiogy, feeding crops, soil nutrients, organic agriculture, climate change, environment

Office management

-Dean, Unity University/Ethiopia

-Research and Publication, Officer: Hope College of Business, Science and Technology

-Training and Consultancy Coordinator, Hope College of Business, Science and Technology

-Head of Horticulture division, College of Agriculture, Hawasa University

- Studies on agronomy and crop physiology of *Plectranths edulis* (Vatke) Agnew

Research Project leading

- Studies on the growing and utilization of cassava plant, and its anti-nutritional factor: cyanide,
- Research coordinator of Ground nut program of the Dryland Coordination Group (Norwegian group) and Hawasa University

Thesis research advising

Advising over two hundred graduate students on development, food security, livelihood, microfinance, irrigation, cooperative, honey production and marketing, production, processing, quality and marketing of vegetables, tropical and temperate fruit crops, coffee, tea and spices; cassava production and cyanide, at Hwassa University, Addis Ababa University, and MA students of Indra-Ghandi Open University/India-St Mary's University/Ethiopia, Unity University

Consultancy experiences

Consulted several national and international institutions/organizations in several subjects, which some of them are:

- At ILRI and African RISE: an assessment on highland fruit crops and vegetable production under the title: Understanding production and marketing constraints of vegetables and fruit crops across the value chain in the Ethiopian highlands: case study at Sinana, Mahoney and Debreberhan. Supervisor Dr Tilahun Amede ICRISAT-Principal Scientist and Country Representatives, Tel :251-911230135, (in the year 2014)
- CIP and USAID project: Evaluating the potato and sweet potato programs in north and south Ethiopia with HEDBEZ Business and Consultancy PLC. Project title: Tackling food insecurity and

malnutrition through diversification: exploiting the potential of potato and sweet potato to reduce food insecurity and dependence on cereal in SNNPR and Tigray (in the year 2014).

- With SOS/SAHEL/Ethiopia- Establishing peeper value chain project in south region particularly in Gurage area. An action research program financed by smallholder livelihood Improvement project (SLIP of SOS/SAHEL).

- With SOS/SAHEL/Ethiopia- Establishing an extension manual on pepper production and processing. Financed by smallholder livelihood Improvement project(SLIP of SOS/SAHEL).

- With Dryland Coordination Group (DCG- Norway): Consulting a project entitled : Contributing to wealth creation and food safety to farmers by reducing yield loss and mycotoxin contaminations of ground nut in selected drylands of Ethiopia".

- With Dryland Coordination Group (DCG- Norway): reviewing, and compiling a report entitled "Impact of Resettlement on the Livelihood, Food Security and Natural Resource Utilization in Ethiopia"

Engaged in several out-reach and community services, which include:

- Several communities in Sidama/Hawassa, Woliyta on the production and protection of root and tuber crops: potato, *Plectranthus edulis,* enset, cassava, yam,

- Several farming communities on the production of groundnut in Eastern and Southern Ethiopia with the Dryland Coordination Group/ Norwegian Church Aid

- Several farming communities on the value Chain of pepper with SOS/Sahel at Hawassa/Sidama, and Gurage zone/Butagera,

- On the production of apple and olive crops at Debreberhan

- Tilahun Amede and Mulugeta Taye. 2015. Home garden assessment: System niches, production and marketing constraints and intensification barriers in the Ethiopian highlands, africa-rising.net , ICRISAT.

Community services

- MulugetaTaye, Lommen, W.J.M. ,Struik, P.C.(2013) **Seasonal light interception, radiation use efficiency, growth and tuber production of the tuber crop *Plectranthusedulis*.** European Journal of Agronomy 45:p. 153 - 164.

- MulugetaTaye, Lommen, W.J.M. ,Struik, P.C.(2012). Ontogeny of the tuber crop *Plectranthusedulis* (Lamiaceae) African Journal of Agricultural ResearchVol. 7(30), pp. 4236-4249

- MulugetaTaye, Lommen, W.J.M. ,Struik, P.C. (2012).Effects of breaking seed tubers on yield components of the tuber crop *Plectranthus edulis*. Journal of Agricultural Science, Cambridge pp 1-13

- Moti Jaleta, Adugna Tolera, AnshaMoti Jaleta, Mekonnen Yohannes, Adugna Tolera, Mitiku Haile, Ansha Yesufe, Kindeya Geberehiwot, Kelemework Tafere, Yemane Gegziabher, and Mekonnen Teferi, Nigatu Regassa, Mulugeta Taye, Abiye Alemu and Kiros Meles Yesufe. 2011. Impact of Resettlement on the Livelihood, Food Security and Natural Resource Utilization in Ethiopia, GCOZA, Rapport No.65. Dryland Coordination group, Norway

Publications:

- MulugetaTaye, Lommen, W.J.M. ,Struik, P.C. (2011).Effects of shoot tipping on development and yield of the tuber crop *Plectranthusedulis*. Journal of Agricultural Science, Cambridge, 150:484-494.
- MulugetaTaye, Lommen, W.J.M. ,Struik, P.C. (2007). Indigenous multiplication and production practices for the tuber crop, *Plectranthusedulis* in Chencha and Wolaita, southern Ethiopia. Experimental Agriculture, 43: 381-400

- Gulelat Dessie and MulugetaTaye (2001) Microbial load and microflora of cassava (*Manihot esculenta,*Crantz) and effect of cassava juice on some food borne pathogens. The Journal of Food Technology in Africa, Vol. 6,
No. 1, , pp. 21-24

- MulugetaTaye (2000) Some quality changes during storage of cassava roots. The Journal of Food Technology in Africa, 5 (2): 64-66.

- MulugetaTaye, and EskindirBiratu (1999).Effect of storage and utilization methods on the total cyanide content of two cassava cultivars. SINET, Ethiopian Journal of Sciences, 22(1) 55-656.

- Alemayehu Chala, Berhanu Abate, Mulugeta Taye, Abdi Mohammed, Tameru Alemu and Helge Skinnes..2014. (DCG Report No. 74). Opportunities and constraints of groundnut production in selected drylands of Ethiopia , Dryland coordination group, Norway

- Mulugeta T., Girma T., Lideta S., Shimeles A., Waga M., Kebede A., (2011) Peeper production, post harvest and marketing, Manual. (with the help of SOS—SAHEL.

- MulugetaTaye (2000). Principles and Practices of Coffee and Tea production. Hawassa University, Institute of Plant and Horticultural Sciences.

- Mulugeta Taye (2010) Spices and herbs production and management, Hawassa University,College of Agriculture

- Mulugeta Taye (2010) Fruit crops production and management, Hawassa University, College of Agriculture

- MulugetaTaye (2009) Root and tuber crops production, Hawassa University, College of Agriculture

Reading materials

Editor : International journal of biodiversity and conservation, India

Manuscript reviewing

Reviewer: African journal of agricultural research, Uganda