HARAMAYA UNIVERSITY

POSTGRADUATE PROGRAM DIRECTORATE

EFFECTS OF CLIMATE CHANGE AND ADAPTATION STRATEGIES AMONG PASTORALISTS AND AGROPASTORALISTS. THE CASE OF MIESO DISTRICT ,WEST HARARGHE ZONE, OROMIA REGIONAL STATE, ETHIOPIA

MA THESIS

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JULY 2021

HARAMAYA UNIVERSITY, HARAMAYA

Effects of Climate Change and Adaptation Strategies by Pastoralists and Agropastoralists. in the case of Mieso, West Hararghe Zone, Oromia Regional State, Ethiopia

A Thesis Submitted to the School of Geography and Environmental Studies

PostGraduate Program Directorate

HARAMAYA UNIVERSITY

In Partial Fulfillment of the Requirements of the Degree of Master of Art in Geography and Environmental Studies.

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July 2021

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We here by certify that we have read and evaluated this thesis entitled ‘**’Effects of climate Change and Adaptation Strategies among pastoralists and agro-pastoralists of Meiso district**’’, prepared under our guidance by Feyera Tilahun. we recommend that it to be submitted as fulfilling the thesis requirement.

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

DEDICATION

I dedicated this Thesis to my beloved father Tilahun Dessalegn , my beloved brother Kisi Tilahun , and to my beloved sister Ilfinesh Tilahun .

BIOGRAPHICAL SKETCH

The author Feyera Tilahun Dessalegn was born in July 2, 1982 in Ref Toko Tane Kebele, Fincha District, Fincha town, Horro Guduru Wollega Zone, Oromia regional state. He started his elementary and Junior School in Kawo Primary School. Then he joined Agemsa Senior Secondary School for his Secondary School education. After succeful completion of his secondary education,he joined Haramaya University and graduated with BA degree in Geography and Environmental Studiees in 2012 G.C. Following this, he attended PGDT (Postgraduate Diploma in Teaching) at Haramaya University from 2014-2015. After graduation, he was employed in Eastern Hararghe Zone, Oromia National Regional State under Ministry of Education and served as Geography teacher at Kobo secondary and preparatory school Starting from 2014-2018 G.C. Since 2021, he continued to serve at HUMS (Haramaya University Model School) in teaching geography. In 2016, he joined Haramaya University to pursue his post graduate studies in Geography and Environmental studies.

ACKNOWLEDGEMENTS

My great appreciation and thanks are due to all those who helped me in having this study completed. It is my pleasure to express my heartfelt appreciation and special gratitude to my Advisor, Solomon Tekalign (PhD) , who gave me appropriate guidance, through comments, corrections and encouragement at all stages of the study. My genuine gratitude also goes to my Co-Advisor .Admasu Bogale (PhD) for his critical comment to accomplishment of this thesis.Thank you very much indeed.

Special thanks go to National Meteorological Agency (NMA),for providing long-term climatic data that supported me to complete the work. I would like also to thank Ministry of Education(MoE) for granting me the research fund. Also, I thank Mieso district Pastoralist Development Office, Disaster Prevention and Preparedness Office and Central Statistics Agency for providing me with Crop and livestock population data.

My Appreciation goes to all my key informants and focus group participants for their time, hospitality, and cooperation in provision of valuable information and data for the success of the study. I am also indebted to mosisa Ajema who has helped me a lot during data encode and analysis.

I also like to extend my gratitude to Umar Ahmed for his support and help during data collection. His commitment and patience in accompanying and helping me in that inhospitable area was unforgettable. And my grateful thanks go to Tesfaye Abera (Ass.Professor) who assisted me during data encode and analysis .

Finally, I like to extend my gratitude and appreciation to my parents and to all my friends at Haramaya University, Who helped me in one or another way throughout my study.

ABBREVIATIONS AND ACRONYMS

ANRS :- Afar National Regional States

ASALs:- Arid and Semi-Arid Lands

CEEPA :- Centre for environmental economics and policy for Africa.

ATPSN :- African Technology and Policy Studies Network.

CSA:- Central Stastical Authority

DFID:- Department for International Development.

FAO:- Food and Agriculture Organization

FGD:- Focus Group Discussion.

FDRE :- Federal Democratic Republic of Ethiopia

GDP :- Gross Domestic Product

GTP :- Growth and Transformation Plan.

IPCC :- Intergovernmental Panel on Climate Change

IFPRI :- International Food Policy Research Institute

IIRR :- International Institute of Rural Reconstruction

ILO :- International Labor Office

ILRI :- International Livestock Research Institute

KII :- Key Informant Interview

Masl :- Mean above sea level

MNL :- Multinomial Logit

MOA :- Ministry of Agriculture

MPLSDPD : Mieso Pilot Site Diagnosis and Program Design

NAPA :- National Adaptation Program in Action

NDMA :- National Drought Management Authority

NMA :- National Metrological Agency

NGOs :- Non-Governmental Organization

NOAA :- National Ocean and Atmosphere Administration

PASDEP :- Plan for Accelerated and Sustained Development to End Poverty

UNESCO :- United Nations Educational, Scientific and Cultural Organisation.

UNFCCC :- United Nations Framework Convention on Climate Change

USA :- United States of America

UoP :- University of Peace

WSPA :- World Society for the Protection of Animals

UNEP :- United Nations Environmental Programme

UNISDR :- United Nations International Strategy for Disaster Reduction

UNECA :- United Nations Economic Commission for Africa

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The Effects of Climate Change and Adaptation Strategies among Pastoralists And Agropastoralists.The Case of Meiso district, West Hararghe Zone, Oromia Regional State, Ethiopia

Abstract

This study investigated the effects of climate change and adaptation strategies by pastoralists and agropastoralists in meiso district,Western Hararghe zone of Oromia, Ethiopia. A sample of 260 households was used and data collected using Focus Group Discussions ,key informant interviews and household questionnaires. Other information was collected from secondary sources.The mann Kendall trend test indicated that precipitation decreased by -12.82mm/year at 0.05significance level. opposed to rainfall, temperature is increasing by 0.045^0c at 0.05 significance level. FGD with pastoralists and agropastoralists indicated the effects of climate change as feed shortage, shortage of water,reduced crop and livestock productivity increased mortality and disease. The major adaptation strategies in pastoral area includes diversification of livestock species and herd mobility.In agropastoral area the major adaptation strategies were mixed crop-livestock farming followed by changing livestock feed. Multinomial logit model show that training services,income access to credit , land scarcity and lack of climate information factors have a significant impact on mobility as an adaptation option at 5% level of significance. Lack of institutional support like access to credit would increase the mobility adaptation choice by 0.56% in the pastoral community. Land Scarcity and lack of access to credit increase the probability of pastoralists and agropastoralists adaptation strategies by 21.7% and 1.15%, respectively. The study recommends a number of policy options and strategies towards climate change. It also proposes need for policy advocacy at national and international levels on climate change issues as well as increasing water use efficiency and productivity,sustainable agriculture; promoting economic diversification and alternative livelihoods. There is also the need for research and development of innovative solutions to the challenges affecting Pastoralism and agropastoralism.

Key words: Adaptation, Agropastoralists, Climate change , Determinants, Mieso, Pastoralist

1. INTRODUCTION

1.1 Background of the Study

According to United Nation Environmental Programme (UNEP, 2014), Pastoralism is exercised by more than 200 million people across the world including nomads, transhumant herders, and agropastoral communities producing high quality of livestock products (milk, meat, fiber, and leather etc.). Pastoralism remains an important livelihood for many, Covering around 45 percent of the world's surface area, rangelands are an important environment, and are home to maybe 200 million people (Reid *et al*. 2014). According to report by Catley and Andy (2017) in Feinstein International Center and Mohammed Yimer (2015) pastoralism is the best alternative than agriculture in rangelands where rainfall is very limited and other sources of long-lasting water source are scarce. Pastoralism is the most resilient form of land use for Arid and Semi-Arid areas and has evolved over time with adaptation strategies for survival (UoP, 2009).

Climate change has already significantly impacted agriculture and is expected to further impact directly and indirectly food production. Increase of mean temperature; changes in rain patterns; increased variability both in temperature and rain patterns; changes in water availability; the frequency and intensity of 'extreme events'; sea level rise and sanitization ; perturbations in ecosystems, all will have profound impacts on agriculture, forestry and fisheries. Climate change and variability that has been experienced in many parts of the world add to the challenges that face the agricultural sector in the Africa. Considerable shifts in long-term averages and variability in rainfall and temperature, sea levels, frequency and intensity of droughts and floods have also been experienced (IPCC, 2007). Although climate change (CC) is a global phenomenon, its negative impacts are more severely felt by poor people in developing countries who rely heavily on the natural resource base for their livelihoods (Gerber *et al.,* 2013).

Developing countries have a much more limited capacity to cope with the problems caused by climate change. Africa remains the only region in the developing world where agricultural yields are low and continue to decline. Most countries in Sub-Saharan Africa (SSA) rely heavily on agriculture for employment and food security for their economies. The sector also has large numbers of smallholder farmers, most of who produce under unfavourable conditions characterized by low and erratic rainfall and poor soils (Mutsvangwa, 2011). Given the importance of agriculture to employment and livelihoods in many developing countries, loss of

agricultural productivity due to climate change will affect their entire economies. Agriculture in Ethiopia is heavily dependent on rain and geographical location and topography, plus a low adaptive capacity, make the country highly vulnerable to the adverse impacts of climate change (Zenebe G., *et.al*., 2011).

Therefore,an attempt was made in this study to assess effects of climate change and its effects on Pastoralism and agropastoralism.This study also identified adaptation strategies pursued by pastoralists and agropastoralists in response to climate change and determinants of adaptation strategies in the study area.

1.2. Statement of the Problem

According to African Union (2010) reports Pastoralism has "evolved over generations as a response to marked rainfall and temperature variability," and that flexible and mobile Pastoralism has great potential for reducing poverty, generating economic growth, managing the environment, and promoting sustainable development. pastoralists have an intimate relationship with their environment and a rich knowledge that enables them to protect and exploit the changing rangeland conditions on which they depend (McGahey *et al.* 2008; Notenbaert *et al*. 2012).

Arid and semi-arid areas are prone to rainfall variability, extreme drought and flash floods. The people in the pastoral lowlands are mainly pastoralists and agropastoralists who have an immediate daily dependence on climate sensitive livelihoods and natural resources (pasture and water), and they are among the most resource-deprived and geographically marginalized. In response to changes in climatic conditions, scarcity of natural resources and the magnitude of hazards in the pastoral and agropastoral areas have been intensifying through time. The harmful impacts of climate change are also compounded by the lack of resources, economic and social infrastructures and institutional capacity. In addition, there has been an intensification of inquiries on specialization and diversification in pastoral economies, which, for the first time, provide detailed overviews that can be used to make inferences concerning the diversity of the social and economic aspects of pastoral livelihoods (Catley *et al*. 2013; Bollig *et al*. 2013).Similarly in Ethiopia, identifying major factors that affect the adaptive capacity of pastorals and agropastorals have recently become prior concerns while attempting to improve the livelihoods of (Tsegaye *et al.*, 2013).

The study conducted by International Food Policy Research Institutes (IFPRI) notes the dependency of Ethiopia on the agricultural sectors, which comprises more than half of the national Gross Domestic Products generates over 85% of the exchange earnings ,and employs around 85% of the population (Deressa *et al*.,2008). Similarly, study conducted by Stark *et al*. (2011), indicated that households have experienced a severe reduction in their assets with an average reduction of 80% in livestock holdings from their peak holdings over the past 10 years mainly by climate change inYabello, Borena zone in southern Ethiopia. Studies by Tsegaye (2013) and Berhanu (2007) examines what and how major factors influence the adaptive capacity of rural communities in the Afar region of Ethiopia, including to what extent adaptation methods are applied and which adaptation methods contribute to household income.There are several public measures and scattered efforts that can be identified in the context of the need to enhance pastoralist adaptive capacity to climate change and variability. Not all individual adaptation measures to climate variability and public actions in pastoral and agropastoral areas are constructive and sustainable. Some can be destructive to the extent that they may increase pastoralist vulnerability (Wassie, 2015). Lack of research evidences to the study of climatic adaptation on pastorals and agropastorals will obviously continue to widen the conceptual differences among various viewers,which may further trigger lack of consensus across the communities of pastorals and agropastorals, policy makers and decision makers (ATPS, 2013).

The Ethiopian government has put in place a number of policies, strategies and laws that are designed to support climate change and variability mitigation and adaptation and sustainable development. Although the current policies, strategies and laws related to climate change and sustainable agriculture in Ethiopia are adequate, they lack detailed guidelines, manuals and action plans and are not sufficiently mainstreamed into existing programmes and projects. There is a lack of adequate research findings on adaptation strategy practices in Ethiopia for the various agro-ecology, soil type, rainfall pattern, farming system, temperature and moisture ranges FAO (2016).

Climate changes also contributes to the occurrence of pest and insect infestations. Farmers in *Doba District* have been responding to climate change through various strategies. But, there was no empirical data that substantiates or supports the existing adaptation strategies practiced by the farmers in research area. The information obtained in various literatures was insufficient and general, but adaptation strategies vary contextually and spatially (within communities and even within individuals). In fact, the available few literatures on climate change adaptation strategies were conducted using regional data, not specific to household-level. Furthermore, the literature on climate change has paid little attention to the analysis of factors influencing adaptation strategies chosen by pastoralists and agropastoralists

smallholder households to adapt to climate change and constraints associated with the choice of the adaptation measure(Belaineh *et al* 2012). Despite extensive research and increased availability of information, existing knowledge on how to adapt to climate change at the grassroots level is extremely fragmented and dispersed (Reid *et al*., 2009).

Studies conducted by Gemechu *et al* (2016) indicated that due to climate impact (drought and feed shortage) the body weight of livestock reduced which imposed low price especially at severe stage. Other constraints like lack of improved breed, conflict on natural pasture, informal marketing of livestock medicine and lack of training in hindering livestock production and productivity in Mieso and Daro labu district.

Changing rainfall and temperature patterns due to climate change have different effects on crops and livestock production. The production system of the study area totally depends on rain fed which is highly sensitive to climate change impact. Even though many research studies have been done at the national and international level, there is still an urgent need for communicating climate change issues for communities in appropriate ways. Providing scientific information concerning climate change for society is appropriate to local stakeholder for adoption of sustainable adaptation and response for solutions. Therefore, this study intends to assess the effect of climate change and pastoralists and agropastoralists adaptation strategies during shock in the study area.

1.3. Objectives of the Study

1.3.1 General Objective

The general objective of this study was to investigate the effects of climate change and adaptation strategies among pastoralists and agropastoralists, in the case of Meiso district, in West Hararghe Zone, Oromia regional state, Ethiopia.

1.3.2 Specific objectives

The study has the following specific objectives:

1. To assess climatic trends of Meiso district.
2. To examine the effects of climate change on the pastoral and agropastoral communities of the study area.

3. To examine major adaptation strategies used by pastoral and agropastoral communities of the study area.
4. To assess determinants of adaptation strategies in the pastoral and agropastoral communities of the study area.

1.4 Research Questions

The study was carried out to answer the questions below:

1.What are climatic trends of Mieso district?
2. How do these changes affects the pastoralism and agropastoralism production systems ?
3.What are the major adaptation strategies used by pastoral and agropastoral communities of the study area?
4. What are determinants of adaptation strategies in the pastoral and agropastoral communities of the study area?

1.5 Significance of the Study

The study provides information for the pastoral development stakeholders and policy makers on the current status of adaptation strategies in the pastoral and agropastoral communities of the study area. The study results will thus guide the policy options, interventions and essential support necessary for sustainability of the nomadic pastoralists and agro-pastoralists. Development actors like the Ministry of Agriculture (MOA), Pastoralists Development Office, National Drought Management Authority (NDMA), and other governmental and Non-governmental organizations (NGO's) will get access to information from the findings and recommendation of the study to improve their interventions. Government and other development actors will utilize the findings of the study to formulate and target awareness and sensitization program to enhance the adaptation strategies for the pastoral and agropastoral communities. Suggestions made here in will be a starting point or rather a clue to those interested in carrying out more researches along this line as this work outlines the gaps and limitations that cannot be covered by other researcher.

1.6 Limitation of the study

The study was limited to Oromia region of meiso district. For a more conclusive result, all the pastoral regions may need to be studied which was not possible due to constraints such as distance from study site, terrain and accessibility. Moreover, 1981-2019 is a short time to make an authoritative conclusion

for climate parameters. In addition, there is general dearth of published literature on issues of climate change among pastoralists and agropastoralists in the study area. This inturn affected the quality of the data.

1.7 Scope of the Study

The study was focused on Oromia regions of Meiso district. The investigator delimited this study to meiso district because of shortages of resources, and time. Within this district, the study was conducted in pastoral and agropastoral areas. Its scope is limited to the effects of change change to livelihood and adaptation strategies in the pastoral and agropastoral communities of meiso district .

1.8 Operational Terms

Adaptation: Adjustment in natural or human systems to a new or changing environment that exploits beneficial opportunities or moderates negative effects. (IPCC, 2007).

Adaptive capacity- The resources available to the community that could help them cope With the effects of climatic factors and diseases.(IPCC,2007).

Agro-pastoral: A practice of agriculture that includes both the growing of crops and the raising of livestock.

Climate Change is commonly used to describe any systematic alteration or statistically significant variation in either the average state of the climate elements such as precipitation, temperature, winds, or pressure; or in its variability, sustained over a finite time period (decades or longer). It can be referred to as the long-term change in global weather patterns, associated especially with increases in temperature, precipitation, and storm activity (IPCC 2013).

Climate variability is the way climate fluctuates yearly as above or below of a long-term average value (NOAA, 2009).

Communities: A group of people living in the same defined area sharing the same basic values, Organization, andinterests (Rifkin et al, 1988).

Household is defined as a farm family unit consisting of a group of interrelated people living together, sharing the same dwelling house, working on the family farm, making farm-level decisions (including adaptation) and pooling their labour to manage their farm under the prime leadership of the household head (Davies and Bennett 2007).

Kebele: The lowest administrative unit in to which a district is sub-divided (CSA, 2004).

Pastoralism: Pastoralism is the livelihood activity of rearing livestock often moving with the herds in search of fresh pasture and water (nomadism). Pastoralist: According to Krätli and Swift (2014), the term pastoralist can be used to indicate a cultural identity and a production/ livelihood system. This means that it can refer to people who practice Pastoralism, those who share a pastoralist background or those involved in activities related to Pastoralism.

1.9 Organization of the Thesis

The thesis is organized into five chapters, chapter one introduces the background of the study, Statement of the study, objective of the study, Research question, significance of the study, definitions of key terms and organization of the thesis, chapter two reviews important literature related with Climate change (annual maximum and minimum temperature , annual rainfall trends, Effects of climate change, adaptation strategies and major determinants of adaptation strategies in pastoral and agropastoral communities. Chapter three includes; research methodologies, chapter four presents results and discussion as follows: profile of the respondents,Perception on temperature and rainfall trends, Effects of climate change on rearing livestock and crop production, major adaptation strategies, determinants of adaptation strategies and policy implications . Conclusions and recommendations are presented in chapter five. References and appendices are stated at the end of the thesis.

2. LITERATURE REVIEW

2.1 Theoretical Framework

2.1.1 Concepts of climate change and variability

IPCC (International Panel on Climate Change, 2014) describes climate change as a change in the state of the climate that can be identified by changes that persists for an extended period, usually decades or longer. Although an area's climate is always changing, the changes do not usually occur on a time scale that is immediately obvious to people. Weather changes can be observed from day to day but slight climate changes are not as readily detectable. Climate takes the following elements into account, the most important of which are: Air temperature and humidity, type and amount of cloudiness and precipitation (eg:rainfall), air pressure, and wind speed and direction. Climate change affect rainfall distribution and weather patterns (Taylor *et al.,* 2012). Climate variability refers to variations in the mean state and other climate statistics such as standard deviations, and the occurrence of extremes among others on all temporal and spatial scales beyond those of individual weather events. Variability may result from natural internal processes within the climate system (internal variability) or from variations in natural or anthropogenic external forces (external variability). Every year in a specific time period, the climate of a location is different. Some years have below average rainfall, some have average or above average rainfall FAO (Food and Agriculture Organization, 2007).

2.1.2 Concepts of Pastoralism and agropastoralism

By definition, the difference between Pastoralism and agro-pastoralism is that the main income-generating mechanism pastoralists is livestock and livestock products. In contrast, cultivation with the small number of livestock production is the main source of income for agro-pastoralists (IFAD, 2008). Pastoralism is defined as a livelihood reliant on livestock both small and large for a majority of household. Pastoralists of course are rarely solely reliant on livestock alone, however, and most pastoral livelihoods are highly diversified. This is essential in often harsh, variable environments, where other income-earning strategies from trade to natural resource harvesting to agriculture are important (Krätli *et al.*,2013). The drylands inhabited by most pastoralists are places of high environmental variability, where the nutrients on which livestock depend are widely scattered in time and space as a result of unpredictable patterns of rainfall. Pastoralists who move to take advantage of this variability can feed their animals better than those who do not. Pastoral livelihoods integrate

variability into processes of production: use of inputs, breeding, land tenure, marketing strategies, and links with other livelihood systems. Mobility is a production strategy, not just a coping strategy, with important consequences for other variables.(Krätli *at el*., 2019). Pastoralism is often the optimal subsistence livelihood, which is generally independent of any particular local environment. A pastoral subsistence pattern (especially nomadic Pastoralism) is very often an adaptation to an irregular climate to reduce the risk in semi-arid open country (O'Neil, 2011).

According to FAO (2015) Ethiopia has the largest livestock population in Africa (first in Africa, and 5th in the world). CSA (2017) data showed that there are 59.486 million heads of cattle, 30.69 million sheep, 30.2 million goats, 59.49 million all poultry (Chicken, laying hens, non-laying hens, pullets, cockerels, cocks), 11 million equines (donkeys, horses, mules) and 1.2 million camels, and 6.18 million beehives distributed in all the administrative regions. Cattle are a very common asset in Ethiopian households; 12.5 million households,or 70 percent of the total population, depend fully or partly on cattle for their livelihoods (FAO, 2018).

The decrease in livestock population will lead pastoralists to search for other options of income generation like destroying trees to produce charcoal which will negatively impact the rangeland ecology (Riginos *et al*. 2012). It is, therefore, better to develop policies which will enhance the livestock productivity as high-income pastoralists gain, they will be responsible to protect the rangeland ecology (Hausner *et al*. 2012). With the increasing sedentarization of pastoralists, the reduction in labor input in mobile livestock rearing may lead to a shift from multiple Pastoralism toward solely pastoral farming or agro-pastoralism production, implying a terrible loss of diversity of Pastoralism. As a result, the practices of Pastoralism have been overwhelmed. If these situations continue, it is likely that pastoral societies across the world will have more unpleasant fates in the future (Dong *et al*. 2016). In addition to this, (UNEP, 2014) stated that the research findings of the last twenty years disclaim the argument that Pastoralism is backward, providing that it is not only economically very important but also preserves the ecosystem.

According to (Tsegaye *et al*., 2013), the annual household income for pastoralists is lower than semi-pastoralists and agro-pastoralists and this indicates the combining livestock production and dryland farming would enhance or maintain the livelihood of the households. This means that agro-pastoralists are likely to have better living standards than pastoralists and semi-pastoralists. However, agro-pastoralists have the challenge of relying on good weather which is never reliable especially around pastoral rangelands. This makes pastoralists better be placed to survive in dry regions as the

shift from Pastoralism to non-pastoral way of life will be difficult for those pastoralists who used to it. Though several development platforms inspire agro-pastoralism, sustainability of pastoral development requires livestock mobility with proper infrastructure and appropriate policies enabling pastoralists to get an access to social services (Sonneveld *et al.,* 2017).

2.1.3 Concepts of Adaptation Strategies

Pastoralists have a long history of involvement in various forms of adaptation methods based on their own indigenous knowledge (African Technology Policy Studies Network 2013).Pastoralists in arid and semi-arid African Sahel have developed diversified adaptation strategies built on principles of flexibility and mobility. These strategies involve spreading and managing risks through cooperative communal herding, diversifying livestock composition depending on the animal food- and water needs (Pedersen &Benjaminsen, 2008). Adaptation in the context of climate change refers to any adjustment that takes place in natural or human systems in response to actual or expected impacts of climate change, aimed at moderating harm or exploiting beneficial opportunities (Adger *et al*.2007). Klein *et al.,* (2005) also argues that adaptation is not a new activity only relevant in the context of climate change, but instead an ongoing process to reduce vulnerability to climate variability as well as human-induced climate change. It is also indicated that adaptation is closely linked to adaptive capacity (Anderson *et al*. 2010).

Adaptive strategies are the strategies in which a region or a sector responds to changes in their livelihood through either autonomous or planned adaptation (Campbell 2008). Adaptation to climate change and variability is the process of adjusting to experienced or expected change. Adaptation strategies are long-term strategies which are mostly planned to changes in broader environmental circumstances (Adger, N *et al*., 2007). Coping and adaptation to climate change and variability are closely related and interchangeably used in the context of disaster response except that they have different time spans. In the climate change context, adaptation is commonly seen as a set of actions and decision making processes (Nelson *et al*., 2007).

Farmers living in Ethiopia’s semi-arid and arid lowlands that have less diversified assets and are heavily reliant on rain-fed agriculture are, along with their livestock, particularly vulnerable to climate change (MacDonald *et al.,* 2011). The people in the lowlands are among the most resource deprived and the most geographically and politically marginalized. Hence, the magnitude and impact of hazards in these areas has been intensifying (World Bank 2010). World Bank estimates there to be

at least 12 million pastoralists and agro-pastoralists in the country of Ethiopia. So far, there has been little opportunity for livelihood diversification and smallholder agriculture still accounts for up to 80% of the population's employment (Wondifraw *et al*., 2014). The deeply disturbed relations between pastoralists and the state have their roots in a long history of governmental interventions and policies that failed to acknowledge Pastoralism as a viable way of life (Devereux, 2010).The livestock sector, which is largely concentrated in arid and semi- arid lowland regions, contributes 12-16% of Ethiopia's gross domestic product and 30-35% of the agricultural GDP (MoA, 2013).

Oromia Regional State, with a population of over 25 million, is one of Ethiopia's nine regional states. It has 8 zones, 200 districts and 375 urban centers (Pantuliano and Mike, 2008). At present 33 pastoral and agropastoral districts of Oromia National Region State are found in 6 zones (Borana, Guji, Bale, east Hararghe, east Shoa and west Hararghe) (ONRS, 2011). Agriculture is the basis of livelihood for the majority of the population in the region, and accounts for two-thirds of the total regional GDP; industrial activities contribute less than 10%. The region is also well endowed with livestock resources, although quality and productivity is very low. Traditional range management practices have deteriorated, and indiscriminate water development has led to the degradation of some wet season grazing areas. Like most part of Ethiopia mixed farming dominates the livelihood of the region. Land is an important asset of households for production of crops and rearing of livestock (ONRS, 2011).

2.2 Empherical Review

2.2.1 Major Climate change

There is new scientific consensus revealing that the global climate is changing (IPCC, 2013). Global mean temperature increased by 0.6 degree ^{0}C in the last century, with the hottest years ever in record occurring after 1990. This warming of the world climate has been linked to a higher concentration of greenhouse gases (GHGs) in the atmosphere, the consequences of which can be manifested in the higher frequency of extremes such as floods, droughts and cyclones (IPCC, 2013). In fact, climatology characteristics such as ambient temperature and rainfall ,observed trend of mean annual rainfall is not clear (World Bank, 2016). Historical records show an increase in global temperature since the late 19th century (Hartmann *et al*. 2012). The last three decades have been reported to be successively warmer than all previous decades, and the first decade in 21st century has been the warmest decade on record. On an average, global temperature has increased 0.72°C since

1950 (Hartmann et al. 2012). With the increase in temperature, frequency of cold days, cold nights, and frost have decreased, while frequency of hot days, hot nights, and heat waves have increased. The Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report (AR5) projects a continuous increase in global temperature if greenhouse gas (GHG) emissions persist unabated. IPCC further predicts an increase in temperature between 0.3°C and 0.7°C over the next two decades and an increase of 0.3–4.8°C by the end of the 21st century, depending upon emission scenarios (Collins *et al*. 2013; Kirtman *et al*. 2013).

Along with increases in temperature, global warming is associated with changes in large-scale hydrological cycle elements, such as an increase in atmospheric water vapor, shifting precipitation patterns, changes in precipitation intensity and extreme events, reduced snow cover and extensive melting of ice, and variations in soil moisture content and runoff (Bates et al. 2008; Hartmann et al. 2013). Precipitation has generally increased from 1900 to the 1950s between 30°N and 85°N latitude and has significantly increased between 10°N to 30°N, but has declined after 1970 to present (Bates *et al*. 2008). The evidence of climate change is compelling: sea levels are rising, glaciers are retreating, precipitation patterns are changing, and the world is getting warmer. According to the Intergovernmental Panel on Climate Change (IPCC, 2014), the current rate of greenhouse gas emissions is likely to cause average temperatures to rise by 0.2˚C per decade, reaching by 2050 the threshold of 2˚C above pre-industrial levels. Recent evidence suggests even more rapid change, which will greatly, and in some cases irreversibly, affect not just people, but also species and eco-systems (Elizabeth *et al*., 2010). In Africa, precipitation amounts are likely to decrease for most parts of Sub-Saharan Africa (SSA) while rainfall variability is expected to increase (IPCC, 2014). Ifejika Speranza (2010) and World Bank (2010) argued that Africa is expected to experience mainly negative climate change impacts, in terms of an increase in the already high temperatures and decrease in the largely erratic rainfall in its context of widespread poverty and low development. Climate change is projected to increase temperature and precipitation variability in East Africa. Temperature in Africa is projected to rise faster than the rest of the world, which could exceed 2°C by mid-21st century and 4°C by the end of 21st century (Niang *et al*. 2014).

Ethiopia is located in a tropical region where differences of temperature are strongly modulated by elevation (Kreyling *et al*,.2010) According the reports of (McSweeney *et al* 2010), Ethiopia comprise of about 61% of the total land mass of the country is lowland where its elevation is below 1500m and are commonly known by warmer and drier. In similar way as like of other Africa countries and the rest of the world, studies on climate have shown changes in temperature and precipitation trends and

variability's during recent decades in Ethiopia (Wong *et al.,* 2010). The change in magnitude and trend vary with locations, time series analysis of mean national maximum and minimum have shown positive trends (NMA, 2010: Beliethathan *et al.,*2009:Gebere *et al.,* 2009). The observed warming is escorted by a steady decline in precipitation in many parts of the country (Funk,2011) although increases have been reported in some areas(Meza 2004 and NMA,2012) and no changes detected in others (Selish and Zank,2004). The analysis of past climate data in Ethiopia showed that an increase of annual minimum temperature by 0.37 °C per decade since 1951 (NMA, 2007) and annual mean temperature by 1.3 °C between 1960 and 2006, whereas as rainfall decline in different parts of the country (Selish and Zank,2004).The human induced climatic change would bring further warming in Ethiopia over the next century as like of the other parts of Africa (Selish and Zank,2004). Ethiopia has a diversified climate, which has different size and diversity of major agro-ecological zones render it suitable for the support of large numbers and classes of livestock (Funk *et al*., 2012).

The long-term climatic change related to changes in precipitation patterns, rainfall variability, and temperature is most likely to increase the frequency of droughts and floods in Ethiopia. The country's heavy dependence on rain-fed and subsistence agriculture increases its vulnerability to the adverse effects of these changes (Kassa, 2015). In terms of rainfall occurrence, there are three seasons in Ethiopia, namely bega (dry season) which extends from October–January, belg (short rainy season) which extends from February–May and kiremt or meher (long rainy season) which lasts from June–September (NMA, 2007). Rainfall in the short rainy season (belg) is caused by moist easterly and south-easterly winds from the Indian Ocean, while in the main rainy season (kiremt) is a result of convergence in low-pressure systems and the Inter tropical Convergence Zone (Daniel, 2011, Tabari *et al*., 2015). Gutu *et al*. (2012) had reported a gradual decline in yearly average rainfall and pronounced reduction both in belg and meher rains.

2.2.2 Pastoralism and agropastoralism Systems

Pastoral and agropastoral production systems exhibit distinct Characteristics, and presents unique opportunities and challenges for agricultural research and development as well as adaptation. The dry land ecosystems these agricultural systems inhabit offer two key features a highly variable climate, and increasingly limited natural resources to which smallholders for generations have strived to adapt (Van Ginkel, M., *et al.* 2013). Pastoralism plays a pivotal role in the national economy by providing labor income, food, nutrition security for the pastoral community. Besides, it is the best system to use marginalized and less productive lands. It also helps sustain and preserve the

natural resources and the ecosystem. Furthermore, it is the best way for communities living in a very harsh environment with high temperature, low amount of rainfall and water sources (Mohammed Yimer, 2015).

Pastoralist people are those whose way of life largely depends on mobile livestock-herding.They live in a range of environments in many countries across every continent in the world. In Sub Saharan African, mobile Pastoralism is predominantly practiced in arid and semiarid lands(ASALs). These areas are hot and dry, with low and erratic rainfall. There are not many livelihoods that are suited to this arid environment but mobile livestock keeping is relatively well adapted. In fact Pastoralism in Africa evolved in response to climate variability over 6000 years ago (Brooks, 2006) when the Sahara entered a period of prolonged desiccation. With no reliable supplies of permanent water, Pastoralism enabled people to adapt to an increasingly arid and unpredictable environment by moving livestock according to the shifting availability of water and pastures (Brooks, 2006).

Pastoralism is not only the way of life for pastoralists, but also a culture, symbol of love and integrate, economic and livelihood system, one of the basic pastoral risk management strategies and rational use of drylands. It is life system mostly found in Africa's vast arid and semi-arid areas which are manifested by rainfall variability, and associated uncertainties in the spatial and temporal distribution of water resources and grazing for animals. Pastoralism is practiced mainly on the grasslands that cover about a quarter of the world's surface (Follet & Reed, 2010). It is closely associated with mobile herds and with the drylands (Robinson *et al*., 2011).

Pastoralists and agro- pastoralists in Ethiopia inhabits the largest livestock population in Africa and more than 61% of its landmass (Pastoralist Forum Ethiopia, 2010). They raise a large portion of the national herd, estimated about 42 percent of the cattle,7 percent of the goats, 25 percent of the sheep, 20 percent of the equines and the total number of camels Pastoralists live mostly in dry, remote areas, whose livelihoods depend on their intimate knowledge of the surrounding ecosystem and on the wellbeing of their livestock. Pastoral systems take many forms, adapted to particular natural, political and economic environments. The types of livestock kept by pastoralists vary according to climatic and environmental conditions, and availability of water and other natural resources, and geographical areas. Due to these determinants, mobility is considered as a key feature qualifying pastoralism and its system (IFAD,2009).

2.3 Effects of Climate change on pastoralism and agropastoralism systems

The increase in frequency of extreme climatological events, climate change has become unequivocal, impacting water resources, agricultural, and food systems (Hartmann *et al*. 2013). Consequences of the long-term climate related to changes in precipitation patterns, rainfall variability, and temperature has increased the frequency of droughts and floods (World Bank, 2010). Among factors which influence livestock production are climate, and location are undoubtedly the most significant. Increased temperatures are expected to reduce agriculture productivity, increase incidences of vector borne diseases, impact hydrological cycle, impact biodiversity and ecosystems, and also lead to higher frequency and intensity of extreme events like cyclones among other impacts (Chaturvedi, 2015). Rises in temperature also adversely affect pastoral livestock production through indirect impacts on pasture growth, water availability and disease distributions (Kassahun *et al*., 2008 and Thornton *et al*., 2009). Increases in temperature directly pose thermal stresses on animals, impair feed intake,metabolic activities and defense mechanisms, thereby hindering their production and reproductive performances (Nardone *et al.,* 2010).

Climate change and variability directly affects agricultural production since agriculture is inherently sensitive to climatic conditions and is one of the most vulnerable sectors to the risks and impacts of global climate change. Climate change will affect food security by reducing livelihood productivity and opportunities (Chichongue *et.al,* 2015). Environmental scientists think Africa is more vulnerable to climate change owing to its high poverty rates, water scarcity and rain-fed agricultural production (Wild, 2015) The argument is “based on two things: geographically and climatically Africa is exposed. Africa in general is already quite hot. Heat it up more and it’s just downhill for animal and plant production” (Wild, 2015). Additionally, some parts of subtropical and central Africa had before now shown a strong increase in temperature between 1961 and 2010 (Wild, 2015). Since Africa has been detected as one of the world’s most vulnerable region to the impacts of climate change (Niang et al., 2014).

In SSA, hydro-meteorological disasters, especially droughts and floods, are the most common forms of natural disasters. As such, drought and floods represent 80% of the loss of life and 70% of economic losses related to natural hazards in SSA (Bhavnani *et al*. 2008). As a consequence of climate change, the frequency and intensity of floods and droughts are projected to increase in the future (Bernstein et al. 2008). Meanwhile, agriculture is a major economic sector in the region, employing 65% of the labor force and contributing 32% to the countries' national gross domestic

products, and is characterized by low productivity and lack of modern farming technologies (Chauvin *et al*. 2012).

Livestock ownership and herd size in traditional farming systems are two related variables which have been used to represent the level of a farmer's dependence on natural resources such as pasture and water for extensive livestock production (Kemausuor *et al*. 2011; Legesse *et al*.2013). Climate change impacts weaken and even reverse the progress made in improving the socio-economic welfare of most African countries. The current and predicted climate influences indicate that a severe impact will be observed more in Africa than in other continents, as the livelihoods of African people are mainly based on rain-fed agriculture and due to low incomes and its geographic exposure Intergovernmental Panel on Climate Change (IPCC,2014). The spatial and temporal variability of rainfall and continuous reduction in rainfall numbers was detected recently in Eastern African countries (Hession, 2011; Liebmann *et al*., 2014). Consequently, the people whose livelihood is mostly dependent on rain-fed agriculture, is becoming under great pressure. The Intergovernmental Panel on Climate Change (IPCC) (Conway 2011; Hawinkel *et al*., 2016).

Adverse climate change effects are considered to be strong in countries located around tropical Africa that depend on agriculture as their main livelihood World Society for the Protection of Animals (WSPA, 2009). More than 60% of Ethiopia's territory is found in the arid and semi-arid lowlands that is inhabited by nomadic pastoralists (Gebremichael *et al.* 2010). According to Gebremichael *et al*., (2010) estimates that 12-15 million pastoralist people are thought to live in these areas; whereas Virtanen and Gemechu (2011) writes that Pastoralism provides the main livelihood for close to 15 million people spread across seven regions of the country. Although pastoralists in Ethiopia occupy the remote arid and semi-arid lowlands which are generally poorly developed in terms of communication and infrastructure, livestock marketing in pastoral areas contributes significantly to national economies, although it is often undervalued.

According to (Solomon *et al*., 2007) developing countries in general and least developed countries like Ethiopia in particular are more vulnerable to the adverse impacts of climate variability and change. This due to their low adaptive capacity and high sensitivity of their socio-economic systems to climate variability and change. Sensitivity and adaptive capacity also vary between sectors and geographic locations, time and social, economic and environmental considerations within a country. The proportions of main pastoral communities are found in that account for the Somali (37%), Afar (29%), and Borena (10%) (ANSR, 2010). Kiremt rain account for 50–80% of annual rainfall totals in

Ethiopia, which has high contribution to agricultural productivity and major water reservoirs. Thus, the most severe droughts in Ethiopia are usually related to a failure of the kiremt rainfall to meet the agricultural and water resource needs (Kassa , 2015). On the other hand, spring rain which is important not only just for the belg crops (accounting for 5–15% of the national food crop) but also for improving pasture for livestock, and for the planting of long-season crops as well as useful for land preparation for meher production and supplementing water for irrigation purposes has been decreased substantially (Eiste et al., 2012). Hence, agricultural production in Ethiopia is predominantly rain-fed whereas inter and intra-annual rainfall variability is high and droughts are recurrent in many parts of the country (Haileselassie *al et*., 2008; Kassa, 2015).

World Bank (2010) has ranked Ethiopia among the most vulnerable countries in the world to the adverse effects of climate change; mainly due to its high dependence on rain fed agriculture, low adaptive capacity and a higher reliance on natural resources base for livelihood, among others (NMA, 2007; World Bank, 2010; EPCC, 2015). In terms of livelihood, smallholder rain-fed subsistence farmers and pastoralists are considered to be the most vulnerable to climate variability and change and need interventions to adapt their livelihood systems to changing climatic conditions (NMA, 2007; EPCC, 2015). The trend of livestock production reduced from time to time due to various factors like Shortage of grazing land & animal feed, drought, lack of improved animal breeds for all livestock type, grazing land, low price of livestock and their product. Currently climate change is a great challenge in the world. Indirectly climate change and variability has significant impact on feed resources on livestock productivity, carrying capacity of rangelands, and feeds, feeding options and grazing managements (Adisu, 2014).

2.4 Adaptation Strategies

The Intergovernmental Panel on Climate Change (IPCC) suggests that it in order to develop an effective strategy for adaptation, it is necessary to understand the weakness of each sector in terms of the nature of climate change, the climatic sensitivity of the region being considered, and the capacity to adapt to the changes. Adaptation will require a reduction in greenhouse gas emissions in order to lower the rate of climate change (Pachauri, 2014). A review conducted by (Tessema, *et.al*., 2014) concluded that pastoral system is sustainable and gives a suggestion that its sustainability will depend on mobility, adaptation and on pastoral institutions.

The adaptation-related process in Africa comprises the continent’s riches in natural resources, sophisticated social networks, and established traditional methods of managing vulnerability through,

for instance, migration, crop and livelihood diversification and small-scale enterprises, all of which are reinforce by traditional knowledge system for sustainable resource management (Cooper *et al*., 2008; Macchi *et al*., 2008). In addition, risk reduction strategies employed by African countries to checkmate the impacts of climate change on individual households, communities, and the general economy consist of early warning system, developing risk transfer plans, social protection schemes, disaster risk contingency funds and budgeting, livelihood diversification and migration (UNISDR, 2011). However, it is unsure to what level these strategies will be able of dealing with impending changes, among them climate change and its collaboration with other development methods (Conway *et al*., 2009). Migration has been used by the poor as an adaptation strategy in the case of extreme climate events (Abebe, 2014).

Pastoralists use mobility as a basic strategy for their livelihood development and risk management systems. Although African pastoral ecosystems are ancestral homeland to a substantial portion of the population for whom Pastoralism is a traditional way of life, Pastoralism is far from static. Pastoralists in many areas are adapting to trends such as new economic opportunities and better access to modern means of communication (AU/DREA, 2010). To adapt the changing climate, pastoralists and agro-pastoralists farmers have, therefore, adjusted and adapted themselves by evolving livelihoods mainly dependent on livestock and livestock-related activities and small-scale agricultural practices (Fre and Tesfagergis, 2013). Adaptation is necessary if the world is to manage the risks posed by Climate Change (Ford *et al*., 2011; New *et al*., 2011; Stafford *et al*., 2011). There is an agreement that pastoral areas face an increased risk of drought events due to increased rainfall variability and high temperatures (IPCC, 2007). Climate change impact has pushed many of the households in the ASALs resort to a number of Adaptation strategies. It is evident that many pastoral and agropastoral households have resorted to settling near trading centres and water points to access relief food, water without burdening their beast of burdens and to seek for casual employment and also to allow easy movement of their herds. However, failure of such coping strategies might endanger the very own survival of the pastoralists and there is already some fear that pastoral livelihoods, especially in East Africa, are fast becoming unsustainable more rapidly than other forms of rural livelihood(Morton, 2010). The pastoralist might therefore be in danger of being the first environmental refugees. The pastoral and agropastoral systems, therefore, needs more research on the impact of climate change (DFID, 2009).

In the face of climate change and variability, populations that depend on agricultural systems may have to adjust their production technologies and practices if they are to continue meeting the food and livelihood requirements that they currently derive from these agricultural systems. Adapting to and coping with a changed climate are not infinitely plastic and there are places where climate change may alter agro-ecological conditions beyond what households can deal with. Recent work points to the possibility of climate-induced livelihood transitions in the mixed crop-livestock rain fed arid and semi-arid systems of Africa (ILRI, 2009).

In responding to livestock loss due to climate change, such livestock-dependent households widely apply local-based adaptation measures that are applicable and easily affordable (Di Falco *et al.* 2012). Important adaptation options currently applied in the agricultural sector include crop diversification, livestock farming, mixed cropping systems, using different crop varieties, changing planting and harvesting dates, mixing less productive, and using drought resistant varieties alongside high yield water sensitive crops (Oyekale *et al*., 2009).

Pastoral adaptations in the lowlands of Ethiopia depend entirely on access to wide tracts of land to make full use of a resource base that is generally poor and unevenly distributed (Holland 2006). Mobility of pastoral and semi-pastoral communities is part of their climate change adaptation and herd management strategies. Some suggested sets of adaptation methods such as diversifying income options, building formal and informal institutions, adjustments in livestock holdings and species, labor mobility, engagement in small irrigation schemes and livestock mobility (Mortiz *et al*. 2003; Berhanu *et al*., 2007; Seo and Mendelsohn, 2008; Crane et al., 2011; Tsegaye *et al*., 2013). Adaptation strategies, such as livestock mobility, diversification, feed purchases and animal restocking, have increasingly become unable to support their livelihoods (Wassie and Fekadu 2014; Kima *et al*. 2015).

In the arid and semi-arid region, livestock production requires constant or periodic movement in search of pasture; a factor that differentiates this form of livestock production from those Practiced by farmers and ranchers (Markakis 2004). Mobility is the basis of the traditional adaptation strategy, based on opportunistic movements within and across geographically distributed grazing units, which are composed of those households that depend on common permanent water sources (Angassa and Oba 2008). It is perhaps the most common and seemingly natural response to environmental risks which pools and distributes risks across space, and is "especially successful in combination with clear information about the spatial and temporal distribution of precipitation" (Agrawal 2010).Rangeland rotation during the wet and dry seasons traditionally prevented overgrazing, while controlled access to

water provided the key mechanism for guaranteeing sustainable use of the grazing lands (Desta and Coppok , 2004) and (Angassa and Oba , 2008). mobility is a way of life for large groups of people in semi-arid regions, and a long-standing mechanism to deal with spatio-temporal variations in rainfall and range productivity; and hence the status of the social group in question matters whether mobility is the desirable adaptation or not (Agrawal 2010).

2.5 Determinants of Adaptation Strategies

Indigenous people with limited access to climate information are more likely to attribute changing climatic conditions, particularly extreme weather events, to a change in their rituals and cultural practices and Irrespective of the driving forces however understanding views of target communities is important to prompt the need to adapt and facilitate support for policy related adaptation decisions (Nyanga *et al*. 2011). The age of a subsistence farmer is closely related to farming experience and their accumulated knowledge of the environment including changes in climatic conditions (Deressa *et al*.2011; Juana *et al*. 2013) that may go back many decades. Studies conducted in African smallholder farming systems have indicated that the level of formal education attained by farmers influences their ability to perceive climate change and its impact (Maddison 2007; Mustapha *et al*.2012). Access to support services such as extension services and climate information is purported to increase farmer perception of climate change and its associated risks (Maddison, 2007, ATPS, 2013).

The major determinants limiting livestock production were feed shortage, animal health, labour scarcity and lack of capital in central Ethiopia (Belay *et al*., 2012). In additions (Hailemariam *et al*., 2013), in a study of traditional sheep production in Southern Ethiopia, state that disease, parasites and lack of proper water and feed resources, followed by lack of extension support, are the major constraints facing sheep farming in the area. The study by Juana *et al*. (2013) indicated that the farmers' age had a positive effect on the diverse adaptation choices. The assumption is that as age increases, the farmers are likely to acquire experience in weather forecasting there by increases the likelihood of practicing different adaptation options.

The major challenges in livestock production systems are; Technical constraints: genetic limitation for production, inadequate and poor quality of feed resources, prohibitive price of crossbreed heifers and poultry, lack of poultry parent stock, and prevalent animal diseases. Institutional constraints:poor linkage between research, extension and technology users, Socio-economic constraints: the unavailability of adequate land, specific problems to pastoral areas (shrinkage and degradation of rangelands, recurrent drought and conflict, (MOA, 2013). Even within the farming community, small-

scale subsistence farmers and pastoralists are particularly vulnerable to climate change related hazards like drought; these hazards include shortage of food and water for humans and livestock, and diseases (World Bank 2010).

However, adaptation possibilities are heavily dependent on varieties of factors such as traditional and modern institutions, market, resource availabilities (Sandford, 2009), human and livestock population in a specific land size (Tsegaye *et al*., 2013) and availability of livelihood options apart from livestock earnings (Berhanu *et al*., 2007; Galvin, 2009). Similarly in Ethiopia, identifying major factors that affect the adaptive capacity of pastorals and agro-pastorals have recently become prior concerns while attempting to improve the livelihoods (Tsegaye *et al*., 2013). Clearly, there is a divergence of opinions about the sustainability of the pastoral way of life and its corresponding contribution towards climatic adaptation in the drylands regions of Africa. This is complicated by the multifaceted nature of adaptation possibilities that are heavily dependent on a variety of factors such as market accessibility and institutions and resource availability (Sandford 2006), demand pressure of human and livestock populations for limited land size (Tsegaye *et al*. 2013) and availability of livelihood options apart from livestock earnings (Adger *et al*. 2005; Berhanu *et al*. 2007; Galvin 2009). Considering the existence of pastoral, semi-pastoral, agro-pastoral and mixed-farming communities in the region, it is difficult to clearly point out exactly how these two debates fit into policy actions without having sizeable evidence. This requires a thorough investigation about how multiple adaptation strategies influence the adaptive capacity of these communities. The most frequently mentioned barriers to take up adaptation strategies elsewhere in Ethiopia include lack of information on adaptation options, shortage of money, shortage of labor, shortage of land, shortage of fertilizer, insecure land tenure, poor market access and poor potential for irrigation (Maddison, D., 2007).

Tracking the best pasture through the mobility of herds is key to maximizing animal nutrition, and therefore productivity, in environments characterized by variability. Combined with livestock selective feeding, strategic mobility can also contribute to the sustainable use, and indeed improvement, of forage resources (Silvestri *et al.*, 2012). Apart from its productivity aspects, mobility is also a strategy to access and exchange products and services, seize market opportunities or walk away from trouble. Mobility is essential for the adaptability and resilience strategies of these communities to adapt with climate change and to mitigate crisis situations (FAFO, 2016).

There are indications that pastoralists are caught in a dilemma. On the one hand, the pressure to cope with and adapt to a multitude of changes has never been as high as today; whereas on the other hand, recent developments have led to reductions in spatial mobility, which have weakened the sustainability and resilience of traditional forms of pastoral production systems (Muller-Mahn *et al*. 2010). Under these conditions, pastoralists are challenged to modify their livelihoods according to the ongoing changes, to search for new alternative strategies, to diversify their livelihoods and at the same time to maintain their adaptive capacities with regard to future changes (Galvin 2009). Similarly, Muller-Mahn *et al*.(2010) indicated that in conditions where traditional coping and adaptation strategies have become increasingly insufficient to sustain the local livelihoods, the state obviously played and still plays a crucial role in changing livelihood strategies and the emergence of new development pathways. The question is whose interests are ultimately decisive for shaping these pathways, and to what extent the pastoralists are able to actively participate in this process. Many of the adaptation strategies that have served drought affected communities well may become inadequate in light of the frequent occurrences of droughts, rapid socio-economic and long-term climatic changes. It is obvious that the increased frequency of drought events have challenged the effectiveness/sustainability of these coping strategies. With dwindling natural resources (water and forage), there is little the pastoralists can do to create access to such resources (UNDP , 2008).

Adaptation strategies such as livestock mobility, diversification, feed purchase and animal restocking have become unable to support their livelihood requirements as they used to get benefits many years ago (Wassie *et al*.,2014). Moreover, their dependence on livestock rearing has got much constrained by population growth, occupation of former grazing areas by human settlements (emergence of new villages) and urbanization (Tsegaye *et al*., 2013). Adaptation is viable if applicable actions adequately reduce magnitude of vulnerability and increase people's adaptive capacity (ability to support system's structure and help functioning) towards improved level of resilience (the rate at which a system regains its structure and function after some adaptation actions) (Stringer *et al*., 2009).While attempting to deal with the existing climate related challenges among the pastoral and agro-pastoral communities, there have been still conceptual differences on whether the sources of the challenges stemmed from natural pressures or from various factors associated to failures in implementation. Failing to address political, social, economic, cultural and ecological factors, some governments perceive the existence of these challenges as if they were the common features of arid and semi-arid regions, whereby they paid little attention to pastoral and agro-pastoral communities (OXFAM, 2008).

Consequently, inadequacy of understanding about the underlying effects of each factor (Crane *et al*., 2011) remains puzzle to clearly verify how locally practiced adaptation strategies uphold the livelihoods of pastorals and agro-pastorals. It is unclear which adaptation strategies can fit to what sort of livelihood options depending on varying climatic zones (Sandford, 2009). The large body of previous study is focused on climate modeling techniques for identifying future threats of climate and variability outlining realistic adaptation approaches (Adgeral., 2005). Some suggested sets of adaptation methods such as diversifying income options, building formal and informal institutions, adjustments in livestock holdings and species, labor mobility, engagement in small irrigation schemes and livestock mobility (Mortiz *et al*. 2003; Berhanu *et al*., 2007; Seo and Mendelsohn, 2008; Tsegaye *et al*., 2013) .

2.6 Conceptual Framework

The conceptual framework used in the present study portrays links between Climate change, Effects of climate change and adaptation strategies . It also show the adapatation strategies and factors that affect the adaptation strategy of farmers to climate change. In the conceptual framework (Figure 1), variability in rainfall and temperature influence Livestock and crop production. These two factors of climate were the independent variables upon which livestock production factors depend. The nature of rainfall and temperature changes dictates the prevalent condition under which the pastoral and agro-pastoral communities live with their major livelihood option of livestock rearing and mixed farming.The prevalent changes in climatic variables of temperature and rainfall is thought to negatively affect livestock and crop production which is believed to erode the livelihoods quality of the pastoral and agro-pastoral communities of Mieso .To avert this and to sustain their livelihoods, the community will strive to employ climate change adaptation strategies. Among these Strategies; Herd mobility, Livestock diversification, supplementary feed and mixed livestock-crop farming.

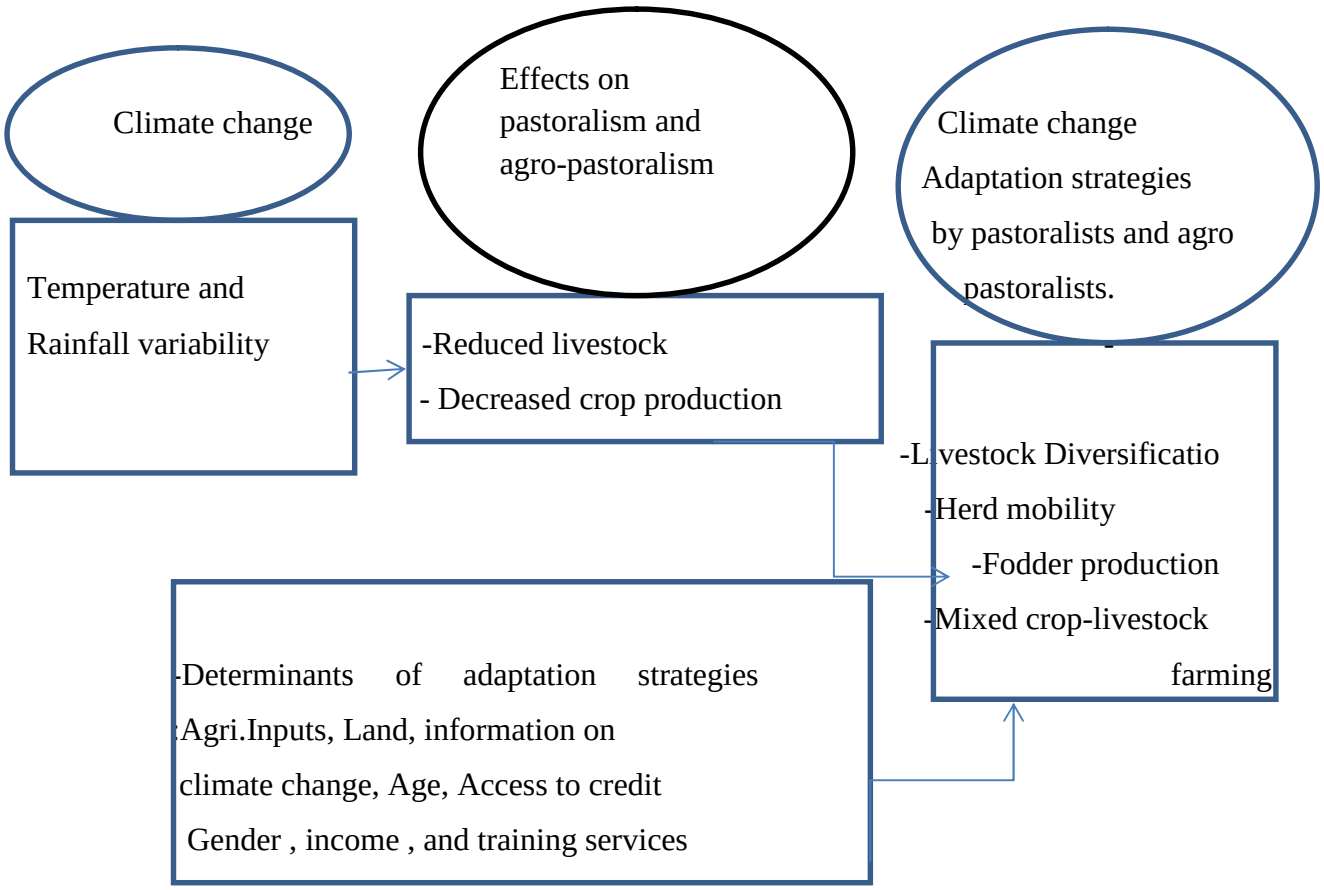

Figure 1:Conceptual Framework of the study

Source: Adopted from Molu Wato (2016).

3. RESEARCH METHODOLOGY

3.1 Description of the Study Area

3.1.1 Bio-physical Background

This study was conducted in Meiso district of West Hararghe zone Oromia regional state. Specifically, the district is located between $8^0$40’00”N latitude and $9^0$20’00”N and $40^0$10’0’’W and $40^0$50’00’ E longitude. Meiso is located 300 km east of Addis Ababa and about 200 km east of Adama. It is located west of Somali region and is one of district in Oromiya where there are pastoralist and agro-pastoral farming system is practiced. Meiso is located east of Doba, north of Chiro&Guba Koricha, northeast of Anchar district; and northwest of Somali and south and southwest of Afar regions.

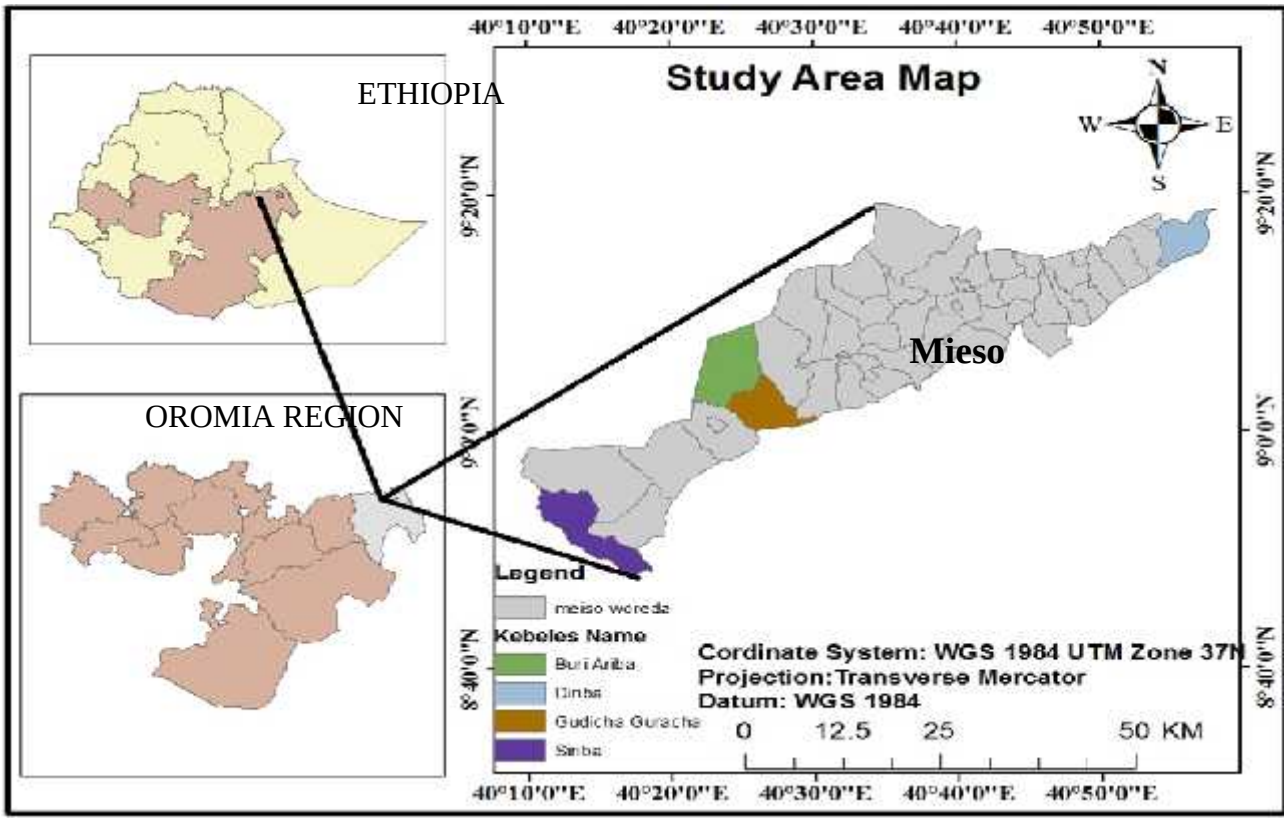

Figure 2: Location map of the Study Area

Source: Ethiopian Mapping Agency.

3.1.2 Topography and Drainage

Topography of the district ranges from 1107 to 3106 m above sea level (m a.s.l), but most of the district is found at about 1700 m a.s.l.The district is surrounded by a chain of mountains in nearly all

directions. The highest mountain is Asebot, which is located north east of Meiso town. The district has a total area of 257,344 Hectares of which about 82 percent is plain land, 9 percent is undulated land and the remaining 9 percent belongs to mountains. According to FAO (Food and Agriculture Organization, 2016) soil Classification system, the major soils of the district are Vertic Cambisol (orthic and ferralic), Haplic Luvisol (Orthic) and Eutric Cambisol (Orthic), accounting for 50%, 16% and 11%, respectively.

3.1.3 Climate

The mean temperature varies between 24^{0C}-28^{0C}. Agro-ecologically, the district is classified as semi-arid “Kola”. The mean annual rainfall ranges from 650 mm to 945 mm,with an average of about 700 mm. The area receives a bimodal rainfall where small rains occur between March and April while the main rains occur between July and September. Most of the rainfall is within only few months and remain dry for most of the months of the year. IPMS (Improving productivity and Market Success, 2006) .The mean annual rainfall is a major limiting factor for agricultural production in the area (Meiso District Agricultural Office, 2015).

3.1.4 Vegetation

The vegetation types of Mieso are broadly being described as thorny bush and shrub dominated grassland (Tesfaye, 2009). The vegetation cover constitutes herbaceous perennials and annuals suchas Pennisetum, Lintonia, Chrysopogon, Erigeron and smalto medium-sized Acacia dominated woody plants. In the study area, the major feed resource comes from rangelands which cover about 73,658 ha (38%) of the total land area IPMS (Improving productivity and Market Success, 2006). The relative high densities of livestock have results in overgrazing of rangeland, which causes progressive deterioration of the vegetation cover and, in consequence, a deficient supply of animal fodder. Feed scarcity is indicated as a factor responsible for the lower reproductive and growth performance of animals especially during the dry season (Legesse G ., 2008).

3.1.5 Population characteristics

According to Central Statistical Agency (CSA ,2013) report, the total population of the Mieso district is 155,981 out of which 79,811 and 76,170 are male and female respectively. From the 43 total population of the about 32,589 is urban dwellers whereas 123,392 is rural resident. The crude population density of the district is 104.5 Out of the total population of the district; about 50.83 percent is male while the female constitute about 48.51 percent of the population in the district. The

Oromo, Somali and other ethnic groups are inhabited in the district. Historically the district/cluster was comprised of both the current Oromia-Meiso,Somali region Meiso as well as some part of the afar regional state. Nevertheless, the Meiso clusters are characterized by manifest differences and sub-group identifications that reflect intricate linguistic, religious, historic and settlement patterns and interactions.

3.1.6 Pastoral and agropastoral systems

Mieso is one of the district in Oromia found in the rangelands of northeast and extensive grazing areas of the eastern Ethiopia, with 257,344 Hectares (ha) total land area, practicing pastoral and agropastoral system. Agriculture and livestock farming are the main source of livelihood for the people of the study area to get their daily food and income. Meiso district is mainly characterized with pastoralist farming system with some of them are agro-pastoralists. The district is mainly known by livestock raring since it is under one of pastoralist area in the west Hararghe zone. Even though, the community is characterized as pastoralist, some of them produce crop like sorghum, maize and Haricot bean for food. Rainfall during the main rain is unpredictable and erratic, and as a result, crops fail in most years due to lack of even distribution of rainfall. In 18 of the 37 kebeles, the predominant agricultural practice is pastoralism; some pastoralists are sedentary and other migrates with their herds in search of forage and water. Cattle and goats are the most common livestock (Mieso District Agricultural office, 2015). The district has a total number of 37 Peasant Associations and 4 town dwellers associations.

3.2. Research Design

Since the emphasis of this research is to investigate the effects of climate change and adaptation strategies employed by pastoralists and agropastoralist in mieso, the investigator was used explanatory sequential research design that employ mixed triangulation research methods. It uses cross-sectional approach. This research design was aimed to collect qualitative data in first stage to assist the second stage quantitative data collection instrument (merdy *et al*,. 2018). Accordingly, in the first stage, the investigator used survey questionnaires to gather primary data from household heads. In the second stage, the investigator used key informant interviews and focus group discussion to cross check the information gathered through questionnaires.

3.3. Types and Sources of Data

Both primary and secondary data were important to conduct this research. The primary data were collected from household survey, key informants interview, Focus Group Discussions (FGD) and observation. The secondary data was acquired and reviewed from metrological stations, published and unpublished documents from rural development bureau, research reports, and government documents.

3.4. Sampling and sampling techniques

Meiso district has 37 pastoralists and agro-pastoralists kebeles with a total population of 86941. The total household's size is 14632. For this study, a multi-stage sampling method was used to select respondents.Within the district farm households were stratified into pastoral and agropastoral production systems (strata) depending on the predominant production system leading to stratification into pastoral system (livestock production) and agropastoral (crop and livestock production) associations or villages. Accordingly, in the first stage the district was stratified in to pastoral and agro-pastoral kebeles. In the second stage, after identifying all kebeles in the pastoral and agro-pastoral system, the investigator represented two (2) kebeles from pastoral and 2 kebeles from agro-pastoral in such a way that these kebeles represents the pastoral and agro-pastoral communities in biophysical and socio-economic aspects. Accordingly, Dirba and Gudicha Guracha from agropastoral while Buri Arba, and Sirba from pastoral kebeles were selected from the district purposively. The number of households in each target kebeles was identified and sample size was determined using stastical procedures. The estimation of population proportion p=0.2 is used ,as this value gives sample size sufficiently large to guarantee an accurate prediction, at 95% confidence interval and 5% error of estimate. The following formula is used to decide the sample size (Naing *et al*., 2007).

$$n = \frac{P(1-P)z^2}{E^2}$$

Where, n=sample size

Z=level of confidence =1.96 which means 95%.

E^2=Maximum allowable error =0.05 which means 5%.

P=estimate of population =0.2

$$n = \frac{0.20(1-0.20)\,1.96^2}{(0.05)^2}$$

$$n = \frac{0.6144}{0.0025}$$

n= 245 households

Accordingly, Dirba consists of 483, Gudicha Guracha consists of 814, buri Arba consists 621, and Sirba consists of 540, having a total of 2458 households (HHs). Finally, by considering time,cost,and available facilities in to account a 10% of sampling intensity were used from each kebele accounting a total of 245 sample households respondents and 3 additional key interview informants (KII) were purposively selected from government officials and totally 260 Respondents were participated in this research.

Table 1: Total number of sample size from each kebeles.

No	Agropastoral Kebeles	Total number of HHs	Sample size
1	Dirba	483	48
2	Gudicha Guracha	814	81
3	FGD (Focus Group Discussion)		6 (purposively selected)
4	Key Informant Interviews		2 (Purposive)
	Pastoral kebeles		
5	Buri Arba	621	62
6	Sirba	540	54
7	FGD (Focus Group Discussion)		6 (purposively selected)
8	Key Informant Interviews		1 (purposively selected)
	Total	2458	260

Sources, own computation,2021

3.5 Data Collection Methods

This study was used Focus Group Discussion (FGD) ,Key informant Interview and Questionnaires. The investigator acquire primary information through questionnaires, FGD and Interview to key informants was another method that the investigator employed for the study. The secondary data used in this study were obtained from the Ethiopian Meteorological Service Agency, agricultural office, published and unpublished documents, different reports, documents and related websites.This study investigates the annual variability of temperature and precipitation for about 38 year period (1981–2019) in the western hararghe of mieso district. Pre-determined key informant interview schedule was used to collect quantitative data while qualitative data were captured using focus group discussions (FGD) and key informant interviews.

3.5.1 Questionnaires

Questionnaire was used as an instrument to collect primary data from selected sample respondents. The investigator used survey questionnaires as the data collection instrument because it enables to collect information rapidly and more standardized way, and it is also more objective (Catherine, 2002). The investigator prepared Sem-structured questionnaire to generate primary data from the selected samples to collect information about Effects of climate change on pastoral and agropastoral systems, major adaptation Strategies, and determinant of adaptation strategies. The investigator and data collector were filled up the questionnaire to the respondents who were unable to fill up questionnaire, the questions were asked to the respondents and answers were filled up by the researcher and data collectors to collect the required data.The investigator was designed a sem-structured questionnaire that includes both close and open ended and employ qualitative and quantitative data from the respondents. The contents of the questionnaire were included personal information of the respondents, HHs demographic information, HHs sources of livelihoods, livestockownership, the adaptation strategies employed by the pastoralists and agropastoralists, the major determinants of adaptation strategies in the pastoral and agropastoral farming systems were gathered through questionnaire. The Investigator were prepared questionnaire in English and translate to local language (Afan Oromo) since most of the respondents were Afan oromo speakers. Again, the investigator was selected enumerators based on their ability to understand Afan Oromo language and trained how to administer questionnaires. Data collection was conducted from November 15 to December 15,2019. Seven (7) enumerators who have good knowledge regarding the study area were trained for the survey. A pre-test survey was conducted on 23 households from October 11,2019 to 18,2019.

A pilot test run was undertaken with local enumerators and key informants before the beginning of FGD and questionnaires.The final questionnaires were revised and rewritten accordingly.The questionnaire used for the pre-test was excluded from the final data entry and analysis. The piloting was carried out to check the suitability of the tools and also whether the field assistants could manage the questionnaire without difficulty. After developing and completing preparation of the Key Informant Interviews, Focus Group Discussion and Semi-structured questionnaire checklists , the feedbacks of which were incorporated in the full survey.

3.5.2 Key Informants Interview

The investigator used key informant interview to collect qualitative data about the issue going to be studied . It was carried out with better informed household heads to get in depth information on which investigator wants to go through on (Roudier,2011). The purpose of interview in this study was to obtain more information in order to strengthen the responses gained from the question based on the response of the interview in the study area.The interviews were done with 3(three) key informants involving kebele administrators and agricultural experts were selected as respondents in the study area. The interview questions focus on a more comprehensive range of issues including socio-economic status (Climate change and variability trends and its effects on pastoral and agropastoral farming system, land size and livestock number, adaptation strategies and determinants of adaptation strategies. To avoid language barriers the interview were conducted in Afan Oromo and Ahmaric languages and finally translated in to English.

3.5.3 Focus Group Discussion

The investigator conducted one Focus Group Discussion (FGD) with pastoral and one with agro-pastoral communities in order to collect data regarding climatic patterns experienced ,climate change effects on livestock and crop production and major adaptation strategies in the pastoralists and agro-pastoralists of mieso district. This Focus Group discussion consisted of 6 elders from pastoral and 6 elders from agro-pastoral communities purposively. Generally, 12 total respondents were participated in focus Group Discussion. Focus group discussions were conducted with people knowledgeable on climate change in the area and alternative climate change adaptation strategies undertaken in the study area.This category of people included leaders, administrators and community elders.

3.6 Method of Data Analysis

After data collection was completed, the Investigator would encode, tabulate, and analyze the questionnaire data in SPSS 20 version.The data collected from officials and key informants were analyzed descriptively in line with the research questions. Descriptive statistical tools such as Mean to socio-economic characteristics of the respondents, percentages and frequencies were used to summarize and categorize the information related with major adaptation strategies used by pastoralists and agro-pastoralists.The annual crop production data collected from Mieso were analysed using quantitative statistical method,excel.The extreme climatic coincidence (precipitation and temperature) and/or gradual climatic change trend were analyzed by comparing with the climatic

data and the primary data and secondary data collected from literatures were presented by using graphs. The temperature and precipitation data were collected from NMSA station, representing the two agro-ecological zone of the district. The annual precipitation and temperature trends were analyzed using SPSS statistical techniques.The temperature and precipitation trend was, thus, compared with the Livestock and crop production data and the effects of climate change trends.

3.6.1 Stastical Tests

Mann-Kendall's test was used to assess the mean annual rainfall trend and temperature for Mieso district for the time period between 1981 and 2019. Mann-Kendall's test is a non-parametric method, (i.e., does not rely on any assumptions on the distributions of the two populations under comparison) which is less sensitive to outliers and test for time sequential order (Partal and Kahya 2006; Yenigun et al. 2008; Gebre et al. 2013; Tsegaye et al. 2015).

3.6.2 Multinomial Logistic Regression model (MNL)

This study employed a multinomial log it (MNL) model to analyze factors influencing adaptation strategies used by farmers to climate change in the study area. Because multinomial estimation is appropriate as it exhibits superior ability to predict discrete choices (Mohammed, 2007; Sosina et al. 2009) and because of the computational draw backs of Multinomial probit (MNP). To describe the MNL model, let y denote a random variable taking on the values {1,2….j} for choices j, a positive integer, and let *x* denote a set of conditioning variables. In this case, y representing the adaptation measure chosen by any farming household in the study area. It is assumed that each farmer faces a set of discrete, mutually exclusive choices of adaptation measures (that means that a person chooses exactly one of the options, not more and not less) and these measures are assumed to depend on factors of x. Therefore, x represents a number of climate attributes, environmental, socioeconomic characteristics of households and other factors. The question is how, *ceteris paribus (changes in independent variables)*, changes in the elements of x affect the response probabilities p(y=j/x), j = 1, 2…. J. Since the probabilities must sum to unity, p (y=j/x) is determined once we know the probabilities for j = 2…j. Let x be a 1x K vector with first element unity. The MNL model has response probabilities: Where βj is K × 1, j = 1……., J equation….(1)

$$p(y=j/x) = \frac{\exp(x\beta j)}{1+\sum_{k-1}^{j}\exp(x\beta k)\, j=1,\ldots,j).}$$

Unbiased and consistent parameter estimates of the MNL model in equation-1 require the assumption of Independence of Irrelevant Alternatives (IIA) to hold. More specifically, the IIA assumption requires that the probability of using a certain adaptation method by a given household needs to be independent from the probability of choosing another adaptation method (that is, P is independent of the remaining probabilities).The parameter estimates of the MNL model provide only the direction of the effect of the independent variables on the dependent variable, but estimates do not represent either the actual magnitude of change nor probabilities (Greene, 2003).To interpret the effects of explanatory variables on the probabilities, marginal effects are hence computed. Differentiating equation-1 partially with respect to the explanatory variables provides marginal effects of the explanatory variables given as: Equation …….(2) $\alpha pj/\alpha xk = pj\ \beta jk \sum_{j-1}^{j-1} (pj\beta jk)$.

The marginal effects or marginal probabilities are functions of the probability itself and measure the expected change in probability of a particular choice being made with respect to a unit change in an independent variable from the mean. The choice of adaptation strategies are based on the actions the sample households take to counter act the negative effects of climate change.

3.6.3 Model Variables

3.6.3.1 Dependent Variables

The dependent variables in this study are adaptation strategies that are chosen by the sample households.These are mixed-livestock farming, divesification, mobility, Fodder production and supplementary feed.

3.6.3.2 Independent Variables

The age of the household head in years was collected and analyzed as a continuous variable. Age of household head is a key factor that is expected to directly influence availability and access to production and livelihood resources (Wasonga 2009; Lugusa 2015). Access to resources is an important driving factor in wealth creation and accumulation, thus determining their availability for use by households. At above 35 years of age, household heads are likely to be richer than younger ones, increasing their chances of adopting fodder production technologies. Different studies provided mixed influence of age on the choice of adaptation strategies to climate change and variability. For example (Yared and Woldeamlak ,2013) showed that age has no influences on choice of adaptation strategies but (Seid etal.,2016) on the other hand showed age has positive influences on the adaptation strategies to effects of climate change and variability.Therefore, this study, hypothesized

that age is a negatively related with the adaptation strategies to effects of climate change and variability.That means as the age of household heads increases , the probability of using different adaptation options also increases.

In the sub-Saharan Africa, female-headed households have more limited access to productive resources such as livestock, land and finances compared to male-headed households (Adesina *et al*. 2010). This study therefore hypothesized that male-headed households are more likely to adopt fodder production technologies due to their higher access to key production resources than their female counterparts. Sex of household head was a dummy variable where a value of 1 was assigned to male-headed households and 2 to female-headed households. Different study provided both positive and negative influence of sex on on farmers choice of adaptation strategies to climate change. For example (Jemma and Mengistu ,2012) stated that male household has positive effect on farmers choice of adaptation strategies to climate change. while (Bates and khan , 2010) stated that sex has positive influence on choice of adaptation strategies to climate variability and change. However , this study assumed that relationship between sex of household head and adaptation options to effects of climate change is positive.

Education level of household head was measured in terms of number of years spent by the respondent in school. The education level of a household head was assigned the value of 1 if not educated, 2 if attained primary education, 3 for secondary education and 4 for household heads with tertiary education. The level of education greatly influences major decision-making in the household. More educated household heads are expected to have better reasonability and deeper insight, enabling them to easily understand the benefits of new technologies on effect of climate change, hence their adoption (Okello *et al*. 2009). Higher education qualifications of household heads and any other member of the household increase the knowledge base about climate change and related adaptation (Komba and Muchapondwa, 2012). Similarly, this study assumed that level of education significantly affects pastoralists and agropastoralists choices of adaptation strategies to the adverse effects of climate change.

The size of land owned in acres was treated as continuous variable; the exact values as given by the respondent were used in the analysis. The bigger the farm size, the more likely the farmer is to adopt suitable adaptation strategies since large farmsize is linked with greater wealth,it is hypothesized that it has positive relationship with different adaptation strategies options to effects of climate variability and change (Hassan and Nhemachena ,2008). Similarly , this study is hypothesized that farmland size

is negatively affects of pastoralists and agropastoralists choices of adaptation strategies to the effects of climate change. That means as farmland size decreases, pastoralists and agropastorlaists communities adoption of different adaptation startegies will also decrease.

Provision of extension and training services to farmers is presumed to capacitate households to adopt new technologies. This offers them basic and technical skills and knowledge on fodder production. The current study hypothesized that access to extension and training of livestock diversification and fodder production together with sensitization on the importance of the practice positively relates to effects of climate change. Access to extension and training services was a dummy variable where a value of 1 was allocated to household heads with access to extension and training services and 0 to household heads with no access.

Table 2:The association between determinants and major adaptation practices.

Variables labels	Description and measurement	Variable type	Sign
Gender	1 if HH is male and 0 otherwise	Dummy	+
Age	Age of HH in years	Continuous	-
Education	School years of the HH	Continuous	+
Trainning	1 if the HH head did participate in tra	Dummy	-
Income of the HHs		Continuous	-
Credit Access	1if amount of credit received annually in birr, 0 otherwise	Continuous	+
Climate Infn	1 if the HH has access clim.inf., 0	Dummy	-
Farm size	Size of land in hectares	Continuous	+

Sources: own computation, 2021

3.7 Reliability and Validity of the data

Hussein (2009) defined triangulation as "the use of multiple methods mainly qualitative and quantitative methods in studying the same phenomenon" for the purpose of increasing study credibility. For the purpose of the study, the investigator used data triangulation. Data triangulation also referred as data sources triangulation depicts the use of multiple data sources in the same study for validation purposes (Hussein 2009). Hence, this methodological triangulation directly refers to the within-method triangulation, because the investigator used key informant interview and Focus Group Discussion under qualitative research method to cross-check the validity of the data collected and to insure its consistency. Within-method type of triangulation implies that multiple complementary techniques within a single

method are used in data collection and analysis. In doing so, the investigator can increase the internal credibility of the research findings.Therefore, to acquire valid and reliable multiple and diverse realities, multiple methods of searching or gathering data are important. Then the use of method and data triangulations to record the construction of reality is appropriate. Engaging multiple methods, such as interviews, focus group discussions and observation will lead to more valid, reliable and diverse construction of realities. Hence, triangulation helped the researcher to understand in-depth and widen the knowledge of the issue and dealing with as well as used as measure of validity and reliability by increasing the accuracy of study.

3.8 Ethical Consideration

Referring to ethical consideration, after identifying the key informants and Focus Group Discussion with who begin the interview process, discussion with all participants of the study area was constructed.The discussion contained information concerning the researcher's full consent (permission) to research process,awerness or description of what the study examines, the right to withdraw from participation at any time, the right of getting any relevant further information about the study, confidentially threatening of participants data were clearly discussed. Therefore, the investigator obtained the informed consent of all participants verbally to start interview and FGD process. Finally,after assuring appropriateness of the key informant interview and FGD instrument and obtaining the informed consent,the instrument were made ready for the final study and main research was conducted in natural setting of selected villages using Questionnaire, Key Informant Interview and Focus group discussion instruments.

4. RESULTS AND DISCUSSION

This chapter deals with the presentation of results and discussion. It is divided into four parts. The first part presents the background of the respondents, the second part presents climate change and variability trends, the third part describes the Effects of climate change on pastoralism and agropastoral systems; the fourth part adaptation strategies among pastoralists and agropastoralists and determinants of adaptation strategies. Under chapter five summary,conclusion and Recommendation were presented.

4.1 Demographic Characteristics of the Respondents

The investigator found it is important to establish the gender proportions of the respondents. As presented in table 3, 70 % of the respondents were men while 30 % of the respondents were women. This gender distribution has a lot of implications in understanding the perception of men and women and the nature of strategies used to cope with adverse climate changes between male and female members of the pastoralists and agropastoralists households. As shown in the table 3, 74.61% of the households are married, 10.3% households are single, 9.61% respondents are divorced and 5.38% household's heads are widowed.

Concerning the educational status of sampled household's, the survey results indicates 40.76% of the total samples have no education, 38.84% of the sampled households were in their primary education , 12.69 % were at highschool and 7.69% of the total Sampled household's were in tertiary education. From this, it was clear that households with no education and primary education accounts about 79.6%. The age of the household's heads is categorized as young, adult and old age populations. Regarding age compositions of the respondents 43.4% of the household's fall under the age category of 31-40 years followed by 40.38% are in age 15-64 years old and 16.1% are in the age group of $\geq$51.

Table 3: Demographic Characteristics of Respondents.

Variables		Frequency	Percent (%)
Sex	Male	182	70
	Female	78	30
	Total	260	100
Age	Young age	113	43.4
	Adult age	105	40.38
	Old age	42	16.1
	Total	260	100
Marital status	Single	27	10.3
	Married	194	74.61
	Divorced	25	9.61
	Widowed	14	5.38
	Total	260	100
Educational level	No education	106	40.76
	Primary education	101	38.84
	High school	33	12.69
	Tertiary	20	7.69
	Total	260	100

Source: Field survey, 2021

As indicated in table 4, Pastoralism was reported to be the main occupation with 65.8 % (n=171) of the respondensts relying on it. About 28.4% (n= 74) are agropastoralists and 5.7 % of the study area communities were involved in other business like petty trade.

Table 4:Socio-economic activity

Activity	Frequency	Percentage
Pastoralism	171	65.76
Agropastoralism	74	28.4
Other business	15	5.7
Total	260	100

Source : Field survey, 2021

As indicated in table 5, more households are engaged in cultivation of food crops (e.g. maize and sorghum) and off-farm employment (e.g. petty trade) in predominantly agropastoral systems as compared to pastoral ones. Agropastoral households obtain more percentage of non-farm income and less of farm income as compared to pastoral households . Whereas herd mobility to remote areas and supplementary feeding of animals are identified as the most commonly used option by more households in pastoral systems than agropastoral counterparts. The variation can be attributed to the fact that livestock rearing is a primary source of livelihood which makes an important source of income in pastoral systems. Subsequently, average livestock holding is relatively larger among pastoral households than their agro-pastoral counterparts. In table 5, the finding indicates that majority of the cattle owners were found to be in the age category of productive labor force. This would entail the possibility of applying various adaptation methods in responding the adverse effects of climatic change. With proper management and planned implementation of community members across rural villages, concerted adaptation actions can be the means to instigate rural youths for creating various income options (Melaku and Hoag, 2014). Hence, the presence of the working age population in the area is the potential resource for developing sustainable climate change adaptation options and minimizes climate-related risks.

Table 5. Respondents Socio-economic characteristics in the study area.

	Production System		Overall mean
characteristics	Pastoral	Agropastoral	
Age of household head (years)	32.17	36.58	34.37
Household size	5.8	7.3	6.5
Education level (school years)	1.4	2.00	1.7
Livestock holding per household	9.8	6.2	8
Private farm size(ha)	0.9	1.9	1.4
Annual farm income ($US)	486.2	540	513.1
Annual non-farm income ($US)	734	1403	1,068.5

Source: field survey, 2021

4.2 Trend of climate change in Mieso district

4.2.1 Maximum and minimum annual temperature trend

Mieso District had the highest average temperature, in all the years. As indicated in figure (5), the overall temperature condition of the study areas showed that there was a continuous increment

overtime,especially after early1990s. Long-term mean maximum temperatures in Mieso ranged from 28.81°C to 32.19°C, with an average of 30.6°C. The majority of positive temperature anomalies occurred after 1993, indicating warmer days after 1993 in comparison to the period between 1983 and 1993. Long term minimum temperatures ranged from 16.37°C to 18.16°C,with a mean value of 17.26°C. A slight increase in mean minimum temperatures could be detected, with increasing anomaly after 1990, indicating a slight warming of nights. Extreme maximum temperatures increased over the 38-year period.

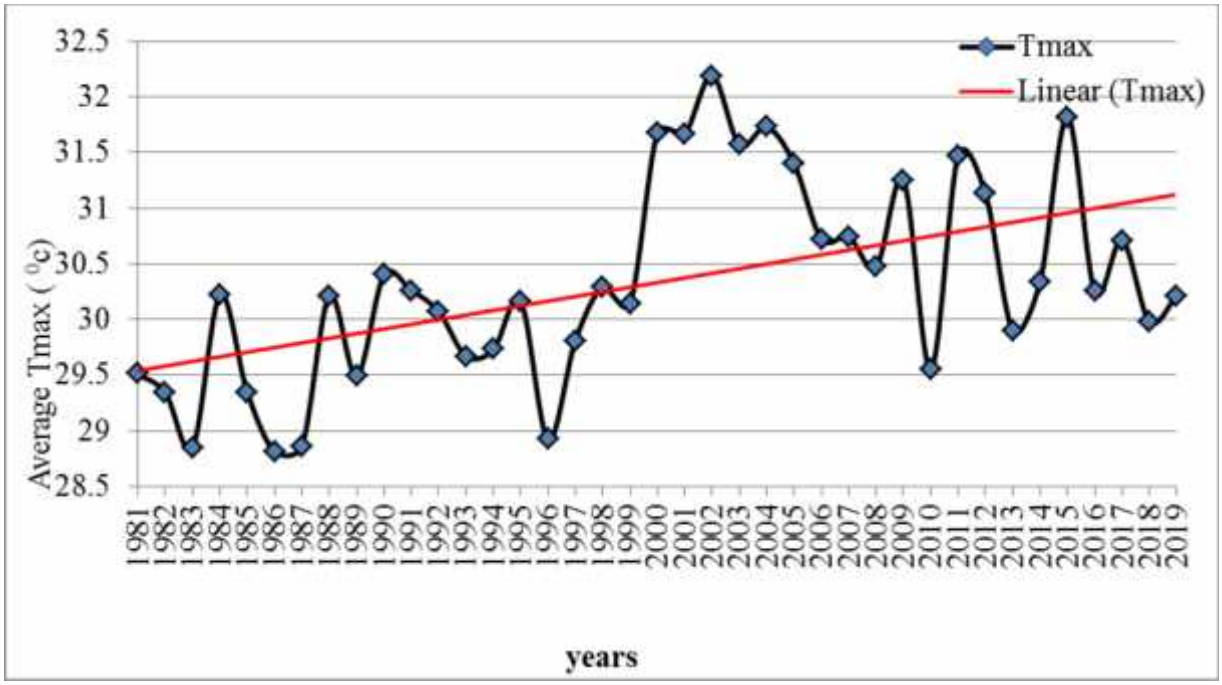

Figure 3: Average maximum temperature trend in Mieso (1981-2019).

Source: extracted from NMA,2021

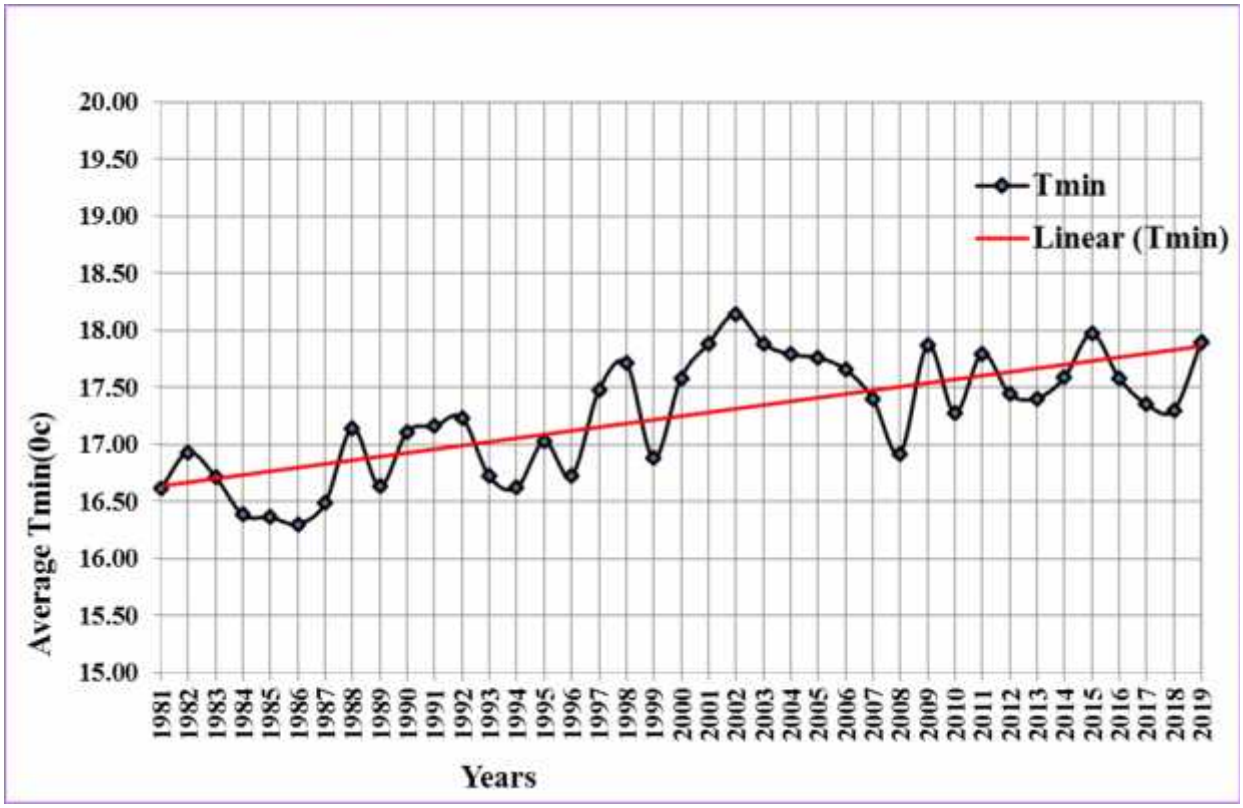

Figure 3: Average Minimum temperature trend in Mieso (1981-2019).

Source: extracted from NMA,2021

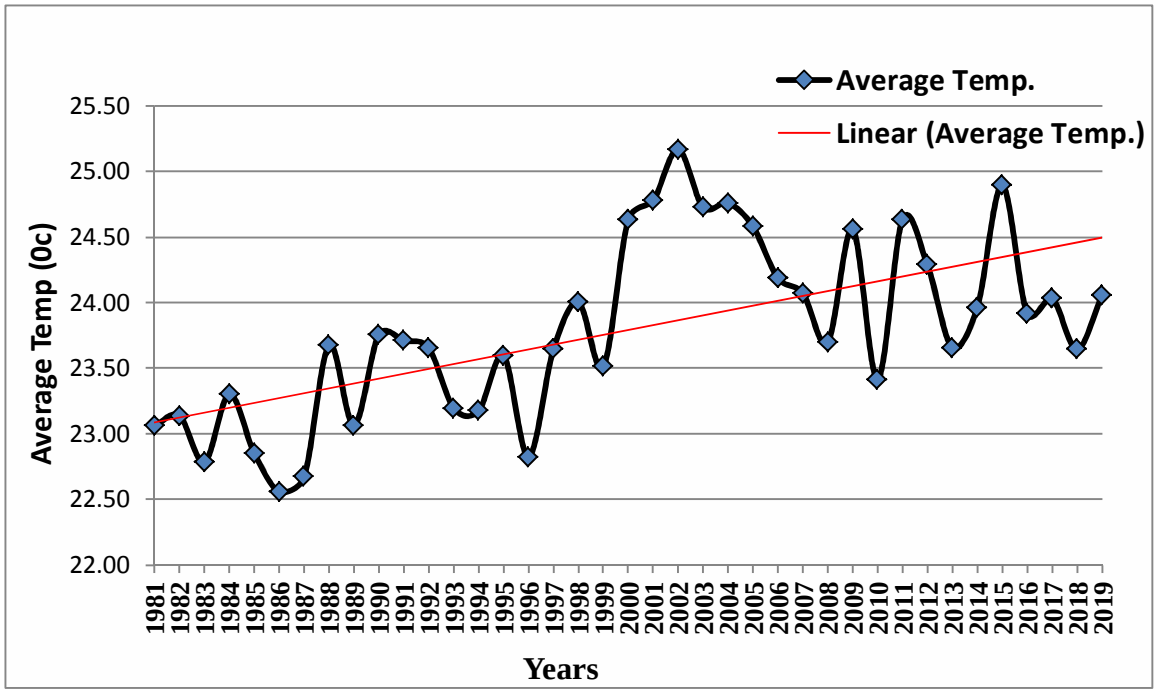

Figure 4: Average temperature trend in Mieso (1981-2019).

Source :extracted from NMA, 2021

As shown in Table (6) the result of mann-kendall trend estimation indicates that there are positive trend in maximum temperature at the study area and statistically significant at 0.05 during September, August and April and no trend is significant in other months but the S(statistic) showed that the mean annual temperature trend is positive. In addition, the sen's slope estimator result that there is positive trend of annual of maximum temperature and also the annual minimum temperature shows positive trend for mieso station. Whereas, the results of sen's slope estimations also indicates increase of annual maximum temperature by 0.045^0C per year and sen's slope shows that there was increasing trend of annual minimum temperature by 0.032^0C per year for the study site. See table 6.

Table 6: Analysis of maximum and minimum Annual Temperature Trend

	Months	Mean	SD	Z	Stat.	Sen's slope
	Sept	29.2	1.6	2.51*	201	0.063
	August	28.7	1.4	2.29*	1.83	0.048
	April	30.6	1.87	1.99*	159	0.065
Annual max.Temp.		30.3^0_c	0.897	2.54*	122	0.045
	March	17.9	0.87	2.63*	210	0.031
	April	18.7	0.81	2.93*	234	0.035
	Sept	17.87	0.73	2.21*	170	0.35
	Oct.	16.97	0.84	2.08*	160	0.044
	Nov.	15.5	0.84	2.14*	171	0.029
Annual MinimumTem		17.2^0c	0.51	1.19	92	0.032

Source : Extracted from NMA, 2021

4.2.2 Annual Rainfall trend of Mieso

Mean annual rainfall in Mieso was recorded at 855.21mm, with 30 percent of rainfall occurring during Belg and 38 percent during Kiremt. Overall, variability is high with a coefficient of variation of 38% percent. The statistical analysis of rainfall data was done using mean and the dispersion of data from mean was done using standard deviation and coefficient of variance as shown in Table 6. The minimum mean monthly rainfall occurred in the month of December (14.6 mm) for all these 38 year data followed by January (17mm) while maximum mean monthly rainfall occurred in month of August followed by July (140.5mm).

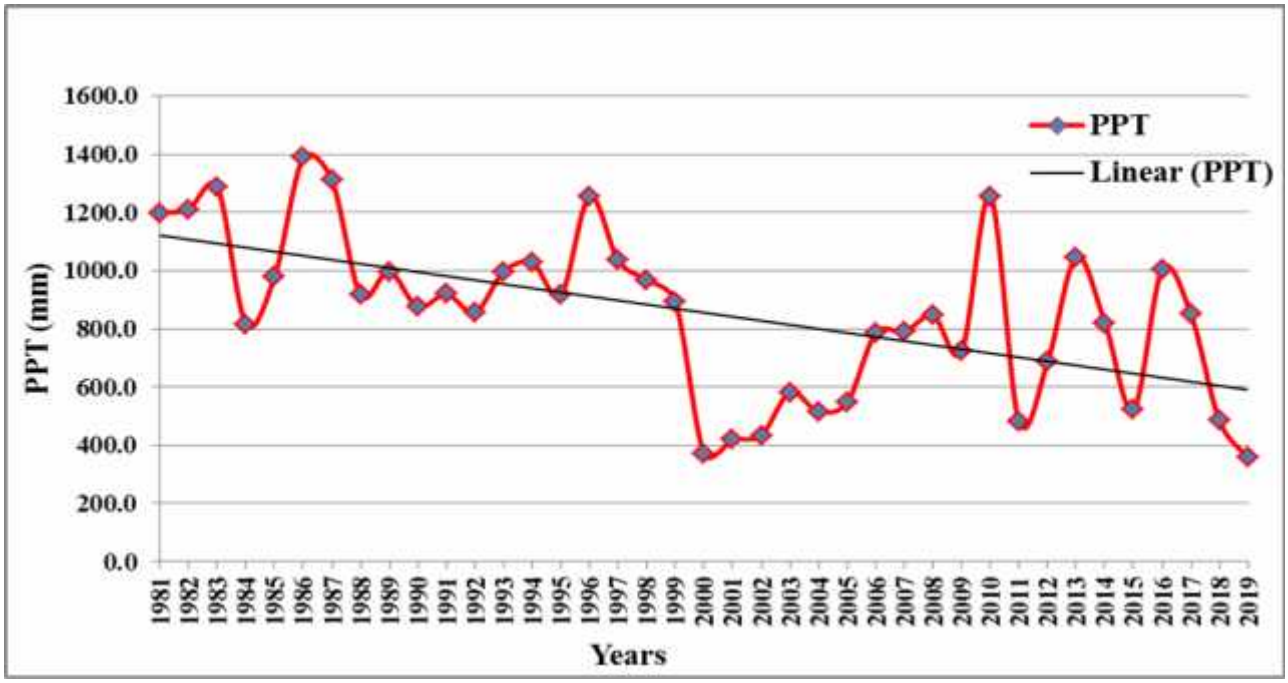

Figure 5 : Total annual rainfall of Mieso (1981-2019).

Source: extracted from NMA, 2021

The Mann-Kendall trend, its statistical significance along with magnitude of Sen's slope for 1981 to 2019 year rainfall data is shown in Table 7. The months of November and july showed increasing monotonic trend and insignificant at 0.05, that mean there is a 5% probability that the investigator make a mistake when rejecting Ho (null hypothesis) of no trend. Mieso station showed negative (decreasing) trend in annual precipitation with decreasing rate of -12.832mm/year. The station had the maximum negative decline in monthly precipitation April, August, September and February respectively. as well as the maximum positive increase (0.25mm/month and 0.082mm/month) during the months of November and July respectively.See table 7.

Table 7: Annual and monthly rainfall trend analysis by using mann kendall test

	Annual rainfall /mon	Mean	SD	CV	Z	Stat.	Sen's slope
Maximum positive	November	19.2	21.46	111.7	1.81	145(+)	0.25mm/year
	July	140.5	58.3	41.5	0.05	5(+)	0.082mm
Minimum negative	April	114	75.75	66.4	3.07*	-245(-)	-3.14mm
	August	178.3	71.3	40	2.26*	-181(-)	-2.37mm
	February	27.86	34.9	125	1.84	-147(-)	-0.304mm
	September	855.2	282.9	32.97	1.96*	-157(-)	-1.57mm
Annual rain		855.	319.7m	38.2	2.05*	-158(-)	-12.832mm

Source: extracted from NMA, 2021

4.3 Effects of climate change on Pastoralism and Agropastorealism

Drought and delay in the onset of rain led to poor grass regeneration/forage deficit, water shortage and heat stress on livestock, and consequently increased the mortality of the livestock,vulnerability to diseases and physical deterioration due to long distance travel for water and pastures (interviews with Mieso district DPPO 2019). The interview with key Informant data suggests that 31% livestock per household were died during the 2017/18 drought caused by low precipitation. The FGD participants also indicated that rainfall and temperature in study area has been decreasing and increasing, respectively, thus negatively affecting the production and management of crop and livestock in the study area. Crop failure and livestock mortality is common problem in the study area due to shortage of rainfall and severe drought. Pastoral livelihood and livestock production which is more correlated with rangeland productivities. In the other ways this rangeland has been affected seriously by the climate change in the lowlands which induces the frequent recurrence of drought that lead to livestock mortality. Pastoralists and agro-pastoralists in Mieso area indicated that climate change had its effect on their production systems through various mechanisms. As indicated in table (7) about 38% of the sample respondents replied feed shortage is the main effect of climate change followed by shortage of water (22%) , reduced crop and livestock productivity (20.7%) and increased mortality (14.6%) and increased disease prevalence (12.3%), respectively. Similarly, as prioritized by respondants during the group discussion, the five major effects of climate change on crop and livestock production ranked by pastoralists and agro-pastoralists were; feed shortage, shortage of water, reduced productivity, Increased mortality and increased diseases prevalence in their order of importance.

Table 8: Percieved effects of climate change on crop and livestock production.

No	Perceived effects of climate change by pastoralist and agro-pastoralists.	Respondents	
		Number	Percentage
1	Feed shortage	98	38
2	Shortage of water	57	22
3	Reduced crop and livestock productivity	54	20.7
4	Increased mortality	38	14.6
5	Increased disease prevalence	32	12.3
	Total	260	100

Source: Field Survey,2021

Interview with Mieso Pastoralists development office Leaders,indicated that livestock production contributes very important role to ensure households family livelihood in the study area. Cattle, Goat, Camel, Sheep and donkey are major livestock reared in pastoral and agro-pastoral of the Mieso district. The major factors contributed to low production and productivities of crops in the study area were drought, shortage and erratic rain fall, shortage of improved variety, diseases and insect pest, lack of training & shortage of agricultural inputs. All the interviewees of the kebeles leaders anonymously reported the existence of repeated serious climatic impacts on the society. According to Respondent A from Dirba , *climate affects all of us because our life is totally intertwined with livestock and crop production…they are our life.* Some farmers also indicated Belg-crop (maize and sorghums) were their staple food, and ‘’Khat’’ is sold to fulfil financial requirements, but the frequent failure in spring rain forced them to totally depend on Meher. In cases of both spring and Meher harvest fails, the situation is even worse. In figure 7 it is shown that the production of crop particularly sorghum and maize were declined due to effects of climate change in 2017,2018 and 2019.

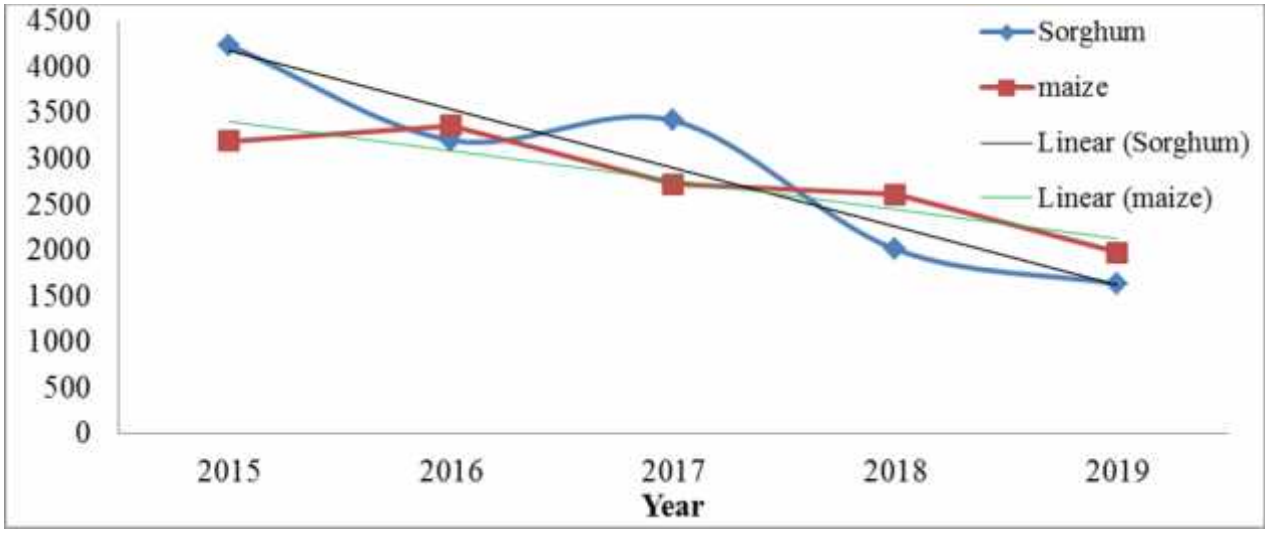

Figure 6: Sorghum and maize Production trend in the study area (2015 to 2019).

Source: Mieso agropastoralist Development Office,2021

In Figure (7) the five years production trends in mieso district was illustrated. Mieso is predominantly Kiremt(Summer) and spring producing district. In the above figure, the declining points show that events of prolonged drought and delay in onset of rainfall.The above fluctuation in sorghum and maize production is mainly explained from climatic variability shocks, particularly drought and late onset of the rains and short rains. According to FGD report, the shortage of *Spring* rain is responsible for decline in production of sorghum and maize in 2016, 2018 and 2019 in the study area. Similarly

in the study area, the highest production loss were observed in the 2017 and 2018 and 2019 due to insignificant rainfall. **(** Mieso district ARDO 2019).

Based on the information gathered through Key Informant interviews, it was reported that the decline in the number of each livestock species namely cattle, goats, camel, sheep and donkey kept by pastoralists and agro-pastoralists of the study areas was high. The drought that took place in the year 2015 in pastoral and agro-pastoral areas of the district had resulted in livestock mortalities of 35%, 23%, and 18% for cattle, sheep, and goats respectively due to the shortage of forage supply and water. According to the FGD with pastoralists and agro-pastoralists, most of the animals were reported to have died during severe droughts, which occurred in 2017 and 2018. Similarly, during the 1991/1992 droughts in the Borana, Southern Ethiopia, the average individual household lost about 79% of its cattle, 95% of its camels, 83% of its equines and 60% of its sheep and goats due to shortage of forage production and water (Kidus 2010).

According to pastoralists officer, the severity of the effect of climate change varies with the species of livestock involved. It was reported that climate variability doesn't have major effect on sheep and goats except that occasional increased mortality reportedly occurs following seasonal disease outbreaks. From the livestock species, the most affected animals are cattle and sheep followed by Donkeys. Owing to the severe drought manifested in 2017/2018, a total of 1054 cattle heads died only during three months (November 2017 to January 2018) in the four selected kebeles.The number of cattle heads died in the four kebeles under consideration accounted for about 28% (3,702 heads of cattle)were died, the highest number of deaths being registered in Sirba followed by Buri Arba ,Gudicha guracha and then Dirba kebeles.

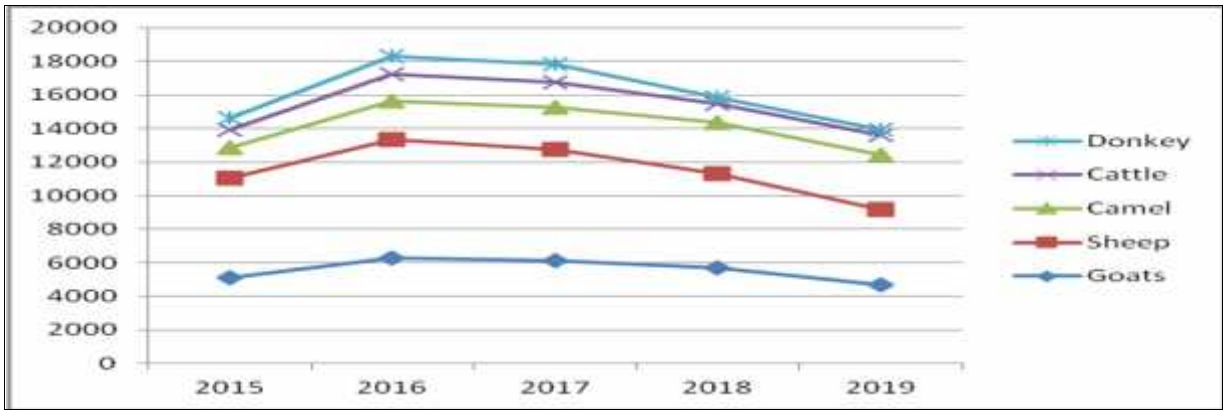

Figure 7: Climate variability and livestock trend of mieso (2015-2019)

Source:Mieso pastoralist and agropastoralists development office,2021

The relationship between rainfall and livestock population is positive for some species of animals and negative for the other livestock. As indicated in figure10 camel, goats,sheep ,cattle and donkeys numbers were increased and decreased with the rainfall. Likewise, the relationship with temperature is not as straight as expected. The investigator decided to analyze the relationship for the 5 years average annual temperatures to enhance the actual position. Cattle, Sheep, and donkey numbers seemed to have negative relationship with average annual temperature and rainfall. This may be so because extreme temperatures do negatively affect livestock population. Figure 10 show that the population of the sheep, goats and camels were decreased over the period between 2015 and 2019. However, the decrease in the populations of sheep and cattle were relatively rapid as the trend lines show.

4.4 Major Adaptation Strategies

In table 9, In the case of agropastoral communities, this study found that mixed crop-livestock farming 158 (44.8 %) was dominantly supporting their livelihood bases. Similarily, about 116 (33 %) agro-pastoral communities were employed changing livestock feed (fodder production) as the second adaptation and about 47 (13.3%) perceived crop diversification as adaptation strategy and non-farming activity and changing cropping calendar were employed as inferior strategy to other adaptation options. FGD in agropastoral communities indicated that in addition to mixed crop-livestock farming and fodder production they were practiced off-farming activities like trade.

Table 9: Climate change adaptation strategies by agropastoral farmers

No	Adaptation choice	Frequency	Percent (%)
1	Crop diversification	47	13.3
2	fodder production	116	33
3	Changing cropping calendar	8	2.27
4	Mixed crop-livestock farming	158	44.8
5	Non-farming activity	23	6.5
	Total	352	100

Source: Field Survey,2021

In table (10), About 156 (48.3%) of the pastoral communities responded that diversifying their livestock to that can tolerate the changing climate (drought-tolerant species),106(33%) of respondents indicated that the growing strain of climate-induced difficulties have pressed them to increase their mobility in terms of distance and frequency. Mobility is a survival and resource management strategy commonly

practiced by herder societies for efficient use of meagre and scattered rangeland resources for sustainable livelihoods in the face of climate fluctuations in the study area. Mobility is a good practical instance of locally adapted strategies in dryland areas (Martin *et al*.,2014).

Focus Group Discussants (FGD) reported that Flexible and responsive mobility is a vital strategy to climate shocks.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. Long distance movements are mainly caused by Feed and forage scarcity triggered by severe droughts. Changing climatic conditions such as reduced annual precipitation and rainfall variability are often recognized to be important factors of rangeland productivity declines. Therefore, higher aridity may imply increased pastoral mobility for household livelihood sustenance (Martin *et al*.,2014). About 28 (9 %) of households reported they have privately fenced communal rangelands for fodder production. Since private enclosures for fodder production are not allowed, the most convenient way to have one is through a calculated stance in pastoral household decision by fencing the communal land for the double purpose of cereal cultivation and dry season hay-making. Non-farming activities and herd destocking were the least adaptation strategies used by the pastoralists of mieso district.

Table 10: Climate change adaptation strategies by pastoral farmers.

No.	Adaptation Choice	Frequecy	Percent (%)
1	Purchasing and providing supplementary feed	28	9
2	Diversification of Livestock species/types	156	48.3
3	Herd mobility/Migration	106	33
5	Herd Destocking	13	4.03
6	Non-farming activities	18	5.6
	Total	321	100

Source: field survey,2021

FGD with pastoralists and agropastoralists indicated that petty trade ,selling livestock, and charcoal making that most of the sample respondents in the study area also practiced non-farming activities were enhanced their adaptation strategies in addition to mobilityand other adaptaion options. In both pastoral and agro-pastoral areas off-farming activities secured and surely reduced their vulnerability as they employed diverse climate change adaptation options to reduce the impacts of climate change on their production systems. Aymone (2009), suggested that expanding smallholder farmers' access to off-farm sources of income increases the probability that they will invest in farming activities. Thus, non-farming

activities were essential to enhance adaptation strategies and helped the communities reduce the effects of climate change and variability. The people of the study area used those activities like climate change and variability adaptation strategies options. Interviews with the leader of Dirba kebele, mentioned that diversification into petty trade was a popular diversification strategy. From the study area's observations, it appears that both the communities of the pastoral and agro-pastoral area diversified their livelihoods into petty trade and charcoal-making as possible activities.

FGD with pastoral elders indicated that the increased use of private Fodder and ranches, purchasing supplementary feed, and collecting hay from marginal or buffer areas are strategies that reduce dependence on mobility between wet and dry season pastures. Although all of the pastoralists continue to practice mobility livelihoods, many are increasing their use of other methods for securing the feed for their livestock need and engaging in other economic activities. During the occurrence of drought or the herders felt that there was little opportunity to find better pastures elsewhere. Instead, those herders depended on their ability to secure feed at the base camp. Although this strategy is a direct consequence of the current drought, that reduced the benefits of mobility was widespread. Transitioning into agro-pastoralism is one of the most common forms of diversification for pastoralists. Though there appear to be significant problems with cropping, most notably the disruption of the traditional seasonal use of grazing areas, cropping has some positive aspects. Poorer households of agro-pastoral areas with few or no livestock reports that cropping provides them with new opportunities to generate much-needed income and consumption of goods. FGD participants mentioned that cropping provided grains for the household to eat and residue for cattle. In sirba , one elder stated, “No one can survive without farming. If there is rain then you get food from the harvest. If there is little rain, the livestock can still eat whatever comes up even if there is no harvest” (Elder FGD participant, sirba , August 10, 2019).

4.5 Major Determinants of pastoral and agro-pastoral community adaptation choice

This section deals with the factors affecting pastoral’s and agropastoral’s decision of implementing adaptation measures to livelihood. The pastoralists and agropastoralists in the study area used livestock and crop diversification, herd mobility, fodder production and mixed crop-livestock farm as a major adaptation strategies. But, choice of an adaptation option(s) determined by a number of factors. To identify these factors and estimate the effect of explanatory variables on choices of adaptation options, the Multinomial Logit model was used. The general interpretation of a parameter estimates from Multinomial Logit model shows how the probability of the outcome changes when the corresponding variable changes by one unit from its mean while the rest of explanatory variables held constant at their

means. The results are shown in Table **(**11). Other factors which are not controlled in this study may have an influence on choice of adaptation.

Table 11: Parameter estimates of explanatory variables from multinomial logit model

Variable	Herd Mobility		Fodder production		Diversification		Mixed crop-LVST	
Ledu	.088	(.789)	.020	(.021)**	.352	(.246)	.075	(.640)
Age	-.827	(.301)	.272	(.329)	.535	(.049)**	.015	(.915)
Sex	.205	(.258)	.428	(.002)***	.174	(.283)	.017	(.954)
Poverty	.298	(.054)	.023	(.868)	-.085	(.538)	.164	(.587)**
Training	-.237	(.009)***	.086	(.677)	.420	(.042)**	-.410	(.135)
Credit	.257	(.023)**	-.031	(.864)	.014	(.939)	-.612	(.040)
Land scarcity	.088	(.000)***	-.698	(.949)	.069	(.811)	.539	(.029)**
Inf. climate	.827	(.019)**	.282	(.348)	-.468	(.113)	-.373	(.200)

=significance at 5% and *=significance at 1% level.

Source: Field Survey, 2021

Results presented in Table(11) show Training services, Access to credit, farm size, and lack of climate information factors significantly impact mobility as an adaptation option at a 5% level of significance. Level of education and sex greatly positively affected fodder production as an adaptation strategy in the study area, whereas age and training services to farmers were identified as significant factors that negatively impacted diversification as an adaptation strategy. However, according to Belayneh *et al*. (2012), age negatively influenced the decision to adopt options related to technology because older farmers are more risk-averse and less likely to be flexible. Therefore, age of the farmer here hypothesized to have both positive and negative influence on adaptation choice decisions to climate change.

Furthermore, lack of access to credit and land scarcity have statistically significant on livestock diversification adaptation strategy. Some of the explanatory variables are highly significant to affect decision for a particular adaptation option and may be insignificant for the other adaptation measures. Thus, the multinomial logit analysis results showed that the decision of choosing each adaptation measure to climate change influenced by different factors at different levels of significance by some factor. Hence, marginal effect is useful to interpret the effect of independent variable on the dependent variable in terms of probabilities. The marginal effects, measure the expected change in

probability of a particular choice being made with respect to a unite change in explanatory variable Greene (2003).

Table 12: marginal effects of explanatory variables from multinomial logit model

Variable	Mobility	Fodder production	Diversification Lvstk	Mixed crop-LVS
Level of education	.0952168	−0.0496239	0.090527	−.069322
Age	-.0526134	0.00392	0.0563597	−.068745
Sex	.0359775	- 0.06129 *	0.0066574	−.054559
Income	.0035823	0.003677	−0.004241	.012515*
Training Services	-.0717447	0.054882	0.0643558	−.001633
Access to credit	0.005622**	−0.037021	0.018792	.024112
Land Scarcity	0.21709***	0.018303	0.0496881	.08083*
Climate informatio	0.01155***	−0.009192	0.017102**	−.009710

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

Source: Field survey , 2019

As indicated in table (12), Land scarcity also has significant and positive effect on adaptation strategies to climate change. Access to credit affect positively the mobility adaptation choice and for a unit increase in lack of access to credit would increase the mobility adaptation choice by 0.56% in the pastoral community. Accesses to credit have a positive effect on the likelihood of using diversification to adapt the climate change. If a farmer has an access to credit then his/her probability of adapting and diversification would increase by 0.18 %. Access to affordable credit increases the financial resources of farmers and then their ability to come across transaction costs associated with various adaptation options that they might want to take (Berman, 2014). For a one unit increase in land scarcity and climate information, the probability of pastoral communities use of mobility adaptation methods increase by 21.7 % and 1.15% respectively, keeping other variables constant. Female-headed households are more likely to adapt to livelihood than male-headed households, and this could partly be attributed to willingness of women to change their livelihood strategy in an effort to support their families.

Being male farmer positively influenced the adaptation of pastoralists and agropastoralists adaptation practices, so the marginal effect indicated those male farmers are 76.7% likely to apply adaptation choices to recruit the climate change effects. This can be due to the fact that women are culturally assigned for domestic activities and even have limited access to critical resources (land, cash, and

labor), which often undercuts their ability to carry out labour-intensive activities like transhumance and soil and water conservation. This finding is thus in line with Kebede (2013), affirming that male farmers are more likely to access information on climate change and pleased to take risks than their counterparts.

Climate information affects significantly the diversification adaptation strategy by the probability of 1.71% for a unit change in feed and forage scarcity. Diversification as a result are more vulnerable to climate risks (Harvey *et al*., 2014). Poverty was also identified by agro-pastoralists as a determinant of fodder production adaptation to climate change. Limited access to resources such as land also contributed significantly toward looking for Diversification in Livestock type as adaptive capacity. Moreover, Land scarcity was identified as significant factor for mixed crop-livestock farming adaptation strategies by 8.0% for a unit increase in land scarcity, keeping other variables constant. A analysis of the factors affecting the decision to adapt to perceived climate change reveals that farmers are more likely to adapt if they had access to credit and land (Bryan *et al*., 2009). Accessing climatic information increased the probability of adapting diversified choices since better information helps farmers to make comparative decision among choices to cope effectively with the changes (Tazeze *et al*., 2012). Therefore, accessing climate information was hypothesized to have a positive influence on farmers' adaptation choice decisions to climate change.

Interview with Key Informants indicated that Livestock is the pastoralists' and agropastoralists main asset and depend more on availability of land for grazing and agriculture. Findings from this study show that pastoralists and agropastoralists have a very limited amount of land and therefore their production systems are threatened. Outcomes of the FGDs are also in agreement with the results obtained from the survey data.

5. SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Summary

The purpose of this study was to investigate the effects of climate change and adaptation strategies by pastoralists and agropastoralists of meiso district, in western hararghe zone,oromia regional state, Ethiopia. The study has four specific objectives these were:- i) To assess major the climatic changes(Temperature and precipitation) in the Study area ii),To assess the effects of climate change on pastoralism and agropastoralism systems iii) To identify the major climate change adaptation strategies of the study area iv) To analyze the major determinants of adaptation strategies used by pastoralists and agropastoralists of the study area.

The study results will thus guide the policy options, interventions and essential support necessary for sustainability of the adaptation strategy for pastoralists and agropastoralists. Development actors like the Ministry of Agriculture (MOA), National Drought Management Authority (NDMA), and other governmental and Non-governmental organizations (NGO's) will get access to the information from the findings and recommendation of the study to improve their interventions. For this purpose the primary data were collected through questionnaires, key informant interview,and focus Group Discussion (FGD) method. Secondary information was collected from various relevant publications, and other national and international journals. The major livelihood system are livestock rearing , mixed farming and crop production. Regarding adaptation strategies of the pastoral and agro-pastoral communities , there were different adaptation strategies on the basis of their production systems. Most of pastoral communities of the study area employed Diversification of livestock species and mobility as adaptation strategies ,while the agro-pastoralists were used Livestock-crop mixed farming and changing supplementary feed and fodder production .

In this study, the investigator tried to present mainly the association between major climatic elements(temperature and rainfall) and production system and major climate change adaptation strategies and determinants of adatation strategies in the pastoral and agro-pastoral communities were discussed. The collected information were accumulated, tabulated and anayzed by the established research technique. Stastistical anaysis on Annual minimum ,maximum and average temperature of the study site indicated that significant increasing trend ,Whereas the annual rainfall showed decreasing trend.

The analysis indicates the pastoral and agro-pastoral communities of the study area undertaken different production system. Some of adaptation strategies employed by the pastoral and agro-pastoral communities were Diversification of livestock types,herd mobility,providing supplementary feed , animal destoking and other non-farming activities as adaptation options. Some of the pastoral households noted that as they mobile from their original place to another area during diffent climatic seasons to search pasture and water for their herds but the other pastoralists shift from rearing livestock to mixed farming. Multinomial logit regession model was used to estimate the identified explanatory variables that affect the adaptation options of the communities.

5.2 Conclusion

In the study area, temperature data indicates a slight increase in average annual temperature and decrease in rainfall which largely attributes to increase in minimum temperature. Change in temperature and rainfall pattern affected livestock and crop production negatively due to its impact on grazing and foliage quality. For the communities of the study area, the major production system were livestock rearing (Pastoralism) and ,Crop and Livestock farming (agro-pastoralism). Pastoralists and agro-pastoralists in Study area indicated that climate change had its effect on their livelihoods through various mechanisms.Major effects of climate change on livestock production, in their order of importance, include feed shortage, water shortage, reduced productivity, and decreased mature weight and/or longer time to reach mature weight.

The decline in the number of livestock species namely cattle, goats, sheep and donkey kept by pastoralists of the study areas was remarkable. According to the respondents, most of the animals were reported to have died during severe droughts, which occurred in 2016,2017 and 2019. Productivity of livestock has also declined over 5 years. Pastoral and agro-pastoral Communities have tried to employ strategies to minimize climate change induced losses. Such strategies include: diversification of livestock species/types, Herd mobility, providing supplementary feed, Engagement of the households in Non-farming activies , destocking, Crop diversification,. For the pastoral communities of the study area , Land scarcity , income,lack of trainning and land scarcity were the major determinants of adaptation strategies. In order to overcome effects climate change, the pastoral and agropastoralists diversified their livestock and crop. For instance, the agro pastoralists diversified their production system and most of the pastoralists were also engaged in low returns activity such as charcoal making and fuel wood selling.

The multinomial logit regression show trainning services to pastoralists and agropastoralists, Access to credit, land scarcity and lack of climate information factors have a significant impact on mobility

as an adaptation option at 5% level of significance. Level of education and gender significantly with positive impact affecting fodder production as adaptation strategy in the study area whereas age and training services to farmers were identified as significant factors with negative impact on diversification as adaptation strategy. Furthermore, Acess to credit and land scarcity have statistically significant on livestock diversification adaptation strategy.

5.3 Recommendation

- Rainfall and temperature variations has affected livestock and crop production in the study area. This study therefore recommends that the metrological department shared rainfall data constantly with the pastoralists and agropastoralists so that they could understand the dynamics of rainfall and temperature variations on crop and livestock production.
- Introduce appropriate technologies for both pastoral and agro-pastoral communities. For pastoral communities building water harvesting, adaptive livestock breed,fodder production on small land, selection and management should be used to minimize these challenges.

- Provision of training by government and NGO's to the Farmers on Modern Farming, rearing animals and diversifying to other economic activity becomes important. Proper and efficient extension services are also necessary to adaptation options. It is therefore, vital to strengthen the extension services provided to farmers and improve their efficiency of crop and livestock rearing and other production system is appreciated.

- Capacity for prospects of climate change adaptation strategies with regard to factors of adaptation strategies must be encouraged. The existing practices must be preserved and promoted. The community should be diversified and commercialized their production beyond subsistence level of farming.

6. REFERENCES

Abdi Etafa, kemal kasim, Yassin Esmael and Muleta Debela . 2013. Cattle Production in West Hararghe: An Opportunity and Constraints Assessments in Darolabu, Odabultum Gemechis and Chiro Districts, Oromia Regional State, Ethiopia. *International Journal of Livestock Production Research* Vol. 1, No. 1, April 2013, PP: 01- 15.

Abebe, M. A. 2014. Climate change, gender inequality and migration in East Africa. Wash. J. Envtl. L. & Pol'y, 4, 104.

Abebe Tadege. 2007.Climate change National adaptation program of action(NAPA) of Ethiopia. Addis Ababa,Ethiopia.

Abera Bekele. 2010. Patterns of drought and community responses in Fentale pastoral woreda of Oromia region. M.A.Thesis Addis Ababa University.Addis Ababa ,Ethiopia.

Addis Gutu, 2014. The effects of climate change on livestock production, current situation and future consideration, *Africa journal of animal production and husbandry* Vol.1 (3) pp.74-86.

AfricanTechnology Policy Studies Network. 2013. The rationale and capacity of pastoral community innovative adaptation to climate change in Ethiopia. ATPS Research Paper No. 25. accssed on 25 july2020.

African Union, Department of Rural Economy and Agriculture. 2010. Policy Framework for Pastoralism In Africa: Securing, Protecting and Improving the Lives, Livelihoods and Rights of Pastoralist Communities. www.africa-union.org.

ANRS (Afar National Regional State).2010. Programme of Plan on Adaptation to Climate change. African Union. 2010. Policy framework for pastoralism in Africa. Addis Ababa: African Union.

Agrawal, A. 2010. Local institutions and adaptation to climate change. In Mearns & Norton (eds) Social dimensions of climate change: Equity and vulnerability in a warming world. The World Bank. Washington, DC.

Agrawal, A. and Perrin N. 2009. Climate adaptation, local institutions, and rural livelihoods. In N.Adger,I. Lorenzoni& K. O'Brian (Eds.), Adapting to climate change: ThresholdsValues, governance pp. 350-367. Cambridge: Cambridge University Press.

AjayiOC,AkinnifesiFK,SileshiG,ChakeredzaS,Mn'gombaS, Ajayi O, Nyoka I., and Chineke T. .2009. Local solutions to global problems: the potential of agro forestry for climate change adaptation and mitigation in southern Africa. Paper presented at the Tropical Forests and Climate Change Adaptation Regional meeting, November 18-20, 2009 Accra, Ghana.

Aklilu A, Dieseling W, Mesfin K, Negash T. 2013. Climate change impacts on

Pastoral Women in Ethiopia: Some evidences from the Southern lowlands.PHE Ethiopia Consortium.16p.

Ashton A., Thornton P., Stokes C. & Togtohyn C. 2012. Is proactive adaptation to climate change necessary in grazed rangelands?*Rangeland Ecol. Manag*., 65 (6), 563–568. doi:10.2111/REM-D-11-00191.1. Retrieved on dec.2020.

Asfaw, S., Carraro, A., Davis, B., Handa, S., & Seidenfeld, D. 2016. Cash transfer programmes, weather shocks and household welfare: evidence from a randomised experiment in Zambia. *Journal of Development Effectiveness*, 1–24.

Anderson, S., Morton J. &Toulmin C.2009. Climate change for agrarian societies in dry Lands:implications and future pathways. In R. Mearns& A. Norton (Eds.), Social Dimensions Climate Change:Equity and Vulnerability in a Warming World 199-230.Washington D.C.: The World Bank.

Aymone G.G. 2009.Understanding farmers perception and adaptation to climate change and variability: the case of Limpopo basin, South Africa. IFRI Discussion paper, International Food Policy Research institute; Washington DC.

Bates, B.C., Z.W. Kundzewicz, S. Wu & J.P. Palutikof, Eds. 2008. Climate Change and Water. *Technical Paper of the Intergovernmental Panel on Climate Change*. Retrieved from https:/www.technicalpaperIn.panel.on cc. Accessed on 21 December 2020.

Berhanu, W., Colman, D., Fayissa, B. 2007. Diversification and livelihood sustainability in a semi-arid environment: a case study from Southern Ethiopia. *Journal of Development Studies* 43: 871-889.

Berman, R. 2014. Developing climate change coping capacity into adaptive capacity in Uganda. p. 253.

Belliethathan S, Tibebe Y, Woldegiorgis G. 2009. The impact of climate change on Millennium Development Goals (MDGs) and Plan for Accelerated and Sustained Development to End Poverty (PASDEP)implementation in Ethiopia. Poverty Action Network of civil society organizations in Ethiopia (PANE), Addis Ababa, Ethiopia.

Brooks, N. 2006b. Climate change, drought and pastoralism in the Sahel. Discussion note for the World Initiative on Sustainable Pastoralism/ www.iucn.org/wisp/documents_english/climate changes.pdf.

Bryan E., Deressa T.T., Gbetibouo G.A. and Ringler C. 2009. Adaptation to climate change in Ethiopia and South Africa: options and constraints, *Environmental Science & Policy*, 12(4), pp 413-426.

Belayneh, L., Yared, A., & Bewket, W. 2012. Smallholder Farmers' perception and adaptation to climate variability and climate change in Doba district, Western Hararghe, Ethiopia. *Asian Journal of Empirical Research*, 3(3), 251–265.

Birch,I.;Grahn .2008. Pastoralism-Managing Multiple Stressors and the Threat of climate ClimateVariability and Change. Available online:http: //hdr.undp.org/ sites/default /files /birchisbe and Grahn richard.pdf accessed on 10 July 2018.

Catherine Dawson. 2002. Practical research methods A user-friendly guide to mastering research techniques and projects contingency planning unit.

Catley, Andy .2017. Pathways to Resilience in Pastoralist Areas: A Synthesis of Research in the Horn of Africa. Boston: Feinstein International Center, Tufts University.

CEEPA (Centre for environmental economics and policy for Africa). 2016. climate change and African agriculture, policy note No.53.

CSA (Central Statistical Authority). 2008. Report of the 2007 Population and Housing Census. CSA, Addis Ababa, Ethiopia.

Central Statistical Authority (CSA). 2009. Statistical Abstract. CSA, Addis Ababa.The Contribution of Livestock to the Ethiopian Economy-Part II Roy Behnke Odessa Centre Great Wolford United Kingdom Fitaweke Metaferia Senior Expert, National Accounts Directorate, Ministry of Finance & Economic Development (MOFED), Ethiopia.*IGAD LPI Working Paper* No. 02–11.

Conway, D., & Schipper, E. L. F. 2011. Adaptation to climate change in Africa: Challenges and opportunities identified from Ethiopia. *Global Environmental Change*, *21*(1), 227-237.

CSA (Central Statistical Agency).2017. Agricultural Sample Survey, Livestock And Livestock Characteristics (Private Peasant Holdings). Addis Ababa, Ethiopia: Central Statistical Agency Of Federal Democratic Republic Of Ethiopia.

CSA (Central Statistical Agency) .2013 . Statistical Abstract: Addis Ababa, Ethiopia.

Chaturvedi ,.2015. The costs of climate change impacts for India: *a preliminary analysis, CEEW Working Paper*. 1-4.

Chichongue O. J, Karuku G. N., Mwala A. K., Onyango C. M. and Magalhaes A. M. 2015. Farmers' risk perceptions and adaptation to climate change in Lichinga and Sussundenga, Mozambique. *African Journal of Agricultural Research*, Vol. 10(17).

Daniel, G Yirgaw .2011. Climate Variability in the Drought Prone Regions of Afar andAmhara, Northern Ethiopia (MSc thesis submitted to Goteborg University, Sweden)

Daro Lebu District Agricultural Office .2015. Report of Mieso district pastoralist development

office, Annual report 2015.

Davies M. & Leavy J. 2007. *Connecting social protection and climate change adaptation*. IDS In Focus 2.3. Institute of Development Studies (IDS), Brighton, UK. Available at:https://op endocs.ids.ac.uk/opendocs/handle/123456789/2535 (accessed on 30 August 2019).

Deressa, T., Hassan, R.M. &Ringler, C. 2008. *Measuring Ethiopian Farmers' Vulnerability Climate Change across Regional States*.International Food Policy Institute.

Deressa T, Hassan M, Ringler C . 2011. Perception of and adaptation to climate change by farmers in the Nile basin of Ethiopia. J Agric Sci 149:23–31,doi: 10.1017/S002185961000068 Retr ieved on 21jan 2020.

Devereux, S. 2006).'Vulnerable Livelihoods in Somali Region, Ethiopia'. Research Report 57, Brighton: IDS.

DFID .2009. Key sheets on climate change and poverty.http://www.dfid.gov.uk/pubs/files/*climate change /keysheetindex.asp*.Accssed on January 12/2020.

DiFalco,S.,M.Veronese,andM.Yusuf .2011. ''Does AdaptationtoClimate Change Provide food Security Micro-perspective from Ethiopia',*American Journal of Agricultural Economics*, 18; doi:10.1093/ajae/aar006, March.

Di Falco, S., M. Yesuf, G. Kohlin, and C. Ringler. 2012. Estimating the impact of climate change on agriculture in low-income countries: Household level evidence from the Nile Basin, Ethiopia. *Environmental Resource Economics* 52: 457–478.

Dong EtAl. 2016. Building Resilience Of Human-Natural Systems Of Pastoralism In The Developing World: *Interdisciplinary Perspectives*, Doi 10.1007/978-3-319-3072-9_1.

Dong, S., et al. 2011.Vulnerability of Worldwide Pastoralism to Global Changes and Interdisciplinary Strategies for Sustainable Pastoralism. *Ecology & Society* ,16, 1-23. https://doi.org/10.5751/ES- 04093-160210 accessed 14 Dec. 2019.

Doss, C. R., and Morris, M. L. 2001. *How does gender affect the adoption of agricultural innovations?*: The case of improved maize technology in Ghana. *Agricultural Economics* 25 (1), 27–39.

Eiste, E., Diriba, K., Sorteberg, A. 2012. Recent drought and precipitation tendencies in Ethiopia. Theor. Appl. Climatol. 112 (3–4), 535–551. Available on line.www.springerlink.com/conten t/r84166851504x2h2/.

Ericksen P., Thornton P., Notenbaert A., Cramer L., Jones P. & Herrero M. 2011. *Mapping hotspots of climate change and food insecurity in the global tropics*. CCAFS Report No. 5. CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS), Copenhagen. Available at: https://cgspace.cgiar.org/handle/10568/3826 (accessed on 31

August 2019).

EPCC (Ethiopian Panel on Climate Change), 2015. First Assessment Report, WorkingGroup II Agriculture and Food Security. Ethiopian Academy of Sciences, AddisAbaba; Ethiopia.

FAO(Food and Agriculture Organization). 2016."Climate-Smart" Agriculture: Policies, Practices and Financing for Food Security, Adaptation and Mitigation. Paper prepared for Hague Conference on Agriculture, Food Security and Climate Change.

FAO (Food and Agricultura Organization).2012. Environment and natural resource management: Adaptation to climate change in semi-arid environments experience andlessons from Mozambique, 71. Rome: FAO.

FAO (Food and Agricultura Organization). 2015. World Cattle Inventory: Ranking Of Countries, Web Site,https://www.drovers. Com/Article/World-Cattle-Inventory-Ranking-Countries-Fao, Accessed November 9/2020.

Federal Democratic Republic of Ethiopia (FDRE). 2015. Ethiopia's Climate Resilient Green Economy. *Climate Resilience Strategy*: Agriculture. Addis Ababa.

Fekede Gemechu, Kinde Lemessa, Tadesse Melka, Birmaduma Gadisa Shimalis Dekeba Asfaw Zewdu. 2016. Effect of Climate Change on Agricultural Production and Community Response in Daro Lebu & Mieso District, West Hararghe Zone, Oromia Region National State, Ethiopia. *Journal of Natural Sciences Research*.vol.6 pp 23-33.

Follet, R.F., and D.A. Reed .2010. Soil carbon sequestration in grazing lands: Societal benefits and policy implications. *Rangeland Ecology & Management* 63:1, 4–15.

Ford, J.D., Lea, B.-F. and Jaclyn, P. 2011. "A systematic review of observed climate change adaptation in developed nations: a letter", *Climatic Change*, Vol. 106 No. 2, pp. 327-336.

Ford, J.D., Berrang-Ford, L., Lesnikowski, A., Barrera, M. and Heymann, S. 2013. "How to track adaptation to climate change: typology of approaches for national level application, *Ecology and Society*, Vol. 18 No. 3 pp. 104-173.

Gebre, H., Kindie, T., Girma, M., Belay, K. 2013. Trend and variability of rainfall in Tigray, Northern Ethiopia: analysis of meteorological data and farmers' perception. *Acad. J. Environ. Sci.* 1 (8), 159–171. https://doi.org/10.15413/ajes.2013.0117.

Gebre Michael Y, Kifle M. 2009. Local innovation in climatechange adaptation by Ethiopian pastoralists.Final report PROLINNOVA–Ethiopia and Pastoralist Forum Ethiopia (PFE), Addis Ababa, Ethiopia.

Gebremichael, Y., W. Bayer & A.W. Bayer. 2010. Emerging responses to climate change in pastoral systems. Rural development news.

Goldman, M. J., and F. Riosmena. 2013. "Adapting to Variability and Drought: The

Shifting Relationship between Institutions and Landscapes in East Africa Savanna lands." *Global Environmental Change* 23: 588–597. doi: 10.1016/j.gloenvcha.

Golafshani, N. 2003. Understanding Reliability and Validity in Qualitative Research University of Toronto, Toronto, Ontario, Canada. *The Qualitative Report*. Vol. 8 No. 4 (597-607).

Greene HW. 2003. Econometric Analysis:New York University Publishing Company. Fourth Edition, pp 8-14.

Gutu, T., Bezabih, E., Mengistu, K., 2012. Analysis of vulnerability and resilience to climate chang e induced shocks in North Shewa, Ethiopia. *Agric. Sci.* 3 (6),871888.https://doi.org/10.4236/ as. 2012.36106.

Hadgu, G., Tesfae, K., Mamo, G., and Kassa, B., 2014. Analysis of Farmers' Perception And adaptation Methods to Climate Variability/Change in Tigray Region, Northern Ethiopia. *Research jourrnal of Agricultural and Environmental Sciences*, 1, 1:15-25.

Hackmann, H. and St Clair, A. 2012.Transformative cornerstones of social science research for glo bal change. International Social Science Council. doi:available at http://www.world Socialscience.org/documents/transformative-cornerstones.pdf Retrieved on 20 October 2020.

Haileselassie, A., Hagos, F., Mapedza, E., Sadoff, C., Awulachew, S.B., Gebreselassie, S.,Peden,D .2008. Institutional Settings and Livelihood Strategies in the Blue NileBasin: Implications for Upstream/Downstream Linkages. Colombo, Sri Lanka.International Water Management Institute. IWMI Working Paper 132.

Hassan R, and Nhemachena,C . 2008. Determinants of African farmers strategies for adapting to climate change. Multinomial choices analysis.African Journal of Agricultural and resource economic , 2:1-7.

Hausner Vh, Fauchald P, Jernsletten J. 2012.Community-Based Management: Under What Conditions Do Sa'mi Pastoralists Manage Pastures Sustainably? Plos One Vol. 7 No. 12. Doi:10.1371/Journal. Pone.0051187.

Hesse, C. and Cotula, L. 2006. Climate change and pastoralists: Investing in people to respond to adversity; IIED, London, UK.

Hession, S.L. & Moore, N. 2011. A spatial regression analysis of the influence of topography on monthly rainfall in East Africa. *International Journal of Climatology*, 31(10):1440-1456.

Hussein, A. 2009. The use of Triangulation in Social Sciences Research: Can qualitative and quantitative methods be combined? *Journal of Comparative Social Work*. University of Agder, Norway/Mzumbe University, Tanzania.

IFAD (International Fund for Agricultural Development). 2008. Annual Report .Ifadifad. (2008).

Annual Report, Enabling Poor Rural People To Overcome Poverty. Ifad. 22.

IFAD (International Fund for Agricultural Development). 2009.Livestock and Pastoralist Community of 273 Practice for pro-poor livestock and fisheries/Aquaculture, 2009.

IFAD (International Fund for Agricultural Development) .2015. Smallholder Livestock Develop: Scaling Up Note. International Fund for Agricultural Development, Rome, Italy.

Ifejika Speranza, C. 2010. Resilient Adaptation to Climate Change in African Agriculture.German Development Institute, Bonn, Germany.

Iqubal A . 2013. Livestock Husbandry. A Sustainable Livelihood in Ethiopia.International. Journal of Economy, Management and Social Sciences. 2(8): 603-607.

ILRI (International Livestock Research Institute) .2009. People, livestock and environment: *Project overview and rationale*.V.4. ILRI, Addis Ababa, Ethiopia.

IIRR (International Institute of Rural Reconstruction). 2004. *Food security in pastoral areas of Ethiopia*. Nairobi, Kenya. ISBN 9966-9705-7-6.

ILO (International Labour Office).2011. The dynamics of employment, the labour market and the economy in Nepal (Geneva). http./www.ilo/org/publns.accessed 22 january 2019.

IPCC Intergovernmental Panel on Climate Change .2007. impacts, adaptation and vulnerability. In: Parry ML, Canziani, OF, Palutikof JP, Vander Linden PJ, Hanson CE (Eds). Contribution of working group II to the fourth assessment report of the Intergovernmental Panel on Climate Change. Cambridge: Cambridge University Press.

IPCC (Intergornmental Panel on climate change).2013.The Physical Science Basis. Contributions of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate change Cambridge University, United Kingdom and New York, NY, USA, 1535 pp.

IPCC (Intergovernmental Panel on Climate Change).2014. Climate Change 2014: Impacts, adaptation, and vulnerability: Regional Aspects. Working Group II Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L.White (eds.)]. United Kingdom: Cambridge University Press.

IPMS .2006. Improving Productivity and Market Success. Pilot Learning Site of Mieso woreda.

Jemal Haji and mengistu Ketema.2012. Climate change adaptation strategies: The case of Babilie district, East hararghe zone, oromia regional state, Ethiopia. Journal of Economics and sustainable development , 3(14):1-12.

Juana, J., Kahaka, Z., & Okurut, F. 2013. Farmers' perceptions and adaptations to climate change in sub-Sahara Africa: A synthesis of empirical studies and implications for public policy in African agriculture. *The Journal of Agricultural Science*, 5(7), 121135.http./www.Google Scholar accessed on 17 October 2019 .

Jon D. Unruh. 2006. Changing conflict resolution institutions in the Ethiopian pastoral commons: the role of armed confrontation in rule-making, Department of Geography, McGill University, 2006.

Karpouzos, D.K. and Kavalieratau, S. 2010. Trend analysis of precipitation data in Piera region (Greece). *European Water*, 30(30), 30– 40.

Kassa, F. 2015. Ethiopian seasonal rainfall variability and prediction using canonicalcorrelation analysis (CCA). Earth Sci. 4 (3), 112–119. https://doi.org/10.11648/j.earth.20150403.14.

Kassahun, A. , Snyman, H. and Smit, G., 2008. Impact of range land degradation on the pastoral production systems, livelihoods and perceptions of the Somali pastoralists in Eastern Ethiopia. Elsevier.

Kato E., C. Ringler, M. Yesuf, and E. Bryan. 2009. Soil and Water Conservation Technologies: A Buffer against Production Risk in the Face of Climate Change? Insights from the Nile Basin in Ethiopia. Washington, DC: IFPRI Discussion Paper No. 871.

Kebede, G. 2013. Spatial and temporal uncertainty of rainfall in arid and semi-arid areas of Ethiopia. *Science, Technology and Arts Research Journal*, 2(4), 106–113.

Kemausuor F, Dwamena E, Bart-Plange A, Kyei-Baffour N,. 2011. Farmers'perceptionof climate change in the Ejura-Sekyedumase district of Ghana. ARPN Journal ofAgricultural and Biological Science 6:25–37

Kidake, B. K., Manyeki, J. K., Kubasu, D., and Mnene, W. N. 2016. Promotion of range pasture and fodder production among the pastoral and agropastoral communities in Kenyan rangelands:Experiences and lessons learnt. *Livestock Research for Rural Development*, Volume 28:23-47. Retrieved from: http://www.lrrd.org/lrrd28/8/kida28151.html. Accessed 21sept. 2020.

Kidus M .2010. The Negative Impact of Climate Change on Ethiopia. retrieved from:https//www. ccas.org/ccas34/11kidus 34248.html. Accessed on 20 Feb.2019.

Kima, S.A., Okhimamhe, A.A., Kiema, A., Zampaligre, N., Sule, I. 2015. Adapting to the impacts of climate change in the sub-humid zone of Burkina Faso, West Africa:*Perceptions of agro-pastoralists, Pastoralism.* 5:1-14.

Komba and Muchapondwa .2012. Adaptation to climate change by farmers in Tanzania, working

papers:299. *Economic research Southern Africa*.

Krätli, S..2019. Pastoral Development Orientation Framework: *Focus on Ethiopia*, Aachen: Bischöfliches Hilfswerk MISEREOR e.V.

Krätli, S.; Huelsebusch, C.; Brooks, S. and Kaufmann, B. 2013. 'Pastoralism: A Critical Asset for Food Security under Global Climate Change', *Animal Frontiers* 3.1: 42–50.

Kreyling J, Wana D, Beierkuhnlein C. 2010. Potential consequencesof climate warming for tropical plant species in high mountains of southern Ethiopia. *Divers. Distrib*. 16: 593–605.

Land O'Lakes International . 2007.How Livestock is used as a coping mechanism With respect to food insecurity among livestock keepers of Africa: a Literature Review from current Perspective, Working Paper.accessed from google scholars oct. 2019.

Legesse G .2008. Productive and economic performance of small ruminants in two production systems of the highlands of Ethiopia. University of Hohenheim, Stuttgart, Germany.

Legesse B, Ayele Y, Bewket W,.2013. Smallholder farmers'perceptions and adaptation to climatevariability and climate change in Doba district,West Hararghe, Ethiopia. *Asian Journal of Empirical Research* 3:251–265.

Liebmann, B., Hoerling, M.P., Funk, C., Bladé, I., Dole, R.M., Allured, D., Quan, X., Pegion, P. & Eischeid, J.K. 2014. Understanding recent Eastern Horn of Africa rainfall variability and change. *Journal of Climate*, 27(23):8630-8645.

Ludi, E., Jones, L., & Levine, S. 2012. Changing focus? How to take adaptive capacity seriously.

Lugusa, K. 2015. Fodder production as an adaptation strategy in the drylands: A case study of producer groups in Baringo County, Kenya. MSc. Thesis, University of Nairobi.accessed 10,2020.

Martin, R.; Muller, B.; Linstadter, A.; Frank, K. 2014. How much climate change can pastoral livelihoods tolerate? Modelling rangeland use and evaluating risk. *Glob. Environ. Chang.* 24, 183–192.

MA (The Millenium Ecosystem Assassment).2005. Ecosystems and Human Well-being: Scenarios, Volume 2, Island Press, 2005.

MacDonald M, Simon J. 2011.Climate, food security,&growth Ethiopia's complex relation ship with livestock.Policy Brief 3.Brighter Green.

Maddison D. 2007. The perception of and adaptation to climate change inAfrica. *The World Bank*, Washington D.C., USA.

Mustapha SB, Sanda AH, Shehu H (2012) Farmers' perception of climate change in central agricultural zone of Borno state, Nigeria. Journal of Environment and Earth Science 2:21–28 Deressa T, Hassan M, Ringler C (2011) Perception of and adaptation to climate change by farmers in the Nile basin of Ethiopia. J Agric Sci 149:23–31, doi:10.1017/S0021 8596100006.

Melaku Berhe, Dana Hoag, Girmay Tesfay, Shunji Oniki and Masaru Kagatsume.2016. Effects of adaptation to climate change on income of cattle owners in the pastoral and agro-pastoral communities of Northern Ethiopia. Invited paper presented at the 5th *International Conference of the African Association of Agricultural Economists*, September 23-26, 2016, Addis Ababa, Ethiopia.

Meze-Hausken E. 2004. Contrasting climate variability and meteorological drought with perceived drought and climate change in northern Ethiopia. *Clim. Res*. 27: 19– 31.

McGahey, D., J. Davies, and E. Barrow. 2008. Pastoralism as conservation in the Horn of Africa: Effective policies for conservation outcomes in the drylands of Eastern Africa. *Annals of Arid Zones* 46(2): 353–377.

Mendelsohn R .2006. Climate change impacts on agriculture. Evenson R, Pingali P and Schultz P editors. Handbook of Agricultural Economics:Agricultural Development.

Mohammed Yimer. 2015. Brief For Gsdr Pastoral Development Pathways In Ethiopia; The *Policy Environment And Critical Constraints*.

Mohammad, A.K. 2007. Factors affecting employment choices in Rural Northwest Pakistan"University of Kassel Witzenhausen and University of Gottingen. *Conference on International Agricultural Research for Development*. October 2007.

Molu Wato.2016. Effects of Climate Variability on Livestock Production and Coping Strategies In Maikona Location, Marsabit County, Kenya. PP 1: 5-7.

MPLSDPD (Mieso Pilot Site Diagnosis and Program Design) .2007. Mieso pilot learning site diagnosis and program design.(Improving Productivity and Market Successes of Ethiopian farmers Mieso Pilot Learning Woreda, 2007. Survey data Mieso, Ethiopia.

Mieso District Coordination office. Pastoral Community Development Project -II Intervention report:Mieso, 2014.

Mieso Pastoral Development Office 2015. Report of Mieso district pastoralist development office, Annual report 2015.

MOARD (Ministry of Agriculture and Rural Development), 2005. Development Program Plan.Addis Ababa, Ethiopia.

MOARD (Ministry of Agriculture and Rural Development).2008. Relief interventions in

pastoralists areas of Ethiopia. Addis Ababa.

Moritz, M., B. Kyle, K.C. Nolan, S. Patrick, M.F. Shaffer, and G. Thampy. 2009. Too many people and too few livestock in West Africa? An evaluation of Sandford's thesis. *Journal Development Studies* 45: 1113–1133.

Mustapha SB, Sanda AH, Shehu H .2012. Farmers'perception of climate changein central agricultural zone of Borno state, Nigeria. *Journal of Environmentand Earth Science* 2:21–28.

Mutsyanwa EP .2011. Climate change and Vurnerability to food insecurity among smallholder farmers`: the case of Gweru and Lupane districts in Zimbabwe.

Nardone, A., Ronchi, B., Lacetera, N., Ranieri, M.S., and Bernabucci, U. 2010. Effects ofclimate changes on animal production and sustainability of livestock systems. *Livestock Science* 130, 57–69.

National Meteorological Services .2007. Climate change national adaptation program of action (NAPA) of Ethiopia. NMS, Addis Ababa.

Ndambiri K, Ritho C, Mbogoh G, Ng'ang'a I, Muiruri J, Nyangweso M, Kipsat J,Omboto I, Ogada O, Kefa C, Kubowon C, Cherotwo H .2012. Analysis offarmers'perceptions of the effects of climate change in Kenya: the case ofKyuso district. *Journal of Environment and Earth Science* 2:74–83.

Nega Debela, Mohammed, C., Bridle, K., Corkrey, R. and McNeil, D. 2015. Perception of climate change and its impact by smallholders in pastoral/agro-pastoral systems of Borana, South Ethiopia.SpringerPlus, 4(1), p.236. DOI 10.1186/s40064-015-1012-9.

New, M., Liverman, D., Schroder, H. and Anderson, K. 2011.Four Degrees and Beyond:The Potential for a Global Temperature Increase of Four Degrees and Its Implications, *the Royal Society Publishing*, London.

Naing L.T Winn and B.N Rusil,2007.Practical issues in calculating sample size.Arch orfac sci.1: 9-1:4.

Niang, I., Ruppel, O., Abdrabo, M., Essel, A., Lennard, C., Padgham, J., & Urquhart, P. 2014. Africa. In: Climate change 2014: impacts, adaptation and vulnerability. Contribution of Working Group II to the Fifth Assessment Report of the *Intergovernmental Panel on Climate Change.* Cambridge UniversityPress, Cambridge. Retrieved from https://www.ipcc.ch/pdf/assessment-report/ar5/wg2/WGIIAR5-Chap22_FINAL.pdf.

NOAA: Climate Literacy: The Essential Principles of Climate Sciences. U.S. *Global Change Research Program.* March 2009.Available at: http://www.climate.noaa.gov/education/pdfs/ ClimateLiteracy-8.5x11- March09FinalHR.pdf. accessed on Septemper 15,2014.

Nyanga PH, Johnsen FH, Aune JB, Kalinda TH .2011. Smallholder farmers'perceptions of climate change and conservation agriculture: evidence fromZambia. *Journal of Sustainable Development* 4:73–85.

Muyanga, M. 2008. Household vulnerability to transient and chronic poverty: Evidence from rural Kenya. In Ninth Annual Conference of Global Development Network (GDN), 29–31.

OCHA, UNEP, ISS and IOM 2010. Advocating for Safe Movement as a Climate Change Adaptation Strategy for Pastoralists in the Horn and East Africa:Highlights and Key Messages.

Okello, J. J., Okello, R. M., and Ofwona-Adera, E. 2009. Awareness and the use of mobile phones for market linkage by smallholder farmers in Kenya. *Eagriculture and government for global policy development*,1–18.Available at https://books.google.com/books?accessed on 22 sept 2020?.

O'Neil D .2011. Pastoralism.http://anthro.palomar.edu/subsistence/sub3.htm Pastoralist Thematic Group (2001) Pastoralist poverty reduction strategy.Unpublished report, March 2001.

Oxfam International . 2008. Survival of the fittest: Pastoralism and climate change in East Africa. *Oxfam Briefing Paper*, 2008.

Pachauri, R. K., Allen, M. R., Barros, V. R., Broome, J., Cramer, W., Christ, R., & Dubash, N. K. ,.2014. Climate change 2014: synthesis report. Contribution of Working Groups I, II and III to the fifth assessment report of the Intergovernmental Panel on Climate Change (p. 151). IPCC.

Partal,T. and Kahya,E. 2006. Trend analysis in Turkish precipitation data. *Hydrological Processes*, 20, 2011– 2026.

Pastoralist Forum Ethiopia.2010. Pastoralism and land: Land tenure, administration and use in pastoral areas of Ethiopia.

Pavanello, S. Pastoralists' Vulnerability in the Horn of Africa: Exploring Political Marginalisation, Donors' Policies and Cross-Border Issues Literature Review; Humanitarian Policy Group, Overseas Development Institute: London, UK, 2009.

Pedersen, J., & Benjaminsen, T. 2008. One Leg or Two? Food Security and Pastoralism in the Northern Sahel. *Human ecology, 36*(1), 43-57. doi: 10.1007/s10745-007-9136-3.

Reid, R.S.; Fernández-Giménez, M.E. and Galvin, K.A. 2014. 'Dynamics and Resilience of Rangelands and Pastoral Peoples around the Globe', *Annual Review of Environment and Resources* 39.1: 217–42.

Reid H., Alam M., Berger R., Cannon T., Huq S., Milligan A., 2009. Participatory Learning

approach:*Community based Adaptation to Climate Change*. Nottingham, U.K.

Russell press united Nations Economic Commission for Africa, 2011. Climate Change and Agriculture:Analysis of Knowledge Gaps and Needs, African Center for climate policy, working paper No7.

Riche, B.et al. 2009.''Climate related vulnerability and adaptive capacity in Ethiopia's Borena and Somali communities: Final assessment report "prepared by the international institutes for sustainable development and the international conservation union With support from save the children UK and CARE. Access from http/www.iisd.org./ Pdf/2010/climate Ethiopia communities .pdf. Accessed on 15 oct.2019.

Robinson, T.P., P.K. Thornton, G.Franceschini, R.L. Kruska, F.Chiozza, A.Notenbaert, G.Cecchi, M. Herrero, M. Epprecht, S. Fritz, L. You, G. Conchedda, and L. See. 2011. Global livestock production systems. Food and Agriculture Organization of the United Nations and International Livestock Research Institute, Rome.

Robinson S, Strzepek K, Cervigni R 2013. The Cost of Adapting to Climate Change in Ethiopia: Sector. Wise and Macro-Economic Estimates. ESSP Working paper 53. 1-23.

Rodriguez, L. 2008 a Global Perspective on the Total Economic: Global Synthesis Report Based on Six Country Valuations. World Initiative for Sustainable Pastoralism (WISP), IUCN.

Rawlinson, P. 2008. Adapting Livestock Production Systems to Climate Change Temperate Zone.Livestock and Global Change conference proceeding. May 2008, Tunisia.

Riginos C, Porensky L, Veblen K Et Al .2012. Lessons On The Relationship Between Livestock Husbandry And Biodiversity From The Kenya Long-Term Exclosure Experiment. Pastoralism: Res, Policy Prac 2:10. Doi:10.1186/2041-7136-2-10.

Rialp, A. & Rialp, J., 2006. International marketing research: opportunities and challenges in the 21st century, UK: Emerald Group Publishing.

Ruijs, A., M. de Bel, M. Kononen, V. Linderhof, & N. Polman. 2011. Adaptation to climate Variability: The role of past experience and institutions. The World Bank.

Silverman, D. 2006. Interpreting qualitative data. 3rd edition. Sage publications. London.

Silvestri, S., Bryan, E., Ringler, C., Herrero, M. and Okoba, B. 2012."Climate change perception and adaptation of agro-pastoral communities in Kenya", Regional Environmental Change, Vol. 12 No. 4, pp. 791-802.

Solomon, A.K., Mwai, O., Grum, G., Haile, A., Rischkowsky, B., Solomon, G.,& Dessie, T. 2014. Review of goat research and development projects in Ethiopia (ILRI project report) Nairobi Kenya: International Livestock Research Institute.

Sofia, T. Effects of Biofuel Production on Farmers' Livilhood in Mieso District of West Hararghe Zone,Oromia Region,Haramaya University, 2010.

Sosina, Bezu. S. Holden and B.C. Barrett. 2009. *Activity Choice in Rural Non-farm Employment* (RNFE): Survival versus accumulative strategy.

Seleshi Y, Zanke U. 2004. Recent changes in rainfall and rainy days in Ethiopia.*International of Journal of Climatology* 24(8):973–983.

Stark J, Terasawa K,Ejigu M. 2011.Climate Change and Conflict in Pastoralist Regions of Ethiopia Mounting Challenges, Emerging Responses.*CMM discussion paper* No.4 October 2011.Pp.1-54.

Sonneveld, B., Van Wesenbeeck, C., Keyzer, M., Beyene, F., Georgis, K., Urbano, F., Meroni, M., Et Al. 2017. Identifying Hot Spots Of Critical Forage Supply In Dryland Nomadic Pastoralist Areas: *A Case Study For The Afar Region, Ethiopia. Land*, 6(4), 82. Mdpi Ag. doi:10.3390/land6040082 .accessed on 25january 2019.

Tabari, H., Meron, T.T.,Willems, P., 2015. Statistical assessment of precipitation trends in the uppe upper Blue Nile River basin. *Stoch. Environ. Res. Risk Assess*. https:/doi.org/10.1007/s00477-015-1046-0.Accessed on 23september 2019.

Taylor RG, Scanlon B, Döll P, Rodell M, Beek RV, Wada Y, Holman I .2012. Ground water and climate change. *Nature Climate Change* 3:322-329.

Tesfaye Z .2009. Vegetation Composition, Biomass Production, and Condition in Bordodde Rangeland west hararghe, Oromiya Ethiopia.

Temesgen, D., Hassan, R.M., Ringler, C., Alemu, T.,& Yesuf, M. 2009. Determinants of Farmers' choice of adaptation methods to climate change in the Nile Basin of Ethiopia.*Global Environmental Change,* 19(3), 248–255. doi:10.1016/j.gloenvcha.2009.01.002 .

Tessema, W.K., Ingenbleek, P.T.M. & Van Trijp, H.C.M. .2014. Pastoralism, sustainability, and marketing. *A review. Agron. Sustain. Dev*. Vol 34: p.75-92. doi: 10.1007/S13593-013-0167-4.

Tazeze, A., Haji, J., & Ketema, M. 2012. Climate change adaptation strategies of smallholder farmers: The case of Babilie district, East Harerghe Zone of Oromia Regional State of Ethio *Journal of Economics and Sustainable Development*,3(14), 2222–2855.

Thornton, P. K., Jones, P. G., Alagarswamy, A., and Andresen, K. 2008. The temporal dynamics

of crop yield responses to climate change in East Africa. Global Environmental Change.

Tsegaye, P. V. 2013. Pastoralism And Livelihood: A Case Study From Northern Afar, Ethiopia. Journal Of Arid Environments, Vol. 91, p 138-146.doi:10.1016/j.jaridenv.2013.01.002. accessed on 13 Nov.2019.

UNDESA (United Nation Department of Economic and Social affeairs).2017. World Population Prospects: The 2017 Revision, Key Findings and AdvanceTables. United Nations, Department of Economic and Social Affairs, Population Division, New York, USA.

UNDP, 2014. Sustaining Human Progress: Reducing Vulnerabilities and BuildingResilience;human Development Report 2014. United Nations Development Programme (UNDP), New York, USA.

UNEP. 2014. Sustainable Pastoralism And The Post 2015 Agenda. Retrieved Novomeber 10, 2020, From Unep:https://sustainabledeveliopment.Un.org/Content/Documents/3777unep. .Pdf.

UNDP, 2008.Fighting Climate Change:Human Solidarity in Divided World;Human development development report 2007/2008, human developmentReport Office, UNDP, New York,USA.

UNISDR (United Nations International Strategy for Disaster Reduction). 2011. EffectiveMeasures to Build Resilience in Africa to Adapt to Climate Change. Briefing Note 04, United Nations International Strategy for Disaster Reduction (UNISDR). Geneva, Switzerland. Retrieved from http://www.unisdr.org/files/24012briefingnote04africa.pdf accessed on sept.14, 2020.

UNFCCC (United Nations Framework Convention on Climate Change) 2012.Retrieved October 20, 2019 from www.unfccc.int/adaptation/items/2973.php.

University of Peace, 2009. Pastoralism: Vulnerability and Adaptation to Climate Change in Darfur, Addis Ababa, Ethiopia.

Van Ginkel, M., et al. 2013. An Integrated Agro-Ecosystem and Livelihood Systems Approach for the Poor and Vulnerable in Dry Areas. *Food Security*,5,751-767.https://doi.org/10.1007/ s12571-013-0305-5. Accessed on 21,oct.2020.

Wasonga, V. O. 2009. Linkages between land-use, land degradation and poverty in semi-arid rangelands of Kenya: The case of Baringo district (Doctoral dissertation, University of Nairobi, Department of agriculture).

Wassie, B., and B. Fekadu. 2014. The impact of climate change on pastoral production systems. A study of climate variability and household adaptation strategies in southern Ethiopian rangelands.. WIDER Working Paper 2014/028.

Wild, S. 2015. FACTSHEET: *Why do many scientists think Africa will be hardest hit by climate*

change? Retrieved on 16,October from https://africacheck.org/factsheets.

Williams AP, Funk C. 2011. A west ward extension of the warm pool leads to a westward extension of the Walker circulation, drying eastern Africa. Clim. Dyn. 37: 2417– 2435.

Wong MC, Mok HY, Lee TC. 2010. Observed changes in extreme weather indices in Hong Kong. Int. J. Clim., DOI: 10:1002/joc.2238.Accessed from http/www.com on 2019.

World Bank, 2010. Development and Climate Change: 2010 World Development Report.The World Bank, Washington DC, New York.

World Bank .2016 . Ethiopia: Database Website(bank.org/en/country/ethiopia).Accessed on 14 September 2019.

Yared Ayele and Woldeamlak .2013. Small holder farmers' perceptions and adaptation to climate change in Doba dostrict, Western Hararghe zone, Oromia regional state, Ethiopia. Asian journal of Empherical research , 3(3):251-265.

Zenebe Gebregziabher, Jesper Stage, Alemu Mekonnen, and Atlaw Alemu, 2011. Climate Change and the Ethiopian Economy: A Computable General Equilibrium Analysis available at http//Inter journal of Env.sc 3-5p accessed on oct. 2020.

7. APPENDICIES

My name is Feyera Tilahun Dessalegn. I am going to conduct research in Haramaya University. This questionnaire is prepared for the study on **"The effects of climate change and adaptation strategies by pastoralists and agro-pastoralists of Mieso district".** The research is planned to investigate the effects of climate change and adaptation strategies in the study area. Your information for the questionnaire will determine the quality of the study. Please give me the correct information!

Note: No need of writing your name. Please reply to questions as per the instruction given for each part, either by putting tick (√) or short responses as required.

7.1 Appendix I: Questionnaires

1. Name of the household head _____Sex _____ Age _____
2. Marital status Married …….. Not married …… other specify ……
3. What is your educational level? 1. No education…… 2. Primary school … 3. Secondary School …..4. Graduate ……
4. Do you have children? Yes/no If yes, how many …… ……....
5. How do you make your life? Livestock rearing, Livestock rearing and cultivation Other/specify/_____
6 Do you or your family member have another source of livelihood other than agriculture? Yes/No, if yes specify_____
7. Do you own land? …. If yes how much? …..
8. How many livestock do you own?
9. How do you characterize the weather of this area in terms of its temperature and precipitation? Is there any change? If yes, how?
10. Have you ever faced any climate related impact in your life time? If yes, what type of climatic shock?
11. What are the major effects of climate change on livestock and crop production?

a. Decreased productivity ☐ c. Feed shortage ☐

b. Increased mortality ☐ d. Prevalence of disease ☐

e. Water shortage ☐

12. If the answer to Q_{11} is yes, did it affect your cattle or/and crop? Yes/No, if yes how much? _____

13. In recent years (within five years),were there any changes in the production of your livestock? Yes ☐ No ☐

14. If yes, what was the trend? A. Increase ☐ B. Decrease ☐

15. In your opinion, have there been changes in rainfall rates in recent years?

Yes ☐ No ☐

16. If yes, what changes did you observe? A. Increase ☐ B. Decrease ☐

17 . Do you think there is any relationship between changes in the production of your crop and livestock and the climatic variable of rainfall? Yes ☐ No ☐ Explain your answer (in terms of the relationship) ……

18. Do you think there is any relationship between changes in the production of your crop and livestock and the climatic variable of temperature? Yes No

Explain your answer……..

19. how did you adapt or what did you do to cope with the situation?

20. Which type of climatic shock is your main concern?

21. What livestock types and number do you own?

a. Goats ☐ C. Donkeys ☐

b. Sheep ☐ D. Cattle ☐

e. Camel ☐

22. What are the major adaptation strategies in agro pastoral communities?

A. mixed crop-livestock farming yes ☐ No ☐

B. providing supplementary feed Yes ☐ No ☐

C. Fodder production Yes ☐ No ☐

D. Changing cropping calendar Yes ☐ No ☐

E. Non-farming activity Yes ☐ No ☐

F. Crop diversification Yes ☐ No ☐

23. What is the major adaptation strategies employed in your area (Only for pastoralists)?

G. Diversification Livestock types Yes ☐ No ☐

H. Herd mobility/Migration yes ☐ No ☐

I. Destocking Yes ☐ No ☐

J. Non- farming Yes ☐ No ☐

24. What are the major determinants that hinder your adaptation strategies?

1. Poverty Yes ☐ No ☐

2. Information on Climate Yes ☐ No ☐

3. Land Scarcity Yes ☐ No ☐

4. Training Services	Yes ☐	No ☐
5. Credit Access	Yes ☐	No ☐
6. Age	Yes ☐	No ☐
7. Gender	Yes ☐	No ☐
8. Level of Education	Yes ☐	No ☐

7.2 Appendix II: Checklists for Key Informant Interview

1. Kebele_____ position/profession_____

2. What is the agro-ecology of your kebele? Pastoral_____ Agro pastoral_____

3. What are the local characteristics of the climate in this area?

4. Do you think there is any relationship between changes in the production of your crop and livestock and the climatic variable of temperature?

5. What are the Major climate change adaptation strategies of the community in this area? Has this changed over the past 5 years?

6. How important are climate conditions for pastoralists and agropastoralists?

7.Can you describe any major climate related events which have happened recently?What was your experience of this? How was your household or the community affected?

8. What are the main stresses (or difficulties) faced by community today? Are these stresses or difficulties changed over the past years? And how?

9. To what extent is the community able to anticipate and identify triggers for forthcoming changes in livelihoods?

10.What are the locally existing opportunities and capacities to foster adaptation of the community to climate change?

11. What are the locally existing barriers and obstacles to adaptation?

7.3 Appendix III: Checklists for Focus Group Discussion

1. Kebele_____ position/profession_____

2. Can you describe any major climate related events which have happened recently?What was your experience of this? How was your household or the community affected?

3. What are the major effects of climate change on livestock and crop production?

4. What are the main stresses (or difficulties) faced by community today? Are these stresses or difficulties changed over the past five years? And how?

5. What are adaptation strategies people put in place when facing climate related events?

6. Are there strategies you devised to survive or reduce the impact imposed on you by the changes in climatic variables?

A. Charcoal burning C.Engaging in small business

B. Sale of livestock

Appendix 1 : Avegae maximum and minium number of Livestock per household in 2019

Pastoralists kebeles	Goats	Sheep	Cattle	Donkeys	Camel
Buri Arba	19.26±9.64	12.7±4.56	4.3±1.39	2.3±1	11.6±5.2
Sirba	17.2±6.7	12+4	3.7+1.43	1.37±0.486	8.3±2.4
Total	18.23±8.17	12.35±4.28	4±1.41	1.8±0.74	9.95±3.8
Agro-pastoralists kebeles					
Diriba	9±12	8.7±10.6	3.97+4.7	1.87±2.2	3.3±1
Gudicha Guracha	12.7±2.5	7.6±5.2	5.2+2	1±1	6.7±1
Total	10.85±7.2	8.15±7.9	4.58±3.35	1.43±1.6	5±1

Appendix 2: Livestock population of meiso district from 2015 to 2019.

Year	Livestock Types					
	Goats	Sheep	Camel	Cattle	Donkey	Total
2015	5,108	5947	1800	1082	695	14632
2016	6,281	7050	2307	1600	1076	18314
2017	6,148	6614	2512	1475	1044	17793
2018	5,711	5579	3051	1109	413	15863
2019	4,688	4504	3216	1214	293	13915
Total	27,936	29,694	12,886	6,480	3,521	80517

Appendix 3: Sorghum and maize production in meiso district 2015 to 2019.

Year	Maize	Sorghum
2015	4239	3193
2016	3201	3361.8
2017	3416.3	2721.5
2018	2013.6	2609
2019	1632	1974

Appendix 4: Maximum Temperature of Meiso (1981-2019)

Parameter	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Tem _Max	1981	31.61	32.25	29.49	26.44	29.07	32.94	30.17	28.12	27.56	27.79	29.12	29.82	29.51
Tem_Max	1982	28.01	29.08	31.39	29.57	30.37	32.19	31.03	28.66	29.48	27.23	27.59	27.53	29.34
Tem_Max	1983	28.27	29.02	32.8	29.04	27.89	29.72	30.61	27.25	27.29	27.57	28.09	28.63	28.85
Tem_Max	1984	29.53	31.04	34.13	33.67	30	29.85	28.95	28.53	27.71	29.5	30.48	29.36	30.22
Tem_Max	1985	30.5	30.51	32.85	28.18	27.61	31.54	28.69	27.22	27.54	28.63	29.37	29.57	29.34
Tem_Max	1986	30.25	32.13	31.81	28.04	28.68	29.75	28.97	26.89	26.55	27.14	28.32	27.48	28.81
Tem_Max	1987	28.5	31.94	28.45	27.69	26.28	27.69	28.35	28.41	29.3	29.63	30.2	30.19	28.86
Tem_Max	1988	29.85	32.3	33.14	31.71	33.5	32.71	29.63	27.77	27.6	27.36	28.1	28.97	30.21
Tem_Max	1989	28.55	29.55	31.13	26.87	30.17	32.29	29.08	28.96	28.7	30.14	29.86	28.54	29.49
Tem_Max	1990	29.98	29.68	28.57	29.03	33.75	34.7	30.56	29.01	29.34	30.29	30.59	29.35	30.4
Tem_Max	1991	31.22	30.78	31.08	30.43	31.04	33.35	29.42	28.42	29.25	30.02	29.98	28.22	30.26
Tem_Max	1992	29.36	29.23	32.72	32.1	31.83	32.91	30.02	26.89	27.99	29.24	29.04	29.58	30.07
Tem_Max	1993	29.38	29.83	33.89	30.14	29.38	30.42	28.61	27.66	28.76	28.97	29.21	29.76	29.67
Tem_Max	1994	30.65	32.16	33.31	32.1	30.48	32.11	28.13	26.86	27.17	28.12	27.79	28.06	29.73
Tem_Max	1995	29.68	30.99	30.77	30	31.93	33.48	29.64	28.5	28.65	29.98	29.89	28.52	30.16
Tem_Max	1996	28.95	32.3	30.89	29.03	28.58	29.31	27.77	26.9	27.77	28.66	28.45	28.55	28.92
Tem_Max	1997	30.16	31.44	32.48	29.19	31.53	31.28	29.35	29	31.48	27.88	26.39	27.68	29.81
Tem_Max	1998	29.09	31.38	33.48	34.31	32.17	33.22	29.1	27.64	28.61	27.56	28.06	29.07	30.29

Tem_Max	1999	30.69	33.65	29.96	31.58	33.62	33.18	28.06	28.11	28.69	27.64	28.2	28.73	30.14
Tem_Max	2001	29.22	32.57	32.15	33.1	34.07	34.35	31.37	29.72	30.4	31.7	30.58	30.96	31.67
Tem_Max	2002	29.44	33	31.6	31.89	34.53	34.5	33.16	31.51	32.47	32.9	31.7	29.68	32.19
Tem_Max	2003	30.78	33.01	33.09	32.02	34.15	33.57	31.34	29.38	30.23	32.26	31.26	27.86	31.57
Tem_Max	2004	31.2	31.78	33	30.47	35.28	33.48	31.73	31.4	31.59	31	30.35	29.41	31.73
Tem_Max	2005	29.85	33.69	31.68	32.47	29.06	32.33	30.57	32.07	32.38	32.2	30.63	30.18	31.4
Tem_Max	2006	31.39	31.82	30.63	30.27	32.65	33.92	30.19	29.37	30.22	30.03	29.93	28.38	30.72
Tem_Max	2007	30.11	31.35	33.05	31.11	33.06	32.79	29.75	29.1	29.16	30.47	29.67	29.33	30.74
Tem_Max	2008	30.72	30.97	34.29	31.36	32.44	33.28	30.29	27.75	29.29	30.33	26.69	28.26	30.47
Tem_Max	2009	29.24	32.08	33.23	32.03	34.74	34.26	29.84	29.88	31.07	29.05	30.45	29.31	31.25
Tem_Max	2010	30.25	29.86	29.31	30.7	31.18	32.84	29.23	27.1	26.97	29.4	28.8	29.04	29.55
Tem_Max	2011	30.51	32.24	32.1	32.55	31.95	32.51	30.9	31.14	31.39	32.55	30.32	29.55	31.47
Tem_Max	2012	30.77	32.32	33.93	31.43	33.61	33.77	29.77	27.92	28.18	30.13	31.27	30.5	31.13
Tem_Max	2013	30.64	32.91	32.62	29.8	31.76	33.09	28.19	27.04	28.63	28.64	27.61	28.18	29.9
Tem_Max	2014	30.19	31.12	31.76	30.86	31.44	34.01	31.26	28.94	28.09	28.01	29.41	29.04	30.34
Tem_Max	2015	29.26	33.03	33.53	33.35	31.66	31.76	33.05	31.2	32.52	32.58	30.48	29.56	31.82
Tem_Max	2016	29.41	31.65	34.65	29.46	28.2	31.43	29.99	28.27	29.88	30.73	30.11	29.33	30.25
Tem_Max	2017	30.4	30.54	32.66	31.9	29.72	33.34	31.55	30.28	29	30.08	30.06	28.96	30.71
Tem_Max	2018	29.42	31.52	31.42	28.24	30.53	31.29	30.74	29.1	29.63	30.29	28.61	29.02	29.98
Tem_Max	2019	31.04	32.78	33.72	31.04	32.62	32.08	31.56	28.82	28.29	25.86	27.72	27.2	30.21

Appendix 5: Minimium Temperature of Meiso (1981-2019)

Parameter	Year	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Ann.
Tem_Min	1981	14.27	16.2	17.63	17.45	17.35	18.71	18.14	17.46	17.55	16.03	14.69	13.84	16.61
Tem_Min	1982	15.26	15.52	16.66	17.59	18.39	18.79	18.36	17.49	17.61	16.33	16.25	14.94	16.94
Tem_Min	1983	14.1	16.34	17.6	18.33	17.98	18.26	18.57	17.67	16.86	16.31	14.7	13.87	16.72
Tem_Min	1984	13.04	13.37	17.07	19.71	18.89	17.66	17.1	16.71	16.74	15.67	16.11	14.54	16.39
Tem_Min	1985	14.78	14.07	17.6	18.23	17.37	17.96	17.66	16.51	16.87	15.8	15.5	14	16.37
Tem_Min	1986	12.98	17.09	16.91	17.78	18.34	18.42	17.45	16.6	16.41	15.4	14.62	13.66	16.29
Tem_Min	1987	12.89	15.58	17.44	16.82	17.47	17.77	17.35	17.42	17.78	17.33	15.23	14.75	16.49
Tem_Min	1988	15.74	17.46	17.89	19.28	18.52	19.74	18.53	17.61	17.71	16.36	13.31	13.57	17.14
Tem_Min	1989	13.15	15.03	17.07	16.76	17.07	18.6	18.01	17.01	17.78	16.36	16.33	16.47	16.64
Tem_Min	1990	15.4	16.91	17.6	17.79	19.31	19.74	18.37	17.27	17.48	16.06	15.43	14	17.11
Tem_Min	1991	15.78	17.19	17.77	18.34	18.55	19.55	17.96	17.65	17.44	16.37	14.7	14.64	17.16
Tem_Min	1992	15.43	15.77	17.72	18.97	19.23	19.33	18.3	17.04	16.78	16.88	15.17	16.21	17.24
Tem_Min	1993	15.76	15.71	17.19	18.56	18.28	18.54	17.33	16.43	16.61	17.12	15.23	13.9	16.73
Tem_Min	1994	13.91	15.4	18.25	19.12	18.12	19.27	17.9	17	16.66	15.56	14.81	13.46	16.62
Tem_Min	1995	13.29	16.28	17.97	18.81	18.72	19.09	18.45	17.43	17.52	16.84	14.59	15.32	17.03
Tem_Min	1996	15.44	16.13	18.44	18.23	18.1	18.35	17.43	16.73	17.27	16.05	15.1	13.44	16.72
Tem_Min	1997	15.76	14.47	18.05	18.4	18.82	19.23	17.9	17.64	18.5	17.79	17.05	16.12	17.49
Tem_Min	1998	16.45	17.65	19.05	20.86	19.48	20.07	18.38	17.75	17.69	17.46	14.34	13.41	17.71

Tem_Min	1999	14.92	16.23	17.68	18.21	19.35	19.34	17.61	17.11	17.37	16.95	14.34	13.48	16.89
Tem_Min	2000	14.2	15.34	16.72	18.79	19.69	20.22	18.98	18.51	18.86	18.01	16.31	15.38	17.59
Tem_Min	2001	14.21	16.21	18.57	19.27	20.22	20.62	19.32	18.76	18.19	18.48	15.03	15.75	17.89
Tem_Min	2002	15.34	15.58	18.53	19.18	19.85	20.12	19.43	18.97	19.4	18.01	15.93	17.45	18.16
Tem_Min	2003	15.53	17.5	19.18	19.37	19.03	19.74	19.51	18.11	18.23	17.7	16.56	14.19	17.88
Tem_Min	2004	17.02	15.71	17.44	19.52	19.4	19.49	18.91	18.74	18.7	17.33	15.92	15.31	17.79
Tem_Min	2005	14.86	16.48	19.31	19.14	18.78	19.37	19.02	19.03	19.82	18.11	15.81	13.42	17.76
Tem_Min	2006	15.55	17.19	17.53	18.31	19.4	19.98	18.68	18.14	18.26	17.71	15.65	15.51	17.66
Tem_Min	2007	15.16	17.31	18.06	18.78	19.44	19.71	18.58	18.45	18.35	16.66	15.02	13.3	17.4
Tem_Min	2008	15.26	14.46	16.22	18.37	19.51	19.3	18.58	17.51	18.02	17.56	14.61	13.67	16.93
Tem_Min	2009	15.51	16.46	18.54	19.07	19.98	20.09	18.31	17.92	18.83	17.12	15.49	17.11	17.88
Tem_Min	2010	14.97	17.53	17.34	19.08	19.88	19.67	18.38	17.42	16.97	16.99	15.25	13.87	17.27
Tem_Min	2011	14.99	16.08	16.94	19.4	19.71	19.91	19.2	19.22	19.63	17.46	17.06	13.97	17.8
Tem_Min	2012	15.27	15.09	17.53	18.93	19.51	19.74	18.51	17.94	17.88	16.46	16.59	15.87	17.45
Tem_Min	2013	15.68	16.41	18.92	19.45	19.77	19.33	18.11	17.25	17.66	17.18	15.63	13.49	17.41
Tem_Min	2014	14.94	17.46	18.53	19.25	19.59	19.32	18.96	18.27	17.74	16.75	16.08	14.16	17.58
Tem_Min	2015	13.8	16.47	18.22	18.72	19.6	19.36	19.42	18.46	19.82	19.09	16.9	15.82	17.98
Tem_Min	2016	16.65	15.83	20.53	19.68	18.36	18.59	18.47	17.41	17.84	17.25	16.01	14.36	17.59
Tem_Min	2017	13.28	16.68	18.53	18.85	19.28	19.46	19.05	18.58	18.42	17.71	15.86	12.55	17.35
Tem_Min	2018	13.92	16.56	17.9	18.76	18.98	19.33	18.19	17.94	17.69	17.56	16.08	14.75	17.3
Tem_Min	2019	14.35	17.77	19.43	19.91	19.83	19.49	19.62	18.38	18.11	16.17	16.62	15.13	17.9

Appendix 6: Precipitation of Mieso station (1981-2019)

Parameter	Year	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Ann.
Precipitation	1981	0.06	7.85	249.4	291.89	16.53	23.98	166.8	218.68	169.99	37.52	10.73	5.18	1198.61
Precipitation	1982	236.8	52.75	66.68	99.64	120.09	41.32	98.51	156.34	111.53	111.01	52.22	63.69	1210.58
Precipitation	1983	14.28	69.57	80	265.01	168.19	46.77	102.42	342.23	155.38	39.45	2.34	2.67	1288.31
Precipitation	1984	0.36	5.49	5.29	18.73	208.33	50.82	186.38	156.9	148.8	14.88	5.88	13.29	815.15
Precipitation	1985	40.74	0.01	48.98	166.92	122.95	57.11	120.75	241.24	142.35	29.06	8.46	1.53	980.1
Precipitation	1986	0	43.81	107.36	230.52	88.23	113.96	134.22	352.35	183.26	67.93	21.41	45.51	1388.56
Precipitation	1987	2.25	19.47	232.46	252.44	320.11	101.44	108.11	151.36	77.27	43.1	2.06	1.9	1311.97
Precipitation	1988	26.49	57.93	21.57	130.27	6.99	50.1	115.63	244.59	173.64	76.93	0.25	12.63	917.02
Precipitation	1989	3.22	54.92	115.47	270.96	13.05	36.91	166.71	165.77	97.62	24.88	13.13	34.52	997.16
Precipitation	1990	21.49	152.39	82.5	113.23	19.35	12.68	131.47	208.94	96.29	27.11	1.54	7.35	874.34
Precipitation	1991	11.24	70.26	108.09	117.02	78.74	15.72	184.33	173.9	90.72	17.4	4.22	47.73	919.37
Precipitation	1992	19.55	92.93	35.35	79.31	61.45	37.86	138.88	234.25	105.59	20.11	18.67	12.33	856.28
Precipitation	1993	26.7	24.67	12.8	184.55	116.76	68.78	174.49	190.23	108.94	73.3	3.47	10.43	995.12
Precipitation	1994	0	0.19	43.53	123.63	116.72	39.21	226.64	227.08	171.9	20.79	54.88	2.66	1027.23
Precipitation	1995	0	57.02	101.75	141.05	46.68	22	145.09	191.79	102.08	21.48	8.89	77.71	915.54
Precipitation	1996	49.88	3.03	183.98	140.07	108.12	84.91	259.52	247.92	109.98	17.73	47.07	3.27	1255.48
Precipitation	1997	14.01	1.54	77.21	103.4	53.78	94.41	171.81	150.04	44.25	274.74	44.43	5.31	1034.93
Precipitation	1998	38.74	48.38	37.92	56.31	82.83	43.83	168.19	198.27	155.92	124.45	12.19	0.93	967.96
Precipitation	1999	4.55	1.84	134.17	45.15	27.76	56.17	182.6	251.36	79.9	103.35	4.33	1.35	892.53
Precipitation	2000	0.63	0	13.89	51.04	40.27	17.21	44.18	118.34	41.45	28.8	11.14	2.93	369.88

Precipitation	2001	0.46	4.12	81.66	23.55	33.14	13.18	43.69	109.89	74.55	24.49	6.59	2.53	417.85
Precipitation	2002	21.64	0.51	94.74	51.91	46.36	19.67	62.8	79.64	29.12	11.9	4.52	11.28	434.09
Precipitation	2003	1.42	17.52	20.39	100.98	25.55	23	78.51	176.02	75.09	0.56	6.31	55.7	581.05
Precipitation	2004	8.47	3.62	54.91	71.96	10.62	42.98	85.6	68.26	88.55	22.8	32.39	25.04	515.2
Precipitation	2005	11.22	2.86	56.1	123.02	152.68	12.43	59.21	55.69	39.08	10.78	23.35	0	546.42
Precipitation	2006	5.48	48.16	96.06	97.89	49.55	28.28	155.79	123	74.74	58.25	6.92	42.25	786.37
Precipitation	2007	5.69	51.22	51.61	138.96	72.42	22.55	145.86	157.02	90.11	38.84	15.2	0	789.48
Precipitation	2008	10.87	0.59	1.18	94.94	57.19	29.48	212.44	231.76	64.9	56.89	84.41	0.78	845.43
Precipitation	2009	26.47	15.08	34.02	72.81	15.11	71.08	165.69	120.4	78.37	88.09	7.57	27.34	722.03
Precipitation	2010	0.05	92.92	103.5	116.61	91.07	60.54	223.6	296.64	235.99	12.06	20.41	2.94	1256.33
Precipitation	2011	1.58	1.35	47.33	84.47	91.1	20.9	89.05	74.29	37.97	11.26	22.41	0.25	481.96
Precipitation	2012	0.48	0.01	3.74	81.57	43.31	33.88	154.84	242.95	109.86	6.13	6.33	3.2	686.3
Precipitation	2013	14.81	0.13	57.08	133.35	40.29	34.25	290.26	217.85	106.5	61.66	88.98	1.49	1046.65
Precipitation	2014	0.19	11.24	57.24	82.15	74.7	23.24	150.36	140.21	184.58	79.95	11	5.6	820.46
Precipitation	2015	4.75	0.35	26.12	14.37	123.38	82.79	31.88	141.03	31.45	12.67	37.52	15.11	521.42
Precipitation	2016	26.72	19.38	33.34	233.13	191.14	22.2	174.71	175.41	69.59	19.13	24.6	14.26	1003.61
Precipitation	2017	0	50.23	128.68	30.63	161.2	22.89	106.04	148.54	180.3	17.01	6.15	0.48	852.15
Precipitation	2018	10.01	1.05	0.76	7.09	11.57	32.15	111.75	101.82	112.76	71.94	12.93	0.40	484.23
Precipitation	2019	0	2.36	3.12	8.76	11.69	92.98	111.83	72.47	23.5	15	5.70	8.77	356.18