EFFECTS OF CLIMATE CHANGE ON LIVESTOCK PRODUCTION, FEED RESOURCES AND RELATED ADAPTATION STRATEGIES IN BORICHA DISTRICT, SIDAMA ZONE, SOUTHERN ETHIOPIA

MSc THESIS

EYOB MARUFA WOBISA

HAWASS UNIVERSITY

COLLEGE OF AGRICULTURE

HAWASSA, ETHIOPIA

APRIL, 2019

EFFECTS OF CLIMATE CHANGE ON LIVESTOCK PRODUCTION, FEED RESOURCES AND RELATED ADAPTATION STRATEGIES IN BORICHA DISTRICT, SIDAMA ZONE, SOUTHERN ETHIOPIA

EYOB MARUFA WOBISA

MAJOR ADVISOR: DERIBE GEMIYO (PhD)

CO-ADVISOR: MERGA BAYSSA (PhD)

A THESIS SUBMITTED TO THE PROGRAM OF CLIMATE CHANGE AND SUSTAINABLE AGRICULTURE

HAWASSA UNIVERSITY

COLLEGE OF AGRICULTURE

IN PARTIAL FULFILLMENT FOR THE REQUIREMENTS OF THE DEGREE OF MASTERS OF SCIENCE IN CLIMATE CHANGE AND SUSTAINABLE AGRICULTURE (CCSA)

HAWASSA, ETHIOPIA

APRIL, 2019

ADVISORS' APPROVAL SHEET

This is to certify that the thesis entitled "**Effects of Climate Change on Livestock Production, Feed Resources and Related Adaptation Strategies in Boricha District, Sidama Zone, Southern Ethiopia.**" Submitted in partial fulfilment of the requirement for the degree of **Master's** with specialization in Climate Change and Sustainable Agriculture, the Graduate Program of the Department of **Climate Change and Sustainable Agriculture**, and has been carried out by **Eyob Marufa Wobisa ID. No CCSA/0608/07**, under our supervision. Therefore, we recommended that the student has fulfilled the requirements and hence here by can submit the thesis to the department.

Approved by advisors

Deribe Gemiyo (PhD)	____________	__________
Name of major advisor	Signature	Date
Merga Bayssa (PhD)	_______________	__________
Name of co-advisor	Signature	Date

DEDICATION

I dedicated this thesis to my beloved father Kalaa Marufa Wobisa whom I lost when I did my thesis work. He was very committed in leading me at a right way. I never ever forget him, RIP.

STATEMENT OF AUTHOR

I declare that this thesis is my own work and all materials used for this thesis have been duly acknowledged. I solemnly declare that no one can submit this work to any other institution anywhere for the award of any academic degree, diploma or certificate.

Name: Eyob Marufa Wobisa, Signature…………………

Place: Hawassa University, College of Agriculture, Hawassa

Date of Submission………………………

ACKNOWLEDGEMENTS

Firstly, I would like to thank my almighty God for giving me health, strength and peace during all my life. I would like also to express my deepest respect and most sincere gratitude to my advisors, Deribe Gemiyo (PhD), SARI and Merga Bayssa (PhD), Hawassa University for their guidance and encouragement at all stages of my thesis work. Their constructive criticism, supervision and comments from the initial conception to the end of this work is highly appreciated.

I would also like to extend my grateful thanks to Boricha District office of Animal and fishery resource for their support in giving secondary information needed for this study. My thanks also goes to Mr. Letefe Lancha, Mss. Shito Kebede and all those farms who participate in the study as respondents, key informants and member of focus group discussion. They all shared their knowledge, skill and experiences for the successful of this study; I would like to thank them from the depth of my heart. Indeed, their cooperation was crucial and this work would not have been possible without their willingness. Data collectors special Ato Mamush Amanuel contributed a lot for the success of the study and I am grateful to him. In addition to all I would like to thank Mr. Eyasu Kayima and Derese Demissie for their direct and indirect support in my thesis work. My sincere appreciation also goes to Hawassa University College of Agriculture Climate change and Sustainable (CCSA) program coordinator for his contribution in the learning teaching process at my study time.

LIST OF ABBREVATIONS

ANOVA	Analysis of Variance
AFC	Age at First Calving
AM	Age at Maturity
BDAFOF	Boricha District Animal and Fishery Office
BWT	Birth Weight
CI	Calving Interval
CSA	Centeral Statstical Agency
CV	Coefficients of Variation
GDP	Gross Domestic products
LS	Livestock
MoARD	Ministry of Agriculture and Rural Development of Ethiopia
MWT	Maturity Weight
MLM	Multinomial Logistic Model
NMA	National Meteorology Agency
OTR	Off-take Rate
PSNP	Productive Seft Net Program
R^2	Coefficient of Determination
r	Correlation Coefficient
SNNPRS	South Nation Nationality Peoples Regional State
SPSS	Statistical Package for Social Science
TLU	Tropical Livestock Unit
WWT	Weaning Weight

Table of Contents

Title **Page**

List of Tables

Table **Page**

List of Figures

Figure **Page**

Effects of Climate Change on Livestock Production, Feed Resources and Related Adaptation Strategies in Boricha District, Sidama Zone, Southern Ethiopia

Eyob Marufa Wobisa, Hawassa University

Major Advisor: - Deribe Gemiyo (PhD), Southern Agricultural Research Institute, SARI
Co-Advisors:- Merga Bayssa (PhD), Hawassa University

ABSTRACTS

Effects of climate change on livestock production, feed resources and related adaptation strategies were conducted in Boricha District, Sidama Zone of Southern Ethiopia with the objective of assessing effects of climate change on livestock production, feed resources and adaptation strategies practiced by farmers in mixed farming system of Southern Ethiopia. Purposive and systematic random sampling techniques were used for selection of sample Kebeles and household, respectively, for the formal survey. Both primary and secondary data were collected and analyzed by using descriptive statistics and multinomial logit model. The study also used 36 years rainfall and temperature data to look over the trends of local climate variability and change. According to the of trend analysis, both the maximum and minimum temperature of the study areas showed an increasing and the rain fall shows decreasing trend with high variability in the last four decades. About 88.4% of farmers perceived that the climate in their local environment was changed over years. Major causes of climate change were both human activities and natural process as 67.1% of respondents perceived. Many of the farmers perceived that climate change greatly affected their livestock production over time. The result of survey shown that climate change is pressing issue now a day, its consequences on livestock feed, and water availability, diseases outbreak and livestock production and productivity were negative. Most of farmers in the study area perceived that due to the effect of climate change, livestock feed (93.8%) and, water availability (92.5%) were reduced and diseases outbreak was increased (85%). The evidence for existence of climate change in the study area were reduction in rainfall amount, increasing environmental temperature, decrease in water sources and livestock feed, outbreak of new livestock diseases and drought occurrence. Different adaptation mechanisms practiced by the farmers in the study area to adapt the impact of climate change were feed and water storage for livestock for dry period, temporal migration to Lake Hawassa, River Bilate, Loka Abaya area and to other places in searching of pasture and water, herd diversification by rearing mixed livestock ***i.e.*** *small and large ruminants together, livelihood shifting, and rearing drought tolerant species of livestock. The result of multinomial logit model indicate that sex, education, family size, farm size, access to extension service and climate information were the major determinant factors that affect the choice of adaptation option of farmers in the study area. Effect of climate change on growth performance and some of reproductive performance of livestock needs further research since there is no record on growth and reproductive performance of livestock in small-scale traditional production system.*

Keywords*:* Adaptation, Climate Change/Variability, Livestock Dynamics, Perception

1. INTRODUCTION

1.1. Background

Livestock production supports the livelihoods of at least 600 million smallholder farmers in the world, particularly in sub-Saharan Africa and South Asia (Thornton, 2010). Demands for livestock products are also expected to nearly double in sub-Saharan Africa and South Asia by 2050 (Alexandratos and Bruinsma, 2012). A change of limate over the last 30 years influenced global agricultural production, negatively affects social and economic activities, and leads to food insecurity of farming community (MoFED, 2010).

Climate change is a change in the state of the climate identified by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer (IPCC, 2007). Climate change can be anthropogenic and natural phenomenon; can affect natural and human systems (MoFED, 2010). The anthropogenic mean climate change effects are exacerbated by the influence of human action and the natural one is aroused by climate variation by nature. The effects of climate change and variability is more severe in developing countries due to their excessive dependent on rain-fed agriculture. Majority of smallholder farmers in Africa depends on livestock-based agricultural production systems and climate change has negative impacts on the system. The negative effects of increased temperature on feed intake, reproduction and growth performance of major livestock species has been well-documented (Porter *et al.*, 2014). It is well established that rainfall variability, which characterizes arid and semi-arid areas, affects the amount and quality of forage available for herbivores feeding (Fynn and O'connor, 2000). Hence, animal responses to climate variability are indirectly mediated by forage production (Hulme, 2005). As a result, forage production and productivity is a major limiting factor to livestock productivity, particularly during the dry season and/or dry years. McCane (1987); Desta and Coppock (2002); Begzsuren *et al*., (2004) and Angassa *et al.*, (2007) identified relationships' existed between rainfall variability and livestock dynamics.

Rainfall regulates livestock populations through influencing pasture productivity and other livestock feed resources. This will affect quality and quantity of feed resources through reducing moisture content of feed for prolonged dry season/period of time and increase lignification. Lignified feed by itself is a feed with low nutritional value and imposed reduction in performance efficiency of animals. Ellis and Swift, (1988); Oba, (2001) reported that droughts cause livestock population fluctuations through weight loss, increased mortality and reduced birth rates. However, such scenarios were not captured in Southern mixed system including Boricha district.

As livestock management practices are aimed at protecting economic interests of farmers, it is also expected that off-take rates are likely to increase during the dry period attempting to reduce risks due to losses of animals. Livestock and feed management practices partly influence livestock population response to climate variability. Managing crop by-products/crop residues and communal and private grazing lands may also enhance livestock productivity. In Boricha district, livestock management is mostly traditional, and kept under extensive production system; animals were allowed to move freely around. Calves and sometimes-small ruminant like sheep and goats are herded around home to keep them from crop farms. Crop leftovers, crop after math and roadside grazing are important feed sources for large animals such as cattle and donkeys and small ruminants like sheep and goat. However, livestock species versus climate changing scenarios have not been well documented in southern Ethiopia in general and in Boricha in particular. Increased awareness on effects of climate variability on livestock and forage production trends would help to design appropriate adaptation strategies for smallholder farmers.

Adaptation is the process through which societies increase their ability to cope up with an uncertain future, which involves taking appropriate action and making the adjustments and changes to reduce the negative impacts of climate change (IPCC, 2001; UNFCCC, 2007; IPCC, 2007; World Bank, 2010). A community/systems is said to have enhanced adaptive capacity if it is able to modify its characteristics or behaviours so as to cope up better with changes in external conditions ***i.e.*** climate change and variability. The choice of adaptation strategies by farmers depends on various social, economic and environmental factors (Deressa *et al.,* 2007; Bryan *et al*., 2013). Understanding the level of farmers' climate change risk perception and vulnerability will promote successful adaptation to improving livestock production and livelihoods of smallholder farmers. Therefore, this study was designed to assess influences of climate variability on livestock dynamics and forage production trends under traditional production systems in Boricha District. It also aimed to identify the level of farmer's risk perception and vulnerability to climate change and variability. In addition to that, the present study aimed to explore ingenious adaptation strategies by which farmers are trying to cope up with climate change and variability.

According to reports of many authors (Agrawal A. and Perrin A., 2008; Heltberg R. *et al*., 2009), climate change adaptation is a complex, multidimensional, and multistage process; in terms of type, scale, timing, and outcome of the responses, as well as the factors that influence adaptation strategies. The existing literature does not sufficiently address the complex, forward looking and site-specific characteristics of adaptation processes. Deressa *et al.,* (2008) investigated significant effects of socio-economic factors on climate change adaptation options. There were also little evidences on factors affecting the choices of climate change adaptation strategies related to livestock sectors in the developing countries in general and mixed production system of Boricha Districts specifically. Therefore, analysis of such factors is important to provide policy makers with information on intervention areas to reduce the vulnerability to the negative effects of climate change. Thus, this paper was aimed to investigating socio-economic factors that determine the decisions made by farmers to adapt climate change adaptation strategies.

1.2. Statement of problems

Climate change is the greatest challenges to the development of the countries and affecting worldwide agriculture and food production. The issue of climate change in developing countries is more severe. Ethiopia as one of developing countries, it is highly vulnerable to climate change due to excessive reliance on rain-fed agriculture which is highly sensitive to climate change, high population growth rate, low economic development, low adaptive capacity and lack of awareness and institutional capacitation. This makes agricultural production highly sensitive to fluctuation in rainfall and other climatic variables. Livstock sector as a component of agricultural production, the effects of climate fluctuation is highly significant and affecting production and reproduction performance and livestock feed resources. Climate change execrated the existing situations and increased the vulnerability of livestock system to the change. It enhances the occurrences of diseases, mortality and off-take rate, reduction in birth rate and livestock feed resources. Due to the loss of livestock assets, economy of rural community collapse into chronic poverty with long-term effects on their livelihood (IFAD, 2011). Climate vulnerability, which is more severe in dry lands where there is already slight rainfall and high temperature resulting in frequent climatic shocks. The situation is observed in dry lands of southern Ethiopia; Boricha District, particular case study area for this research, where temperature is getting higher and rainfall lower than used to before (Hameso, 2012; Tsegaye, 2014). Same authors revealed that rain fall variability is greatly affecting agricultural production in dry land area of Boricha district more than any other area in Sidama zone. It is the most severely affected area in the zone due to its semi-arid and dry climatic conditions. It experiences higher temperature and receives less rainfall (Hameso, 2012; Tsegaye, 2014). According to MoARD (2013), Boricha district is a major recipient of PSNP fund in Sidama zone. Rural livelihoods in the district remain extremely vulnerable to climate variability and sever food insecurity. Tsegaye (2014) identified that, impacts of climate change and variability on household food insecurity is very significant even though farmers were trying to cope up/adapt from it. However, there are limited studies that were focused in livestock sector on analyzing effects of climate fluctuation on livestock production and feed resources and farmers' risk perception in mixed production system in general and Boricha District specifically. There are also gaps in livestock related adaptation strategies to cope up from the shock of climate change and to estimate level of vulnerability of farmers. Hence current study attempted to analyze effects of climate change on livestock production, livestock feed resources, farmers level of risk perception, level of vulnerability and adaptation strategies to climate change in the smallholder farmers in Boricha district of southern Ethiopia.

1.3. Objectives

The general objective of the study was to assess effects of climate change on livestock production, feed resources and adaptation strategies of smallholders in the study area with the following specific objectives.

- ❖ To assess the climatic trends (rainfall and temperature) of the locality (study area)
- ❖ To assess smallholder farmers risk perception on climate change
- ❖ To assess effects of climate change on livestock production and feed resources
- ❖ To identify indigenous adaptation strategies of smallholder farmers to climate change in mixed crop-livestock system
- ❖ To identify determinant factors that affect farmers choice of adaptation strategies to climate change

1.4. Research questions

The objectives of this study were achieved by answering the following research questions:

1. What are climatic (rainfall and temperature) trends of the study area?
2. What are the risk perception of farmers on climate change and its effect on livestock production trends in the study area?
3. What are the associations between climate change and livestock production and feed resources in the study area?
4. What adaptation strategies/options are farmers applying to cope up from the risk of climate change in the study area?
5. What are determinant factors that affect farmers' choice of adaptation strategies to climate change?

2. LITERATURE REVIEW

2.1. Climate change and Variability: A brief

Climate change is a change in the state of the climate that changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer (IPCC, 2007). The change in climate system attributed directly or indirectly to human activities (anthropogenic) greenhouse gas emissions that alter the composition of the global atmosphere observed over long periods. Such change includes average temperature, precipitation, humidity, wind condition, among other aspects of the earth's climate change. Climate variability on the other hand refers to long-term fluctuation of weather that can occur without interference from human activities; the drivers are El Niño Southern oscillation. All these fluctuation in the climate will results in loss of crop and livestock species in smallholder farmers (Sarah *et al*., 2012). The interaction between livestock and climate is positive in some places and negative in another place. The positive aspect of climate change improves the performance of livestock production while in cases of negative the efficiency of livestock performance reduces. Therefore, livestock production in changing climate is dynamic since a manner of interaction between livestock and climate changes over years.

2.2. Climate change at global level

In addition to IPCC (2007), IPCC (2014) defined climate change giving more elaboration as "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods". Climate change also embraces the observed and projected rise in average global temperature, and the related impacts, including an increase in severe weather incidents; glaciers and sea level rise, melting of icebergs, and changes in the timing and amount of rainfall (CARE, 2009).

Greenhouse gases, such as carbon dioxide (CO2), nitrous oxide (N2O), methane (CH4) emission that are warming the planet, affect the earth's climate. Most of the warming is driven by increasing atmospheric concentrations of CO2 released by burning fossil fuels. There are also other Green House Gases (GHGs) which are entirely anthropogenic and are identified as hydro fluorocarbons (HFCs) and per-fluorocarbons (PFCs). There is much information that suggests human activity is responsible for the high concentration of greenhouse gases and the associated changes in climate. In this respect, the IPCC Fourth Assessment Report (AR4) (IPCC, 2007) boldly states that global warming since 1750 is the net effect of human activity. Consequently, most of the observed increases in globally averaged temperatures since the mid-20th century are believed to be due to the observed increase in anthropogenic greenhouse gas concentrations. The rise in the greenhouse gases has induced a rise in the amount of heat in the atmosphere as the heat that would normally be emitted back in to space is trapped in the atmosphere. This increase in heat has led to the greenhouse effect, resulting in changes in the attributes of the climate. Climate models are important tools to simulate a changing climate (IPCC, 2013). The model simulations are compared with observations focusing on the actual global temperature rise during the last century up to the present. The comparisons clearly show that the observed temperature warming trends can only be expounded when greenhouse gas emissions from human activities are included in the climate models (IPPC, 2013). Accordingly, temperature is likely to rise between 2°C-4.5°C by 2100 showing a two-fold increment of the carbon dioxide in the atmosphere. In context of Africa, the warming in this century is likely to be greater than the global average (3°C).

2.3. Climate Change effects in Africa

Climate change is expected to have adverse ecological, social and economic impacts. Climate change affects many institutions and productive sectors including agriculture, forestry and energy in Africa and across the world. The economy of Africa nations will be more affected by climate change, partly due to their greater exposure to climate shocks and also because of their limited adaptive capacity. However, no country is immune (World Bank, 2009) and of the developing countries, many in Africa are seen as being the most vulnerable to climate variability and change. Poor agricultural productivity; which is mainly rain-fed, is one of many factors driving vulnerability of developing countries. Climate change will create large incremental risks (UNDP, 2007) and a small incremental risk of more droughts can lead to large human development setbacks.

A climate change impact on livelihood has been well documented by different authors (UNFCCC, 2007; Omari, 2010; Thornton, 2010). Even with a small temperature rise of 1-2.5%, the consequences could still be severe, exerting far-reaching impacts on the livelihood of many people. Poverty, illiteracy and lack of skills, weak institutional capacity, limited infrastructure, lack of technology and information, low levels of primary education and health care, poor access to resources, low management capabilities and armed conflicts has been reported as a contributing factors to impacts of climate variability. Agricultural GDP in Africa is expected to fall between 2-8% due to climate change (Fischer *et al*., 2005). Climate change also resulted in net revenue losses in Africa farmers, particularly as a result of increased variability and extreme events. The temperature rise in 10% will lead to visible loss in net incomes that could be gained per hectare; that is on average 8.2% for rain fed production (Kurukulasuriya and Mendelsohn, 2006a). The current climate variability and drought are major challenges for the livestock sector and the species biodiversity. In livestock sector, climate change would affect pasture productivity in quantity and quality (***i.e.*** increasing the lignin content and other unavailable phenolic chemicals), reduce livestock productivity and reproduction, increase in distribution and incidence of animal and plant diseases (NMSA, 2001). Climate change may also result in deterioration of pasture towards lesser quality pasture (C4). Climate change may also affected livestock feed grain and crop residues availability in mixed system and may over-burn the prices of livestock feeds. Climate variability (***i.e.*** temperature and rainfall) may result in the spread of disease and parasites into new regions or may result in increase in the incidence to which a particular disease which is already existed, which will lead to a decrease in animal productivity and increase in animal mortality (Baker & Viglizzo, 1998). Trypanosomiasis which is the diseases of livestock in lowland area currently also moved toward the highlands of Ethiopia due to ecological changes (Markos, 2007). Climate change may also increase mobility of people with their livestock due to habitat destruction and changes in land use, which may occur at globally and locally level (McDermott *et al*., 2001; Reiter, 2008), and may results in transmission of infection zoonotic tick-borne diseases occurred when there is an overlap of activities between reservoir, vector and humans.

2.4. Climate change and crop-livestock farming system in Ethiopia

Mixed farming system is dominant types of farming system in highland part of Ethiopia. Crops and livestocks complement one another and most rural communities' practices since one buffer the loss of another. Crop and livestock sectors are highly integrated and one complements another (Getachew *et al*., 1993). Farm diversification is fairly practiced in crop-livestock production system: when farmers face challenges by the loss of crops, livestock can be optional sources of food and income. Cecilia (2015) identified that livestock can provide a buffer against losses in crops in a particular season. Therefore, livestock is a key asset for poor communities in fulfilling multiple economic, social and risk management functions in crop-livestock farming system. It is a rapidly growing agricultural subsector, and its share of agricultural GDP is 35-49 percent and rising, driven by population growth, urbanization and increasing incomes in developing countries. Demand for all livestock products is expected to nearly double in sub-Saharan Africa and South Asia by 2050 (Alexandratos and Bruinsma, 2012). Livestock system on the other hand is challenged by many factors, as climate variability is one and critical challenges among; temperature and rainfall variability which has been exaggerated the livestock production of this era. The climate change effect is expected to induce the vulnerability in to livestock production systems through impair feed intake, metabolic activities and defense mechanisms (Nardone A. *et al*., 2010). Climate change is both anthropogenic and natural phenomenon, which influences agricultural production and negative effect on the social and economic activities and lead to food insecurity (MoFED, 2010). According to IPCC (2007) Africa is one of the regions that will be hard hit by the impact of climate change like increasing in temperature and reduction in rainfall. Agricultural production and food security in many African countries could be affected by climate change and variability. Climate change affect the agriculture in multidirectional ways: there is a strong linkage between climate vulnerability, poverty and food insecurity (FAO, 2011). Therefore, assessing the farmers' level of risk perception and adaptation strategy is critical and necessary in the county like Ethiopia where the vulnerability to climate variability is high.

2.5. Climate Change Effects on Livestock Sector of Ethiopia

Agriculture remains the backbone of most African economies (Hussein *et al*., 2008), and the sector is the largest domestic producer across the continent and employs between 70-90% of the total labour force (FAO, 2007). Agricultural sector also supplies up to 50% of household food requirements and up to 50% of household incomes. Livestock sector as a component of agriculture, it has own shares in the economy of smallholders. Livestock is a key asset for rural poor people in fulfilling multiple economic, social and risk management functions. Most of the income is generated by beef cattle, dairy cattle, goats, sheep and chickens. The 92% of total revenue from livestock in Africa is generated from those major livestocks. In Ethiopia, entire population of rural areas involved in activities related to animal husbandry in one or other way. Livestock contributed 35-49% of agricultural GDP (Sintayehu *et al*., 2008). Country has more than 50 million of livestock, which is the largest in Africa and eighth largest globally and plays pivotal role in the provision of varies functions. Livestock provided draft power, household livelihood/ food security, income generation, transportation, fuel, fertilizer, and social function. Livestock and livestock products are an important source of foreign exchange. Mixed crop-livestock farmers comprise more than 80% of the rural population and supply most of the country's food. The production of commercial livestock products: meat and milk, skins and hides, and poultry have increased by more than 50% (ILRI, 2016). Therefore, for rural communities, losing livestock assets could trigger a collapse into chronic poverty and have a long lasting effect on their livelihoods. Though livestock is the asset of many rural poor communities, it is highly vulnerable to climate variability and extremes (Easterling *et al*., 2007; FAO, 2007; Thornton *et al*., 2007; IFAD, 2010). The impact of climate change is expected to heighten the vulnerability of livestock systems and reinforce existing factors that are affecting livestock production systems (Gill & Smith, 2008). In case of Ethiopia increasing temperatures and changing rainfall patterns (***i.e.*** variability) is main effects of climate change and variability, which could translate into the increased spread of existing vector-borne diseases accompanied by the emergence and circulation of new diseases. Climate change could also generate new transmission diseases in some area. Death of domestic animals due to climate change resulted in farmer's wealth and livelihood reduction (Pettengell, 2010). More than 95% of Ethiopian population thrives under extensive livestock management systems. Major feed sources for livestock are crop by-products (***i.e.*** crop residues) under mixed crop-livestock production systems in the highlands and pasture under lowland pastoral livestock production systems. There has been frequent drought and a decrease in annual rainfall over the last few decades, which diminished the biomass yield of pasture and crop residues (Gray and Muller, 2011). Pasture and crop-residue quality have deteriorated due to climate change and total availability of feed and fodder resources are constantly scarce.

2.6. Risk perception and vulnerability of farmers to climate change and variability

Climate change and variability resulted in droughts, increased temperatures, and erratic and unpredictable rainfalls and drying rivers, incidences of crop and livestock losses. Farmers constantly stressed declining agricultural production due to unpredictable, sometimes incessant rains on the one hand, as well as low rainfall, coupled with high temperatures on the other hand, and the occurrence of extreme climatic events including hailstorms, frost and persistent droughts. Farmers perceive that the current climate condition is bad and leads to reduction in livestock as well crop production. Sarah *et al.*, (2012) reported that local perception to current climate is bad as decreased rainfall, high seasonal variation, and increased temperature, high frequency of drought and high incidence of animal diseases. Droughts are identified as a potential risk and source of losses in agricultural production (Herrero *et al*., 2010);

an increase in the frequency of drought leads to decreased agricultural production. Farmers can losses all their livestock due to single drought and are likely to fall in to poverty (Barbier *et al*., 2009). Climate change and variability increases farmers' vulnerability as they lose their livestocks and crops; which are natural assets of them up on which their livelihood relayed. According to Cutter (2001), vulnerability is likelihood that an individual or group will be exposed to and adversely affected by circumstances. Vulnerability by Vogel (1998) is the characteristics of individuals or groups in terms of their capacity to anticipate, cope with, resist and recover from the impacts of environmental change. All the above definitions are almost same with IPCC (2007) definition: is the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability of human population to climate change; which leads to environmental change by drought and flood and the change of environmental and social policy results in series impacts. Impacts of the changes are felt unequally throughout a community or region (Galvin *et al.*, 2001). The severity of impacts experienced will depend on which resources are available to a given group or individual. Although various communities may face similar risks, they may not be equally vulnerable. According to Few *et al.,* (2015), the most vulnerable group of people to climate change and vulnerability are women, children/youngster, pastoralists and smallholders/poor farmers. Disabled people, elders, children and the rural and urban poor are especially highly vulnerable to the impacts of climate change and variability (NMA, 2007; Amsalu and Adem, 2009), since these groups often have lower adaptive capacities and limited access to resources for adaptation practices. These all categories are interconnected in terms of their characteristics and vulnerability experiences that intersect them. Rovin *et al.,* (2013) identified, increased vulnerability to water and crop shortages in both rural and urban Ethiopia according to age and gender. Such kind scenario was not reported in livestock sector in mixed production system of southern Ethiopia special in Boricha district.

2.7. Adaptation strategies and capacity of farmers to respond to climate risk

2.7.1. Indigenous strategies to adapt climate change and variability

The livelihoods of tropical and sub-tropical people are dependent on livestock and therefore, climate change adaptation must be practiced (Thornton *et al.*, 2013). Climate change will affect about 1.3 billion poor people whose livelihoods are fully or partially dependent on livestock for household food security. On the other hand, livestock production is a major contributor to greenhouse gas emissions. According to Gerber *et al*., (2013), livestock sector, particularly ruminants, contributes approximately 14.5% of total anthropogenic greenhouse gases (GHG) emissions at global level. Therefore, livestock keepers will have to adapt to climate change and variability.

The adaptations are necessary and required for significant changes in production technology and livestock production systems, which could affect productivity, incomes and livelihoods of smallholders. Improving manure management through compost preparation is one of traditional adaptation practice of smallholder farmers to climate change. By 2010 livestock greenhouse gas (GHG) emission in Ethiopia was estimated at 65 Mt CO2e through methane emission from digestion process and nitrous oxide from excretion (EPA, 2011). It accounts for more than 40% of the total emission of the Ethiopia. The integration of crops and animals allows efficient feed and manure use and avoids manure oversupply, reducing CO_2, N_2O and CH_4 emissions from over-fertilization, storage and manure dumping. Improved manure management including distribution systems, such as slurry injections into soils, covering manure and slurry storage sites reduces CH_4 emissions (Sara and Sajal, 2009). In addition, CH_4 can be captured and used as biogas, where the 14,000 biogas projects in Ethiopia started by effective composting process (NBPE, 2008). This project helped famers producing 20-30 tons of quality compost per family every year. In aerobic composting, assuring sufficient aeration will avoid CH_4 and N_2O emissions. Partial microbial digestion of farmyard manures (composting); promotes its potential to be converted into securer forms of soil carbon (IFOAM, 2009). Moreover, the application of compost has improved the production of crops, vegetables and protects biodiversity. It increases food availability for a growing human population (IFOAM, 2009). Livestock mobility and diversification, feed purchase, shade preparation/dry period, rearing heat/drought tolerant animals and animal restocking are another strategies practiced by smallholder to adapt climate change (Wassie and Fekadu, 2014; Kima *et al.*, 2015). Animal mobility is temporary and important during dry season to have water to their animals. By re-stocking their flock smallholder farmers can minimize the risk of climate change stress to their animals. Climate variables are found to be the major determinant for the choice of the primary livestock species among farmers, diversification and mobility. Hence, changes in climate likely drive selection of animal species that are best adapt or cope up under the changed conditions and thus alter livestock species composition at the household level is essential. Megersa (2013) reported livestock species diversification as traditional adaptation strategies to climate change by smallholder farmers. Cattle are apparently the most vulnerable livestock species to the adverse effects of climate change scenarios (Seo *et al*., 2010), and decrease in abundance along a drier and warmer climate gradients (Zhang *et al*., 2013). Shifting from cattle to small ruminants in Africa (Seo *et al.*, 2009) has been linked to adaptation of livestock production to changing environmental conditions. Diversifying livestock species that can browse and graze together more drought-tolerant seems to be a primary adaptation strategy to changing climate (Megersa, 2013). Differences in livestock species in terms of feeding behavior and tolerance to water and feed shortages enable herders to utilize more diverse ecological niches and serve as a buffer against climate related risks in addition to economic benefits (Morton, 2007; Doti, 2010).

2.7.2. Adaptation capacity of farmers to the risk of climate change and variability

Adaptation to climate change is very much influenced by adaptive capacity, which is defined as "the potential or ability of a system, region, or community to adapt to the effects or impacts of climate change" (Smith and Pilifosova, 2003). Adaptive capacity is based on access to diverse resources such as technology, knowledge, skills, stability and infrastructure; and stability and management capability (IPCC, 2011; Bohle *et al*., 1994). As related to community, adaptive capacity is determined by the socio-economic characteristics of the communities and their capability in responding effectively. The capacity to adapt to climate change varies across regions, countries, wealth and age groups, awareness and will differ over time. The most vulnerable regions and communities are those that are highly made vulnerable to the changes anticipated in the climate and have limited adaptive capacity. Countries with low economic resources, poor levels of technology, weak information and skills, poor infrastructure, unstable or weak institutions, and weak empowerment and limited access to resources have little capacity to adapt and are highly vulnerable (Below *et al.*, 2010; IPCC, 2001). Below *et al*. (2010) and IPPC (2001) identified that adaptation depends significantly on the adaptive capacity of an affected system, region or community to be able to cope effectively with the impacts and risks of climate change. Hameso (2015) identified that; gender, age and education are indicators of the degree of vulnerability to climate variability and/or change in southern Ethiopia, Sidama Zone. The poor, marginalised, female-headed households, people with low or no literacy, and low technological capability as well as children and old people were most vulnerable. Families with female-headed households are more vulnerable due to lack of productive labour, even when they had land and livestock. Poor farmers appear to be most vulnerable for having low asset and resource base. CARE (2011) encouraged for giving vulnerable people a voice in decision-making will ensure that adaptation initiatives are responsive to their needs, priorities and aspirations. By practicing the activities listed in this paper and in another articles/Books/ Journals, local adaptation mechanisms/plans should be practiced to make vulnerable groups more active in capacity building. The high vulnerability of people in developing countries particularly in Africa to climate variability and/or change is ascribed largely to their low adaptive capacity, which results from deteriorating ecological resources, unequal land distribution, extensive poverty and high reliance on the natural resource base. Developing countries are generally considered most vulnerable to the effects of climate change than more developed countries, largely because of their limited capacity to adapt to climate change (Thomas and Twyman, 2005). Improving adaptive capacity is therefore important in order to reduce vulnerability to climate change (Elasha *et al*., 2010).

2.8. Determinants of farmers' choice of adaptation strategies to climate change

Climate change and variability is more sever and death in developing countries due to high vulnerability and least capacity to adapt the changes (IPCC, 2001; UNFCCC, 2007). This is particularly true in the continent of Africa in which high vulnerability to the impacts of climate change and variability is exacerbated by widespread poverty, recurrent droughts and floods, dependence on natural resources and biodiversity, over dependence on rain fed agriculture and conflicts that have engulfed the continent (Nyong *et al.*, 2007). This is particularly true in Ethiopia, where more than 85 % of its population is dependent on rain-fed agriculture. Ethiopia experienced the warmest days that showed an increment in temperature in recent years, particularly by 0.37 % in every ten years (Marye, 2011). This unexpected increment in temperature and high variation in rainfall resulted in yield reduction in agriculture; sometimes complete loss of crops and death of livestock. In order to minimize the effects of climate variability on lives, livestocks and livelihoods, there have been pursuing various indigenous adaptation options. However, the choice of particular adaptation measures may be positively or negatively affected by specific variables like household head's education, access to extension and credit services, climate information, agro-ecology, household income, livestock holding, farming experience, household head age, family size, perception to climate variability, and gender of the household head (Deressa *et al.,* 2009; Gutu *et al.,* 2012; Badge *et al.,* 2013; Yibekal *et al.,* 2013; Belay, 2014; Menberu and Yohannes 2014; Misganaw *et al.,* 2014). Multinomial Logistic model (MNL) is one of tools to analyze the determinants of farmer's choice of adaptation strategies. MNL model is widely used in adoption decision studies involving multiple choices and is easier to compute. The advantage of using a MNL model is its computational simplicity in calculating the choice probabilities that are expressible in analytical form (Tse, 1987). The existing adaptation measures practiced by the farmers' and the determinant factors that affects farmers' choice of adaptation in Boricha District is limited. Understanding the factors associated with adaptation would help policy makers for future intervention to address the challenges of sustainable development to climate variability. Thus, the one of the purpose of this study was to identify the determinant factors that affect farmers' choice of adaptation in southern Ethiopia in generally and in Boricha District specifically.

3. MATERIALS AND METHODS

3.1. Description of study Area

The study was conducted in Boricha District at 33km southeast of Hawassa, regional capital. The district is bordered by Loka abaya, Shabadino, Dale, Hawassa Zuria district and Tula sub-city of Sidama zone and Hawassa city and Duguna Fango and Fango district and Dimtu city of Wolyita Zone administration. The district has 39 rural and 5 urban Kebles with total population of 324,996 of which 312,301 found in rural area and 12,695 found in urban area (Southern region people projection report, 2010). Geographical location of the district is 6^o 46' to 7^o 01'N of longitude and 38^o 04' to 38^o 24' E of latitude. It extends from the lowest point at southwest of Bilate River with an altitude of 1320 m.a.s.l. to northeast 2080 m.a.s.l. The 78% of district was dry-woynadega and 22% was dry-kola with annual rainfall between 900-1400 mm while temperature ranges between 15-29 ^{o}c. The 90 % of people live in the district are dependent on crop and livestock farming and remaining 10 % are on trade and other off-farm activities. Total livestock population of the district is about 355,442 (BDAFOF, 2017) of which 138,218 are cattle, 43,597 are sheep and goats, 10,504 are equines and 140,989 are local chicken breed and 22, 134 are hybrid chicken. The estimated area of the district was 588.05 k.m^2 with the following main land use system. Rainfall and temperature variability's are the most important climate change characteristics of the district. Yirba is the administrative center for the district. Farming practices of the area depends on rain-fed agriculture with crop-livestock mixed farming system. In mixed farming system animal husbandry and crop production complements to each other. The major livestock species are cattle, sheep, goat and poultry whereas the major crops by area coverage are maize, haricot bean, coffee, horticulture crops and tef (CSA, 2007). Two cropping seasons are practiced in the area with light rain season (*Belg*) from March to May and the heavy rain season (*Meher*) from June to September. Heavy rains are mainly use for land preparation and planting long cycle crops like maize whereas light rains use for planting haricot bean, potato and others. The sources of feed for the livestock include crop residues and aftermaths, residues left after harvesting main crops. Some farmers cultivate improved forages like elephant grass (*Pennisetum purpureum*), susbania (*Susbania grandiflora*) and Leuceana (*Leucopenia leucocephala*) and legumes species like cowpea (*Vigna unguiculata*), pigeon pea (*Cajanus Cajan*) and others.

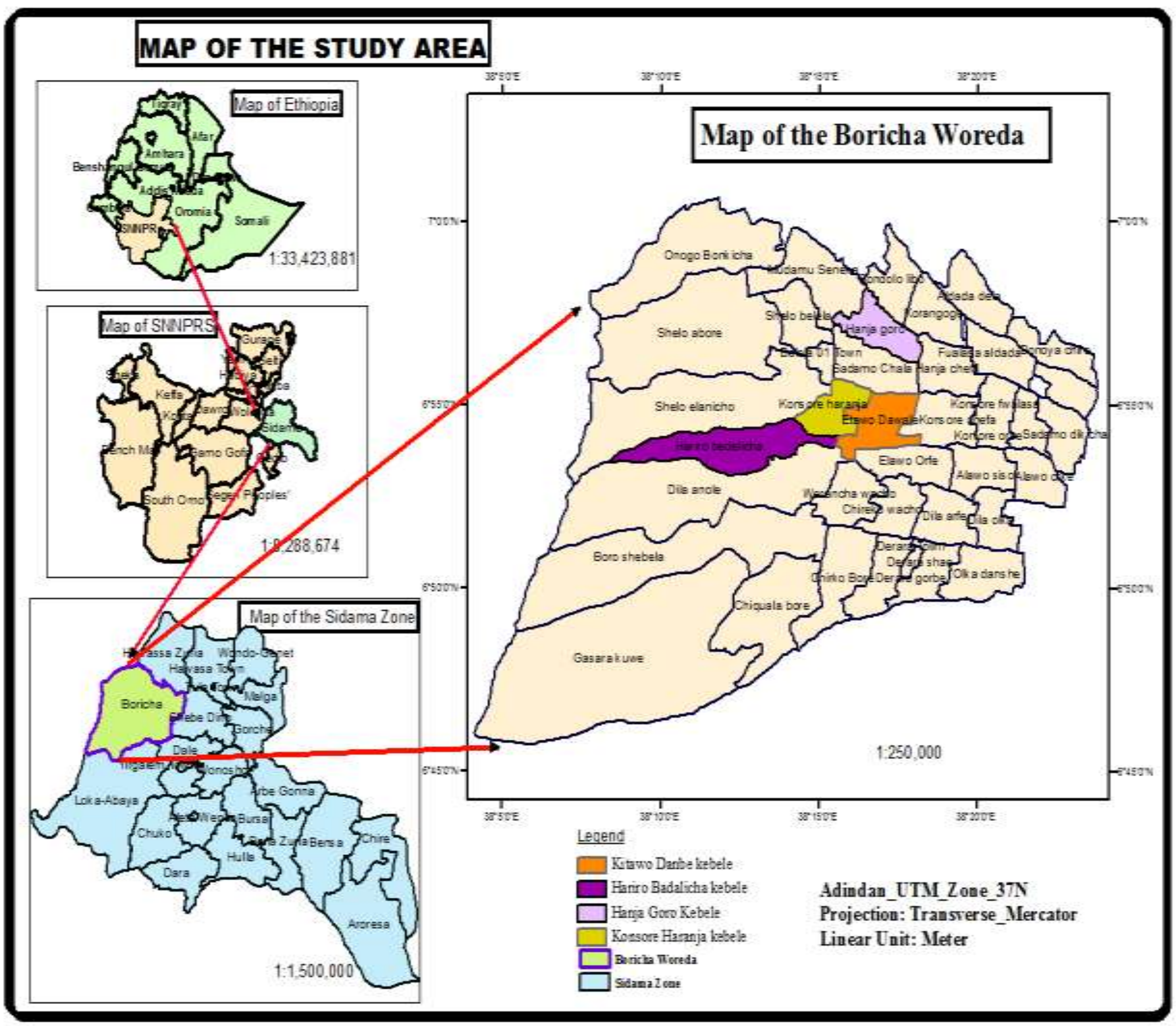

Figure 1: **Map of the study area**

3.2. Land use system of the study area

Of the total, most of lands covered by annual (59.7%) and perianal crops (17.5%) (**Figure 2**). Land used by cooperatives, privates, lands which will be productive in future time, etc. were covered in other land categories (8.0%) (**Figure 2**). Grazing land in the study area had small shares and showing declining trends due to expansion of crop production. This implies that there was high pressure on grazing land in converting in to cropland to feed increasing family members.

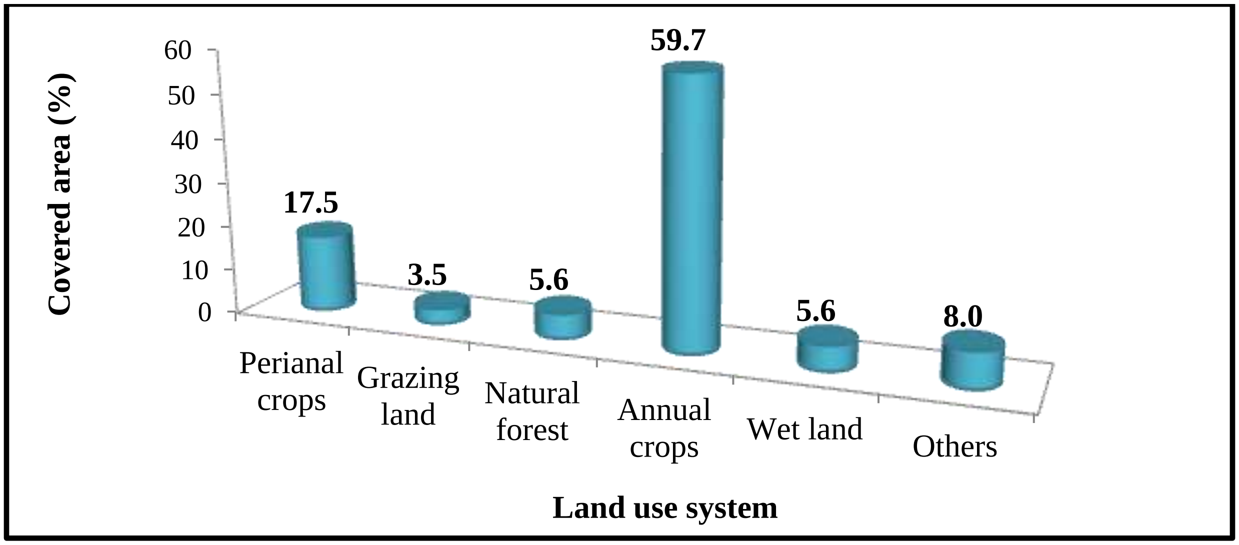

Figure 2: Main land use system and area coved (Ha) by system in the study area

3.3. Sampling procedure and sample size

Purposive multi-stage sampling procedure was used to choose sample *Kebeles*, which are most likely exposed to climate changes and environmental stresses and accessibility of the area for data collection. Four (4) *Kebeles* were selected from the Woreda based on the exposure to climate changes in the past 10 years. Sample size of household can be determined by using the formula of Yamane (1967) at 95% of CI with 5% of degree of variability and 8% (0.08) level of precision (**Table 1**). $n = \frac{N}{1 + N(e)2}$, Yamane (1967), Where **n** is the sample size, **N** is the population size (total household head size), **e** is level of precision, $n = \frac{3060}{1+3060(0.08)^2} = 146$

Table 1: Total households and number of sampled households from four selected Kebeles

Name of selected Kebeles	Total households	No of sample households
Konsore Haranja	720	35
Kitawo Danbe	902	43
Haraira badalicha	746	36
Hanja Goro	692	32
Total	**N = 3060**	**n = 146**

The selection of individuals for interview were targeted on number of livestock owned, experiences in coping up of climate hazards, etc. For this, all the households with at least two heads of livestock were list out from total households of each Kebeles. Systematic random sampling technique was applied for the selection of households for interview from the list. Four focus group discussion (FGD); one from each Keble with 12 members was organized to crosscheck information obtained from household questioner. Groups were composed of Keble's leader, elders who had special knowledge about the area, developmental agents (Das), spiritual and traditional organizations leader and school directors. Key informants with special knowledge about the area due to long years living in that area were selected for interview. Those individuals were selected by DAs and Kebles leaders with researcher's supervision.

3.4. Demographic and socio-economic characteristics of respondents

Sex, marital status and education level of the respondents were presented in **Table 2**. Of total 89.7% of respondents were male headed and the remaining (10.3%) were female headed. Most of respondents (98.6%) participated in the study were married and they were able to read and write (94.5%). The implication is that they can record every aspect of their life with regard to the effects of climate change. Education by itself could have positive impacts in climate change adaptation strategies; as educated farmers can decide to take measure on changing climate than that of uneducated farmers.

Table 2: Sex, marriage status and education level of the respondents in the study area (**N= 146)**

Variables		Frequency	Percent (%)
Sex of the HH			
	Male	131	89.7
	Female	15	10.3
Marital status of the HH			
	Married	144	98.6
	Widowed	1	0.7
	Divorced	1	0.7
Education level of the HH			
	Unable to read and write	8	5.5
	Primary school	131	89.7
	Secondary school	2	1.4
	College diploma	5	3.4

HH = Households, % = Percent

Demographic characteristics of respondents were presented in **Table 3**. These characteristics had its own role on climate adaptation option though the role could be positive or negative. The study report showed that average age of sampled households was 46.0 years with average land size of 2.4 hectares. The sampled respondents were also had the average of 5.8 family size with long years (24.6 years) of farm experience which can influence adaptation strategies of farmers. The study also identified that the average livestock holding of respondent were 5.5TLU with 7656.7 ETB of farm incomes; which can vary among individual farmers. Farmers who had high income, large farm size and livestock holding with high farm experience might easily adapt the effects of climate change; as their capacity of adaptation is higher, ***i.e.*** level of vulnerability to climate variability is low. On other hand, age and family size of respondents might have positive or negative effects on adaptation to climate change of farmers; since older and farmers with high family size might fear to take measure of adaptation. This might be due to low level of adaptive capacity of farmers. Average family size reported in this case (5.8) was higher than that of national average (4.6) reported by (CSA, 2016).

Table 3: Demographic characteristics of respondents in the study area (**N= 146**)

Demographics of respondents	N	Mean±SE
Age of respondents	146	46.0±10.0
Family size of respondents	146	5.8±1.9
Farm experience of respondents (Years)	146	24.6±8.1
Farm size (ha) of respondents	146	2.4±1.5
Farm income(Birr) of respondents	146	7656.7±4170.8
Livestock holding size (TLU)	146	5.5

N = Number of respondents, **SD** = Standard deviation of mean, **TLU** = Tropical Livestock Unit

Livestocks were major income sources of small holders next to crops in crop-livestock production system. Mean livestock holding per household in the study area were presented below in **Table 4.** Cattle, goat, poultry, sheep and mules with tropical livestock unity (TLU) of 5.5 were livestocks species kept by smallholder farmers in the study area. Among them cattle, goat and poultry were the major livestock reared in the study area. Generally, livestock population shows declining trends from time to time though variation among individual farmers were observed. This was because of the effects of climate variability, which had direct relationship with livestock population. Decline in livestock population directly correlated with decline in rainfall amount (**Figure 12**), which resulted in decline in livestock feed availability and quality. Higher livestock holding (5.6 TLU) than the current result (5.5 TLU) was reported by Gashaw *et al.*, (2017) in Chire district, Sidama Zone. Lower number of TLU in the study area may be due to the decline in availability and deterioration of quality of the feed with variation of rainfall. Variation in rainfall may be in terms of time, frequency, amount and distribution and this may resulted in increase in lignification of available livestock feed resources. Samuel (2018) in Loka-abaya district of Sidama Zone reported lower than the current figure.

Table 4: Average heads of livestock holdings per household in the study area

Livestock types	Mean+SD
Cattle	6.8±2.3
Sheep	0.95±0.6
Goat	8.4±2.2
Poultry	5.6±2.2
Mules	0.7±0.8

3.5. Study data types

Both qualitative and quantitative data were used for this study. Analysis were aimed on peoples' perceptions, vulnerability and adaptation strategies using empirical and socio-economic data to establish effects of climate change on livestock population and forage production dynamics in study area using primary and secondary data and information.

3.6. Data sources and collection mechanisms

3.6.1. Primary data sources

Primary data were collected from farmers through house-to-house interview on climate perception, vulnerability and adaptation strategies. Total 146 households based on the exposure to climate change stress and vulnerability with at least two of livestock were selected from four *Kebeles* with the help of experts of Animal and Fishery Resource Office. The respondents were categorized by the age, sex, education level, wealth status (income), farm experience, etc. The reason for this category was that there was a variation among households in the level of averting risk due to climate variation and the adaptation capacity and vulnerability of households to climate change. Other than individual interview carried out using pre-tested household questionaries, about 4 focus group discussions were conducted using checklists. Key informants who had special knowledge about the area were also participated in the study. The selection of those households participated in groups and key informants were done with the help of experts from Woreda office of livestock, and they were experienced/model farmers or elders in the study areas.

3.6.2. Secondary data sources

Secondary data sources include long-term climate and livestock population data. Climate data include rainfall and temperature whereas livestock population data include total livestock population (cattle, goat, sheep, poultry and mules), productive animals' number (to investigate why these numbers increased or decreased). Climate data were obtained from Ethiopian national meteorology agency (NMA) whereas livestock data were collected from Boricha District and Sidama Zone finance and economic development office (SZFEDO). For this study, 36 years rainfall and temperature data and 10 years livestock population data under traditional production system were used. There could be variation in annual rainfall and from year to year; assessed by coefficient of variation system (CV). The coefficient of variation (CV) were assessed by the following formula: $= \frac{\textbf{SD of annual RF}}{\textbf{Mean of anual RF}}$ **,** Where **SD** = Standard deviation, **RF** = Rainfall. By using the same formula, it is possible to compute CV of Belg and Kiremt rainfall of the area. Standard precipitation index (SPI) is calculated to assess the rainfall anomalies in the study area for about 36 years. The SPI values were used (McKee *et al.,* 1993) to define the drought intensities and to set criteria for a drought event for any timescale. A drought event occurs at any time when the SPI is continuously negative and reaches an intensity of -1.0 or less. SPI is the number of standard deviations that observed cumulative precipitation deviates from the climatological average (total average rainfall) (McKee, 1993). The standard precipitation index (SPI) values and its corresponding moisture level were presented in **Table 5** below.

Table 5: Standard precipitation index (SPI) values and corresponding moisture level

SPI values	Moisture Level
2.0 and above	Extremely wet
1.5 to 1.99	Very wet
1.0 to 1.49	Moderately wet
-0.99 to 0.99	Near normal
-1.0 to -1.49	Moderate drought
-2 and less	Extremely drought

Trends in livestock population and feed resources of District had assessed. The number of livestock population converted to Tropical Livestock Unit (TLU) to aggregate the populations for different types of species (cattle, goats and sheep, poultry and mules) under mixed production system.

3.7. Statistical methods of data analysis

The Statistical Package for Social Sciences (SPSS) version 16.0 and Excel 2010 were used to summarize the data. Descriptive statistics were used to determine mean annual rainfall and temperature as well as for coefficient of variation (CV) for 36 years. Regression and correlation were calculated to determine the relationship between mean annual rainfall, temperature and livestock populations or feed sources changes. The coefficient of determination (R^2) was calculated to measure the strength of relationship between rainfall variability and livestock population. Statistical package, STATA version 13 was used to analyses the effects of exploratory variables on farmers choose of adaptation strategies.

3.7.1. Empirical Model Specification: MNL model

Major factors determine choose of adaptation strategies to climate change and variability were analyzed by using Multinomial Logit Models (MNL). Many researchers (Nhemachena and Hassan, 2008; Temesgen *et al.,* 2009; Deressa *et al*., 2009) used MNL model to analyses climate change adaptation strategies of smallholder farmers. Therefore, the multinomial logit model (MNL) is appropriate to model of climate change adaptation strategies of smallholder farmers in the study area. The choice of a given adaptation option is discrete because it is chosen among other alternative option. Let P_{ij} represent the probability of choice of any given adaptation option by small farm households, then equation representing this will be,

$$P_{ij} = \beta_{\circ} + \beta_1 X_1 + \cdots + \beta_k X_k + e \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..(1)$$

Where *i* takes values (1, 2, 3, 4, 5), each representing the choice of adaptation option (1= Temporal mobility of animals, 2= Livestock herd diversification, 3 = Feed and water storage, 4 = Livelihood shifting, 5= Keeping drought tolerant animals,

X_1 are factors affecting choice of an adaptation option, β are parameters to be estimated and e is randomized error. With j alternative choices, the probability of choosing adaptation option j is given by, $P(Y_i = j) = \frac{e_{zj}}{\sum_{k=0}^{j} e_{zk}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$

Where Z_j is a choice and Z_k is alternative choice that could be chosen (Greene, 2000). The model estimates are used to determine the probability of choice of an adaptation option given j factors that affect the choice X_i .

$$\ln(\frac{P_{ij}}{P_{ik}}) = \alpha + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_K X_K + e \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..(3)$$

P_{ij} and P_{ik} are probabilities that a farmer will choose a given adaptation option and alternative adaptation option, respectively. $\ln(\frac{P_{ij}}{P_{ik}})$ is a natural log of probability of choice j relative to probability choice k, α is a constant, β is a matrix of parameters that reflect the impact of changes in X on probability of choosing a given adaptation option , e is the error term that is independent and normally distributed with a mean zero. The marginal effects, measure the expected change in probability of a particular choice being made with respect to a unit change in explanatory variable (Greene, 2003).

$$\frac{\partial Pj}{\partial Xi} = P_{j(\beta j - \sum_{k=P_k \beta_j}^{J}) = Pj(\beta j - \beta)} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots.. (4)$$

The marginal effects measure the expected change in probability of a particular choice being made with respect to a unit change in an explanatory variable (Greene, 2003; Long, 1997). Before running the model, it is useful to look into account the problem of multicollinearity among the independent variables. Variance Inflation Factor (VIF) must be used to test the degree of multicollinearity among continuous and dummy variables.

The value of VIF for the different variables must be less than 10. To measure multicollinearity associated with variance inflation factor is defined as:

$$VIF\ (Xi) = (1 - \mathrm{Ri}^2)^{-1} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots.. (5)$$

Where Ri^2 is the multiple correlation coefficients between explanatory variables. The larger the value of Ri^2, the higher the value of VIF (Xi), causing multicollinearity in the variable (Xi). Therefore, in this study, only those variables, whose coefficients were statistically significant at less than or equal to 10% probability levels were discussed. Similarly, the contingency coefficients, which measure the association between dummy variables, were computed in order to check the degree of association among the dummy variables. The values of contingency coefficient ranges between 0 and 1, in which zero indicates no association between the variables and values close to 1 indicates a high degree of association and 0.75 were a cut-off point.

3.7.2. Dependent variables

The dependent variables were the main variables, which were used as adaptation options to climate change in mixed crop-livestock production system. They were temporary mobility of animals, livestock herd diversification, feed and water storing, livelihood shifting and keeping drought tolerant animals.

3.7.3. Independent variables

These variables indicate factors that affect the farmers' choice of adaptation strategies to climate change in crop-livestock production system. From the reports of different authors (Temesgen *et al.*, 2009; Abebe, 2007; Zelalem, 2014; Eyasu, 2017; Markos, 2017; Samuel, 2018) majority of them are focused on household characteristics, farm characteristics and institutional factors as factors that affecting farmer choice of adaptation options to climate change. For the current study, the following independent/exploratory variables were considered.

1. Sex (SEX): It is the femaleness or maleness of household head. It is dummy variable (0 for female and 1 for male): It was hypothesized that male-headed respondents are more adapt to climate change than female-headed.

2. Age of the household head (AGE): This is a continuous variable defined as the number of years of the respondents starting from the year of birth. Older people have relatively richer experiences of the social and physical environments as well as greater experience of farming activities (Haile *et al.,* 2005). Hence, it was hypothesized that age positively/negatively affects adaptation option to climate change and variability of the farm households.

3. Level of education of the household head (EDUC*):* This is the number of years spent by the heads of the household for acquiring education. As the level of education of the household head increased the farmers' proximity for new information and the probability of accepting new technology also increase. Hence, it was hypothesized that levels of education positively affect adaptation option to climate change and variability of the farm households.

4. Family size (FMSIZE): Family size is the total family member of the household. The existence of large number of children under age of 15 and old age of 60 and above in the family could affect adaptation option of the farm household. Hence, it was hypothesized that the family size are positively or negatively affects household adaptation options to climate change and variability.

5. Land holding (FMLSIZE): Farmland size is the total landholding of the farm household that uses for the farming activities. The farm households with holding large farm land are positively affect the use of adaptation option to climate change and the farm size measure in terms of hectare. Therefore, the variable is continuous and it's expected was a positive sign for the farmers adaptation options to climate change.

6. Livestock holding (TLU): Livestock ownership is the total livestock that farmers can own on the livelihood. Livestock is a vital instrument in the case of adaptation to climatic change and variability. This is because livestock is essential for farm household to use as for harvesting, transportation and for financial purpose by selling them. This implies that farmers with more numbers of livestock is the richer and can respond to the adverse effect of climate change through adaptation method. This is a continuous variable and expected a positive sign for the farmers who used adaptation options to climate change.

7. Farm income (FARMI): Farm income is an income return to the household from farming activities. This is a continuous variable and expected a positive sign for the farmer's adaptation options to climate change.

8. Farm Experience (FEX): According to study of Gbetibouo (2009), there is a positive relationship between experience in agriculture and the implementation of improved agricultural technologies. Hence, it was hypothesize that farm experience positively affects adaptation options of the respondents.

9. Access to Agricultural extension service (AGEXS): This is a formal service and plays a great role that affects for farmers' adaptation options to climate change. This variable is also a dummy, which represent 0 if farmers' get agricultural extension service 1 otherwise and the expecting sign was a positive.

10. Access to climate information (ACCI): Farmers get information about climate change from different sources (social media, his neighbors' and local govt.). Access to climate information (such as on set or off set of rainfall) helps the farmer to adjust their production system based on the climate information and affects the farmers' choice of adoption option to climate change. The variable is also a dummy, which represent 0 if farmers get information about climate change 1 if not and the expected sign was positive.

Table 6: Description of explanatory variables and its relationship with adaptation strategies

Variables	Nature of variables	Measurement	Expected r/ship
Sex of the respondents	Dummy	1= Male, 0 = Female	+/-ve
Age of the respondents	Continuous	Year	+/-ve
Education level	Discrete	Year	+ve
Family size	Continuous	Number	+/-ve
Land holding	Continuous	Hectare	+ve
Farm experience	Continuous	Year	+ve
Farm income	Continuous	Birr	+ve
Livestock holding	Continuous	TLU	+ve
Access to climate information	Dummy	0=Yes, 1=No	+ve
Access to extension service	Dummy	0=Yes, 1=No	+ve

4. RESULTS AND DISCUSSION

4.1. Trends of climate variables in the study area

4.1.1. Analysis of rainfall variability

Annual, Meher (summery) and Belg rainfall with its standard deviation (SD) and coefficient of variation (CV) in the study area were presented in **Table 7**. This shows that there was high coefficient of variation in rainfall between Kiremt and Belg season (**Table 7**). Farmers in the study area received high rain fall in Belg especially in March, April and May; known as short rain season. The Belg rains started at the gate of March and continue up to the end of May; which is less intensive than that of Kiremt rain. Farmers in the study area use Belg rain special for preparation of land and to plant annual crops like maize and sometimes to plant short time vegetable (Cabbage). Kiremt rain started at the beginning of June and end up to the August. Sometimes the Kiremt rain continues up to the half of September and another time it stops at the end of August; which helps farmers to plant short time plants like haricot bean.

Table 7: Coefficient of variation (CV) in rainfall in the study area (**1981-2017**)

Rail fall (mm)	Mean rain fall (mm)	Standard deviation (SD)	CV (%)
Annual	1008.9	242	24
Kiremt (Meher)	285.1	98.9	34.7
Belg	374.8	120.25	32.08

CV*= Coefficient of variation****, SD****= Standard deviation*

Source: National Meteorology Agency (2017)

Long years' rainfall data (1981-2017) in the study area shows that there was decreasing trend in rainfall with high variability (***Figure 3***). According to the result, the trend of annual rainfall decreased with 4.74 mm/year (***Figure 3***) with high coefficient of variation (CV) 24% (**Table 7**).

Generally, the area received most of the rainfall during the short rainy season (Belg) and main rainy season (Kiremt). Similar result identified by NMS (2001); Samuel, (2018) reported that the average annual rainfall of the country has shown very high variability over the past years.

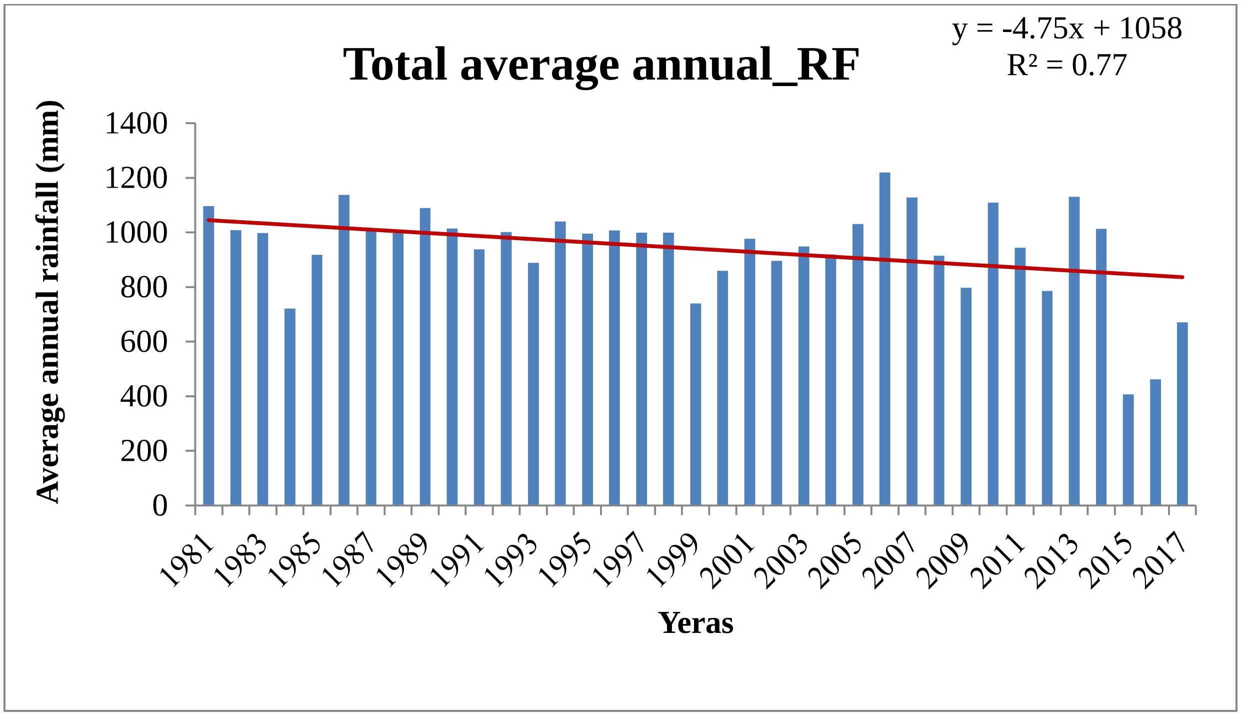

Figure 3: Trends in annual rain fall in the study area (1981-2017)

Source: National Meteorology Agency (2017)

The standardized anomaly of rainfall in the study area is presented in ***Figure 4.*** The results indicated that in last 36 years (1981-2017) most part of the year (20 years), the district received normal rainfall. Standard precipitation index (SPI) value above 2.0 shows that there were high rainfall and the moisture level of the area was extremely wet. SPI value near 1.0 indicated that the moisture level of the area showed near normal and the impact is not negative still. In addition to these in last 16 year, the area receives the rainfall below the normal value in the last 36 years. SPI value -2.0 and above showed that the moisture level of the area were very low and resulted in extremely drought. However, SPI value near to -1.0 is near to normal in moisture level still.

Both positive and negative anomalies (SPI) have significant impact on crop and livestock production in the study area. The positive anomalies might result in potential improvement in crop and livestock production, though extreme wetness might result in loss of crop production. Whereas, the negative one (SPI) could results in potential reduction in yields since our agriculture was rain dependent. Still SPI value near to -1.0 is normal and may not result in loss of potential yields.

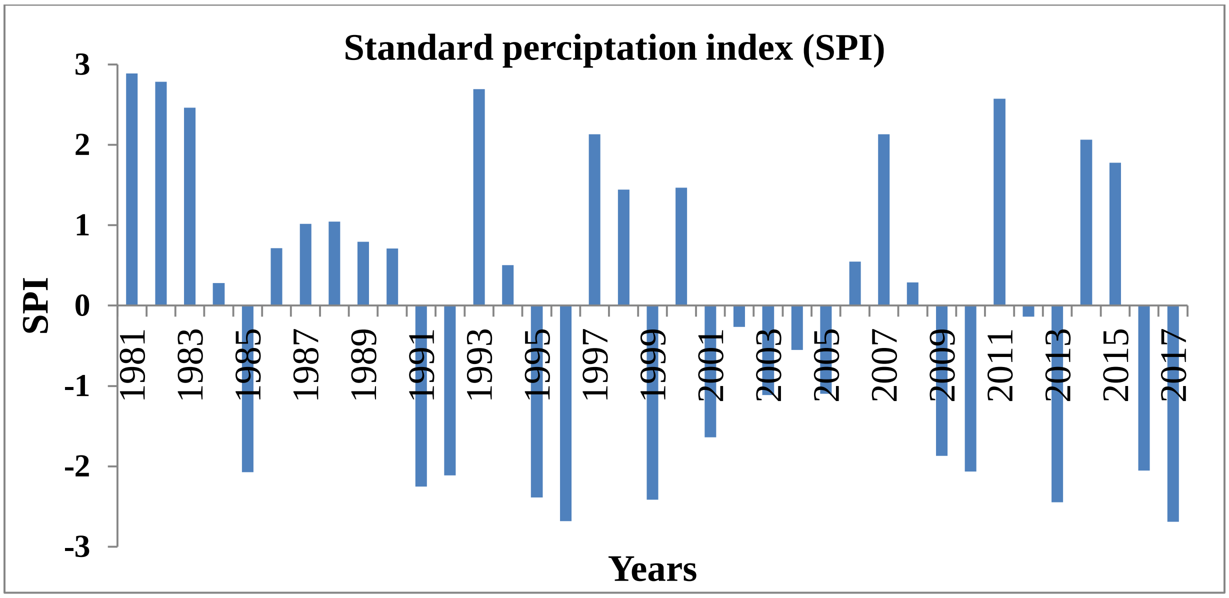

Figure 4: Standard precipitation index of total annual rainfall in the study area (1981-2017)

Source: National Meteorology Agency (2017)

There was high inter-annual variability in the amount of Belg and Kiremt rainfall in the study area. The result of 36 years rainfall analysis (1981-2017) in figure below shows that there were decreasing trends in Kiremt and Belg rainfall in the study area. Belg and Kiremt season rainfall has declined by 4.3 and 2.77 mm per year (**Fig. 5**) with CV of 32.08 and 34.7, respectively (**Table 7**) over the last four decades. The degree of variation in amount of rainfall was higher for Kiremt season (34.7) than that of Belg season (32.08). Similar results were identified by

Betelehm (2014); Samuel (2018); Derese (2018), which reported that there was high inter annual variability of rainfall with high variability in Kiremt season than of Belg.

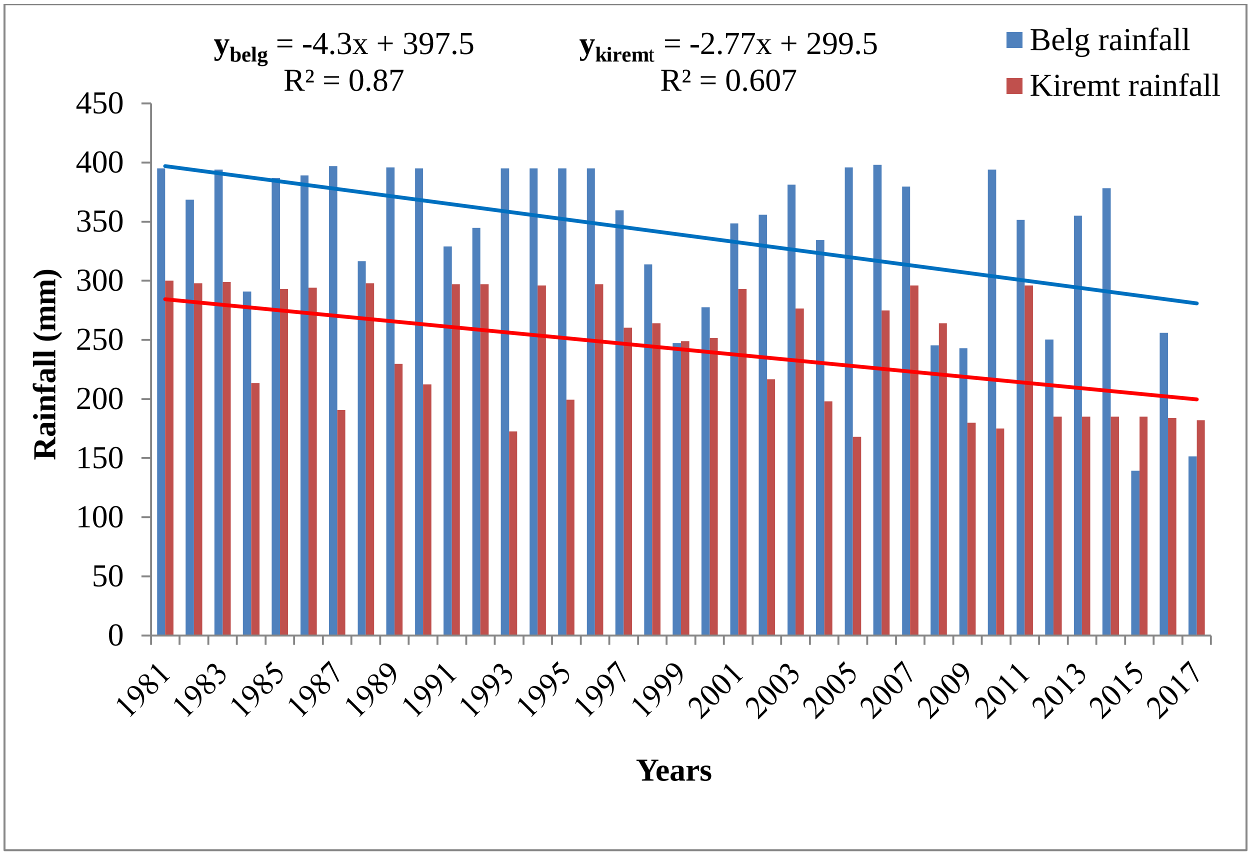

Figure 5: Trends of Kiremt and Belg rain fall in the study area (1981-2017)

Source: National Meteorology Agency (2017)

4.1.2. Analysis of temperature variability and its trends

There was high variability of temperature from time to time and both maximum and minimum temperatures showed increased trends in the study area. Similarly, increasing trends in mean annual temperature of Ethiopia was reported by UNDP (2008). As indicates in below (**Fig. 6**) the maximum annual temperature of the study area over last 36 years showed an increasing trend with 0.034 ^{o}c per year or 0.34°c per decade from the period 1981 to 2017, while average minimum temperature was increased 0.043 ^{o}c per years and 0.43 ^{o}c decade in the same years

(**Fig. 7**). Similarly, the previous studies by (NMA, 2001, 2007; Samuel, 2018) have reported that the average annual maximum and minimum temperature of the Ethiopia has increased by 0.1°C , 0.37°C and 0.32°C per decade.

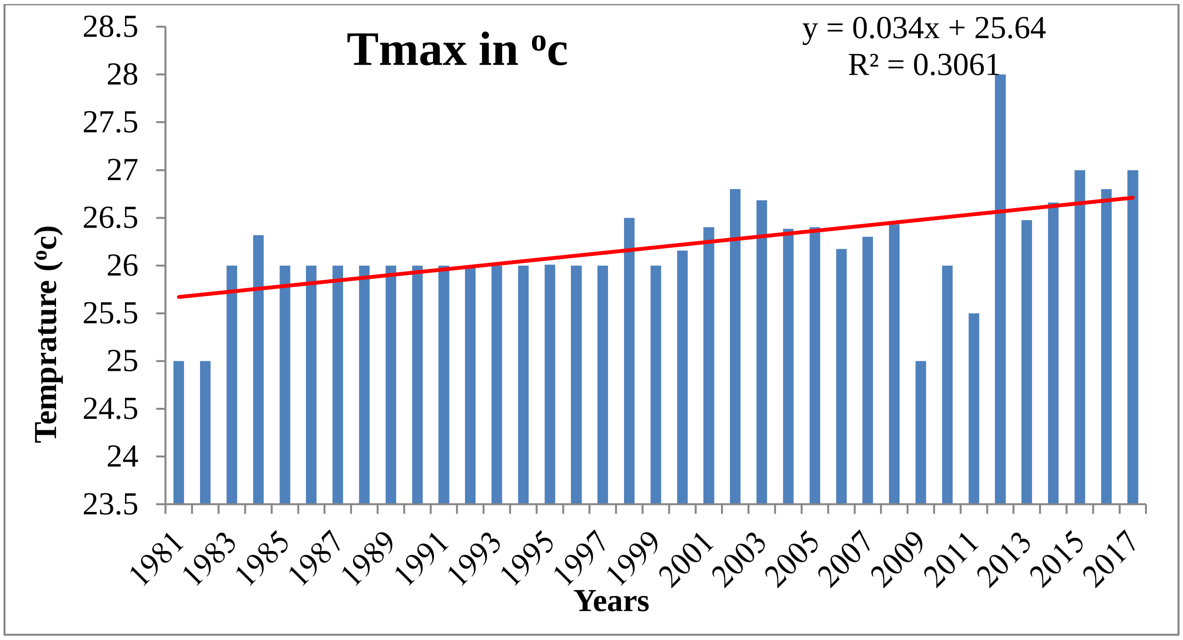

Figure 6: Trends in maximum annual temperature in the study area (1981-2017)

Source: Ethiopia Meteorology Agency (2017)

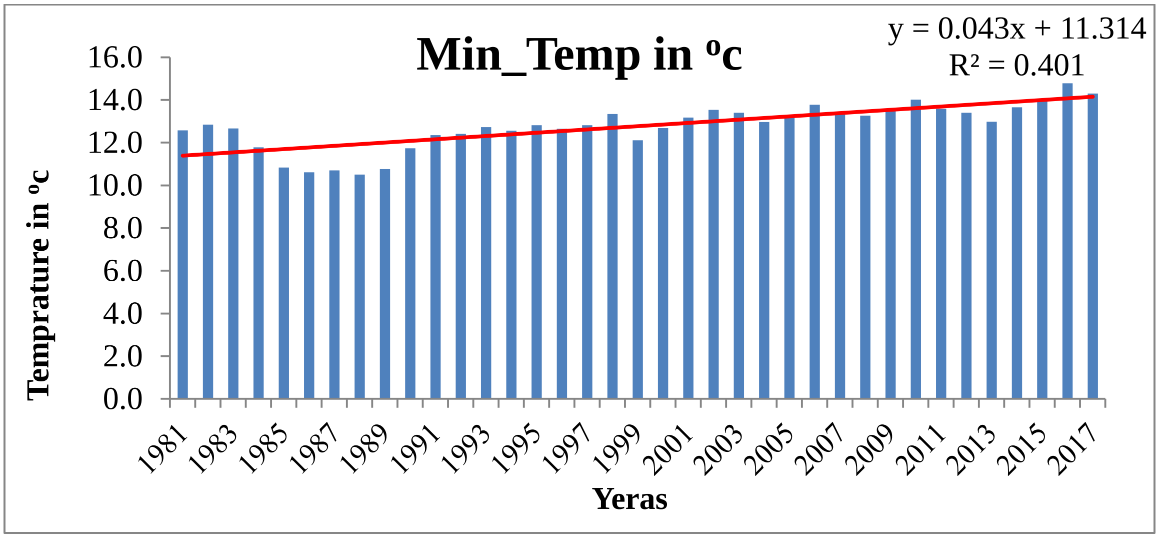

Figure 7: Trends in minimum annual temperature in the study area (1981-2017)

Source: Ethiopia Meteorology Agency (2017)

4.2. Farmers' Perception on Climate Change and Variability

About 88.4 % of respondents perceived, that the climate of their environment is extremely changed and the remaining 8.2 % perceived as a climate is slightly changed (***Figure 8)***. Few farmers (2.2 %) in the study area perceived nothing about climate change ***i.e.*** they do not have any idea about climate change. Fewer numbers of respondents (1.2%) perceived, there was no climate change in their locality. In lined with this, previous study by Sarah *et al.*, (2012) reported that local perception of farmers to current climate is bad as decreased rain fall, high seasonal variation, and increased temperature, high frequency of drought and high incidence of animal diseases, which resulted in high vulnerability of farmers unless successful adaptation measure is not applied. Similar result were also reported by Betelhem,(2014); Samuel, (2018) which identified general perception of farmers about change in their local climate, mainly in terms of increased temperature and decreased rainfalls in Dire-Dawa and Loka Abaya districts. According to the reports of FGD and key informant women's, poor farmers, and elders were most vulnerable to the effects of climate change and variability; which in lined with reported by Amsalu and Adem, (2009). The reason behind is that these groups of people were often have lower adaptive capacities and limited access to resources to practices in adaptation measures.

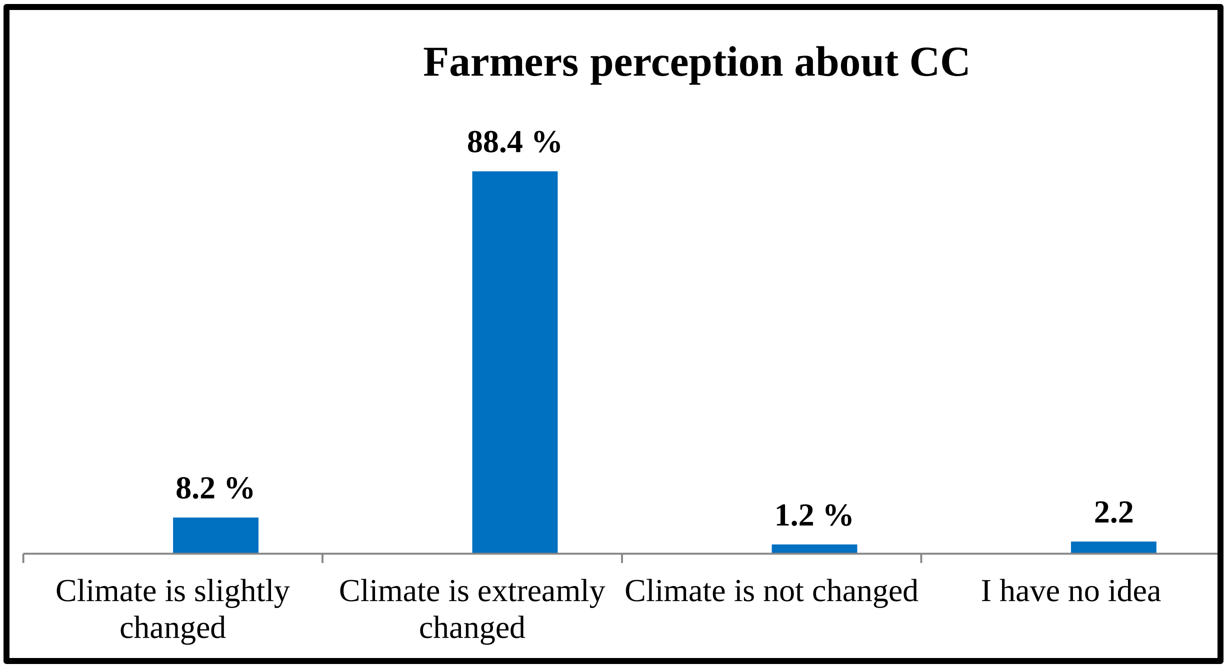

Figure 8: *Perception of farmers about climate change in their environment*

4.2.1. Perception of farmers on major causes of climate change

About 67.1 % of the respondents perceived that both human induced action and natural process was the major causes of climate change in the study area (***Figure 9)***. Few respondents (19.2 %) in the study area perceived that human action only was another causes of climate change. About 8.2 % of respondents perceived that natural process only was another causes of climate change. On other hand, 5.5 % of respondents perceived that climate change was God's punishment against the wrong action done by human being. In most of time, human activities like tree-cutting/deforestation would result in major causes of climate change in the study area. High population growth rate and increased population pressure on expansion of agricultural land also contributing to climate change of the area. In lined with current study, Debela *et al*., (2015); Samuel (2018) indicated that the cause of climate change were as a result of super natural forces, natural physical processes, deforestation and the impact of anthropogenic factors. FGD participants also reported that the expansion of agricultural land by cleaning existed forest due to high population growth is also acerbating the existing problems of climate change in the study area. The FGD participants revealed that there were forests and big trees in this area before few years ago, but changed to croplands now a day. The forestlands were abandoned and the natural trees were cut-off for the purpose of building houses and charcoal production.

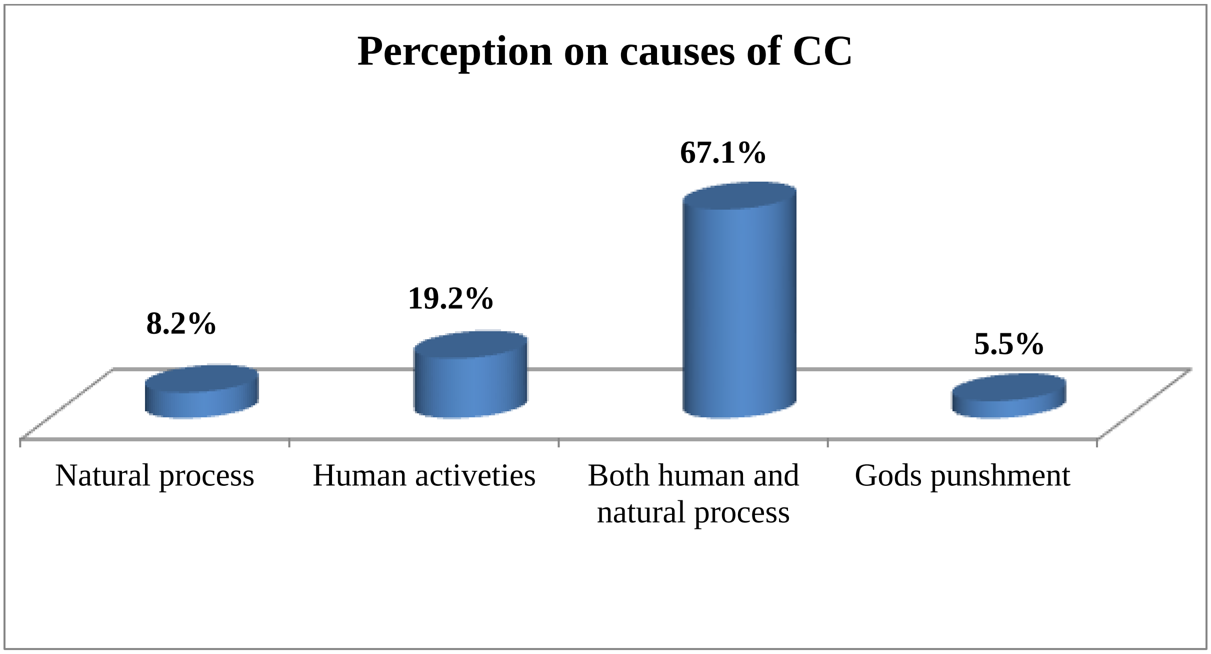

Figure 9: Perception of farmers on major causes of climate change (CC) in the study area

4.2.2. Trends and Consequences of Climate Change on Livestock performance

The farmers in the study area perceived that there were the influence of climate on tends of production and reproduction traits (**Table 8**). The result of report showed that climate had both direct and indirect effects on production and yield of livestock farms. Direct influences of climate change on livestock farm is heat stress by rising temperature and that also resulted in indirect influences like loss of the appetite, struggle for maintainace other than production and generally reduce the reproduction and production efficiency. Due to climate change, some traits like age at first calving (AFC), calving interval (CI), heat stresses and diseases occurrence showed increasing trends, which resulted in negative impacts on livestock productivities. Due to the influences of climate change; feed **(93.8%)** and, water availability (**92.5%)** is reduced and diseases occurrence is increased (**87%).** Decreasing trends were also observed on traits like milk off-take, feed intake and body weight of major livestock due to the effects of climate change. Previous study by Megersa (2013) reported the decline of productivity (milk yield) of livestock in southern Ethiopia of pastoral area of Borana due to the impact of climate change in lined with present results. Similarly, direct and indirect effects of climate change on livestock productivity were reported by Samuel (2018); Derese (2018) different agro-ecology of Sidama Zone, southern Ethiopia.

Table 8: Trends of climate change effect (direct or indirect) on livestock productivity in the study area (**N= 146**)

Variables	**Trends of climate change effects**		
	Increased (%)	**Decreased (%)**	**No change (%)**
Feed availability	2.1	93.8	4.1
Water availability	0	92.5	7.5
Diseases occurrence	87	6.8	6.2
Milk off take	5.5	87	7.5
Calving interval	93.8	0	6.2
Feed intake	4.8	89.7	5.5
Age at first calving	94.5	0	5.5
Heat stress of animals	95.9	0	4.1
Body weight of animals	4.8	91.8	3.4

N= *Number of respondent, % = Percentage*

During the assessment of perception of farmers about their local climate condition; about 88.4 % of respondents reported that climate is extremely changed. Local climate change indicators listed below **(Figure 10)** were the major one reported by respondent in the study area. According to the perception of farmers in the study area, decreased in rainfall amount and increased in environmental temperature were two main indicators of climate change. Reduction in livestock feed and water volumes were also another indicator as farmers' perception; which were resulted by climate change ***i.e.*** rainfall and temperature. Few farmers in the study area is perceived also that drought (6.2%) and occurrence of livestock diseases (7.5%) were increased; they were suffered by failure of crops, loss of livestock by the incidence of diseases and insufficient water for both human and livestock. Generally, climate change indicators listed above can be categorized as direct indicators; rise in environmental temperature and decrease in rainfall amount and indirect indicators; decreases in water resources and livestock feed, livestock diseases and drought occurrences.

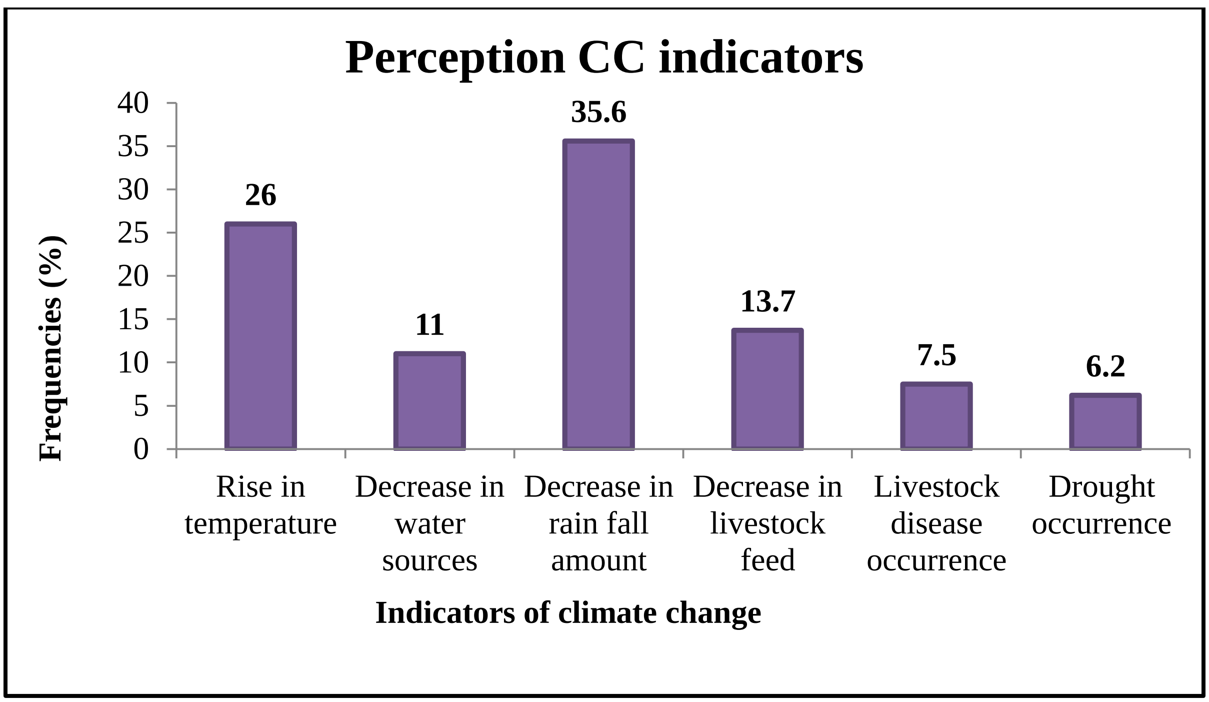

Figure 10: Perception of farmers on indicators of climate change in Boricha District

The consequences of climate change on livestock production in the study area were presented in ***Figure 11***. The result of report showed that shortage of livestock feed; drying of water bodies and livestock death due to the occurrence of livestock diseases were major consequences of the climate change on livestock production in the study area. The problems related with climate variability also resulted in reduction of growth (birth weight, weaning weight, maturity weight etc.) and reproduction (age at first calving, calving interval, age at maturity etc.) performance ***i.e.*** efficiencies of livestock. Increased age of maturity and decreased expected outcomes from each animal were also another consequence. Drying of water body was also another consequence of climate change as it resulted in pressing problems of livestock feed and drinking water availability.

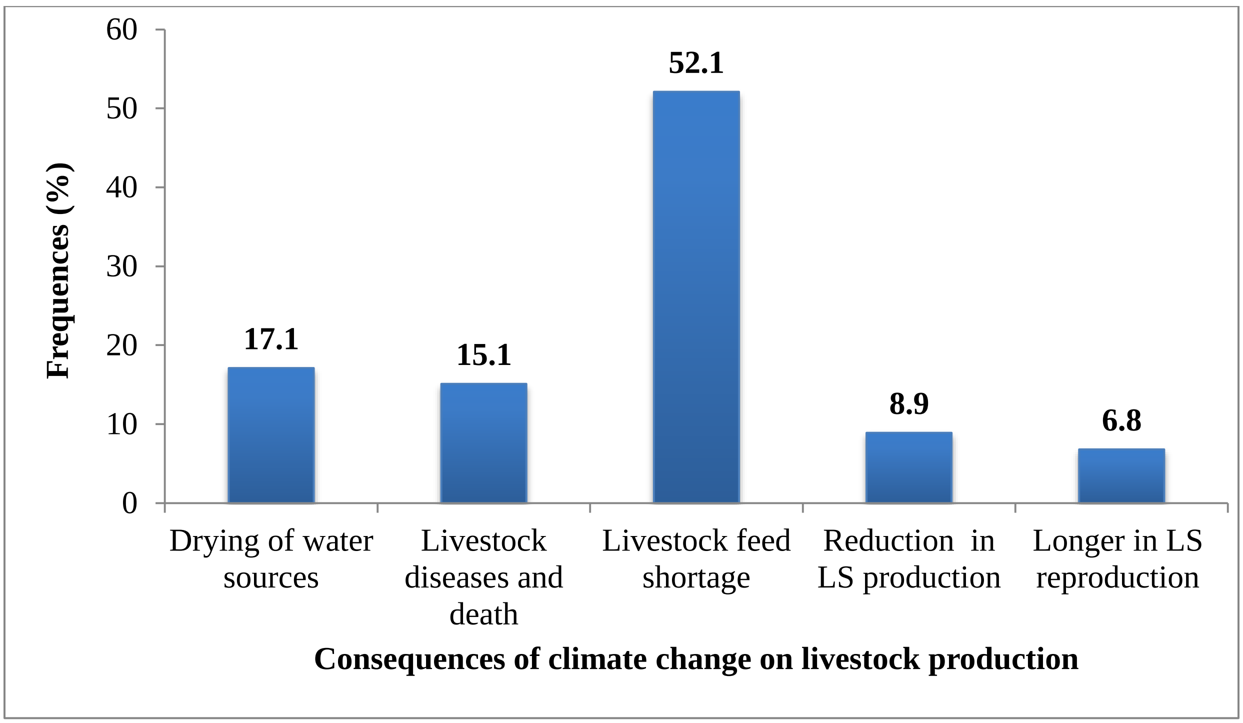

Figure 11: Consequences of climate variability and change on livestock production in study area

Perception of farmers on trends of livestock holding in the study area was presented in **Table 9**. As indicate below in the **Table 9** those livestock like cattle, poultry and equines showed decreasing trends whereas goat showed increasing trends in the study area. This is because of climate variability, which resulted in reduction in availability of water and livestock feed resources. Small ruminants (goat) were more resistant to high temperature and shortage of rainfall; their ability to browse the available feed made them more resistant than other livestock; large ruminants. Cattle and sheep were more susceptible to feed and water shortages, as well as increased temperature than that of goats and chicken. Similar trends were identified by Hammesso, (2015); Samuel, (2018); Derese, (2018), which showed declining trends in animal number at a household level in different districts of Sidama zone.

Table 9: Farmers perception on the trends of livestock holding over time in the study area

Livestock types	Trends	HHs share (%)
Cattle	Decrease	69.6
	Increase	11.1
	No change	19.3
Sheep	Decrease	38.2
	Increase	3.5
	No change	58.3
Goat	Decrease	10.8
	Increase	64.2
	No change	25.0
Chicken	Decrease	68.7
	Increase	8.2
	No change	23.1
Equines	Decrease	58.1
	Increase	23.3
	No change	18.6

4.3. Major livestock feed types and feeding system in the study area

The major types of livestock feeds and feeding systems in the study area were presented in **Table 10 and 11**. Type of livestock feeds and its trend over last 20 years and at current time in the study area was presented in **Table 10.** The result of study showed that main livestock feed in the study area over last 20 years were natural pasture (70.6%), crop residues (69.1%) and crop after math (64.0%) with increasing trends. At current time natural pasture shows decreasing trends since expansion of crop production and crop residues, crop after math and improved forage shows increasing trends again. Farmers were changed in to production of improved forage since agricultural extension services were available. In lined with current study, Gashaw *et al*., (2017; Stegaye *et al*., (2015) and Samuel., (2018) reported that natural pasture, crop residue and root crops are major livestock feed resources Chire and Lokka-Abaya Districts of Sidama Zone. Crop residues and grazing lands were the major feed sources for livestock in Alaba district (Yeshitila *et al*, 2008) was also in lined with the result of study.

Table 10: Types of livestock feeds and its trend over last 20 years and at this time (**N= 146**)

Feed types	Trends in livestock feed over last 20 years and at this time					
	Over last 20 years			**At current time**		
	Increased **(%)**	Decreased **(%)**	No change **(%)**	Increased **(%)**	Decreased **(%)**	No change **(%)**
Crop residues	69.1	11.0	19.9	78.0	11.7	10.3
Natural pasture	70.6	16.4	13.0	18.5	52	29.5
Improved forage	14.4	58.9	26.7	61.0	23.4	15.6
Crop after math	64.0	10.5	25.5	71.0	15.7	13.3

N*= Number of respondent,* ***%*** *= Percentage*

The result of the study indicated that most of farmers practiced zero grazing (cutting and carrying system) (43.8%) and free grazing system (39.7%) as major types feeding system of the study area (**Table 11**). Some farmers perceived they were practicing enclosed grazing (16.4%) system by allowing their animals to graze in enclosed area. Enclosed grazing system mostly was used for pregnant, milking cows and calves; as they need special caution. Previous study by Yeshitila *et al*, (2008) in Alaba district, identified that crop residues and grazing lands were the major feed sources for livestock; which in lined with the current result. The same author also stated that grazing of pastures, fallow lands and crop-residue are major feed resource of livestock in Ethiopia.

Table 11: Major types of livestock feeding systems practiced by smallholders in the study area (**N= 146**)

Feeding system	**Percent (%)**
Free grazing	39.7
Zero grazing	43.8
Enclosed grazing	16.4

According to the view of FGD, free grazing feeding system was dependent on season in the study area due to the existence of free crop fields after the harvest of crops. This was practiced mainly in September, October, November and December; sometimes in January. Farmers used zero grazing and enclosure mainly during cropping seasons. In this season, few farmers used roadside grazing system.

4.4. Effect of rainfall variability on trends of livestock population

Relationship between rainfall variability and livestock population trends for last 11 years were presented in ***Figure 12***. The result indicated that there was direct relation between rainfall variability and trends of livestock population as rainfall increases, the population of livestock also tends to increase which means the farmers' rear large number of animals due to high livestock feed access. The variation in rainfall resulted in reduction of quantity and quality of livestock feed; which in turn affect livestock population. When annual rainfall tends to decrease below the average, which makes farmers decrease their herd size due to scarcity of livestock feed caused by shortage of rainfall. Therefore, livestock population dynamics can be determined by the amount of rainfall in the study area. The result of current study in lined with reported by Abdeta and Oba, (2007); Megersa, (2013); Samuel, (2018) in which livestock herd dynamics is strongly determined by variation in rainfall amount. The effect of rainfall amount on livestock population dynamics over last 11 years is showed in ***Figure 12*** below.

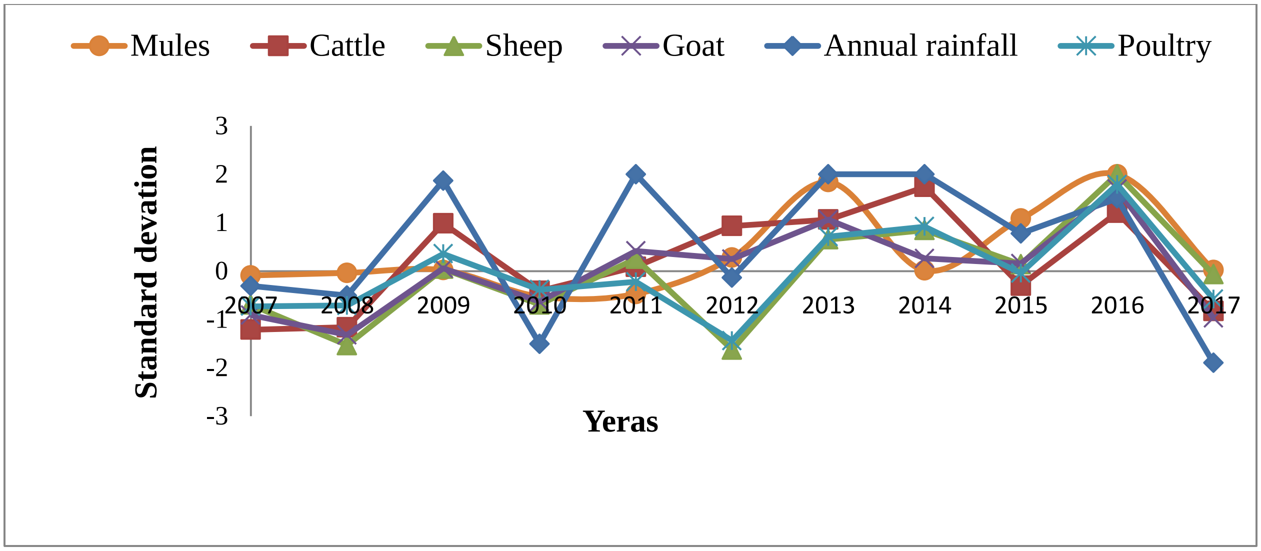

Figure 12: Standardized deviation of mean annual rainfall and livestock population (TLU)

Source: NMA and Boricha Woreda livestock and fish resource development office (2017)

4.5. Major constraints that affect livestock production and productivity in the study area

The major constraints of livestock production and productivity are indicated below in **Table 12**. Respondents mentioned that scarcity of grazing resources or pasture and water, because of rainfall failures, were among the major factors causing the decline in livestock production and productivity. In addition to that, frequent occurrences of livestock diseases were also another constraints of livestock production in the study area. Previous study by Zelalem *et al.*, (2009); Samuel, (2018) reported that feed scarcity, shortage of water and high prevalence of diseases resulted in decline of livestock productivity in Sidama and Borana Zone of Southern Ethiopia.

Table 12: The major constraints that affect livestock production and productivity in study area **(N= 146)**

Constraints	Percent (%)
Feed shortage	45.2
Water shortage	31.5
Livestock diseases	23.3

4.6. Livestock production related adaptation strategies of climate change

Adaptation strategies to climate change and variability with relation to livestock production in the study area were presented in **Table 13**. The result of study revealed that storing feed and water for dry period (35.6%), livestock herd diversification **(**24.7%) and temporal mobility to other area with their animals (16.4%) were most important strategies practiced in the study area. Some farmers practiced livelihood diversification (12.3%) to minimize the risk of climate change and some of them tried to keep drought tolerant animals (goat) (11%). As FGD and key informants reported; government organization and sometimes NGOs' (for critical prolonged dry period) supported in livestock feed transportation. The same groups and key informants reported that some of farmers were practiced reducing stock number (***i.e.*** increasing off-take rate during dry period). Study by Samual, (2018) identified feed and water storage for dry period, and temporal mobility of farmers to another places with their livestock in Loka Abaya area in lined with the present results. Similarly, Zelalem *et al.,* (2009) reported that the Borana pastoralists used seasonal mobility as adaptation strategy to cope up with the seasonal shortage of grazing resources and water; which is comparable with the current result. The most commonly used adaptation strategies to climate change are shown below in **Table 13**.

Table 13: Livestock related adaptation strategies to climate change in the study area (**N=146)**

Adaptation Practices	Frequency	Percent (%)
Temporal mobility to other area	24	16.4
Livestock herd diversification	36	24.7
Feed and water storage	52	35.6
Livelihood shifting	18	12.3
Keeping drought tolerant animals	16	11.0

% = Percent, **N** = Number of respondents

4.7. Determinants of Farmers' Choice of Adaptation Strategies to Climate Change

4.7.1. Multinomial Logistic Model Analysis Result

Multinomial logistic regression analysis was estimated to determine the factors influencing a households' choice of adaptation strategies to reduce adverse effect of climate change and variability in the study area (**Table 13**). Identifying these factors and estimates its effect on choices of adaptation options were analyzed by using Multinomial Logit model (MLM). The estimation of the MNL model was made by normalizing one category, which was normally referred to as the "base category." In this analysis, "feed and water storage" adaptation option was used as the base category.

Test for multicollinearity: For a model, all VIF values were below 10. The test result shown that there were no serious problems among continuous and dummy variables (**See Appendix V and VI**).

4.7.2. Estimated results of the multinomial logit model (MLM)

The model runs the choices of adaptation option and display the level of significance of variables the estimation. The results of MNL model showed how exploratory variables influence farmer's choice of adaptation option to climate change and variability in the study area. The model analyses used feed and water shortage as a base category and, evaluate others as alternative options.

Table 14: Marginal effects of independent variables on choice of adaptation option from MLM.

Variables	Temporal mobility to other area	Livestock herd diversification	Livelihood shifting	Keeping drought tolerant animals
	Coef (P -value)	Coef (P -value)	Coef (P -value)	Coef (P -value)
AGE	-.0050763	.007079	-.0062073	-.0065177
	(0.0511**)	(0.424)	(0.341)	(0.400)
SEX	.0699135	-.1169281	-.0747087	.1961508
	(0.471)	(0.356)	(0.392)	(0.012**)
EDUC	-.0069563	.0615723	.0036944	.0221819
	(0.857)	(0.031**)	(0.002***)	(0.349)
Family Size	.0080385	-.0358956	-.0159997	.029552
	(0.837)	(0.433)	(0.050**)	(0.467)
Farm Size	-.0081306	.0246989	-.017087	-.0184478
	(0.735)	(0.361)	(0.090*)	(0.457)
Farm Income	-7.31e-06	.0000122	5.95e-06	-7.11e-06
	(0.340)	(0.010***)	(0.309)	(0.418)
Farm Experience	.0014409	-.0030869	.0105666	.0018603
	(0.683)	(0.473)	(0.009***)	(0.594)
TLU	.0108215	.0110687	-.004415	.0014426
	(0.029**)	(0.273)	(0.068*)	(0.891)
Access to CI	.1628203	.1830381	.0069299	.0070114
	(0.180)	(0.063*)	(0.092*)	(0.022***)
Access to Ex.S	-.225989	.2305977	.1010821	-.1194626
	(0.958)	(0.088*)	(0.082*)	(0.991)

*Note: ***, ** and * for 1%, 5% and 10% significance, respectively, Number of observation=146*
Base category: Feed and water storage, MLM = Multinomial Logistic Model

In above MNL model age and livestock holding (TLU) had significant effects on the moving from place to place with their animals as adaptation option. The relationships between exploratory variables were negative and similarly negative correlation was observed between age and temporal mobility to other places. Livestock holding (TLU) of respondents was positively correlated with adaption option; temporal mobility to other places. In addition to that enhanced livestock composition ***i.e.*** livestock herd diversification were positively correlated with education, farm income, accesses to climate information and extension services. Livelihood shifting was another adaptation option and positively correlated with family size, farm income, farm experiences, access to climate information and extension services. On other hand, farm size and livestock holding (TLU) were negatively correlated with livelihood shifting in the study area. Keeping drought resistant/tolerant animals were also another adaptation option positively correlated with sex and access to climate information of respondents. Most of expected parameters of model analysis confirm the expectation and few of them were not, ***i.e.*** insignificant on choice of adaptation strategies.

Age of respondents

Adaptation strategies of respondent households to climate change were negatively affected by the age of respondents (**Table 14**). The result suggested that as age of respondents increased by one units (years), the probability of household using mobility from place to place with their livestock as adaptation option decrease by factor of 0.0050763 at 5% of level of significant. These were because when the age of the farmers increased, the probability of moving from place to place would be limited. This could also limit the movement of farmers to search feed and water for their livestocks due to lack of power as before. Study by Adesina and Baidu-Forson (1995) identified that, older farmers fear the risk and lag behind in adopting different adaptation decision in lined with the present study report. On other hand, aged households were more experienced about his environment; which is positive effects of being aged and disagree with my result. The results of current finding were also different from reported by Tazeze (*et.al.,* 2013), because as the age of the household head increases, the person is expected to acquire more experience in weather forecasting and that helps increase in likelihood of practicing different adaptation strategies to climate change.

Sex of respondents

The result study indicated that being male as a household head increases adaptation to climate change. Male-headed households were more likely to adopt keeping heat tolerant animal species by a factor of 19.6 % at 1% level of significant. Male households were better in adapting some measures to climate change and variability agrees with the fact that male-headed households often have a higher probability of adopting agricultural technologies in Africa (Buyinza and Wambede, 2008). Similarly, (Deressa *et al.*, 2009; Legesse *et al.*, 2013; Mulatu, 2013) noted that being male-headed increased significantly the ability and choice of households' climate change coping strategies. This is so because; male-headed households are relatively flexible in search of adapted livestock species for specifically harsh environment. The other possible reason for this is that much of the farming activities are done by male while female were more involved in the processing, this gives male headed households an edge in terms of farming experience and information on various adaptation strategies and what is needed to be done in response to the climatic instability.

Educational level of respondents

Education status as exploratory variable had positive effects on livestock herd diversification as adaptation options to climate change. As a model result indicated that when education of house hold increase by one level the probability of livestock herd diversification increased by factor of 6.2% at 5% significant level (**Table 14)**. The results of present study was in lined with reported by (Igoden *et al.,* 1990; Lin, 1991; Maddison, 2006; Temesgen, 2010; Samuel, 2018) in which education level of household head and practicing climate change adaptation strategies had positive relationship. This could be due to educated household heads were more active than that of uneducated in accepting climate information and other extension services from extension workers. Many authors (Ndambiri *et al.,* 2013; Deressa *et al.,* 2009 and Tesso *et al.,* 2012) reported that education was likely to enhance farmers' ability to receive, interpret and comprehend information relevant to making innovative decisions in their farms. In contrast with that, Mulatu (2013) noted a negative relationship between education and selection of climate change adaptation options.

Family size of respondents

Family size and livelihood diversification was negatively correlated as family size of the households increases by one person, the probability of choosing livelihood diversification as an adaptation option were decreased by factors of 1.6% at 5% level of significance. This was because of the households with high family size becomes inefficient in diversifying his activity since he holds big responsibility for large family members. Household heads with large families may be attempted to earn income in order to ease the consumption pressure imposed by a large family rather than diversifying livelihoods. In lined with current study Yirga, (2007) identified that households with large families might be forced to divert part of the labor force to off-farm activities in an attempt to earn income in order to ease the consumption pressure imposed by a large family. The main of diverting the family in this case was not to diversify the livelihood, but to make easy consumption pressure of his/her large family.

Farm size of respondents

Farm size of respondents was negatively correlated with livelihood shifting as adaptation option. The study result indicated that, as a farm size of respondents increased by one hectare, the probability of choosing livelihood shifting as adaptation option decreased by a factor of .1.7% at 1% level of significance. This is because of that, farmers who have larger farm size would become more initiative to livelihood shifting to become more productive ***i.e.*** increased in farm size of the household decreases the likelihood of adapting to climate change using livelihood shifting as adaptation option.

Access to climate information

Climate information was important pre-condition for farmers to take up different adaptation measures to climate change as reported by (Madison 2006). Even though climate information delivery techniques were poor in the study area, access to climate information from different sources had significant and positive impact on the adaptation strategies. Access to climate information aid farmers to adjust their production system to climate change and its influences on farmers' choice of adaptation options. There was positive correlation ship between livestock herd diversification, livelihood shifting, and keeping drought tolerant animals with access to climate information. The result of the present study indicate that access to information about climate change significantly increasing the probability of livestock herd diversification by a factor of 18.3% at 10%, level of significant. The farmers who aware more about climate can adjust his activities with changing environment and think different opportunities. Diversify the livestock herds can maximize the farmers' income and survivality in changing situation. That means access to information about climate change can helps the household to participate in farming different livestock species together (cattle, sheep, goat, poultry, etc.) to create incomes from many sources and reduce the negative impact of climate change. Similarly the previous studies by (Megersa, 2013), stated that, information on climate has a significant and positive impact on the probability of using different livestock species. In addition to that, availability of better climate information helps farmers to make comparative decisions among alternative adaptation practices and hence choose the ones that enable them to cope better with changes in climate (Baethgen *et al*., 2003; Jones, 2003).

Access to extension service

Extension visit to the households has positive influence on the probability of adopting the prevailing adaptation options. Increased access to extension service has increased the probability of using climate change adaptation options (Deressa *et al.,* 2008, 2009; Tesso *et al.,* 2012; Mulatu, 2013). This would help farmers to had information about what be a risk of climate change, and other problems related with their production, and how can they adjust themselves with the coming situation. The result of present study indicated that access to extension services had significant and positive impact on livestock herd diversification and livelihood shifting as adaptation strategies by a factor of 23.1% and 10.1% respectively, at 10% level of significant. This implies that the extension services had important roles in promoting the use of adaptation strategies to minimize the risk of climate change and variability. Because, farmer to farmer or farmers to extension worker extension service and social network increased awareness and use of climate change adaptation options.

5. SUMMARY AND CONCLUSION

5.1. Summary

The current study was conducted on the effects of climate variability on livestock dynamics, Feed resources and related adaptation strategies in Boricha district, Sidama zone, southern Ethiopia. The result of study indicated that most of farmers were male-headed and able to read and write; the dominant one is married.

Average annual rainfall of the study area showed decreasing trend with high inter-annual variability over last four decades. Both Belg and Kiremt rainfall also showed decreasing trend with high variability (1981-2017) and farmers receive high rainfall during Belg season, as it was main rain season in the study area. The study also revealed that, temperature variability and its trends analysis in both case ***i.e.*** average annual minimum and maximum temperature showed increasing trend from the period of 1981 to 2017 over the last four decades in the study area.

On other hand, most of farmers in the study area perceived that their local climates were change over time. Their perceptions on major causes of climate change were human induced action and natural process, but few farmers argued that climate change is caused by god’s punishment. Farmers also perceived that current climate of their environment is bad as decreased rainfall amount, high inter-annual variation, and increased temperature; which resulted in shortage feed and water availability, high frequency of drought and incidence of animal diseases. Due to the effects of climate change and variability, some of reproductive and productive traits were increased and some of them were decreased. Crop failure and livestock losses were another serious problems posed by climate change. Livestock holding of smallholder farmers over the year were also showed decreasing trends as perceived by many farmers in the study area.

Decrease the herd size due to scarcity of livestock feed in quality and quantity with lack of enough water for livestock were caused by shortage of rainfall. Rise in environmental temperature, decrease in rainfall amount, livestock feed and water sources, and drought and livestock diseases occurrence were the main indictors of climate change and variability. Feed shortage, drying of water body, livestock diseases and death, longer in reproduction traits and lowering of production traits were the major consequences of climate change on livestock production and productivity.

The major livestock feed in the study area were crop residues, natural pasture, improved forage and crop left over after harvesting of main crops over last 20 years. Currently, the availability of natural pasture showed declining trends since agricultural land expansion with increased population growth is critical problem. Livestocks in the study area were constrained by many factors like shortage of water and feed, livestock diseases and decline in performance due to series effects of climate variability.

Adaptation strategy of farmers in response to the risk of climate change were temporary mobility to another places with their animals, livestock species diversification, feed and water storage for dry period, livelihood diversification and keeping drought tolerant animals. Farmers choices of adaptation strategies were significantly influenced by age, sex, education, family size, farm size, farm income, farm experience, number of livestock owned, access to extension service and climate information.

5.2. CONCLUSION

- Uncertainty of climate due to unexpected variability should averted by applying appropriate adaptation strategies. Therefore, weather forecasting and effective early warning information to the farmers is crucial in order to minimize the effect of climate variability. The extension services should also be improved to link farmers with current information related with climate risks and stallholders should be participated to take action of adaptation strategies.
- Farmers should encourage in water harvesting and livestock feed storage for dry period. Even though, transporting livestock feed and water to the area in every dry season could be short term solution for the problem of water and feed shortage, constructing constant water tanks and water drinking trough of livestock, and aware farmers to manage the existed livestock feed resources can play significant role in response to climate change.
- Government and non-government organization (NGO) need to be involved in training of farmers on awareness creation to take measure on mostly known adaptation strategies practiced in the study area.
- Farmers need to adopt rearing diversified livestock species (goat and sheep) which have drought tolerating capacity. They should also encourage participating in different livelihoods activities; on-farm or off-farm activities as adaptation and mitigation strategies to climate change.
- Farmers should also be encouraged to participate in technology transfer by cultivating improved and drought tolerant livestock feed species.
- Further research is need to analysis the effects of climate change on growth and some of reproductive performance traits since there is no record in small-scale traditional livestock production system at a time.

REFERENCES

Abate, F. S., 2009. Climate Change Impact on Livelihood, Vulnerability and Coping Mechanisms in West-Arsi Zone, Ethiopia. Journal article.

Alemayehu Mengistu, 1985. Feed resource in Ethiopia. Proceedings of the second PANESA Workshop on Animal Feed Resources for Small Scale Livestock Producers. Nairobi, Kenya, 11-15 November 1985.

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

Angassa, A., and Oba, G. 2007. Relating long-term rainfall variability to cattle population dynamics in communal rangelands and a government ranch in southern Ethiopia. *Agricultural Systems* 94: 715-725.

Baethgen, WE, Meinke, H and A., Gimene, 2003. Adaptation of agricultural production systems to climate variability and climate change: Lessons learned and proposed research approach. Insights and Tools for Adaptation: Learning from Climate Variability, 18–20 November, 2003, Washington, DC.

Begzsuren S, Ellis JE, Ojima DS, Coughenour MB, and Chuluun T 2004. Livestock responses to droughts and severe winter in the Gobi Three Beauty National Park, Mongolia. Journal of Arid Environments 59: 785-796.

Betelhem Abebe., 2014. Adaptation to climate variability and changes in the small farming households, Dire Dawa administration: Ethiopia.

Buyinza M. and Wambede, N., 2008. Extension of agroforestry technology adoption: Mixed intercropping of crotalaria (*Crotaloria grahamiana*) and maize (*Zea mays L.*) in *Kabale* district, Uganda. *Environmental Research Journal*, 2 (3): 131-137.

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

Central Statistical Agency (CSA) [Ethiopia] and ICF. 2016. Ethiopia Demographic and Health Survey 2016. Addis Ababa, Ethiopia, and Rockville, Maryland, USA: CSA and ICF.

Coppock DL and Reed JD 1992. Cultivated and Native browse legumes as calf supplements in Ethiopia. Journal of Range Management 45: 231-238.

Cutter SL., 2001. A research agenda for vulnerability science and environmental hazards. IHDP Update Newsletter 2/01. Newsletter of the International Human Dimensions Programme on Global Environmental Change.

Debela, N., Mohammed, C., Bridle, K., Corkrey, R. and McNeil, D., 2015. Perception of climate change and its impact by smallholders in pastoral/agropastoral systems of Borana, South Ethiopia. *SpringerPlus*, *4*(1), p.236.

Deressa TT, Hassan RM, Alemu T, Yusuf M, Ringler C. 2008. Analyzing the determinants of farmers' choice of adaptation methods and perceptions of climate change in the Nile Basin of Ethiopia. IFPRI Discussion Paper 00798 September 2008.

Deressa TT, Hassan RM, Ringler C, Alemu T, Yusuf M. 2009. Determinants of farmers' choice of adaptation methods to climate change in the Nile Basin of Ethiopia. Glob. Environ. Change 19(2):248 255. doi:10.1016/ j.gloenvcha.2009.01.002.

Desta, S and Coppock, D.L., 2002. Cattle population dynamics in the southern Ethiopian rangelands, 1980–97. Journal of Range Management 55:439–451.

Digambar, D. S., 2011. Impact of Climate Change on Livelihood and Biodiversity in Rural Communities (A case study of Siddhi Ganesh and Nepane Community Forestry User Groups of Sindhupalchwok District of Nepal).

Diagnostic survey report, 2003. Ireland Aid Ethiopia operational research and capacity building for food security and sustainable livelihood project, Addis Ababa, Ethiopia, July 14-27, 18p.

Doti, T., 2010. Climate variability, pastoralists' vulnerability and options. The case of the Borana of Northern Kenya. In: D.A. Mwiturubani and J.A. van Wyk (Ed.), Climate Change and Natural Resources Conflicts in Africa. Monograph 170. Institute for Security Studies, Pretoria, South Africa.

Ellis EJ and Swift DM 1988. Stability of African pastoral ecosystem: Alternate paradigms and implications for development. Journal of range management, 41:450-459.

Ellis JE, Galvin KA: Climate patterns and land-use practices in the dry zones of Africa. *BioScience. DOI.* 1994, 44: 340–349. 10.2307/1312384.

FAO, 2008. Crop and Food Supply Assessment Mission to Zimbabwe. Special report. FAO/WFP. 18 June 2008. http:// www.fao.org/docrep/010/ai469e/ai469e00.htm [accessed 02 February 2010].

EPA (US Environmental Protection Agency). 2011. Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990 – 2009, Washington, DC, EPA. Accessed on 21 July 2011 at http://epa.gov/climatechange/emissions/dayownloads11/US-GHG-Inventory-2011-Complete_Report.pdf.

Few, R., Satyal, P., McGahey, D., Leavy, J., Budds, J., Assen, M., Camfield, L., Loubser, D., Adnew, M., and Bewket, W., 2015, Vulnerability and Adaptation to Climate Change in Semi-Arid Areas in East Africa. ASSAR Working Paper, ASSAR PMU, South Africa, 111 pp.

FDRE (Federal Democratic Republic of Ethiopia), 1997: Environmental Policy of Ethiopia. Environmental Protection Authority with Ministry of Economic Development and Cooperation (MEDAC), Addis Ababa.

Funte S., T. Negesse and G. Legesse, 2010. Feed resources and their management systems in Ethiopia highlands; The case of Umbulo Wacho Watershed in Southern Ethiopia. Tropical and Subtropical Agro-ecosystems, 12:47-56.

Fynn RWS, and O'Connor. T.G., 2000. Effect of stocking rate and rainfall on rangeland dynamics and cattle performance in a semi-arid savanna, South Africa. Journal of Applied Ecology 37; 491-5007.

Gashu G, Tegene N, Aster A., 2017. Assessment of Availability and Nutritive Values of Feed Resources and their Contribution to Livestock Nutrient Requirements in Chire District, Southern Ethiopia.

Galvin KA, Boone RB, Smith NM & Lynn SJ.,2001. Impacts of climate variability on East African pastoralists: Linking social science and remote sensing. Climate Research 19:161-172.

Gerber PJ, Steinfeld H, Henderson B et al. 2013. Tackling climate change through livestock: a global assessment of emissions and mitigation opportunities. Rome, Italy: Food and Agriculture Organization of the United Nations (FAO).

Gbetibouo G., 2009. Understanding farmers' perceptions and adaptations to climate change and variability: The Case of the Limpopo Basin, South Africa International Food Policy Research Institute, South Africa.

Hammesso S., 2015. Perceptions, vulnerability and adaptation to climate change in Ethiopia: the case of smallholder farmers in Sidama Southern Ethiopia.

Herrero M, Henderson B, Havlik P *et al.* 2016. Greenhouse gas mitigation potentials in the livestock sector. Nature Climate Change 6:452-461.

Herrero, M., Ringler, C., van de Steeg, J., Thornton, P., Zhu, T., Bryan, E., Omolo, A., Koo, J. and Notenbaert, A. 2010. Climate variability and climate change and their impacts on Kenya's agricultural sector. Nairobi, Kenya. ILRI.

Herrero, M., Thornton, P.K., Nouala, S., Notenbaert, A., Ericksen, P. and de Leeuw, J. 2010b. Coping with drought and climate change in the pastoral sector in sub-Saharan Africa: policy considerations. Policy paper as input into the 8th Conference of Ministers of Livestock and Animal Health in Africa, May 2009, Kampala, Uganda. 6 p.

Hulme PE., 2005. Adapting to climate change: is there scope for ecological management in the face of a global threat? Journal of Applied Ecology, 42: 784-794.

IFOAM EU Group., 2009. Proceedings of the 2nd European Organic Congress. http://www.organic-congress-ifoameu.org/Admin/Public/DWSDownload.aspx?file=%2fFiles%2fFiler%2fEOC2009%2fpdf%2f2nd_European_Organic_Congres_2009Proeedings.pdf.

IPCC., (2007). Climate change impacts, adaptation and vulnerability. Contribution of working group II to the fourth assessment report of the intergovernmental panel on climate change, MLParry, OF Canziani, JP Palutikof, PJ van der Linden, CE Hanson (eds), Cambridge University Press.

IPCC (2014). 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 University Press, Cambridge, United Kingdom and New York, NY, USA.

Izaurralde RC, Thomson AM, Morgan JA, Fay PA, Polley HW, Hatfield JL, 2011. Climate impacts on agriculture: implications for forage and rangeland production. Agronomy Journal 103, 371-381.

Jones, J.W., 2003. Agricultural responses to climate variability and climate change. Paper presented at Climate Adaptation.net Conference Insights and Tools for Adaptation: Learning from Climate Variability, 18–20 November, Washington, DC.

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.

Legesse B, Ayele Y, Bewket W. 2013. Smallholder farmers' perceptions and adaptation to climate variability and climate change in Doba district, west Hararghe, Ethiopia. Asian J. Empir. Res. 3(3):251-265.

Maddison, D., 2006. The perception and adaptation to climate change in Africa. CEEPA. Discussion Paper No. 10. Centre for Environmental Economics and Policy in Africa. Pretoria, South Africa: University of Pretoria.

Megersa., 2013.Climate change, cattle herd vulnerability and food insecurity: Adaptation through livestock diversification in the Boranna pastoral System of Ethiopia, PhD Dissertation.

Mergia Abera, Adugna Tolera and Getnet Assefa, 2014. Feed Resource Assessment and Utilization in Baresa Watershed, Ethiopia. International Journal of Science and Research (IJSR) ISSN (Online): 2319-7064 Volume 3 Issue 2, www.ijsr.net.

McCabe. J.T. 1987. Drought and Recovery: Livestock Dynamics among the Ngisonyoka Turkanaof Kenya. Human Ecology, 15: 371.

Mogotsi K, Nyangito MM, Nyariki DM 2012. Vulnerability of rural agro-pastoral households to drought in semi-arid Botswana. *Livestock Research for Rural Development* 24(10):183.

Morton, J.F., 2007. The impact of climate change on smallholder and subsistence agriculture. Proceedings of the National Academy of Sciences 104; 19680–19685.

MoFED., 2012 Ethiopia's Progress Towards Eradicating Poverty: An Interim Report on Poverty Analysis Study (2010/11), Ministry of Finance and Economic Development, Government of Ethiopia, Addis Ababa.

Mohammed-Saleem, M. A. and Abate Tedla, 1995. Feed improvement to support intensification of ruminant production systems in the Ethiopian Highlands. pp. 296-306. In: Proceedings of the 3rd Annual Conference of the Ethiopian Society of Animal Production. Addis Ababa, Ethiopia, 27-29 April 1995.

Mulatu ND., 2013. Determinants of farmers' preference for adaptation strategies to climate change: evidence from north shoa zone of Amhara region Ethiopia.

Ndambiri HK, Ritho CN, Mbogoh SG., 2013. An evaluation of farmers' perceptions of and adaptation to the effects of climate change in Kenya. Int. J. Food Agric. Econ. 1(1):75-96.

NBPE (2008). National Biogas Programme Ethiopia (NBPE) Programme Implementation Document (Draft version).

NRC (National research Council), 1981. Effect of Environment on Nutrient Requirements of Domestic Animals. Subcommittee on Environmental Stress, National Research Council (NRC). Washington, DC, National Academy Press.

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

Oba G. 2001. The effect of multiple droughts on cattle in Obbu, northern Kenya. *Journal of Arid Environments* 49(2):375–386.

Oxfam America 2010: The rain doesn't come on time anymore - poverty, vulnerability, and climate variability in Ethiopia. Oxfam International Research Report, April 2010., Ethiopia.

Rovin, K., K. Hardee and A. Kidanu, 2013. ‘Linking population, fertility, and family planning with adaptation to climate change: perspectives from Ethiopia’, *African Journal of Reproductive Health* 17(3): 15-29.

Salami, Adeleke; Kamara, Abdul B.; Brixiova, Zuzana, 2010, Smallholder Agriculture in East Africa: Trends, Constraints and Opportunities, Working Papers Series N° 105 African Development Bank, Tunis, Tunisia.

Samuels I, Allsopp N, Hoffman MT: How could herd mobility be used to manage resources and livestock grazing in semi-arid rangeland commons? *African Journal of Range & Forage Science* 2013, 30(1&2):85–89.

Samual Menbere, 2014. Livestock feeds and feeding system in *Enset (Ensete ventricosum)* dominated mixed farming system of Southern Ethiopia. Online Journal of Animal and Feed Research. Vol, 4 (6); 150-158pp.

Seyoum Bediye, Getinet Aseffa, Abate Tedla, & Dereje Fikadu, 2001. Present status and future direction in feed resources and nutrition research targeted for wheat based crop livestock production system in Ethiopia. In: P. C Wall (ed.). Wheat and Weed: Food and Feed. Proceedings of Two Stakeholder Workshops. CIMMYT, Mexico City. Improving the Productivity of Crop Livestock Production in Wheat-based Farming Systems in Ethiopia, Addis Ababa, Ethiopia, 10 - 11 October 2000. pp. 207 - 226.

Seo, S.N., McCarl, B.A., and Mendelsohn, R., 2010. From beef cattle to sheep under global warming? An analysis of adaptation by livestock species choice in South America. Ecological Economics 69, 2486–2494.

Seo, S.N., Mendelsohn, R., Dinar, A., and Kurukulasuriya, P., 2009. Adapting to climate change mosaically: An analysis of African livestock management by agro-ecological zones. The Berkely Electronic Journal of Economic Analysis and Policy 9 (2) article 4.

Sisay B., 2017. Effects Of Phosphorus Fertilizer And Inoculation On Yield And Nutritive Values Of Grain And Haulm Of Selected Grain Legumes In Mixed Crop-Livestock Production System Of Ethiopia. Msc Thesis, Hawassa University.

Solomon Bogale, 2004. Assessment of livestock production system and feed resource base in Sinana Dinsho district of Bale Highlands, Southeast Oromia. MSc. Thesis. Alemaya University, Alemaya. 135 pp.

Stige LC, Stave J, Chan K, Ciannelli L, Pettorelli N, Glantz M, Herren HR and Stenseth NC 2006. The effect of climate variation on agro-pastoral production in Africa. PNAS 9:3049- 3053.

Teka K., V. Rompaey, J. Poesen, Y. Welday, J. Deckers. 2012. Impact of climate change on small-holder farming: a case of Eastern Tigray, Northern Ethiopia Afr. Crop Sci. J., 20 (2012), pp. 337–347.

Taddesse T., 2011. Farmers' perception and adaptation mechanisms to climate change and variability: the case of La'ilay Maichew woreda, central Tigray, Ethiopia.

Tesso G, Emana B, Ketema M., 2012. Econometric analysis of local level perception, adaptation and coping strategies to climate change induced shocks in North Shewa, Ethiopia. Int. Res. J. Agric. Sci. Soil Sci. 2(8):347-363.

Thornton, P., Van de Steeg, J. Notenbaert, A. and Herrero, M. 2013. The livestock, climate change and poverty nexus. The Futures of Agriculture. Brief No. 43 - English. Rome: Global Forum on Agricultural Research (GFAR).

Thornton P, Cramer L (eds), 2012. Impacts of climate change on the agricultural and aquatic systems and natural resources within the CGIAR's mandate. CCAFS Working Paper 23. CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). Copenhagen, Denmark. Available online at: **www.ccafs.cgiar.org.**

Thornton PK, Herrero M, Jones PG, 2011. Adaptation to climate change in mixed crop-livestock farming systems in developing countries. In: Handbook on Climate Change and Agriculture (eds R Mendelsohn and A Dinar). Elgar, UK. Pp 402-419.

UNDP., 2008. Situation report: Drought/Food crisis in Ethiopia 27th June 2008.

Yemane Taro.,1967. Statistics. An introductory analysis, 2nd edition. New York. Harper and Row.

Yeshitila Admassu, Tessema Zewdu and Azage Tegegne., 2008. Availability of livestock feed resources in Alaba Woreda, Southern Ethiopia. Proceedings of the 16th annual conference of the Ethiopian Society of Animal Production (ESAP) held in Addis Ababa, Ethiopia, October 8 to 10.

Yirga, C.T., 2007. The dynamics of soil degradation and incentives for optimal management in Central Highlands of Ethiopia. Ph.D. Thesis. Department of Agricultural Economics, Extension, and Rural Development, University of Pretoria, South Africa.

Vogel C., 1998. Vulnerability and global environmental change. LUCC Newsletter 3(March): 15-19.

Zelalem Y, Aynalem H, Emmanuelle G., 2009. Effect of climate change on livestock production and livelihood of pastoralists in selected pastoral areas of Borana, Ethiopia.

APPENDICES

Appendix I: Definition and Concept of key terms

Climate change: refers to the variation of earth's global or regional climate over a long period, whether due to natural variability as normal changes or result of human induced activities (IPCC, 2007). There is a consensus among scientists that climate change will have disproportionally harmful socio-economic effects on the most vulnerable people and rural communities of developing countries.

Climate change impacts: the effects of climate change on natural and human systems (IPCC, 2007).

Vulnerability: is the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes (IPCC, 2007). It is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity.

Adaptation: Adaptation refers to adjustment in ecological, social or economic systems in response to actual or expected climate stimuli and effects or impacts. By the impact of climate change, systems become more vulnerable to natural or anthropogenic hazards, there is a greater need to develop responses (***i.e.*** adjustments in existing practices, processes or structures) that are able to counter potential future disasters. Such a response is known as adaptation to climate change. Thus, adaptation is the ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damage, to take advantage of opportunities, or to cope with the consequences which can be both to current, actual or projected conditions (UNFCCC, 2007).

Adaptive capacity: is ability of people or a system to modify or change its characteristics to cope better with existing or anticipated external stresses (IPCC, 2001; Smit and Wandell, 2006).

The ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences is known as adaptive capacity. A system or a community is said to have enhanced adaptive capacity if it is able to modify its characteristics or behaviours so as to cope better with changes in external conditions.

Perception: is the process of attaining awareness or understanding of a phenomenon including climate change

Livestock production: it is production of farm animals for the benefit of human being as agricultural commodity or as food animals.

Mixed crop-livestock system: it is the land use system in which crops and livestock complement one another.

Dynamics: a characteristic/manner of an interaction. From the concept of this study, "**Livestock dynamic**" shows a manner of interaction between climate and livestock production.

Appendix II: Household Questionnaire

Basic Information

Name of District _____________ Name of Kebele _________________ Village's name __________

Sex of the HH head: _______________ (1=Male, 2=Female)

Date of interview______________________

Enumerator's name _____________________________

DETAILS OF HOUSEHOLD CHARACTERISTICS

	Household's Description	Codes	Response
1	Age of the respondent (years)		
2	Marital status	(1=Married, 2=Single, 3=Widowed , 4=Divorced)	

3	Level of Education of the HH head	(1= *None*, 2=*Can read and write*, 3. Primary school, 4=*Secondary*, 5= *Above secondary*)		
4	What family members of different age category within the household look like?		No. of persons	
			M	**F**
	How many children aged less than 16 years			
	How many adults aged between 18 and 65 years			
	How many persons aged above 65 years			
	Total			

Farm characteristics, income sources and livestock holding

1. How long have you lived in this village?______(years)
2. Do you have a land? 1= Yes 2=N0
3. If yes for Q2 how much hectares of land do you have?(Total farm size)
4. Which type of agricultural activities do you practice? 1= Cropping only, 2=Raising Livestock only, 3= Cropping and Livestock 4= None
5. How long you have been farming? (Years) _______________
6. Do you have livestock before 20 year? 1=Yes 2=No
7. Do you have livestock currently? 1=Yes 2=No

3. If Yes, what do you have? (herd size and its(composition trends)

Type of animal	NO	Trend in animal raising in the last 20 years				No change
		Increased	What is the reason for the Increase	Decreased	What is the reason for the decrease	
		1=Yes 2= No	List the reasons	1=Yes 2= No	List the reasons	
Cattle						
Goats						
Sheep						

Chicken						
Mules						

8. Trends in the number of herd size including young stocks reared by household within last 20 years?

No	Type of animals	No of animals owned before 20 years	No of animals owned now
1	Cattle		
2	Sheep		
3	Goat		
4	Mules		
5	chicken		

9. Farmer's perception about climate change and its impact on livestock production

9.1. What is your perception about climate condition of your locality?

1. The climate is totally changed 2. the climate is slightly changed

   3. The climate is not changed 4. I have no idea

9.2. If your answer for Q1 is "climate is changed" what are the local indicators of the observed climate change?

Local indicator	1=yes 2=No	How you perceive trends in the last 20 years (1=increased , 2=declined, 3=No change
Temperature rise		
Reduction in the frequency and intensity of rainfall		
Occurrence of drought		
Livestock diseases occurrence		
Water resources		
Reduction in livestock inputs (forage) and water		

10. What do you think is the cause of climate change?

1. Human actions 2.Natural process 3. Both human action and natural process 4. Punishment from God/Allah 5 . Rapid population growth

11. Do you think that does climate change can cause any effect on trend of livestock productivity in your locality? 1.Yes 2.No If yes, how it affect?

Indicator	increased	decreased	No change
Feed availability			
Water availability			
Disease occurrence			
Milk off take			
Calving interval			
Feed in take			
Age at first calving			
Heat stress			
Mature weight of the animal			

12. Are you observing any new disease spread to your animals in your locality?

1. Yes 2.No

13. If yes what type disease is occurred due to climate change? ……………

14. Is your animal face heat stress? 1. Yes 2.No

15. If yes when or at what time the animal feel heat stress?

1. during the dry period 2. During the cold time (summer) 3. Both times

16. If there heat stress what makes on the productivity of the animals?

1.Decrease feed intake of the animals 2. decline milk productivity of the animals

3. cause death to the animals 4. other

17. If it decreases the productivity of animal how it affect it?

1. By decrease pasture production 2. by causing decline of drinking water 3. By causing health problem to the animals.

18. Is there any new livestock disease that occur in your in you locality? 1. Yes 2. No

19. Do you have access to information about climate change? Yes 1 No 2

20. If yes, where do you get the information?

1.From social media 2. From extension workers 3. From your neighbors' 4. others

21. Which type of species of livestock more affected by the drought?

1.Cattle 2. sheep 3. goat 4. chicken 5. other

22. At what time interval the drought occur in your locality (frequency of drought)?

23. Which type of species of livestock more affected by the drought?

1.Cattle 2. sheep 3. goat 4. chicken 5. other

24. What was the main source of feed for your livestock before 10 years?

1. grazing pasture   2. Crop residues   3, steam of Inset plant   4. others

25. What major feed resources did you use 20 years back compared to your current practice of livestock feeding? (rank in the table)

Feed types	**20 years ago**	**Now**
Natural pasture		
Crop residues from cereals		
Crop fields		
Stored feeds (hay or standing hay)		
Purchased feed resources		
Other Crop residues		

26. What types of fodders and pastures have you planted? 1. Napier grass 2. Rhodes grass 3. Fodder trees 4. Mucuna/Lablab

5. Others (Specify) ---------------------------

27. Did you experience fodder shortage? 1. Yes 2. No

28. How do you cope with feed shortage?

1. Buy from neighbors 2. Use conserved fodder and pasture

3. Use preserved crop residue 4. Graze on the road side

5. Get from neighbors for free 6. Others (specify)

29. What adjustments have you made in your farming to the impacts of climate change stated above?

Please list all the possible response identified at FGDs level below

Which type of adaptation strategies you have mostly practicing for your livestock production in response to climate change in your locality.	What are the reasons for not doing the listed response (0=lack of money, 2= lack of information, 3= shortage of labour, 4= Other , specify
1. Temporal mobility to other area	
2. Livestock herd diversification	
3. Feed and water storage	
4. Livelihood shifting	
5. Keeping drought tolerant animals	
6. Others specify...	

Appendix III: Questions for Focus Group discussions (FGD)

1. Do you know what climate change means? Is the pattern of weather is changing? How do you explain the change? What would be the cause?
2. What do you think are the local indicators of Climate change in your kebele?

3. Do you feel any change in weather of your locality in terms of temperature and rain fall? How it is…………………………………………………………………………………..

4. How change in rain fall and temperature affect the productivity of livestock?

……………………………………………………………………………………………….

5. Is there any decline in production, the type and the number of animals kept by the farmers?

…………………………………………………………………………………………….

6. What is the possible coping mechanism used by livestock producers during the dry period (shortage of rain fall) in your locality?

7. How do you cope up or adopt the impacts of climate change on your livestock production?

……………………………………………………………………………………………….

8. What are the major constraints you have that hinder your coping mechanism? And the measurement taken?

1. Lack of climate information 2. Lack of access to climate information

3. Lack of technology 4. Lack of money 5. Others and the measurement taken

Appendix IV: **A Check list for Key informant**

1. What is the role of your office to combat the hazard? Any constraints?
2. Is there any form of climate change in the District? If, 'Yes', please explain it
3. Have you observed any change in temperature and rainfall trend over the past 20 years?
4. What are the impacts of climate related hazard or change in temperature and rainfall exerted on agriculture specifically livestock production?
5. What are the challenges to combat the existed problem?
6. What is your future plan in increasing livestock productivity under changing climate?
7. What are the local coping mechanisms used to reduce current climate related risks and adapt to the future climate change?

8. What is the role of institutions like GOs, NGOs, in facilitating adaptation of livestock to climate change in your district?
9. Do local communities take part in making decisions with regard to adaptation mechanisms and how to implement Community based adaptation (CBA) in district level? If, yes, how / please explain it. If not why please explain it.
10. What are the main challenges to undertake CBA to climate change in your district? And how do you think it can be improved?

Appendix V: Rain fall and temperature data of Boricha District

Monthly rainfall of Boricha District in mm

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1981	0.5	39.1	266	207.5	135.8	83.8	218.7	161.1	173.9	74.6	31.4	3.6
1982	40	57.8	71	127.8	169.7	120.5	128.8	104.7	113.8	112.1	206	75.1
1983	2.2	60.9	127.5	294.8	273.7	136	195.2	177.6	163	138.5	91.6	3.1
1984	0	0	32.7	47.6	210.7	40	71	102.6	149.8	35.4	20.4	10.8
1985	7.8	2.2	63.7	180.3	158.5	95.6	115.7	96.2	122.3	47.3	25.3	3.8
1986	0	80.1	109.9	161.3	145.2	140.2	113.4	109.6	148.5	85.8	10.8	33.2
1987	1.3	43.5	203.8	151	290.8	65.6	47	78	109.6	135.2	5.6	3.5
1988	18.6	48.2	62	189.6	65.1	147.5	219.5	135.5	144.2	143.4	0	8.5
1989	30.1	36.2	99.3	207.9	88.8	95.4	72	62.3	164.2	105.1	41.2	87.3
1990	30.4	199.5	160.7	130.8	110.1	51.9	75.5	84.9	74.8	61	24.7	9.9
1991	30.7	68.6	116.1	93.3	119.6	105.2	82.9	109.1	97.3	75	0.7	39.2
1992	36.5	81.9	102	121.2	121.4	95.1	101	131.2	183.8	217.4	83.1	35
1993	103.1	96.4	39.5	190.6	252.2	83.3	35.2	54.1	84.3	182.6	24.5	0.6
1994	0	5.4	64.4	197.8	146.6	119.7	193.3	100.6	100.2	55.5	46.2	10.6
1995	0	33	103.3	261.7	110.9	63.9	73.5	61.9	148.3	71.6	13.8	53.8
1996	57.4	25.1	158.2	173.7	153.6	195.5	116.2	97.4	156.7	68.9	22.9	0
1997	21.6	0	57	196.1	106.5	70.3	102.4	87.6	83.2	216.7	172.3	23.5
1998	73.2	63.9	73	121.7	119.1	76.6	97.4	90.2	85.2	181.9	17.2	0
1999	12.1	0.1	100.4	64.9	82.1	75.9	90.9	82.1	87.7	127.7	9.8	5.7
2000	0	0	14.7	121	141.8	57.8	102.4	91.3	96.8	140.2	66.9	27.2
2001	15.8	16.7	105.4	95.9	147.1	116.1	87.2	100.8	123	146.8	8	13.9
2002	44.1	19	145	109.5	101.2	67.5	53.7	95.5	93.5	65.3	0	101.1
2003	34.7	5.8	102.1	217.9	61.4	82.1	83.3	111	110.1	61.2	42.5	36.6

2004	75.5	54.2	39.5	184.8	110.2	50.1	65.2	82.7	123.3	78.8	41.2	13.8
2005	30.7	10.7	91.9	174.3	224.7	59	103.4	53	120	104	59	0
2006	2.7	48.1	129.1	175.3	127	101.4	117.5	134.8	94.6	175.9	43.7	69
2007	34.5	46.7	86.3	144.6	148.8	156.9	104.5	142.3	170.6	79.5	13.4	0
2008	12	4.6	11.3	119.3	114.9	65.1	107.2	91.9	135.1	168.9	84.8	0
2009	42.9	13.3	61.5	91.7	89.8	71.6	48.8	54.1	87.2	151.3	22.3	62.6
2010	34.5	84.7	131.7	200.5	175.9	97.5	73.5	99.6	116.4	39.1	39.7	16.6
2011	0.5	16.1	31.8	99	220.8	69.2	112.1	161.6	86.3	62.8	83.9	0
2012	0	0	30.3	125.4	94.6	67.2	142.8	74.2	123.6	76.3	44.1	6.7
2013	27.6	2.2	93.3	182.9	78.8	100.8	141.9	126.8	139.8	173.9	62.4	0
2014	1.6	37	122.5	111	144.9	62.6	98.1	127.9	116.3	144.8	42.9	3.1
2015	0	0	14.7	47.8	76.9	80	39	26	29.3	32.3	46.8	13.5
2016	1.1	7.4	21.1	172.2	62.7	43.5	34.3	16.4	15.6	36.6	49.5	1.7
2017	28.4	28.3	42.07	78.1	31.3	51	43.06	64	86.9	97	73.5	47

Monthly maximum temperature in °C of Boricha District

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1981	28.0	28.2	25.7	23.6	24.2	23.6	21.4	21.9	22.8	24.7	26.1	27.2
1982	27.0	26.9	28.4	25.3	24.4	23.9	22.1	22.7	24.3	24.4	25.3	26.1
1983	28.1	28.2	29.6	26.4	25.0	24.7	23.1	23.0	24.2	24.7	25.8	26.8
1984	27.9	29.0	30.2	29.3	25.1	23.2	23.0	23.8	24.2	26.7	26.7	26.7
1985	27.0	27.7	28.1	24.2	23.7	22.8	22.4	22.8	24.6	25.8	27.1	27.7
1986	27.2	27.2	27.0	24.6	23.9	22.1	21.8	22.9	23.7	24.9	26.1	26.7
1987	27.0	27.6	26.2	25.3	24.2	23.1	23.4	23.7	24.9	24.7	26.1	27.0
1988	27.4	28.3	28.7	26.3	24.7	23.2	21.0	22.1	23.2	23.8	25.4	26.1
1989	26.4	26.5	27.0	24.2	24.7	22.5	21.1	23.0	23.5	24.4	25.4	24.7
1990	26.1	26.4	26.2	25.9	25.4	24.1	22.4	22.7	24.5	24.6	26.0	26.2
1991	27.9	27.7	27.0	26.6	25.5	24.2	21.4	23.2	24.7	25.6	26.4	26.5
1992	27.3	27.1	28.7	26.8	24.9	24.0	22.8	22.5	24.2	23.8	25.3	25.7
1993	25.8	25.9	28.4	25.9	24.4	22.9	22.3	23.0	24.0	25.1	26.9	27.9
1994	28.9	29.5	28.6	26.2	24.3	23.2	22.0	23.0	25.0	26.0	26.2	27.4
1995	28.7	28.9	27.0	25.4	25.7	25.1	23.2	23.3	24.8	25.5	26.9	27.6
1996	27.4	29.3	27.9	25.9	25.3	22.4	22.1	23.1	24.1	25.2	26.3	27.0
1997	27.8	29.2	29.3	25.4	25.5	24.2	22.8	24.3	27.0	24.9	25.3	25.5
1998	26.2	27.5	28.8	28.7	26.4	24.5	23.0	22.9	24.6	23.9	25.7	27.0
1999	27.9	29.9	27.2	26.6	25.6	25.0	22.3	23.9	24.7	24.0	25.7	26.7
2000	28.7	29.8	30.4	27.3	23.6	23.5	23.6	23.8	25.0	24.6	26.1	27.5
2001	28.2	29.5	28.0	26.8	25.7	23.9	23.8	24.2	25.5	25.8	27.2	28.2
2002	28.1	30.1	28.0	27.8	26.3	24.9	25.3	24.4	25.6	26.1	27.9	27.1
2003	27.4	30.0	29.8	27.3	26.6	24.8	22.9	24.0	25.9	27.1	27.7	26.7
2004	27.9	28.2	29.3	26.2	26.2	24.8	24.0	24.5	25.3	26.0	26.7	27.5
2005	28.3	30.6	28.8	28.0	24.6	24.1	23.2	24.5	25.0	25.7	26.4	27.6
2006	29.3	29.6	28.1	25.9	26.1	24.9	23.3	23.8	25.1	25.6	26.1	26.3
2007	27.7	29.2	29.8	27.0	26.0	23.6	23.5	23.4	24.6	26.0	27.0	27.8
2008	28.9	29.3	30.4	27.8	25.3	24.8	23.2	23.5	24.9	25.8	25.8	27.5
2009	28.1	29.4	30.3	27.2	26.8	26.0	24.7	25.3	26.3	26.0	27.9	26.9
2010	28.4	28.1	27.5	26.5	25.3	24.5	23.0	23.7	25.0	26.9	28.0	28.0
2011	29.1	30.0	29.8	29.5	25.9	24.5	24.2	23.8	24.8	26.6	26.2	26.7
2012	29.4	30.4	31.4	27.2	27.0	25.3	23.6	24.3	25.0	26.8	27.2	28.3
2013	29.2	31.1	29.8	26.6	25.2	24.1	23.0	23.7	25.5	25.7	26.1	27.7
2014	29.4	28.8	28.9	27.4	26.1	25.6	24.3	24.7	25.0	25.5	26.7	27.5
2015	29.8	31.1	31.2	29.9	28.1	26.8	26.9	27.6	28.3	28.7	29.3	28.7
2016	29.9	31.0	30.9	28.9	27.6	27.0	26.6	26.8	27.6	27.7	27.9	29.1
2017	29.7	29.9	31.2	29.5	28.4	26.9	26.7	27.8	28.1	28.5	29.5	28.4

Monthly minimum Temperature in ºC of Boricha District

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1981	11.8	12.1	13.8	13.7	13.3	12.7	12.8	12.6	12.5	12.3	11.8	11.5
1982	12.3	13.5	13.0	13.5	13.4	12.6	12.6	13.0	13.0	12.4	12.9	11.9
1983	11.6	12.8	14.1	13.3	13.7	13.2	12.8	13.8	13.0	12.4	11.1	10.2
1984	9.9	9.3	12.2	12.9	13.4	12.6	12.5	12.7	11.9	10.9	11.8	11.2
1985	10.2	9.8	10.8	11.7	10.8	10.9	12.8	11.0	11.3	10.5	10.3	9.9
1986	9.2	10.2	10.4	11.9	11.2	11.7	11.3	10.8	11.1	9.8	9.6	10.1
1987	9.6	9.7	12.2	11.0	12.0	11.4	10.8	11.2	10.7	11.2	9.1	9.5
1988	10.1	11.1	11.0	12.0	11.3	10.7	10.6	11.2	11.0	10.8	7.9	8.3
1989	9.1	9.3	11.0	11.1	10.5	10.8	11.5	11.2	11.4	10.7	10.5	12.0
1990	9.8	13.0	12.4	13.4	12.7	11.7	11.7	12.2	11.6	10.9	11.4	10.1
1991	12.1	12.3	12.9	12.1	13.0	12.7	12.5	12.5	12.4	11.9	12.3	11.5
1992	12.2	12.9	13.0	12.8	12.3	12.4	11.8	12.2	12.3	12.5	11.9	12.6
1993	12.8	12.6	12.9	14.5	13.6	12.9	12.6	12.3	12.0	12.7	12.2	11.5
1994	10.9	12.3	13.7	13.6	13.7	13.2	12.9	13.0	13.1	11.7	11.9	10.7
1995	11.1	13.0	13.4	14.2	13.3	13.0	13.3	13.2	12.8	13.1	11.3	12.1
1996	12.8	12.6	13.2	13.8	13.5	13.6	13.0	12.9	13.3	12.0	10.5	10.5
1997	12.5	11.4	13.0	12.8	12.7	12.6	13.0	12.9	13.4	13.5	14.0	12.0
1998	13.1	13.8	14.3	14.9	15.2	13.1	13.6	13.8	13.4	13.9	10.9	10.1
1999	11.6	11.5	13.6	13.0	13.1	12.8	12.6	12.2	12.0	12.5	10.3	10.1
2000	10.8	11.2	12.7	13.5	13.3	12.7	13.4	13.4	13.1	13.7	12.6	11.7
2001	12.1	12.3	13.7	14.1	14.0	13.6	13.2	13.7	13.3	13.8	12.0	12.3
2002	13.3	12.9	14.3	13.9	14.1	13.4	13.8	13.7	13.3	13.3	12.6	13.8
2003	12.5	13.2	14.2	14.7	14.4	13.5	13.4	13.4	13.3	13.2	13.0	12.0
2004	12.9	12.6	12.6	13.2	13.3	12.8	13.0	13.5	13.3	12.8	13.0	12.6
2005	12.2	13.2	14.7	14.8	14.1	13.9	13.4	13.6	13.6	13.5	11.7	10.2
2006	12.8	13.5	14.4	14.2	14.1	13.8	14.0	13.9	14.1	14.2	13.0	13.3

2007	12.9	13.8	13.5	14.3	14.5	13.9	13.7	13.6	14.2	12.4	12.6	11.0
2008	11.9	12.6	13.0	14.1	14.2	13.9	13.9	13.7	14.0	13.6	12.6	11.7
2009	12.2	13.3	13.9	14.5	13.9	13.4	13.4	13.8	14.2	14.0	12.6	13.9
2010	13.2	15.2	14.6	15.2	15.5	13.9	13.9	13.8	14.0	14.0	12.7	12.2
2011	12.8	12.4	14.4	14.6	14.8	14.2	13.6	13.6	14.2	13.4	13.7	11.2
2012	11.8	11.6	14.5	13.5	14.6	14.5	13.9	13.7	14.0	13.5	13.1	12.0
2013	12.1	13.0	14.1	13.4	12.9	13.7	13.5	13.3	13.3	13.5	11.4	11.5
2014	12.5	13.6	13.7	13.8	13.7	13.4	14.9	14.3	14.2	14.5	13.4	11.9
2015	12.6	11.7	14.4	14.2	14.7	14.2	14.0	14.1	14.3	14.3	15.0	14.6
2016	15.0	15.1	15.8	15.9	15.3	14.8	14.7	14.9	15.1	15.4	13.3	12.0
2017	13.5	15.3	14.5	15.4	15.3	13.8	13.9	14.4	14.0	14.1	12.8	12.3

Appendix VI: The Variance Inflation Factors (VIF) of the explanatory variables

Variables	Collinearity Statistics	
	Tolerance	VIF
Age of house hold (HH)	.186	5.389
Family size of household	.183	5.468
Farm of size respondents	.615	1.625
Farm experiences of respondent	.944	1.060
Farm Income of respondents	.919	1.088
Livestock holding (TLU)	.590	1.694

Appendix VII: Contingency coefficients for dummy explanatory variables

Variables	Contingency coefficient
Access to extension services	0.350
Access to climate information	0.292

Biography

The author of the present thesis was born in 1989 in the former Shebedino woreda of Southern Ethiopia. He attended his elementary and junior secondary schools in Balela and Leku between 1996 and 2003. He attended Senior Secondary Schools in Leku between 2004 and 2005 and preparatory school in Hawassa tabor Senior and preparatory school between 2006 and 2007. He joined Hawassa University, in 2008 where he studied Animal and Range science.

He graduated in July 2010 with the Bachelor of Sciences in Animal and Range science. He was employed in Boricha woreda Office of Agriculture and Rural Development 2011/2013 for three years. He worked as Animal production expert in the Animal production working team.

He was admitted to the School of Graduate Studies of Hawassa University in 2014 for his graduate studies in the specialization of Animal Breeding and Genetics (AnBG). Again, he was employed in Bule Hora University in Animal and Range Science Departments as a “Lecturer” for three consequetive years starting from Oct 2017. He was also admitted to the School of Graduate Studies of Hawassa University again in 2016 for his graduate studies in the specialization of Climate Change and Sustainable Agriculture (CCSA).