EFFECT OF CLIMATE CHANGE ON LIVESTOCK PRODUCTION: ADAPTATIVE STRATEGIES IN TELTELLE DISTRICT OF BORANA ZONE, SOUTHERN ETHIOPIA

M. Sc. THESIS

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This is to certify that the thesis entitled "**Effect of Climate Change on Livestock Production: Adaptative Strategies in Teltelle District of Borana Zone, Southern Ethiopia**" submitted in partial fulfillment of the requirements for the degree of **Masters of Science** with specialization in Climate Change and Sustainable Agriculture, and has been carried out by **Galma Halake Huka** Id. No PGCSA/009/10, under our supervision. Therefore, we recommended that the student has fulfilled the requirements and hence hereby can submit the thesis to the department.

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DEDICATION

This thesis is heartily dedicated to my mother Elema Halake, my wife Dhakki Shere and my child Yadani Galma for their encouragement and appreciations during my work at Hawassa University.

STATEMENT OF AUTHOR

I declare that this thesis is my original work and all sources of materials used for this thesis have been duly acknowledged. I solemnly declare that this thesis is not submitted to any other institution anywhere for the award of any academic degree, diploma or certificate.

Name……………………………………………………….Signature………..…………

Place: College of Agriculture, Hawassa University, Hawassa

Date of Submission…………………………………………………………………

ABBREVATION AND ACRONYMS

CV	Coefficient of Variation
DJF	December-January-February
DLRD	District Livestock Resource Development
ENMA	Ethiopia National Meteorological Agency
FAO	Food and Agriculture Organization
FDRE	Federal Democratic Republic of Ethiopia
FGD	Focus Group Discussion
GDP	Gross Domestic Product
HHs	Households
IFAD	International Fund for Agricultural Development
ILRI	International Livestock Research Institute
IPCC	Intergovernmental Panel on Climate Change
IUCN	International Union for Conservation of Nature
JJA	June-July-August
KII	Key Informant Interviews
MAM	March-April-May
masl	meter above sea level
n	Sample size

N	Total population of selected kebeles
ONRS	Oromiya National Regional State
SD	Standard Deviation
SNNPRS	Southern Nations Nationalities and Peoples Regional State
SON	September-October-November
SPI	Standard Precipitation Index
SPSS	Statistical Packages for Social Sciences
TDADO	Teltelle District Agriculture Development Office

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Effect of Climate Change on Livestock Production: Adaptative Strategies in Teltelle District of Borana Zone, Southern Ethiopia

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ABSTRACT

This study focused on effects of climate change on livestock production and adaptation strategies practiced by the pastoralists in Teltelle district. The specific objectives of the study were to analyze trends of rainfall and temperature data, to assess effects of climatic factors on livestock production, rangeland condition and adaptation strategies practiced by pastoralists of the district. The study was based on a cross-sectional survey of 185 sample households, six focus group discussions (each focus group discussions had 8 individual members), and 13 key informants. Primary data were collected using surveys, interviews and focus group discussions. Secondary data were obtained from Ethiopia National Meteorological Agency, Addis Ababa, and District Livestock Resource Development Office. Data were analyzed using both descriptive and inferential statistics. Long term trends of rainfall and temperature data were analyzed by linear trend analysis. Standard Precipitation index and Coefficient of Variation were used to analyze rainfall deficit and variability. Relationship between climate data and livestock population were analyzed by regression and correlation analysis. Climatic factors that affect livestock production and rangeland condition were analyzed using rank index method. Multinomial logit model was also used to analyze determinants of adaptation choice of herders. 90.9% and 87.9% of household respondents perceived decreasing trend of rainfall and increasing of temperature respectively. Thirty six years trend of annual rainfall decreasing by -0.7639mm per annual and mean annual minimum temperature increasing by 0.0168^{0}C. The 18 years of annual rainfall were below average (507.81$\pm$103.73mm) while 14 years categorized as drought years. Coefficient of Variation of main rainy season (31.97%) and short rainy season (33.9%) were highly variable but annual rainfall (20.43%) was moderately variable. The highest correlation values of livestock population were with the main rainy season (r = 0.855). Major factors affected livestock productions in the district were shortage of feeds, shortage of water and recurrent drought, while variability of rainfall, bush encroachment and flood affected availability and quality of feeds. 92.5% of sample households practiced adaptive strategies while 7.5% did not. Livestock mobility, livestock diversification, area enclosures and hay making were major adaptation strategies practiced by herders. The basic barriers to climate change adaptation were lack of capital, lack of information and reduction in number of livestock per households. In conclusion, rainfall variability and high drought frequency in the district affected livestock production, feed availability and quality, and reduced effectiveness of adaptation strategies practiced by pastoralists. Therefore, future policy better focus on improving water source management, improving livestock management, improving rangeland management, and encouraging the adaptation strategies applied by pastoralists.

Key term: Climate Change, Livestock Production, Drought, Adaptation, Teltelle District

1. INTRODUCTION

1.1. Background of the study

Climate change is defined as the significant variation of the mean state of climate relevant variables such as temperature, precipitation and wind in a certain period of time, commonly over 30 years (IPCC 2007). Whereas, livestock refers to domesticated animals intentionally reared in an agricultural setting to produce food or other products (World Bank, 2016). Since the 1960s there has been a period of climatic change with global land-surface temperature rising about 0.5–0.6 oc (Hansen, Sato & Ruedy, 2012), which is a major concern of livestock production systems and livestock productivity in the world (Miraglia *et al*., 2009).

Many scientists have confirmed that climate change is occurring and it is believed that the effect of climate change would be most pronounced in developing countries, compared to developed countries (IPCC 2007, World Bank 2012). This is because developing countries often have agricultural based economies and agricultural production highly depends on annual weather conditions and natural resources as well as low adaptive capacity. Climate change and variability in Ethiopia poses particular risks to poor farmers and pastoralists who depend on climate sensitive livelihoods and natural resources. In addition to the physiological effects of higher temperatures on individual animals, loss of animals as a result of droughts and floods, or disease epidemics related to climate change may increase. Indirect effects may be felt via ecosystem changes that alter the distribution of animal diseases or the supply of feed (ONRS, 2011).

On average about 43% of the national GDP of developing countries is generated by agriculture and related activities (Norton *et al.* 2010, IFAD 2010). For stance, livestock production in Africa accounts for about 30% of the gross value of agricultural production, with 92% of that coming from the production of beef cattle, dairy cattle, goats, sheep, camels and chickens (IFAD, 2009; IUCN, 2010). Ethiopia is home to Africa's largest livestock population and the livestock sector is an integral part of the farming systems in the country. The livestock sector has a significant contribution to Ethiopian economy (Funk *et al.,* 2012). The subsector contributes 16.5% the national GDP, 47% of the agricultural GDP, 15% of export earnings, 30% of agricultural employment and 80% support and sustain livelihoods of all rural population (CSA, 2017).

Pastoralists in Ethiopia are mainly found in six lowland regions; Afar, Oromiya, Somali, Southern Nations, Nationalities and People's (SNNP) Regional States, Gambella and Benishangul-Gumuz Regional States. In this country, pastoralists account for about 16–20 million of Ethiopia's 105 million people and livestock in pastoral regions accounts for an estimated 42% of the country's total livestock population as well as cover 60% of the land area in Ethiopia. The main livelihoods of pastoralists include pastoralism and agro-pastoralism (Behnke *et al*., 2007). Pastoralists in Ethiopia in general and in the Borana lowland in particular have the highest incidence of poverty due to high frequency of drought occurrence and the least access to basic services compared with other areas (Oxfam, 2008).

Annually, Ethiopia loses 2 to 6% of its annual agricultural production due to climate change, unless appropriate adaptation measures are put in place. The impacts of climate change would be manifested more in the loss of agricultural production (MoFED, 2010). Adaptation to climate change is critical and could reduce the adverse impact of climate change on livestock production. The goal of adaptation is neither the prevention of all negative impacts from variable and changing climate, nor merely clean-up after each climatic disturbance or disaster. Rather, the goal of adaptation is long-term resilience, to create the conditions in which society and managed ecosystems are largely able to absorb the impacts from climate variability and change, such that any residual impacts beyond their coping capacity remains within (socially defined) acceptable limits of risks. Adaptation to climate change necessitates that farmers first notice that the climate has changed and then identifies useful adaptations and implement them (Maddison, 2006).

1.2. Statement of the problem

The relationship between the livestock sector and climate change is much more complex and generally overlooked (Reilly et al., 1996; McCarthy *et al*., 2001; Seo and Mendelsohn, 2007) yet livestock plays a crucial role in poverty reduction and rural development in Africa (Nin *et al.*, 2007; Seo and Mendelsohn, 2008; IUCN, 2010). Livestock production in African rural communities largely depends on natural resources specifically pasture and water (Seo and Mendelsohn, 2008; IUCN, 2010). Climate change would therefore affects livestock production directly through effects on livestock performance and indirectly through effects on the environment (Calvosa *et al.*, 2010).

For Borana pastoralists, livestock serve as: source of food, source of income, indicators of wealth and social functions. Recently, the livelihoods of the Borana pastoralists are at risk due to climate change, especially drought. The main important natural resources for livestock production are rangeland and water sources. Drought that occurs from lack of rainfall leads to reduction of both water and forage availability in the rangelands that in turn threatens the survival of livestock and affect livestock production (Rass, 2006). In recent times it has been observed that livestock die more quickly, more regularly, and in larger numbers in this environment in response to dry or drought years compared to what was experienced in previous generations (Solomon, 2003).

In Borana zone, droughts in the 1980s and 1990s resulted in the deaths of 37-42 percent of cattle. Over a period of 17 years, losses in the form of cattle mortality in Borana were valued at some US$300 million (Desta and Coppock, 2004). Taking the 2011 drought as an example, the Food and Agriculture Organization (FAO) estimates that the death rate of cattle, sheep and goats was 60 percent, 40 percent and 25-30 percent (an average of 27 percent), respectively (OCHA, 2011). Thus, Teltelle district of Borana zone where this study was conducted is one of the areas affected by climate change, especially rainfall variability and high drought frequency.

On the other hand, most studies conducted in Borana lowland were mainly focused on the effects of climate variability on livestock population rather than livestock production and productivity. There is also research gap due to many previous studies focused on few districts of Borana zone repeatedly. Therefore, local study is very important to assess effects of climate change on livestock production and productivity in Teltelle district.

To reduce effect of climate change on livestock production herders practice different adaptation options. However, there is little quantitative evidence about effectiveness of climate change adaptation options in the district.

Therefore, the major goals of this study were to investigate effect of climate change in terms of rainfall variability, droughts frequency and high temperature on livestock production and the types of adaptive strategies practiced by herders in Teltelle district of Borana zone.

1.3. Objectives of the study

1.3.1. General objective

The overall objective of this study is to analyze the effect of climate change on livestock production and adaptation strategies in Teltelle district of Borana zone, Southern Ethiopia.

1.3.2. Specific Objectives

1. To analyze long term trends of rainfall and temperature data of Teltelle district.
2. To assess effects of climatic factors on livestock production in the district.
3. To assess rangeland condition in the study area.
4. To assess adaptation strategies practiced by the pastoralists of the district.

1.4. Research Questions

1. What are the long term trends of rainfall and temperature data of Teltelle district?
2. What are major effects of climatic factors on livestock production in study area?
3. What is the condition of rangeland in study area?
4. What types of climate change adaptation strategies practiced by pastoralists of the district?

1.5. Significant of the study

Climate change and variability become a serious challenge for the livestock rearing and crop production in Borana lowland where the amount and distribution of rainfall is insufficient. Local studies are necessary to understand the extent of climate change and adaptation strategies practiced by herders. This study was essential to enable pastoralists and agro-pastoralists of the study area to better understand the effects of climate change and practice adaptation strategies for resilience of communities as well as to serve as references for others researchers who want to do research in this area.

1.6. Scope of the study

Because of the financial and time constraints, the researcher delimited to the study of the effect of climate change on livestock production and adaptation strategies in Teltelle District of Borana zone, Southern Ethiopia, by assessing the perceptions of pastoralist and agro-pastoralist respondents beside analyzing of long term trends of meteorological data of the district.

1.7. Limitations of the study

In this study, the researcher faced many problems and challenges that might had a significant impact on the results of the study. Among these problems: inaccessibility of climate data, unwillingness of respondents to give information, lack of available and relevant recent data source, financial problem and lack of internet access were the major ones.

2. LITERATURE REVIEWS

2.1. Basic Concepts of Climate Change, Effects and Adaptation Strategies

Climate change refers to a change in the state of the climate that can be identified (e.g. by using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcing such as modulations of the solar cycles, volcanic eruptions, and persistent anthropogenic changes in the composition of the atmosphere or in land use. Human influence on the climate system is clear and recent anthropogenic emissions of greenhouse gases are the highest in history (IPCC, 2014).

Climate change has many elements, affecting biological and human systems in different ways. Global average temperature increases mask considerable differences in temperature rise between land and sea and between high latitudes and low; precipitation increases are very likely in high latitudes, while decreases are likely in most of the tropics and subtropical land regions (IPCC, 2007). Climate change is inevitably resulting in changes in climate variability and in the frequency, intensity, spatial extent, duration, and timing of extreme weather and climate events (IPCC, 2012).

Effects of climate change generally refer to effects on lives, livelihoods, health, ecosystems, economies, societies, cultures, services, and infrastructure due to the interaction of climate changes or hazardous climate events occurring within a specific time period and the vulnerability of an exposed society or system. Effects are also referred to as consequences and outcomes. The effects of climate change on geophysical systems, including floods, droughts, and sea level rise, are a subset of effects called physical effects (IPCC, 2014).

Thus, climate change is one of the biggest environmental challenges and it has become a major concern to society because of its potentially adverse impacts worldwide. There are already increasing concerns globally regarding changes in climate that are threatening to transform the livelihoods of the vulnerable population segments. The earth's climate has warmed on average by about 0.7^{o}C over the past 100 years with decades of the 1990s and 2000s being the warmest in the instrumental record (Watson, 2010).

Climate change Adaptation is the process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment to expected climate and its effects (IPCC, 2014). Adjustments or interventions include natural and human systems adjustments or interventions of government organizations, non-governmental organizations, private sectors, public sectors and policies IPCC (2001).

2.2. Theoretical and Empirical Framework

2.2.1. Effect of Climate Change on livestock production in Ethiopia

Ethiopia's climate is typically tropical in the south-eastern and north-eastern lowland regions, but much cooler in the highland regions of the country. Mean annual temperatures are around 15-20°C in high altitude regions, whilst 25-30°C in the lowlands. National average temperature has increased by 1^{0}C since the 1960s (FDRE, 2015). The number of hot days and nights in a year is increasing overtime. On the other hand, the observed trend of mean annual rainfall is not clear (World Bank, 2016). Despite the inter-seasonal and inter-annual rainfall variability, nationally rainfall remained more or less constant in the second half of the twentieth century (FDRE, 2015). In line with the meteorological evidences is that many farmers across Ethiopia perceive that increasing temperature, decreasing and erratic rainfall in their villages in the past twenty to thirty years (Hadgu *et al.,* 2014). Regional projections of climate models indicate a substantial rise in mean temperatures in Ethiopia over the 21st century and an increase in rainfall variability, with a rising frequency of both extreme flooding and droughts due to global warming (Robinson *et al.,* 2013).

In Ethiopia, a significant change in climate has already occurred and this change affected the livestock production system in the country (Anne, 2013). Ethiopia is home to Africa's largest livestock population, and it is the continent's top livestock producer and exporter (MacDonald and Simon, 2011). The recent livestock population of Ethiopia estimates that the country has about 57.83 million cattle, 28.89 million sheep, 29.70 million goats, 2.08 million horses,7.88 million donkeys, 60.51 million poultry, 5.92 million beehive, 0.41 million mules and about 1.23 million camels CSA(2016). At household level, it is a source of high quality food, cash income, and energy for farm activities, soil nutrient and social prestige (Shapiro *et al.,* 2015). Despite of these significant contributions at national and household levels, climate change is a growing threat to the livestock sector in Ethiopia (GoE, 2011).

Climate change is expected to result in fall in productivity, Livestock productivity may be lower that by 50% in 2050s compared to without climate change scenario. Agricultural GDP with climate change may be lower by 3% to 30% than without climate change agricultural GDP in 2050. Climate change may increase the number of people looking for food aid by 30% (World Bank, 2010), increase drought expenses by 72% in 2050s (FDRE, 2015). Livestock productivity is affected most severely under the Ethiopia dry scenario, in which the ratio between future and baseline productivity falls to a low value of approximately 0.70 in the moisture reliable humid lowland zone, or a 30% decline in productivity. Under each scenario, there is a downward trend in productivity over the 2001 to 2050 period (Robinson *et al.*, 2013).

Generally, Shortage of feed and water contribute to reduced productivity and reproductive performance of livestock. This includes slow growth rate of animals, loss of body condition, reduced milk production and poor reproductive performance in mature animals (Woldeamlak *et al.*, 2015). Therefore, climate change and variability in Ethiopia increases feeds shortages and water scarcity in general and particularly true for Borana lowland which affected livestock production and productivity.

2.2.2. Effects of climate change on livestock production in Borana lowland

2.2.1.1. Effects of drought on livestock production

Mengistu (2016) stated that Borana pastoralists operate livestock production under the constraint of climate variability, the single most serious being drought. The majority of pastoralists of Yabello and Dirre district of Borana zone believe that the rain pattern has changed in the past twenty years; that rains have become more erratic, and that there are fewer rainy days. They also believe that the number of hot days in a year has increased. The frequency of drought coupled with the recovery periods of livestock was highly disrupts the livestock size and compositions. Especially, cattle are the most vulnerable livestock type observed in Borana zone.

Other study conducted in Borana lowland also confirmed that, until the early 1980s the Borana pastoral production was considered to be one of the few remaining sustainable pastoral systems in East Africa. Since then, the savannah ecosystem of Southern Ethiopia has been experiencing greater cattle population die-offs during periodic droughts (Desta and Coppock,

2002) and deterioration of the range as evidenced by the proliferation of bush encroachment and a general decline in forage production (Oba *et al*., 2000).

According to Zelalem *et al.* (2009), the four major effects of climate change on livestock production in Borana pastoralists of Moyale and Dillo district include feed shortage, water shortage, reduced productivity, and decreased mature weight and/or longer time to reach mature weight. Again, he reveled that heavy infestation of invasive species due to climate change has reduced the availability of herbaceous species and hence resulted in a critical shortage of feed. On the same way, Stark *et al*. (2011) described that in Borana zone, invasive species linked by pastoralists to both restrictions on bush burning and climate change are severely reducing or eliminating viable grazing areas. Trends indicative of climate change, such as increasingly recurrent drought, floods, erratic rainfall patterns, and high temperatures are adding significantly to these stresses. The effect of climate change on the range lands is remarkable.

Similarly, Abate (2009) reports the drought and delay of rainfall led to increased mortality of livestock, vulnerability to diseases and physical deterioration due to long distance travel for water and pastures. McKeon *et al*. (2009) and Izaurralde *et al*. (2011) also noted that the drought affected livestock production by drying wetlands, pasture land, water resources, streams and decreasing availability of drinking water for livestock. Thus, high frequency of drought and rainfall variability in Borana lowland led to feeds shortages, low livestock production and productivity through destruction of rangeland and affecting water availability and quality.

2.2.1.2. Effects of heat stress on livestock production

Heat stress is a condition in which the body has problems dissipating excess heat. Results of inadequate heat dissipation range from general discomfort to symptoms of heat rash, heat syncope, heat cramps, heat exhaustion, and heat stroke. It is caused by a combination of environmental factors (temperature, relative humidity, solar radiation, air movement, and precipitation) (Habeeb AA., *et al*, 2018).

Heat stress will reduce milk production in dairy cows: a 10% drop in yield at 27-32^{o}C (80-90^{o}F) and 50-90% humidity; and more than 25% drop at 32-38^{o}C (90-100^{o}F) with 50-90% humidity and the effects are more pronounced in higher producing cows. Heat stress also lowers natural immunity making animals more vulnerable to disease in the following days and weeks. Reduced feed intake (which is a natural response to reducing metabolic heat) and rapid shallow breathing; open mouth breathing with panting at higher temperatures. Respiration rates increase with increasing temperatures from 14 to 34^{o}C (57-93^{o}F) (Morrill K., 2011). High production animals are subjected to greater influence by climatic factors, particularly those rose under tropical conditions, due to high air temperatures and relative humidity.

For the same temperature increase, Thornton *et al*. (2008) predicted a dry matter intake decrease by 18% and milk decrease by 32%. Parons *et al*. (2001), also argued that high temperatures may reduce feed intake, lower milk production, lead to energy deficits that may lower cow fertility, fitness and longevity. As Amundson *et al* (2006) reported Reproductive functions of livestock are vulnerable to climate changes and both female and males are affected adversely. Heat stress also negatively affects reproductive function. The climate change scenario due to rise in temperature and higher intensity of radiant heat load will affect reproductive rhythm via hypothalamo- hypophyseal–ovarian axis. The main factor regulating ovarian activity is gonadotropin-releasing hormone from hypothalamus and the gonadotropins i.e. follicle-stimulating hormone and luteinizing hormone from anterior pituitary gland (Madan and Prakash, 2007).

According to the FAO (2007) among the direct effects of climate change are high temperatures and changes in rainfall patterns, translating in an increased spread of existing vector-borne diseases and macro parasites of animals as well as the emergence and spread of new diseases. Climatic factors or seasonal changes greatly influence the behavior of animals due to neuroendocrine response to climatic elements, consequently affecting production and health of animals (Sejian *et al*., 2010; Baumgard *et al.*, 2012). So, changes in climatic factors such as temperature, precipitation and the frequency and severity of extreme events like droughts in Borana pastoralist was directly affected livestock yields, including milk and milk production (Martello *et al.,* 2010).

2.2.2. Climate Change Adaptation Strategies

2.2.2.1. Climate change adaptation strategies in Ethiopia

Adaptation to climate change at the regional level can be categorized into two primary categories: indigenous adaptation and system or introduced adaptation (Hoffmann, 2010). Increased effects of climate change make the rural agrarian people to practice various adaptation and coping strategies. These include mainly indigenous knowledge and wide variety of skills developed outside the formal education over a long period of time among the rural communities (Moongi *et al*., 2010).

Among introduced adaptations improving local genetics through cross breeding with heat and disease tolerant breeds, strengthening local breeds that have adapted to local climatic stress and feed sources as well as improving veterinary services. If climate change is faster than natural selection the risk of survival and adaptation of the new breed becomes greater (Hoffmann, 2008).

The acceptance of climate change adaptation strategies is determined by numerous demographic, socioeconomic and organizational or institutional characteristics (Deressa *et al.* 2009, Hassan and Nhemachena 2008, Shongwe *et al*. 2014). Several studies have confirmed that adaptation to climate change increases food productivity (Falco *et al*. 2011). However, Howden *et al*. (2007) argued that achieving increased adaptation action will require integration of climate change related issues with other risk factors. In most cases, simple and feasible adaptation such as altering varieties and planting times to avoid drought and heat stress avoid significant negative impacts on crops. Therefore, assessing the effectiveness of adaptation options, enhancing existing climate risk management, understanding likely adoption rates, and developing more resilient agricultural systems are urgently needed.

A better understanding of climate change adaptation choices and adoption of adaptation strategies to address the increasing water scarcity over time is becoming a great concern to policy makers to comprehend the tendency of adaptation changes, and their barriers to adaptation. To limit the impact of climate change, it is therefore relevant to examine the uptake of indigenous and introduced climate change adaptation strategies in Ethiopia. Rural producers of arid and semi-arid areas where there is recurrent drought and unreliable rainfall have learned to cope with the existed situations. However, in the course of widespread poverty, highly unpredictable rainfall pattern and frequent extreme events coupled with increasing population and fragile resources, these coping strategies are becoming insufficient (Oxfam, 2010).

Adaptation strategies address not only the tolerance of livestock to heat, but also their ability to survive, grow and reproduce in conditions of poor nutrition, parasites and diseases (Hoffmann, 2008). Such measures could include: (i) identifying and strengthening local breeds that have adapted to local climatic stress and feed sources and (ii) improving local genetics through cross-breeding with heat and disease tolerant breeds. Livestock producers have traditionally adapted to various environmental and climatic changes by building on their in-depth knowledge of the environment in which they live. However, increased human population, urbanization, environmental degradation and increased consumption of animal source foods have made some of those coping mechanisms ineffective (Sidahmed, 2008).

The following have been identified by several experts (FAO, 2008; Thornton, *et al*., 2008; Sidahmed *et al*, 2008) as ways to increase adaptation in the livestock sector: Production adjustments: diversification, intensification, integration, of pasture management, livestock and crop production, changing land use and irrigation, altering the timing of operations, conservation of nature and ecosystems.

2.2.2.2. Climate change coping strategies in Borana pastoral areas

Coping strategies refers to the strategies that have evolved over time through peoples' long experience in dealing with the known and understood natural variation that they expect in seasons combined with their specific responses to the season as it unfolds (Cooper *et al*., 2008). In Southern Ethiopia, pastoralists have been developed various possible coping strategies to overcome the distress effect of drought through their experience. However, the increased frequency of drought threatens to overwhelm these coping mechanisms and resilience of the pastoralists (Stark and Ejigu, 2011).

The pastoralists practice some adaptation and coping strategies for their resilience of communities. From these strategies, herd mobility is one of the long history livestock related coping strategies that dictated by season and the availability of forage, as well as personal relationships, family structure, and immediate demands in search of water and pasture. Nowadays, herd mobility was highly confronted by different factors such as expansion of farm land, land degradation and bush encroachment. On the other hand, the proportion of goat to other livestock was increasing in spite of the recurrent demolition effect of drought. It is a clear indication that goat population are ascended due to its reproduction frequency characteristics, drought resistant, low feeding cost, economical purchasing cost and management especially during feed shortage. As a result, the populations of small ruminant are relatively increasing than other livestock, cattle, though a social affair is favoring cattle (Mengistu, 2016).

A water resource is a key resource affected during severe drought in Borana pastoralist area. Build of water harvesting scheme such as deep well and shallow pond to harvest available rain water both for human and livestock drinking are common. However, still the favorable quality of drinking water is a challenge. As compared to the dry season, the average distances from water sources are much lower in wet season. But, it needs an integrated effort to develop sufficient potable water or water healing mechanism to overcome problem related to water cleaning issues (Habtamu *et al.*, 2012).

Therefore, improving water resource management and expansion of motorized water scheme, and improving breeds system that are tolerant to drought and heat stress were very important to climate change adaptation strategies in Borana lowland which improved livestock production and productivity.

2.3. Conceptual Framework of the study

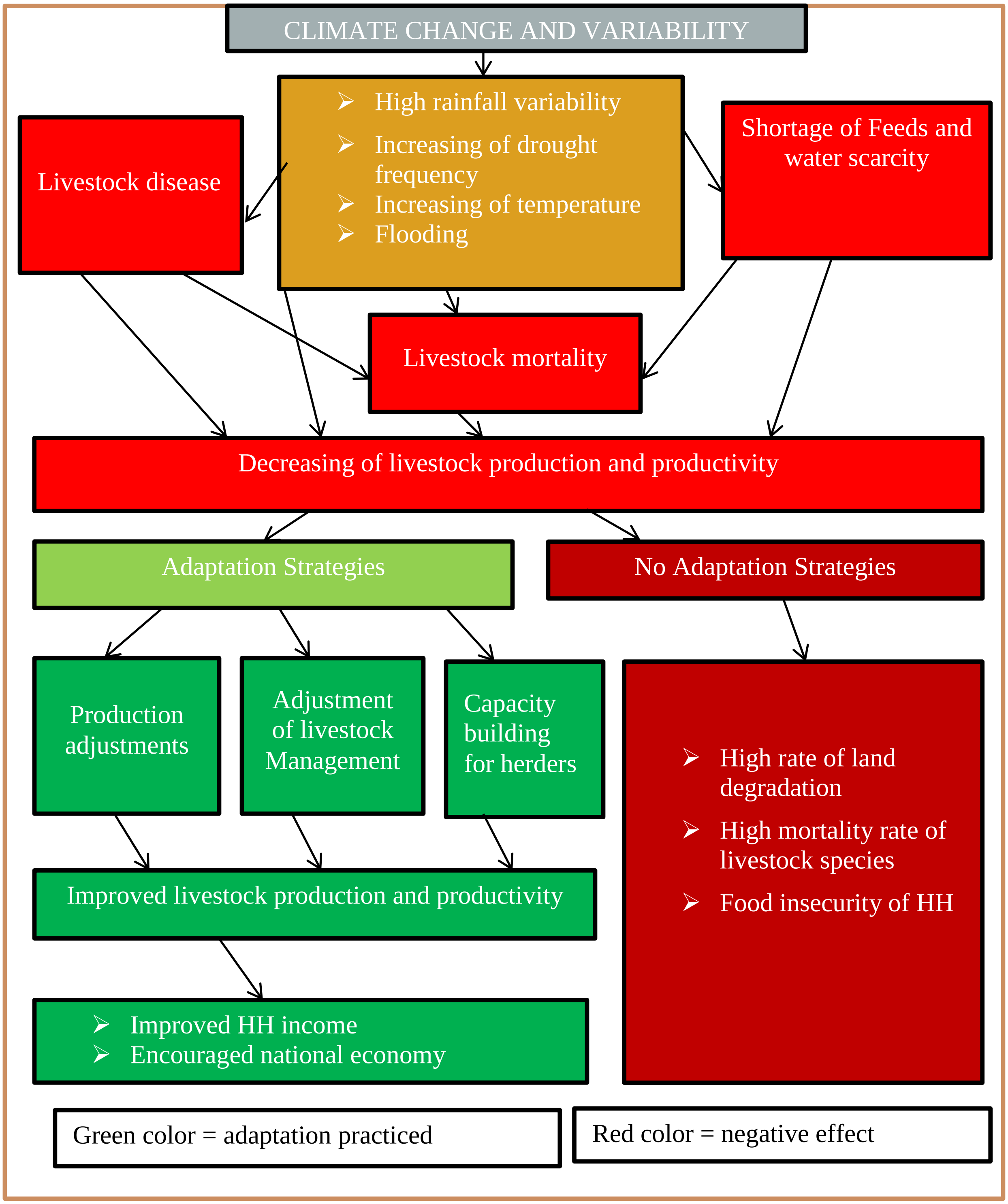

Figure 1: Conceptual framework of the study

Source: Adopted from Hoffmann, (2010).

3. MATERIALS AND METHODS

3.1. Description of Study Area

3.1.1. Geographical location of Teltelle district

The study was conducted in Teltelle district of Borana zone, Southern Ethiopia. Teltelle district is one of the 13 rural districts of Borana zone in Oromiya National Regional State. The district is located 668 km South of Addis Ababa and 100 km South West of Yaballo, zonal city, between $4^0$01’33”N - $5^0$14’12”N latitude and $36^0$40’04”E - $37^0$37’13”E longitude in the West of Borana zone (Arc GIS 10.1, 2013). It is bordered on the South by Dillo district of Borana zone and Kenya, on the West and North by the SNNPRS, and on the East by Elwayya district of Borana zone. The total area of the district is 8,586.9 km^2 (TDADO, 2018).

3.1.2. Agro-ecology of Teltelle district

Agro-ecology of the district is characterized by arid climate with low and erratic rainfall. The altitude of the district ranges from 400 masl up to 1840 masl (Arc GIS 10.1, 2013). The district experienced bimodal types of rainfall; *Gann*a (March, April and May) is main rainy season and *Hagayya* (September, October and November) is short rainy season, and two dry seasons; *Bona Hagayya* (December, January and February) is dry and hottest season and *Bona Adoolessa* (June, July and August) is dry and coldest season. Between 1981-2016 years, the rainfall of short rainy season was range from 316mm to 261mm and main rainy season was range from 113mm to 397mm, while the annual rainfall of the district was range from 316mm to 749mm. Temperature ranges from 19^oC to 35^oC with average of 29^oC (ENMA, 2018).

3.1.3. Human Population of Teltelle district

The total human population of the district is 104, 148, of whom 51,800 are male and 52,348 are female (TDAO, 2018).

3.1.4. Production system in Teltelle district

Major production systems of the district are pastoral and agro- pastoral systems. Cattle, goat, sheep, donkey, mule, camel and poultry are major livestock raised, while maize, sorghum, teff, wheat and haricot-bean/common-bean are major crops produced in study area. Soil types in district are *vertisols* (black soil), *fluvisols* (brown soil) and *Ferrasol* (red soil) (TDADO, 2018).

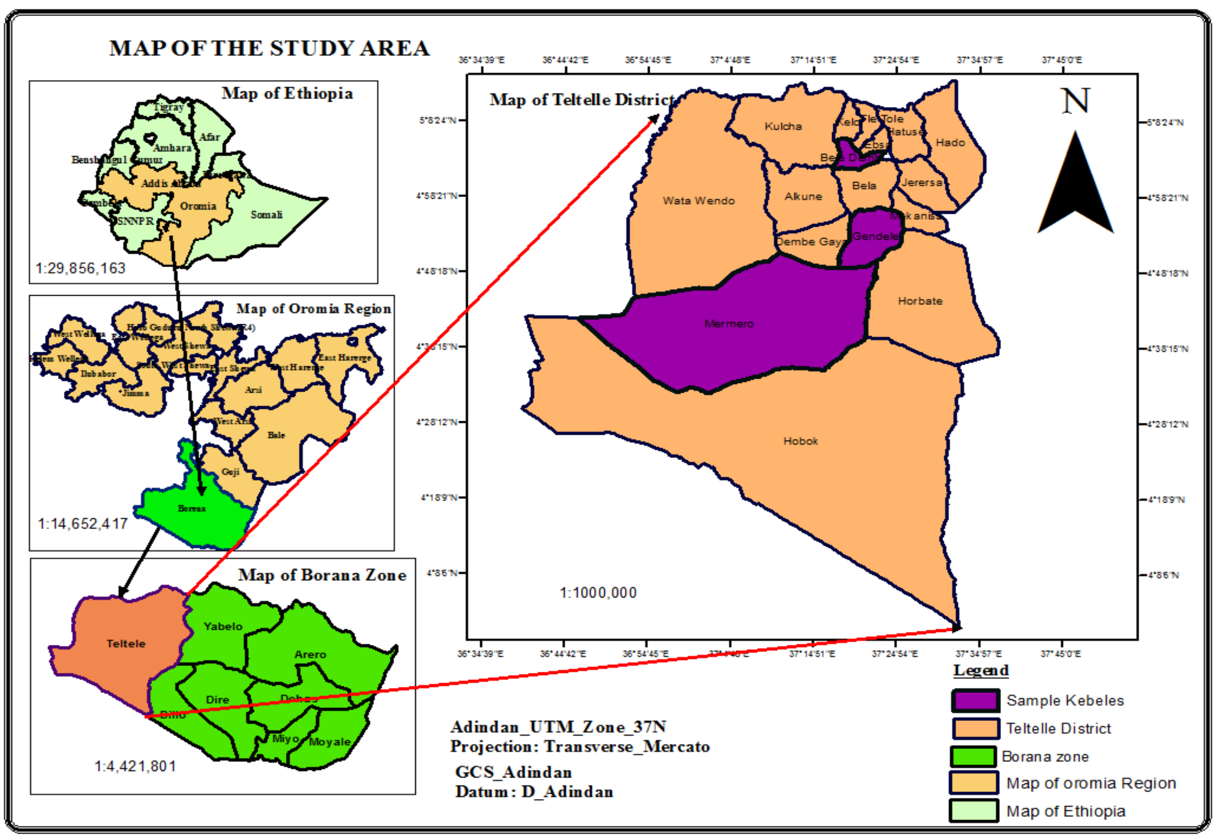

Figure 2: Map of study area

Source: Processed from Arc GIS 10.1, (2013).

3.2. Research Design

Cross-sectional survey was conducted to collect data about effects of climate change on livestock production and adaptation strategies practiced by pastoralists. Both qualitative and quantitative data were collected at one point in time from a sample selected to represent a larger population.

3.3. Sampling Techniques and Procedures

Target population of the study was households of the district who own livestock and the study was following a multi-stage sampling procedures. The selection of the district is predicated on spatial difference, which links to the fact that vulnerability of climate change effects on livestock production and hence adaptation measures vary from place to place. Accordingly, Teltelle district was purposively selected with the main criteria of the severity effects of drought and represents the major production systems of the district. The district has 21 *kebeles* with 13,899 HHs (13 agro-pastoral *kebeles* which have 8,736 HHs, 6 pastoral *kebeles* that have 3,793 HHs and 2 urban *kebeles* which have 1,370 HHs*)*. Secondly, the district was divided into two strata by using stratified sampling procedure based on production systems of the district(pastoral and agro-pastoral), and probability proportional to size method 1 *kebele* from pure pastoral and 2 *kebeles* from agro-pastoral, totally 3 *kebeles* were selected by using simple random sampling procedure. Then, sampling households were selected by using systematic random sampling technique. Simplified formula provided by Yamane (1967) was used to determine the required sample size at 95% confidence level and 7% level of precision as showed below.

$$\boldsymbol{n} = \frac{\boldsymbol{N}}{(\mathbf{1}+\boldsymbol{N}(\boldsymbol{e})^{\mathbf{2}})} = \frac{\mathbf{2027}}{(\mathbf{1}+\mathbf{2027}(\mathbf{0.07})^{\mathbf{2}})} = \mathbf{185}$$

Where n is sample size, N is total population of selected *kebeles* and e is precision level.

Bowley's (1926) proportion allocation method was used to assign sample sizes for each selected *kebele*. $\mathbf{ni} = \frac{nNi}{N}$ Where ni is assigned sample size for each *kebeles*, n is total sample size, Ni is population size of single *kebele* and N is total population.

Table 1: Sample households of the study area

Sample *kebeles*	Production system	Household size			Sample size		
		Male	Female	Total	Male	Female	Total
Bule Dambi	Agro-pastoral	407	83	490	40	5	45
Gandhile	Agro-pastoral	495	135	630	53	4	57
Marmaro	Pastoral	802	105	907	74	9	83
Total		1704	323	2027	167	18	185

3.4. Data Type and Data Source

Both primary and secondary data were used for the study. Primary data were collected directly from sample households, focus group discussions members and key informants through questionnaires. Secondary data were obtained from Ethiopia National Metrological Agency (ENMA), and District livestock resource development office.

3.5. Methods of Data Collection

3.5.1. Meteorological Data

Thirty six years of meteorological data including monthly rainfall, and mean monthly maximum and minimum temperature of the district were obtained from Ethiopia National Meteorology Agency (ENMA). Based on meteorological data taken from ENMA, climate data of the district were analyzed to observe the trends of climate variables during 36 years.

3.5.2. Household survey

Semi-structured questionnaires were prepared both for qualitative and quantitative data and the pastoralists were interviewed on related issues about their perception of climate change, effect of climate change on livestock production and adaptation strategies practiced by herders. The interview schedule was pre-tested among 20 randomly selected pastoralists from 2 non-sampled *kebeles* having similar characteristics to the sampled household and one *kebele* from each production systems (pastoral and agro-pastoral). Data collection from households was carried out by applying face to face interview of the pastoralists.

3.5.3. Key informant interviews (KII)

A total of thirteen (13) key informant including; 3 developmental agent, 6 elder informants,3 traditional early warning predictor (*uchuu*) distributed each for 3 sample *kebeles*, and 1 expert from district livestock resource development office were selected to generate information about effects of climate change on livestock production and adaptation strategies.

3.5.4. Focus Group Discussions (FGDs)

Six (6) FGDs of Pastoral and agro-pastoral representing different age groups, with different education level, both male and female, and different wealth groups were selected from each sampled *kebeles*. Relative wealth status ranking method was used to identify wealth groups; which declare that a household is poor or rich in the context of its village. Two (2) FGDs from each 3 *kebeles* and one FGD comprised of 8 individuals, totally 48 FGD members were used during discussion. The discussion was aimed to assess the effects of climate change and adaptation strategies for livestock keepers. It was help to cross-check the data obtained from household survey.

3.5.5. Field Observation

Field observation was conducted throughout the whole process of the research in order to make sure that the validity of information obtained.

3.5.6. Livestock population data

Ten years livestock population data and reports of livestock mortality during 2016 drought were obtained from District livestock resources development office by short checklist interviews.

3.6. Methods of Data Analysis

To achieve objectives of the study, both descriptive (percentages, frequency, rank index and mean value), and inferential (multinomial logit model) statistics were used to analyze collected primary and secondary data while MS excel, Statistical Packages for Social Sciences (SPSS) version 20 and STATA version 14.2 were the majors tools for analyzed data and present the findings of the study.

Trends of long term rainfall and temperature data were analyzed as monthly, seasonally and annually by undertaking linear trend analysis. Long term rainfall data were also analyzed as seasonally and annually by using Standard Precipitation index (SPI) and Coefficient of Variation (CV). SPI was used to quantify the precipitation deficit for multiple timescales.

Table 2: SPI values to define drought magnitude

SPI Values	Moisture levels
≥ 2+	extreme 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
-1.5 to -1.99	severe drought
≤ -2.00	extreme drought

Source: McKee *et al*. (1993).

Standardized Precipitation Index (SPI) was calculated as the difference between the annual total of a particular year and the long term average rainfall records divided by the standard deviation of the long term data. SPI= $(X-\bar{X})/SD$ Where SPI is Standardized Precipitation Index, X is discrete precipitation data, $\bar{X}$ is mean and SD is Standard Deviation.

Intra seasonal rainfall Variability was analyzed using the coefficient of variation (CV). According to Hare (1983), CV (%) values were classified as follows: < 20% as less variable, 20-30% as moderately variable, and > 30% as highly variable. CV= $SD/\bar{X}$ *100 Where CV is Coefficient of Variation; SD is Standard Deviation and $\bar{X}$ is mean.

Mann-Kendall test was also used to analyze the long term trend of rainfall and temperature data of the district. Man-Kendall test, a technique based on the Kendall tau statistics has been introduced to test for randomness against trend in climatological time series (Zhang. *et al*, 2001). The test statistics(S) for the Mann-Kendell test is given as:

$$s = \frac{\sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \operatorname{sgn}(Y_j - Y_i}{\sigma_s} \qquad \sigma_s = \sqrt{\frac{N(N-1)(2N+5) - \sum_{i=1}^{n} t_i i(i-1)(2i+5)}{18}}$$

Where: N is the number of data, Yj and Yi are the data values in two consecutive periods; ti is the number of ties, i.e. equal values, of extent i and N is the number of tied groups. The function sign(Yj-Yi)=1 if Yj- Yi >0; sign(Yj- Yi)=0 if Y=0 and sgn(Yj- Yi)=-1 if Yj- Yi<0.

The long term relationship between climate data and livestock population were analyzed by multiple regressions and correlation analysis. The equation for multiple linear regression relationship is expressed as: $Yi = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 \ldots\ldots\ldots + \beta_k X_k + \varepsilon_{i,}$ Where Yi is the dependent variable, $X_1 \ldots. X_k$ are independent (explanatory) variables considered to have influence on the Y variable. β_1 ….β_k are regression slopes corresponding to the respective Xi. So, β_i is defined as the rate of change in Y for a unit change in Xi, while the effects of the other independent variables remain constant. ε_i is the residual variance in Y after taking into consideration the effects of the Xi variables included in the model. Correlation analysis between data of rainfall, temperature and livestock population is given as below:

$$r = \frac{\Sigma xy}{\sqrt{(\Sigma x^2)(\Sigma y^2)}}$$

Where r is correlation coefficient, X is independent and Y is dependent variables

Major factors affecting livestock production and rangelands in the district were analyzed by using ranking index method. Ranking index method was computed with the principle of weighted average which employed by Musa *et al.*, (2006): Index = Rn*C1+Rn-1*C2+….+R1*Cn/∑ Rn*C1+ Rn-1*C2….R1*Cn Where; Rn= Value given for the least ranked level (example if the least rank is 3rd rank, then Rn=3, Rn-1=2 and … R1= 1). Cn= Counts of the least ranked level (in the above example, the count of the 3rd rank = Cn, and the counts of the 1st rank = C1).

Following the descriptive statistics, the study employed multinomial logit model to assess adaptation strategies and factors affecting adaptation choices of the herders'. The MNL model was used by many researchers to analyzed climate change adaptation strategies of farmers/pastorals (Nhemachena and Hassan, 2008; and Temesgen *et al.*, 2009;). Therefore, the multinomial logit model is appropriate model to analyzed climate change adaptation strategies of pastoral and agro-pastoral of 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 pastoralists, then equation representing as;

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

Where *i* takes values (1, 2, 3, 4, 5, 6), each representing the choice of adaptation option (1= Livestock diversification, 2= Hay making 3= Temporary migration for searching water and feed, 4= Area enclosure, 5= Bush thinning, 6= Income diversification).

$X_1 \ldots X_k$ 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,

$$P(Y_i = j) = \frac{e_{zj}}{\sum_{k=0}^{j} e_{zk}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

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 pastoral 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).

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

Before running the model, it is useful to look into account the problem of multicolinearity among the independent variables. The explanatory variables for this study include household characteristics such as gender, age of the household head, education level, family size, farm size , and livestock ownership; institutional factors such as extension services on livestock production, information on climate, access to credit and market.

Variance inflation factor test was used to test the multicolinearity for continuous independent variables. Multicolinearity associated with variance inflation factor is defined as:

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

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 multicolinearity in the variable (Xi).

3.7. Variables of the study

Table 3: Variables of the study

Independent variables	**Definition**
Sex of the household	Dummy 1 if male, 0 otherwise
Age of the household	Continuous
Education level	Categorical
Family size	Continuous
Source of Income	Continuous
Livestock holding	Continuous(in TLU)
Land holding	Continuous(ha)
Access to climate information	Dummy 1 if there, 0 otherwise
Access to extension services	Dummy 1 if there, 0 otherwise
Distance to market	Continuous (km)
Access to credit services	Dummy 1 if there, 0 otherwise

4. RESULTS AND DISCUSSION

4.1. Trend Analysis of Climate Data of Teltelle District

4.1.1. Trend analysis of rainfall data

4.1.1.1. Trends of monthly rainfall

The trend of monthly rainfall of Teltelle district is shown in Fig 3 and 4. Monthly rainfalls of main rainy season (March, April, and May) were decreasing by -0.562mm, -0.109mm, and -0.056mm respectively in the years of 1981-2016. The March, April and May range from 17mm to 93mm, 32mm to 212mm, 18mm to 141mmrespectively. The mean and SD of March, April and May were 53.32±24.073mm, 109.18±45.6m,75.33±29.97mm, respectively.

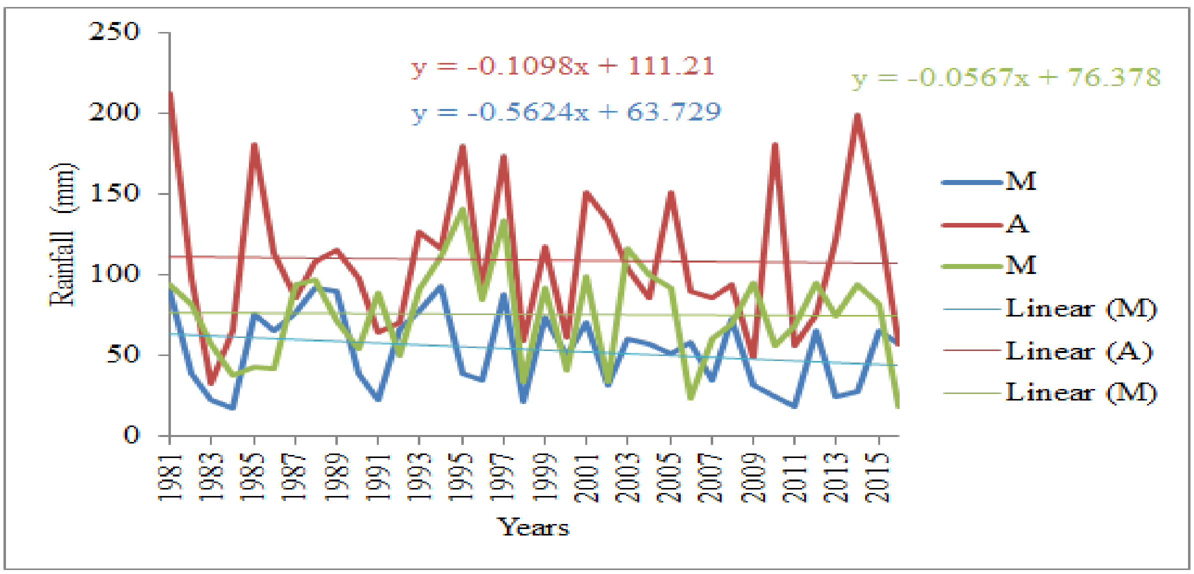

Figure 3: Trends of monthly (MAM) rainfall of Teltelle district
Note: M, A and M indicate March, April and May respectively.

On the other hand, the trend of monthly rainfall of September was decreasing by and -0.154mm while rainfall trends of October and November were increasing by 0.038mm and 0.591mm respectively. Monthly rainfall of September, October and November were range from 10mm to 53mm, 35mm to 116mm and 13mm to 147mm respectively. The means and SD of September, October and November were 24.83±12.23mm, 63.74±17.488mm and 63.11±35.708mm respectively.

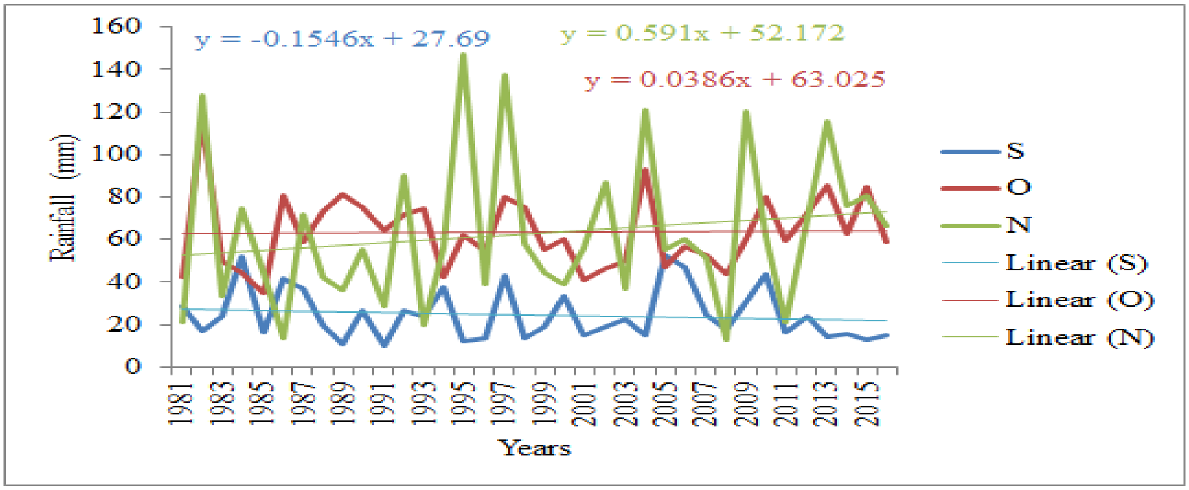

Figure 4: Trends of monthly (SON) rainfall of Teltelle district
Note: S, O and N indicate September, October and November respectively.

The trend of monthly rainfall is very important to analyze the duration and amount of seasonal rainfall of one location. Too late, early and variability in monthly rainfall has effect on seasonal rainfall, because seasonal rainfall is the sum of each monthly rainfall of those months categorized under that season. As Figures 3 and 4 showed, the trends of four monthly rainfalls were decreasing except two months (October and November) in last 36 years. Decreasing trends of monthly rainfalls had negative effect on both main and short rainy seasons of the district, which affects livestock production through affecting feeds and water availability for livestock.

4.1.1.2. Trends of seasonal rainfall

Trends of seasonal rainfall in the study area are presented in Fig 5. Last 36 years of meteorological data of the district shows that, main seasonal rainfall was decreasing by -0.728 mm and short rainy season slightly increasing by 0.008mm. The main and short seasonal rainfalls were ranged from 112.6mm in (1983) to 396.668mm in (1981), and 35.8mm in (2016) to 260.99mm in (1982) respectively, while the mean and SD of main and short seasonal rainfalls was 237.83±76.05mm and 148.8±50.51mm respectively. The CV of main and short seasonal rainfalls was 31.97% and 33.9% respectively in last 36 years.

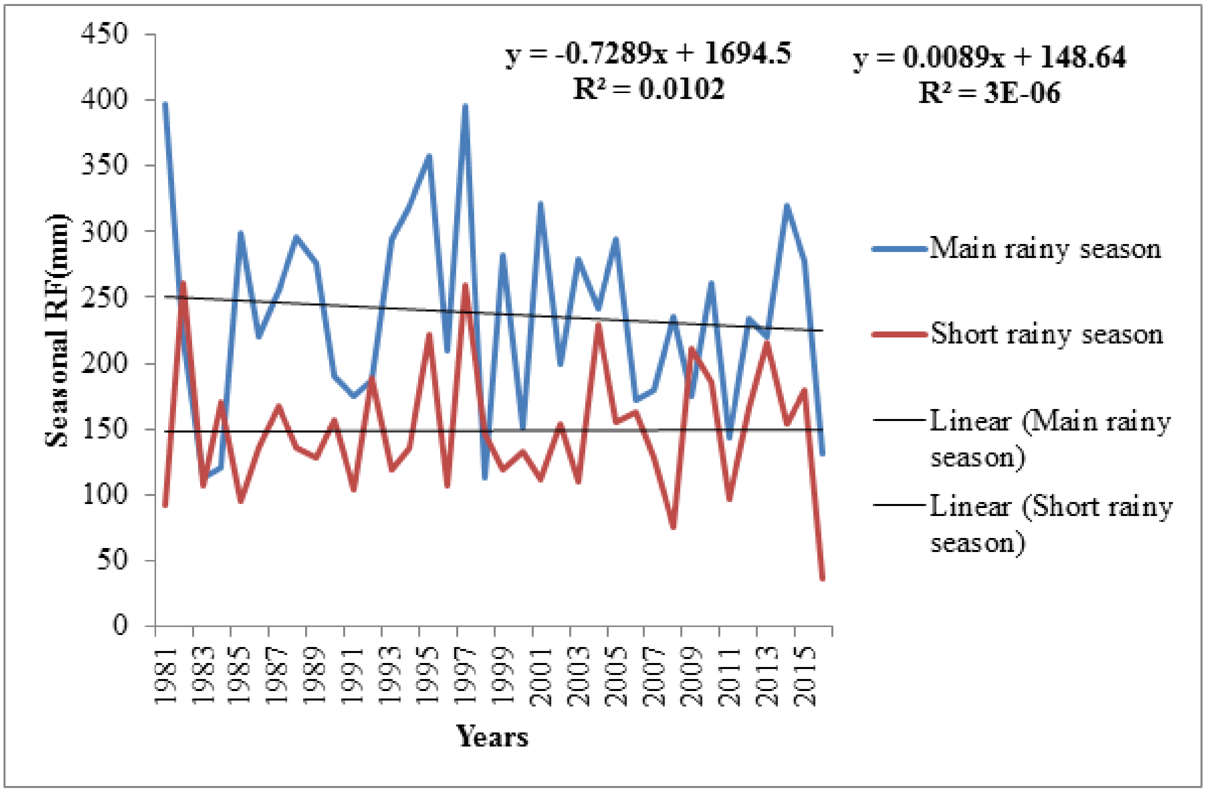

Figure 5: Trends analysis of seasonal rainfall of Teltelle district

According to NMSA (1996), a rainfall amount with CV of less than 20% is less variable, CV between 20% and 30% is moderately variable and CV greater than 30% is highly variable. So, the study site experienced high rainfall variability during two seasonal rainfalls. As value of CV increase the livestock population rate decrease, especially cattle and sheep. This indicated that variability of rainfall lead to decreasing in livestock population which had negative effects on livestock productivity. Generally, the result of 1981-2016 years of seasonal rainfalls of the district showed decreasing of rainfall and highly variable in pattern. Especially, decreasing in the main rainy season had major negative effects on livestock production and productivity.

This resulted was supported by studies conducted in Borana zone. Tilahun *et al.,* (2017) confirmed that the distribution of seasonal rainfall is more important than total quantity in determining primary productivity. The seasonal rainfall of Borana zone during main rainy season is erratic and its pattern highly variably in amount. Pastoralist and agro-pastoralist depends highly on the main season rainfall and decrease in the amount of rainfall has resulted in tremendous death of livestock. Similarly, Adugna and Aster (2007) noted that the Borana area experiences bimodal rainfall thus dividing the year into four seasons: two wet and two dry seasons. However, the rainfall pattern is very erratic and unpredictable, making crop production unreliable. The actual length of the rainy season is getting shorter and shorter through time, and the area is more prone to frequent droughts.

4.1.1.3. Trend of annually rainfall

The trend of annual rainfall of Teltelle district is presented in Figure 6. Meteorological data of the district showed that the trend of annual rainfall of 36 years was decreasing in the amount. The trend of annual rainfall of the district had been decreasing by -0.7639mm, and ranged from 316.477mm in 1983 year to 748.976mm in 1995 year, whereas mean annual rainfall of the 36 years was 507.8±103.73mm. Out of 36 years, annual rainfalls of 18 years were below average and CV of annual rainfall was 20.43%.

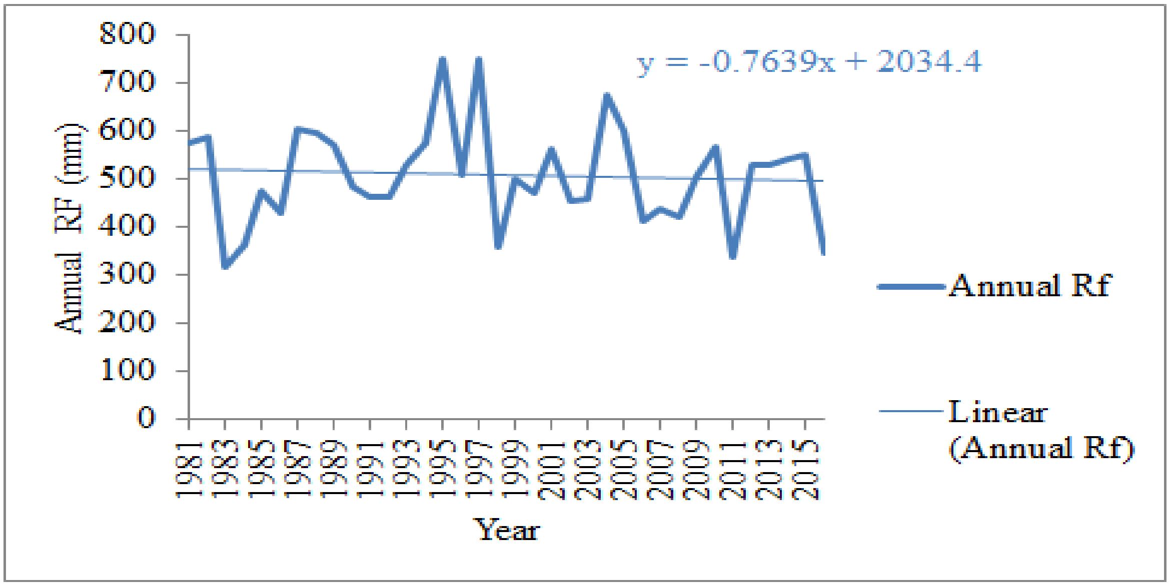

Figure 6: Trend analysis of annual rainfall of Teltelle district

This reduction of annual rainfall of the district is supported by others researches. The average annual rainfall reduction in Borena is far greater than the national average and the experience of highland Ethiopia (Woldeamlak and Conway, 2007).

4.1.2. Drought analysis in study area

4.1.2.1. Analysis of seasonal standard precipitation index (SPI)

The seasonal drought analysis of the study area is presented in Figure 7. The result of SPI seasonal rainfall of the district indicated that out of 36 years, the main seasonal rainfall of 19 years were below average, while 12 years were categorized as different drought types based on its SPI value. That means during the 12 years the district had been affected by shortages of rainfall. Drought years of 1983, 1984, 1992, 1998, 2000, 2007, 2011 and 2016 were categorized as extreme main rainy season drought (SPI values: -7.03, -4.84, -4.81, -6.5, -8.62, -2.24, -3.62 and -4.69), and 1990, 1991, 2006 and 2009 severe main rainy season drought (SPI values: -1.54, -1.9,-1.99 and -1.92) respectively.

On the other hand, the result of SPI of short seasonal rainfall showed that 18 years of 36 years short seasonal rainfall were below average and out of those years, 14 years of rainfall amount categorized as different drought types. Drought year of 1981,1983,1985,2003, 2008, 2011 and 2016 categorized as extreme short rainy seasonal drought (SPI values of those years: -5.19, -3.09, -3.76, -2.86,-4.5, -2.21 and -4.08), 1991, 1996, 1999 and 2001 severe short seasonal rainfall drought (SPI value: -1.64, -1.99, -1.59 and -1.785), and 1994, 2000 and 2007 moderate short seasonal rainfall drought (SPI value: -1.37, -1.113 and -1.32) respectively.

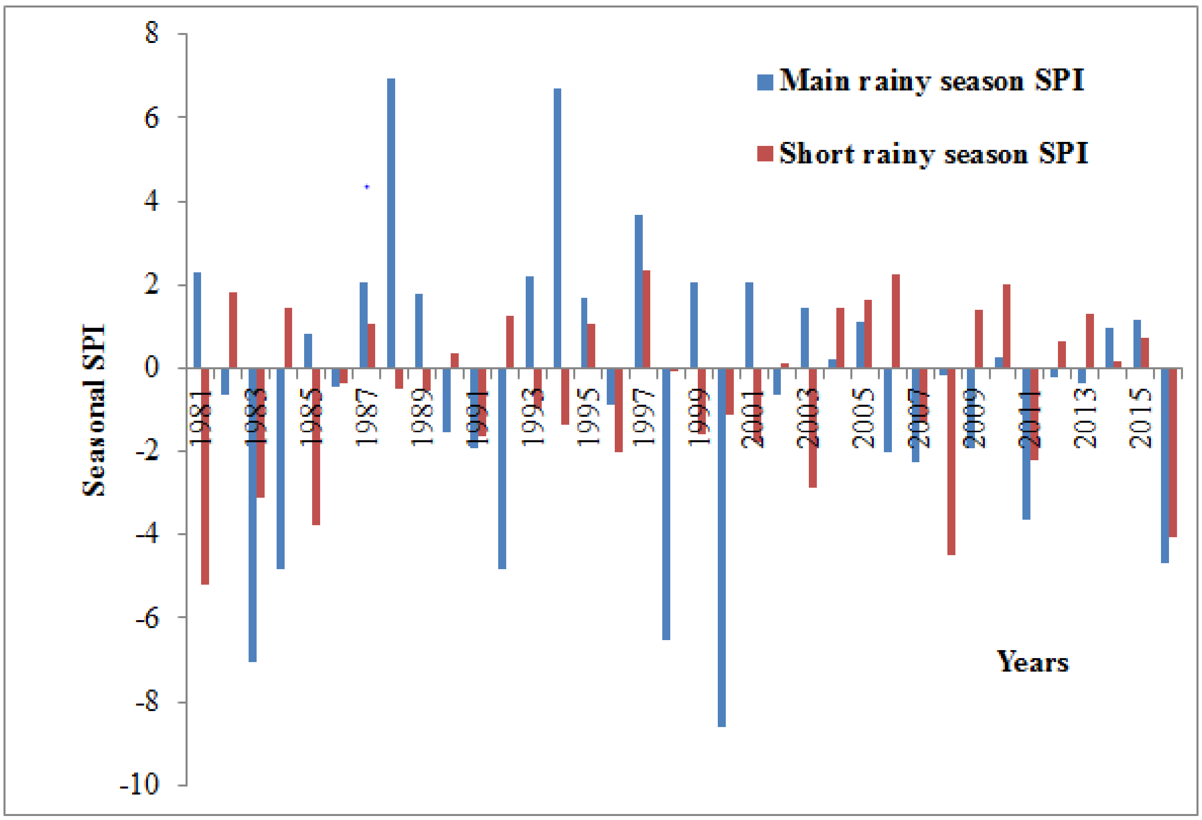

Figure 7: Seasonal SPI of Teltelle district

Drought is a common phenomenon in study area, but the frequency, severity and magnitude is different from before. Droughts occur due to either failure of the main and short rainy seasons or below average of both rainy seasons. As figure 7 showed the frequency of both main and short rainy seasonal drought increased from decade to decade with major effect on livestock production and productivity.

4.1.2.2. Analysis of annual standard precipitation index

The annual drought analysis of the district is shown in Figure 8. According to meteorological data of the district, out of 36 years of annual rainfall half (18) year's annual rainfall is below average and district had been affected by shortage of rainfall for 14 years. The drought years of 1983, 1984, 1986, 1998, 2006, 2007, 2008, 2011 and 2016 were categorized as extreme annual drought (SPI values: -11.888, -5.907, -2.243, -6.181, -3.557, -2.868, -3.026, -7.954 and -6.824), and 1991, 1992, 2000, 2002, 2003 were moderate annual drought (SPI values: -1.367, -1.485, -1.109, -1.489 and -1.344) respectively in the district.

Figure 8: SPI of Annual rainfall of Teltelle district

Among the major annual drought years of (1983, 1984, 1986, 1991, 1992, 1998, 2000, 2002, 2003, 2006, 2007, 2008, 2011 and 2016), the droughts of 1983, 1986, 1991, 2000, 2007, 2011 and 2016 were due to the failures of both the main and short seasonal rainfall, while the droughts of 1984, 1992, 1998, 2002 and 2006 were due to failure of main seasonal rainfall, and 2003 and 2008 drought year due to the failure of the short seasonal rainfall. Out of three decades of last 36 years, the last of three decade (2001-2010) had high drought frequency which shows climate variation from decade to decades or year to year which takes high livestock mortality in the district (See Figure 17).

A research conducted by Oxfam International (2010) also confirmed that in 1972-1974, 1984-1985, 1999-2000, 2002-2003, 2007 drought attacked lowlands of the region, particularly resulted in the loss of thousands of livestock in Borena zone. Droughts have frequently hit the Borana area, causing heavy livestock mortalities, particularly of cattle (Desta and Coppock, 2002; Angassa and Oba, 2007).

4.1.3. Trend analysis of the temperature

4.1.3.1. Trends of mean monthly maximum temperature

The result of 36 years meteorological data of mean monthly maximum temperature trend of the district is presented in Figure 9 and 10. As Figure 9 shows the trend of mean maximum temperatures of December and February were increasing by 0.016^0C and 0.034^0C respectively, while the trend of mean monthly maximum temperature of January was slightly decreasing by -0.005^0C. The mean and SD of maximum temperatures of December, January and February were 31.7 ± 2.09^0C, 33.248 ± 1.9^0C and 34.075 ± 1.7^0C respectively.

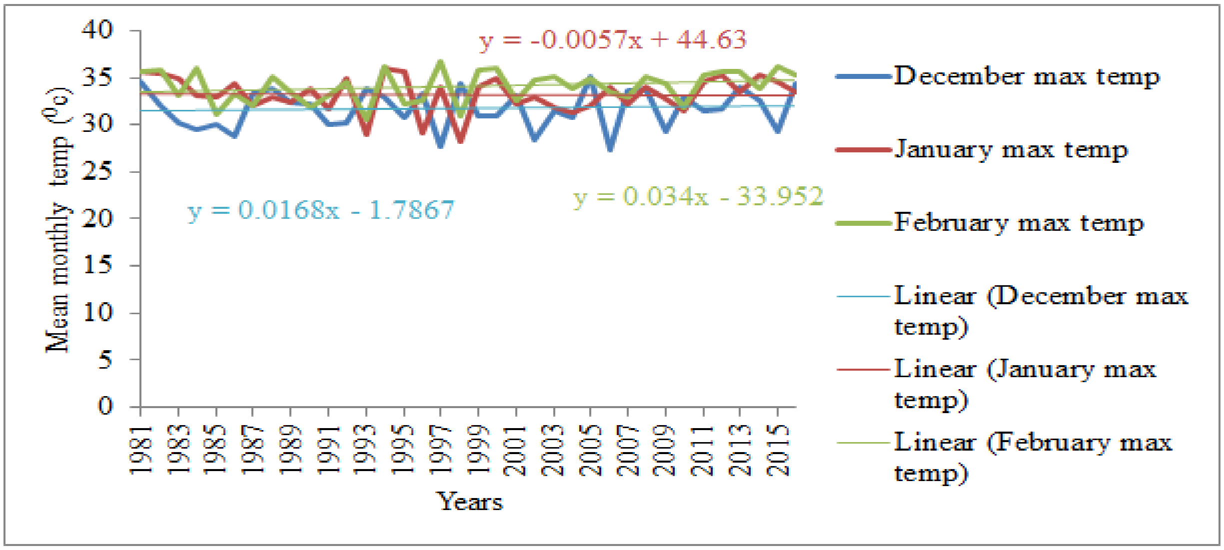

Figure 9: Trend of mean monthly (DJF) maximum temperature of the district

Note: max temp and min temp means maximum temperature and minimum temperature

On the other hand, the trend of maximum temperatures of June, July and August were increasing by 0.012^0C, 0.033^0C and 0.020^0C, and range from 25.88^0C to 30.86^0C, 26.77^0C to 30.23^0C and 28.63^0C to 31.42^0C respectively. The mean and SD of maximum temperature of JJA were 29.54 ± 1.032^0C, 29.096 ± 0.732^0C and 30.16 ± 0.556^0C respectively.

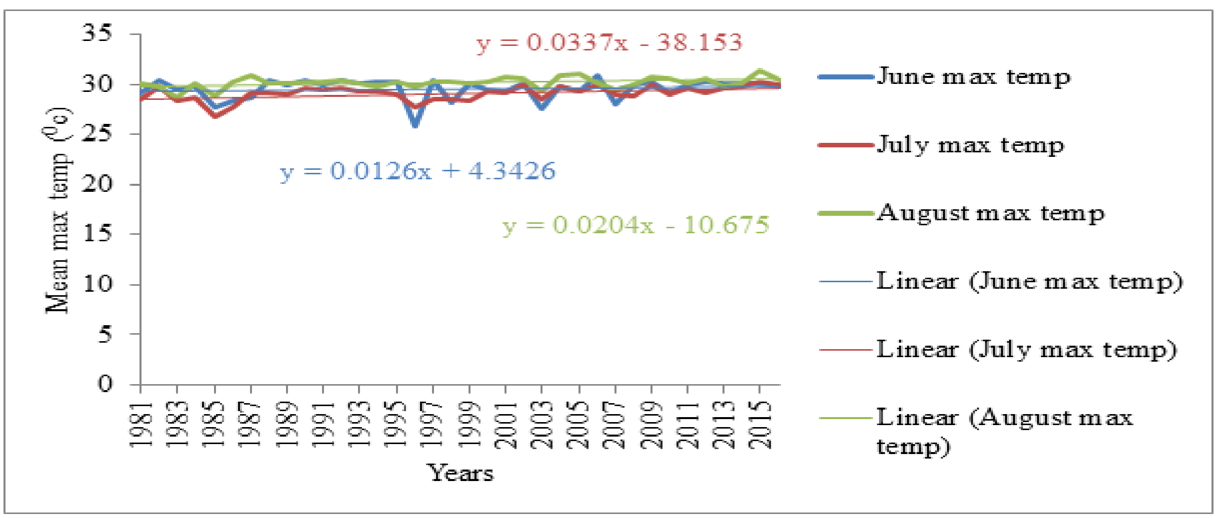

Figure 10: Trend of mean monthly (JJA) maximum temperature o study area

In general, the mean monthly maximum temperatures of the district were increasing during thirty six years. The increasing of the temperature was affects livestock production and productivity through restricting livestock movement and reducing duration of grazing.

4.1.3.2. Trends of mean monthly minimum temperature

The trend of mean monthly minimum temperature of the district is presented in Figure 11 and 12. According to Figure 11, the trends of mean monthly minimum temperatures of December, January and February were increasing by 0.021^{0}C, 0.011^{0}C and 0.022^{0}C in 1981-2016 years respectively. The minimum and maximum of mean monthly minimum temperature of December, January and February range from 18.57^{0}C, 19.23^{0}C and 19.79^{0}C, to 21.28^{0}C, 21.98^{0}C and 22.62^{0}C respectively. The means and SD of mean monthly minimum temperature of December, January and February were 19.75$\pm$0.627^{0}C, 20.6$\pm$0.637^{0}C and 21.29$\pm$0.9^{0}C respectively.

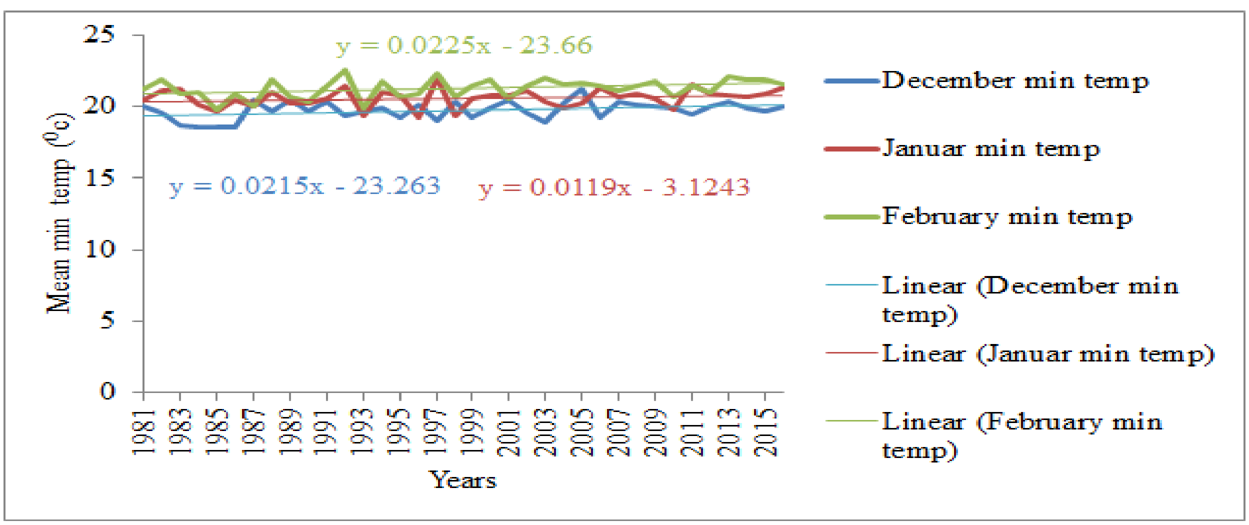

Figure 11: Trend of mean monthly (DJF) minimum temperature of study area

As showed on Figure 12, the trends of mean monthly minimum temperatures of June, July and August were increasing by 0.026^{0}C, 0.035^{0}C and 0.037^{0}C respectively. The minimum and maximum of mean monthly minimum temperature of June, July and August range from 18.36^{0}C, 18.16^{0}C and 17.96^{0}C to 20.53^{0}C, 20.06^{0}C and 19.95^{0}C while means were 19.5^{0}C, 19.18^{0}C and 19.19^{0}C respectively.

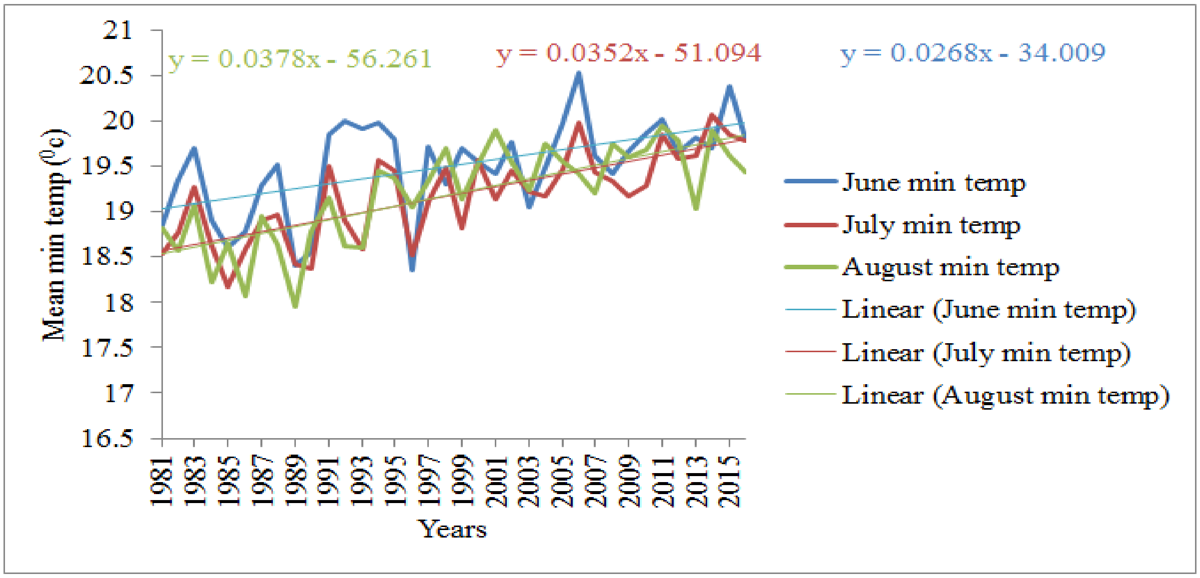

Figure 12: Trend of mean monthly (JJA) minimum temperature of the district

The mean monthly minimum temperatures of the district were increasing during thirty six years. The rates of increasing of mean minimum temperature were higher than maximum temperatures of the district which showed increasing of hot days from time to time and year to year.

4.1.3.3. Trend of mean seasonal temperature of the district

4.1.3.3.1. Trends of mean seasonal maximum temperature

As the resulted of 36 years indicated, the seasonal maximum temperature of long dry season and short dry season of the district slightly increasing. The mean maximum temperatures of long and short dry season were increasing by 0.015^{0}C and 0.022^{0}C respectively. The mean maximum temperature of long dry season ranged from 31.096^{0}C in 1993 to 35.29^{0}C in 1981.

On other hand, the mean maximum temperature of short dry season of the district ranged from 27.755^{0}C in 1985 to 30.562^{0}C in 2015. The means and SD of mean maximum temperature of long and short dry season were 33.01±1.110^{0}C and 29.60±0.646^{0}C respectively.

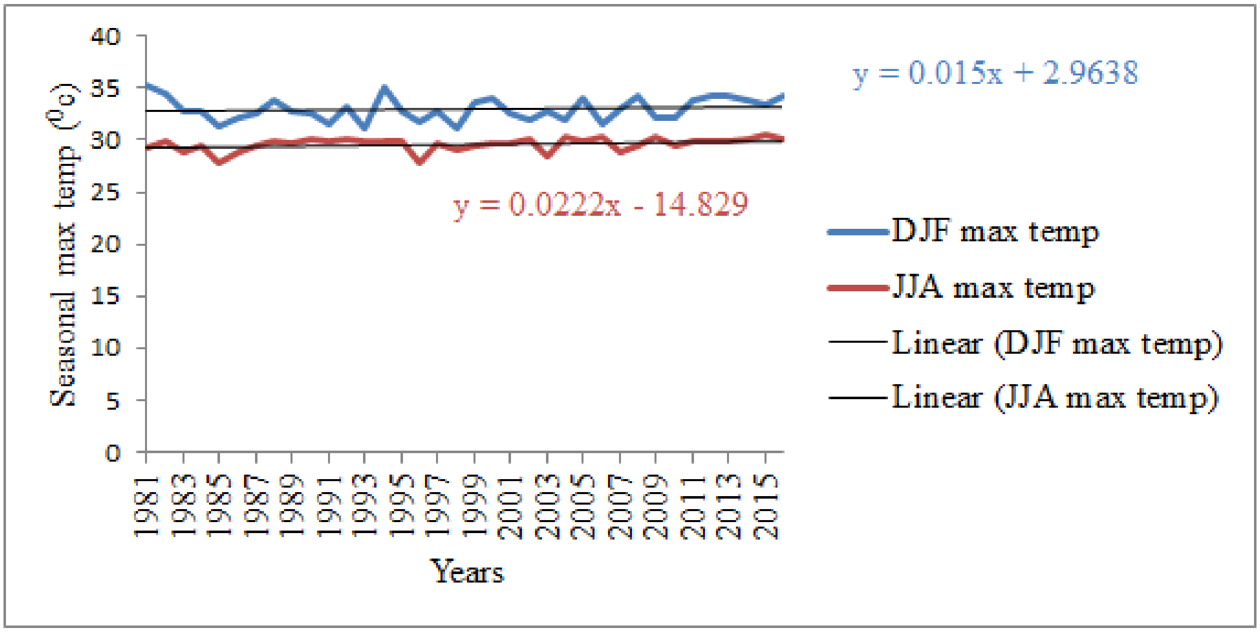

Figure 13: Trend of mean seasonal maximum temperature of Teltelle district

Note: DJF and JJA indicated December-January-February and June-July-August respectively

The mean seasonal maximum temperature of the district was increasing in 36 years. The increasing rates was more pronounced in short dry season rather than long dry season which had negative effects on livestock production and productivity through affects feeds availability and quality in the district.

4.1.3.3.2. Trends of mean seasonal minimum temperature

The same to seasonal mean maximum temperature, seasonal mean minimum temperature of the district also increased in last 36 years. The seasonal mean minimum temperature of long and short dry season increasing by 0.018^{0}C and 0.033^{0}C respectively during 1981-2016 years. The minimum temperature of long dry season ranged from 19.37^{0}C in (1985) to 21.1557^{0}C in (1992) and short dry season minimum temperature ranged from 18.258^{0}C in (1989) to 19.97^{0}C in (2006).The means and SD of mean minimum temperature of long and short dry season were $20.55\underline{+}0.435^0$C and $19.29\underline{+}0.459^0$C respectively in 1981-2016 years.

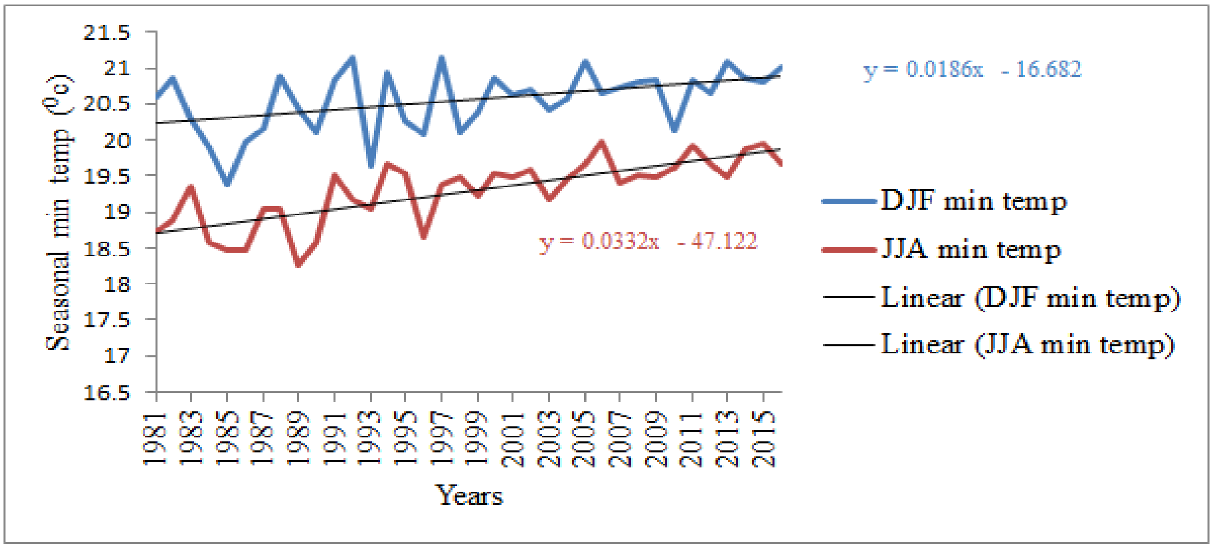

Figure 14: Trend of seasonal minimum temperature of Teltelle district

Among the four seasons, short dry season is very cold and dry potentially varying in minimum temperature. The highest maximum temperature had been identified during long dry season (December-January-February) which adversely affects the livestock production. Rising in temperatures, coupled with declined precipitation reduce crude protein and digestible organic matter contents of the plants, thereby posing nutritional stresses to grazing animals (Craine *et al*., 2010).

4.1.3.4. Trend of mean annual temperature

The trend of mean maximum and minimum annual temperature is presented in Figure 15. The results of 36 years of Teltelle district meteorological data of temperature indicated that, the annual mean maximum temperature was slightly decreasing by -0.005^0C, while annual mean minimum temperature was increasing by 0.016^0C per annually. The annual maximum temperatures of the district range from 29.875^0C in (1996) to 32.121^0C in (1981), while annual minimum temperatures range from 19.052^{0}C in (1985) to 20.384^{0}C in (2016) and their means and SD were 31.19$\pm$0.56^{0}C and 19.93$\pm$0.329^{0}C respectively.

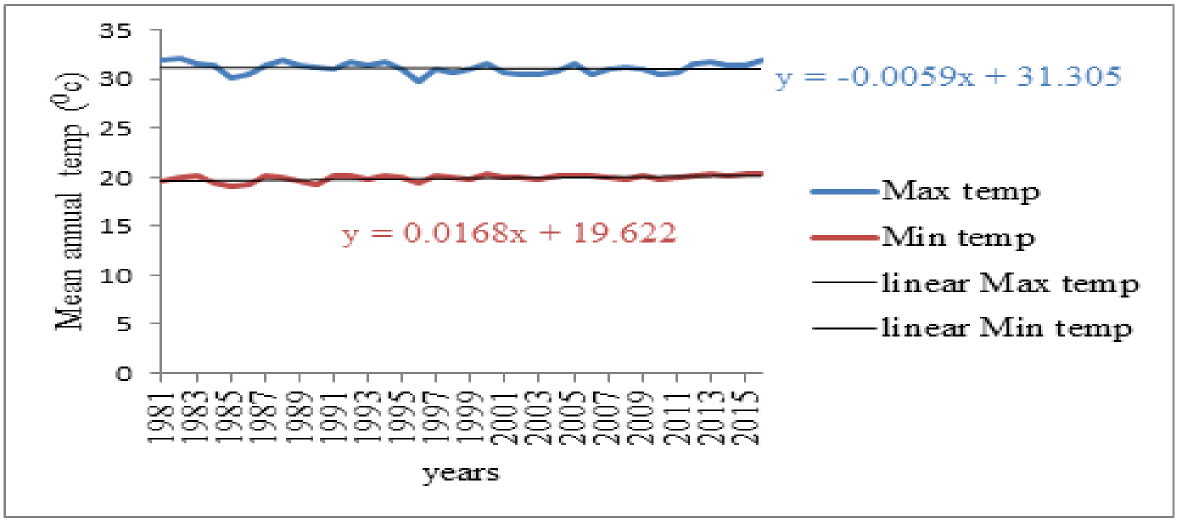

Figure 15: Trend of annual maximum and minimum temperature of Teltelle district

Similar to the result of meteorological temperature data of the district, other studies supported the increasing of temperature in general. The observed monthly, seasonal and annual temperature at Borana zone show increasing from time to time, which directly and indirectly affects the livestock production. Many studies (e.g. Thornton *et al.*, 2009; Nardone *et al.*, 2010) confirmed that an increase in temperature directly posed thermal stresses on animals; impair feed intake, metabolic activities and defense mechanisms, thereby hindering their production and reproductive performances.

4.1.4. Trend analysis of climate data by mann-kendell test

The result of Mann-kendell test of district climate variables is showed in Table 4. The trend of mean minimum temperature of 36 meteorological data was highly significant (p = 0.0008) while trends of annual rainfall and maximum temperature were not.

Table 4: Trend analysis of climate data of study area by Mann-kendell test

Variables	Mann-kendell tau	Significant value
Annual rainfall	-0.076	0.522
Maximum temperature	-0.085	0.470
Minimum temperature	0.393*	0.000

** shows significant at 1% level*
Source: ENMA, 2019

Mann-kendell test is very important to show the strong trend magnitude of the climate variables. The coefficients of annual rainfall and maximum temperature of the district shows decreasing in last 36 years but not as such significant. That means the trend magnitude of those variables were weak compare to mean minimum temperature. Increasing of mean annual minimum temperature was confirmed by other study. In Ethiopia, the average annual minimum temperature over the country has been increasing by 0.25^0C every ten years while average annual maximum temperature has been increasing by 0.1^0C every decade (NMA, 2007). It is interesting to note that the average annual minimum temperature is increasing faster than the average annual maximum temperature (ENMSA, 2001).

4.1.5. Perceptions of Pastoral Households on Trends of climate Variables

4.1.5.1. Rainfall

The perceptions of pastorals and agro-pastorals of the study area on trend of rainfall are displayed in Table 5. According to pastoral household perceptions, rainfall pattern become more variable in last three Borana gadaa periods (last 24 years). Out of respondent who perceived the change in rainfall pattern 96.7% of the pastoral households and 91.6% of agro-pastoral household respondents felt high variable in the rainfall pattern, and the remaining respondents, 3.3% of pastoral and 8.4% agro-pastoral felt slightly variable. Among interviewed respondents, 93.3% of pastoral and 88.5% agro-pastoral household believed the amount of rainfall become decreasing in last 24 years, while 6.7% of pastoral and 11.5% agro-pastoral of households believed no change.

Table 5: Perception of respondents on trends of rainfall data of study area (%)

Variables	Trends	AG(n=102)	Pas (n=83)	Total (n=185)
Rainfall pattern	High variable	91.6	96.7	94.15
	Less variable	8.4	3.3	5.85
Amount of rainfall	Decrease	88.5	93.3	90.9
	No change	11.5	6.7	9.1
Duration of rainy season	Decreasing	88.3	90.4	89.35
	No change	11.7	9.6	10.65
Starting of rainy season	On time	15.5	4.8	10.15
	Too late	84.5	95.2	89.85
Ends of rainy season	Too early	88.3	92.8	90.55
	No change	11.7	7.2	9.45

Source: Field survey, 2018/19

Out of interviewed household, 90.4% of pastoral and 88.3% of agro-pastoral perceived decreasing of rainfall duration, but 9.6% of pastoral and 11.7% of agro-pastoral felt that there was no change in the trend. On other hand, 95.2% of pastoral and 84.5% of agro-pastoral household respondents felt that the rainy season start too late, while 4.8% of pastoral and 15.5% of agro-pastoral of households interviewed felt no change. Regarding the end of the rainy season, 92.8% of pastoral and 88.3 of agro-pastoral respondents perceived that rainy season ceased too early, whereas 7.2% of pastoral and 11.7% of agro-pastoral felt no change in last three Borana gadaa periods (Table 5).

KII and FGD also responded that, the rainfall pattern is changing from time to time and temperature generally increasing. They felt that the duration of main and short rainy seasons decreased by half of a month and a month respectively. On the contrary, the duration of long and short dry season increased by a month and half of a month respectively in last three Borana gadaa periods. That means main rainfall becomes starting from 15th March to end of May and the Short rainfall become starting from 15th September to 15th November. So, dry and hottest season become starting from 16th November to 14th March, while dry and coldest season become take 1st two weeks of September.

Results of household perception on trend of rainfall were confirmed by other study. A trend of declining amount and variability of rainfall as well as rising temperature reported by the herders of Southern Ethiopia reinforce similar perceptions of local people documented elsewhere in Ethiopia (Kassahun *et al*. 2008).

4.1.5.2. Drought

The perception of household respondents on drought is showed in Table 6. The result indicated that 85.5%, 84.3% and 84.3% of pastoral, and 84.5%, 83.5% and 83.5% of agro-pastoral household interviewed perceived drought frequency, drought severity and drought magnitude increased respectively. However, 14.5%, 15.7% and 15.7% of pastoral and 15.5%, 16.5% and 16.5% of agro-pastoral household respondents felt no change of drought in frequency, severity and magnitude in last 24 years respectively.

Table 6: Perception of respondents on drought occurrence in study area (%)

Drought	Trends	Agro(n=102)	Past(n=83)	Total (n= 185)
Frequency	Increase	84.5	85.5	85
	No change	15.5	14.5	15
Duration	Increase	83.5	84.3	83.9
	No change	16.5	15.7	16.1
Magnitude	Increase	83.5	84.3	83.9
	No change	16.5	15.7	16.1

Overall, the results of household respondents, KII and FGD perceived the increasing of drought frequency, severity and magnitude in study area. Thus, increasing of drought occurrence from decade to decade had effects on availability and quality of feeds and water resources which directly and indirectly affected livestock production. The results of pastoral household perceptions were also supported by other studies. Borana pastoralists expressed that drought cycles have shortened from 5-10 years to 3-5 years (Oxfam, 2011). As a result, the density and reproductive performance of livestock decreased to a lower level while livestock mortality was increasing (Herrero *et al*., 2010).

4.1.5.3. Temperature

The perceptions of household interviewed shows that, the degree of temperature is become increasing in last 24 years. Out of pastoral household respondents, 90.4% were believed high variable of temperature pattern and hot days, and 83.1% believed increasing of trend of cold day, while 9.6%, 9.6% and 16.9% of household respondents believed no change of temperature pattern, trend hot days and trend cold days respectively. On the other hand, 85.4%, 87.4% and 84.5% of agro-pastoral household interviewed felt the high variable of temperature pattern, trend of hot days and cold days, while 14.6%, 12.6% and 15.5% felt no change respectively.

Table 7: Perception of respondents on temperature of the district (%)

Variables	Trends	Agro (n=102)	Past(n=83)	Total (n = 185)
Temperature pattern	High variable	85.4	90.4	87.9
	Slightly variable	14.6	9.6	12.1
Trend of hot days	Increasing	87.4	90.4	88.9
	No change	12.6	9.6	11.1
Trend of cold days	Increasing	84.5	83.1	83.8
	No change	15.5	16.9	16.2

Source: survey, 2018/19

4.2. Effect of Climate Change on Livestock Production in Teltelle District

4.2.1. Trends of livestock population in 2007 – 2016 years

The 10 year trends of livestock population of the district are indicated in Figure 16. The livestock population of the district is increasing, but not at continuous rates. Following the rainy years the number of livestock increase (especially, cattle and sheep) while in dry years declined in high rate (except some drought resistant species like goats and camel).

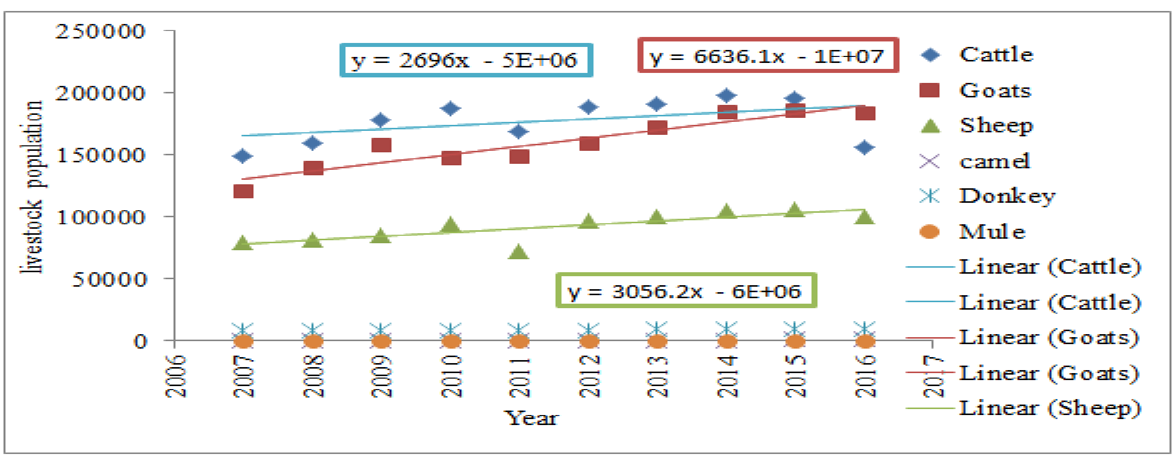

Figure 16: Trend of livestock population in study area in 10 years

For example, during the dry year of 2016 there were high reductions in livestock population of the district. As showed in Figure 17, among the major livestock in the district; cattle, goats, sheep and donkey declined by 20.07%, 1.24%, 4.99% and 4.6% respectively due to drought. The drought mortality rate of cattle and sheep were high while that of goats was relatively low. These drought mortality rates show the ability to resist drought by different livestock species. That means goats have ability to resist drought effect while cattle have less.

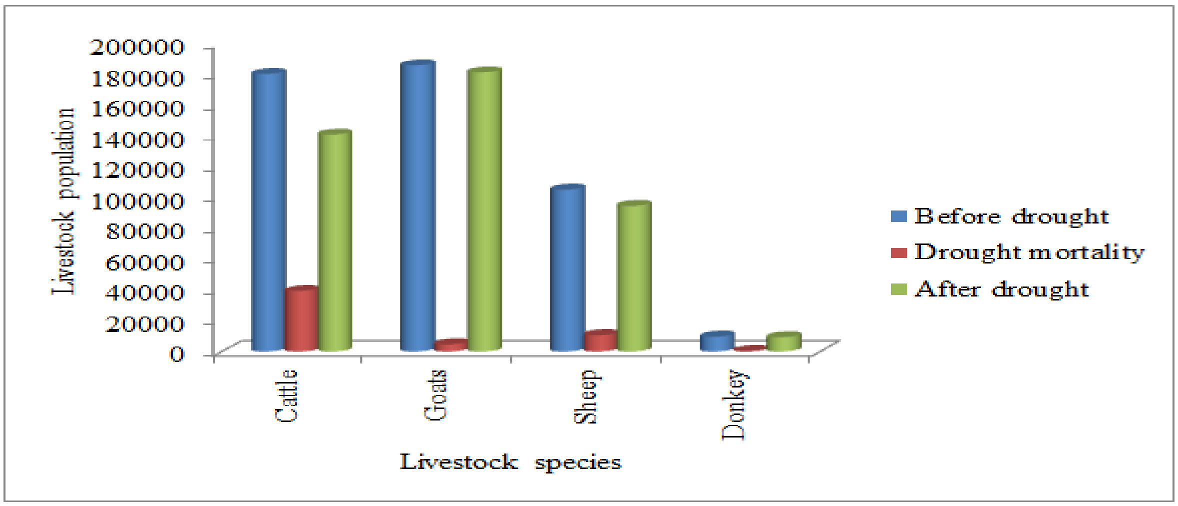

Figure 17: Consequence of 2016 drought on livestock population of study area
Source: District livestock population resource development office, 2019

On the other hand, the ratio of livestock to households become decreasing from time to time. According to the results of livestock per household data of 2009 and 2018 showed, the mean of livestock per household decrease from 26.59±12.484 in (2009) to 14.27 ±6.092 in (2018), see Table 8.

Table 8: Descriptive statistics of TLU of 2009 and 2018 of study area

Variables	N	Minimum	Maximum	Mean	Std. Deviation
TLU(2009)	185	6	73	26.59	12.484
TLU(2018)	185	5.5	37	14.27	6.092

In general, livestock rearing is the most dominant economic activity followed by crop cultivation in Teltelle district of Borana zone. As human population increase from time to time the need of rearing livestock increase in the district. But, livestock production and productivity is highly variable from decade to decade and year to year, and the number of livestock per households declined. The main reason for decrease in livestock number per household could be due to increasing human population, declining availability of grazing land, and shortage of feed, which is influenced by high frequency of drought occurrence and climate variability in the district.

A study conducted in the neighboring Yabelo district, confirmed that households experienced a severe reduction in their assets, with an average reduction of 80% in livestock holdings from their peak holdings over the past ten years mainly due to climate change induced shocks (Stark *et al.*, 2011). The decline in the number of livestock species namely cattle, goats, sheep and donkey kept by pastoralists of Moyale and Dillo areas were remarkable in which most of the animals were reported to have died during severe droughts, which occurred in 2005 and 2008 (Zelalem *et al.*, 2009). Other study also confirmed that the declining trend in cattle number per household in the present study and its significant correlation with variation in the long and short rains in the preceding year, suggest that reduction in the rainfall amount and widening rainfall variation drive the downward trend in cattle number in southern Ethiopia (Bekele *et al.*, 2013).

4.2.2. Perceptions of respondents on trends of livestock productivity

Perceptions of herders on trends of livestock productivity during last 24 years are showed in Table 9. Most of pastoralists and agro-pastoralists household interviewed confirmed that the effects of climate change on livestock production is widely; decreased in milk production, production life, lactation length, and oppositely increasing age at sexual maturity, age at first calving and calving interval. Out of pastoral respondents, 88%, 86%, 85.1%, 82.3%, 82.3% and 84.4% felt decreasing of milk production, decreasing of lactation length, decreasing of production life, increasing of age at sexual maturity, increasing of age at first calving and increasing of calving interval while 12%, 14%, 14.9%, 17.7%, 17.7% and 15.6% of respondents of households agreed not change respectively. Beside agro-pastoral respondents, 86%, 85%, 80.1%, 83.3%, 83.3% and 86.4% felt that the decreasing of milk production, decreasing of lactation length, decreasing of production life, increasing of age at sexual maturity, increasing of age at first calving and increasing of calving interval while 14%, 15%, 19.9%, 16.7%, 16.7% and 13.6% of respondents of households agreed not change respectively.

Table 9: Perceptions of respondents on trend of livestock productivity in study area (%)

Variables	**Trend**	**Pastoral (n=83)**	**Agro- pastoral (n=103)**	**Total (n=185)**
Milk production	Decrease	88.0	86.0	87
	No change	12.0	14.0	13
Lactation length	Decrease	86.0	85.0	85.5
	No change	14.0	15.0	14.5
Production life	Decrease	85.1	80.1	82.6
	No change	14.9	19.9	17.4
Age at sexual maturity	Increase	82.3	83.3	82.8
	No change	17.7	16.7	17.2
Age at first calving	Increase	82.3	83.3	82.8
	No change	17.7	16.7	17.2
Calving interval	Increase	84.4	86.4	85.4
	No change	15.6	13.6	14.6

Source: Survey, 2019

According to KII and FGD, livestock production and productivity of the district decreasing from decade to decade due to high rainfall variability and frequency of drought. For example, in 1980s the average age at sexual maturity, age at first calving and calving interval were 3-3.5, 4-4.5 and 1-1.5 years, but after 1990s increased to 3.5-4.5, 5-5.5 and 2-3 years respectively.

4.2.2.1. Major effects of climate change on livestock production and productivity

The ranking order of the effects of climate change on livestock production as per the respondents of pastoral households were: reduction of milk production (1st), reduction of lactation length (2nd), reduction of reproduction rate (3rd), increasing of calving interval (4th), reduction of production life (5th), increasing of age at first calving (6th), increasing of age at sexual maturity (7th) and livestock mortality (8th) due to drought and climate related disease through affecting feeds and water resources, and reducing livestock performance.

In agro-pastoral, household interviewed ranked effect of climate change as; reduction in milk production (1st), reduction of lactation length and reproduction rate (2nd), Increasing of calving interval (4th), reduction of production life (5rd), increasing of age at first calving (6th), increasing of age at sexual maturity (7th) and livestock mortality due to drought (8th) were the major one.

Table 10: Effect of climate change on livestock production and productivity in study area

Variables	Pastoral		Agro-pastoral	
	Index	Rank	Index	Rank
Reduction of milk production	0.205	1st	0.173	1st
Reduction of lactation length	0.179	2nd	0.144	2nd
Reduction of reproduction rate	0.166	3rd	0.144	2nd
Increasing of calving interval	0.154	4th	0.139	4th
Reduction of production life	0.099	5th	0.129	5th
Increasing of age at first calving	0.091	6th	0.117	6th
Increasing of age at sexual maturity	0.070	7th	0.107	7th
Livestock mortality due to drought	0.038	8th	0.026	8th

*Note: Index = Rn*C1+Rn-1*C2+…. +R1*Cn/∑ Rn*C1+ Rn-1*C2….R1*Cn Where; Rn= Value given for the least ranked level and Cn= Counts of the least ranked level.*

Thus, effects of climate change on feeds and water availability and quality leads to the reduction of livestock production and productivity in study area. There are different climate factors that advance or delay age at first calving and longer calving interval with decreased milking. The time taken by an animal to attain puberty and sexual maturity depends among others on the quality and quantity of feed available, which affects growth rate (Thornton *et al*. 2009; Nardone *et al*. 2010).

4.2.2.2. Factors affecting livestock production and productivity

Most household interviewed responded; shortage of feeds, shortage of water, drought and heat stress were major factors which affected livestock production and productivity in study area. The agro-pastoral respondents were ranked shortage of feeds (1st), shortage of water (2nd), drought (3rd) and heat stress (4th). Beside pastorals respondents, they ranked Shortage of water (1st), shortage of feeds (2nd) drought (3rd) and heat stress (4th), see Table 11.

Table 11: Factors affecting livestock production in Teltelle district

Variables	Agro-pastoral		Pastoral	
	Index	Rank	Index	Rank
Shortage of feeds	0.325	1^{st}	0.251	2^{nd}
Shortage of water	0.275	2^{nd}	0.255	1^{st}
Drought	0.266	3^{rd}	0.247	3^{rd}
Temperature	0.135	4^{th}	0.245	4^{th}

*Note: Index = Rn*C1+Rn-1*C2+…. +R1*Cn/∑ Rn*C1+ Rn-1*C2….R1*Cn Where; Rn= Value given for the least ranked level and Cn= Counts of the least ranked level.*

Among factors which influence livestock production and productivity; drought and heat stress were undoubtedly the most significant. In fact, climatology characteristics such as ambient temperature and rainfall patterns have great influence on pasture and food resources availability cycle throughout the year among animal populations. This means during rainy season pastures are available in higher quantities and show good nutritional quality whereas dry season's pastures have poor nutritional quality with high fiber and low protein contents, which often results in declining the animal production. Woldeamlak *et al*, (2015) confirmed that, Shortage of feed and water contributes to reduced productivity and reproductive performance of livestock. This includes slow growth rate of animals, loss of body condition, reduced milk production and poor reproductive performance in mature animals. The effect of climate change on livestock production was measured through the effects of climate change on natural pastures (grazing grass and shrubs), water resources, livestock diseases and biodiversity (Thornton &Herrero, 2008; Thornton, 2010). Similarly, the increasing in drought frequency and the rise in temperature adversely affect pastoral livestock production through pose thermal stresses on animals; impair feed intake, and thereby hindering their production and reproductive performances, and disease distributions (Nardone*et al*., 2010).

4.2.3. Correlation between climate change and livestock population

The results analyses of correlation between livestock and climate variables of the district during the 2007-2016 years are presented in Table 12. As result showed, cattle population had strong positive correlation with main rainfall (at p = 0.003), while negative correlation with maximum temperature (at p = 0.037). On the other hand, goat population had strong positive correlation with minimum temperature (at p = 0.002). Whereas, sheep had positive correlation with main rainfall (at p = 0.022) and negative correlation with maximum temperature (at p= 0.019) respectively. Camel, donkey and mule population had positive correlation with minimum temperature (at p = 0.037, p = 0.019 and p = 0.009) respectively.

Table 12: Correlation of climate data and livestock population of study area

Variables	**Cattle**	**Goat**	**Sheep**	**Camel**	**Donkey**	**Mule**
Annual RF	.735*	.35	.526	.463	.276	.230
MAM RF	.855**	.521	.707*	.440	.342	.279
SON RF	.458	.095	.225	.494	.178	.168
Max temp	-.661*	.665*	-.720*	.383	242	.127
Min temp	-.003	.845**	.358	.661*	.718*	.772**

*Note: **, * Significant at 0.01 and 0.05 level (2-tailed).*
Source: ENMA and District livestock resource development office, 2019.

Statistically, values close to -1 indicate a strong negative (inverse) relationship, values close to 1 indicate a strong positive relationship and value close to zero indicates poor relationship which is not significant. For stance, cattle and sheep population were strong positive relationship with main rainfall and negative relationship with maximum temperature. On other hand, goat population was strong positive relationship with minimum temperature.

4.2.4. Regression of climate variables on livestock population

According to the regression result of major livestock species with climate variables during last 10 years (2007-2016) of study area showed, cattle, sheep and donkey populations were 98.3%, 84.7% and 81.8% depends on main rainfall respectively. Goat, camel and mule populations were 86.8%, 76.3% and 66.9% depends on minimum temperature respectively.

Table 13: Regression results of livestock population and climate data of study area

Model	Unstandardized Coefficients		Standardized coefficients	R^2	Adjusted R^2	T	Sig.
	B	Std. Error	Beta				
Cattle(Constant)	125214.071	12720.119				11.176	.000
Main RF	260.586	60.405	.836	. 983	.662	4.314	.003
Goat(Constant)	1395220.190	260525.445				5.355	.001
Tmin	7849.114	2738.590	.420	.868	.831	2.866	.024
Sheep (Constant)	1067588.817	138664.715				7.699	.000
Main RF	129.823	35.403	.325	. 847	.975	3.667	.010
Camel(Constant)	36023.924	9609.210				3.749	.007
Tmin	1875.161	478.875	.725	.763	.697	3.916	.006
Donkey(Constant)	34629.346	8278.545				4.183	.004
Main RF	4.662	1.362	.571	.818	.768	3.42	.01
Mule(Constant)	81.931	24.171				3.39	.01
Tmin	7.075	1.190	.910	.669	.804	5.94	.00

Source: ENMA and District livestock resource development office, 2019.

Statistically, the coefficient of determination (R^2) value is used to express the degree of dependence of dependent variable on independent variable, which showed the strength relationship. As Table 13 indicated that among six dependent variables, cattle, sheep and donkey populations highly depends on main rainfall, while goat, camel and mule populations were mainly depends on minimum temperature that indicated strong relationship between two variables.

4.3. Effects of Climate Change on Rangeland in District

According to the perceptions of household respondent, major source of feeds resources in the district include natural pastures, hay, crop residues and weeds, and the quantity and quality were variable with climate condition especially rainfall. Pastoral household respondents ranked major feeds resource as natural pastures (1^{st}), hay (2^{nd}), crop residues (3^{rd}) and weeds (4^{th}). On other hand, agro-pastoral households ranked major feeds resources as natural pastures (1^{st}), crop residues (2^{nd}), hay (3^{rd}), and weeds (4^{th}).

Table 14: Major feeds resources of the district

Major feed resources	Pastoral		Agro-pastoral	
	Index	Rank	Index	Rank
Natural pasture	0.461	1	0.284	1
Hay	0.288	2	0.254	3
Crop residues	0.158	3	0.267	2
Weeds	0.091	4	0.193	4

Source: survey, 2019.

FGDs and KII were supported the decreasing of feeds resource availability and quality due to rainfall variation and increasing of unpopular plants species into rangeland from time to time during their interviewed and discussions.

Increasing temperatures and decreasing rainfall reduce yields of rangelands and contribute to their degradation. So, as temperature increases, and rainfall decreases and becomes more variable, the niches for different grassland species are change. Due to high climate variability, the availability and quality of feed in the rangelands were very variable from season to season in the district. Study conducted on Borana rangeland also confirmed above results. Borana pastoral areas experience a relatively harsh climate with low, unreliable, and erratic rainfall as well as regularly high temperature which affected rangeland quantity and quality (Ayana and Adugna, 2006). A warming and drying trend in climate negatively affects the rangeland productivity by lowering the quantity and nutritional quality of forages besides causing water scarcity (Thornton *et al*., 2009).

4.3.1. Factors affecting rangeland

Household survey results showed that, rangeland of the district had been affected by climate factors and they were ranked as: rainfall variability, bush encroachment, drought and floods were 1^{st} , 2^{nd} , 3^{rd} and 4^{th} respectively, see table 15.

Table 15: Factors affecting rangeland of the district

VARIABLES	Pastoral		Agro-pastoral	
	Index	Rank	Index	Rank
Rainfall variability	0.295	1^{st}	0.294	1^{st}
Bush encroachment	0.292	2^{nd}	0.287	2^{nd}
Drought	0.255	3^{rd}	0.249	3^{rd}
Flood	0.160	4^{th}	0.168	4^{th}

*Note: Index = Rn*C1+Rn-1*C2+.... +R1*Cn/∑ Rn*C1+ Rn-1*C2....R1*Cn Where; Rn= Value given for the least ranked level and Cn= Counts of the least ranked level.*

Also, responses of KII and FGD were confirmed that; high rainfall variability, drought frequency and flood occurrence in the district were affected rangeland conditions. That means, rainfall variability and drought affected rangeland through dried up rangeland ecosystem and decreased range productivity while flooding is eroded fertile soil of the rangeland and create holes. Another problem raised by FGD was bush encroachment, which declining range condition in study area. The rapid expansion of bush encroachment and invasion of new plant species (parthenium) in the district affect range from year to year and feeds generally declined. This resulted is confirmed by other study. Prolonged drought including a shortage and erratic rainfall can cause serious range degradation (Abate *et al*., 2016). In Yabello district rainfalls during drought is hardly adequate to allow grasses to grow and unable to fill the surface water ponds (Alemayehu, 2004). Factors influencing rangeland degradation include increases in encroachment by undesirable woody plants (mainly *Acacia mellifera*, *Acacia nubica and Prosopis juliflora*), expansion of weeds (mainly *Xanthium abyssinicum, Parthenium hysterophorus and Malvaceae spp*.), reduction in herbaceous/woody layers and recurrent droughts (Mengistu, 2016)

4.3.2. Bush encroachment in study area

Major types of bush encroachment in the district are presented in table 16. According to household respondents, bush encroachments were the major and sever factor hampering sustainable livestock production in the district, and they were ranked the major bush species covered the rangeland based on its intensity as; *Acacia mellifera, Acacia reficiens, Acacia horide*, and others 1st , 2nd , 3rd and so on.

Table 16: Major Bush encroachments in the district

Variables		**Pastoral**		**Agro-pastoral**	
Scientific name	Local name	Index	Rank	Index	Rank
Acacia mellifera	*Saphansa*	0.221	1st	0.227	1st
Acacia reficiens	*Sigirsoo*	0.157	2nd	0.139	2nd
Acacia horide	*Caaccannee*	0.137	3rd	0.132	4th
Acacia senegal	*Hidaadhoo*	0.137	3rd	0.107	7th
Acacia nubica	*Waangaa*	0.132	5th	0.125	6th
Dichrostechys	*Jirimee*	0.132	5th	0.139	2nd
Acacia drepanolobium	Fulleessa	0.085	7th	0.129	5th

*Note: Index = Rn*C1+Rn-1*C2+…. +R1*Cn/∑ Rn*C1+ Rn-1*C2….R1*Cn Where; Rn= Value given for the least ranked level and Cn= Counts of the least ranked level.*

On the other hand, major bush ranked by household respondents may feeds for other animals or useful plant for other services (e,g, *Acacia mellifera* feeds for Bee), but the consideration point is based on land use purpose for major economic activity of the district by herders. That means some bush in rangeland may useful plant in other land use types. In general, increasing of bush encroachment in rangeland cause shortage of feeds resource and affected livestock productivity in the district, and others studies were confirmed the results. The causes of bush encroachment have been a contentious issue in rangeland ecology, where possible causes include shortage of rainfall, notably wet cycles (Kraaij, 2003; Ward, 2005); heavy grazing, absence of hot brush killed fires, loss of large trees and soil nutrient changes. However, it is noteworthy that some woody plants are considered to be of some value because they provide leaves and pods to browsers (goats/camels) and to a lesser extent to sheep and cattle during dry periods (Solomon *et al*., 2007). On the other study reported by Woldeamlak *et al.*, (2015); apart from increased temperatures, prolonged dry seasons and frequent droughts, bush encroachers and alien invasive species are causing significant reduction in availability of livestock feed. Invasive species such as *Prosopis juliflora, Parthenium hysterophorus, Lantana camara and Opuntia ficus-indica* have expanded in rangelands of the pastoral districts of Teltele and Filtu. The bush encroachers are threatening the livelihoods of Borana and Somali pastoralists and the ecosystems. *Acacia mellifera, Acacia bussi, Acacia bresvispica, and Acacia senegal* were among the major encroaching species in both sites.

4.4. Climate Change Adaptation Strategies in Teltelle District

4.4.1. Adaptation methods practiced by herders' of study area

To reduce the effect of climate change, pastoralists and agro-pastoralists of the district practiced adaptation strategies. As the household interviewed results shows, most of pastorals and agro-pastorals (92.41%) applied; livestock mobility to search feeds and water (19.48%), livestock diversification (18.38%), area enclosures (16.18%), hay making (15.68%), bush thinning (12.39%) and income diversification (10.29%) as the major adaptation strategies while few respondents (7.59%) did not. Moreover, herders who did not adapt have given many reasons for their failures to adapt which include lack of information, lack of money, shortage of labour, shortage of land and poor in livestock owned.

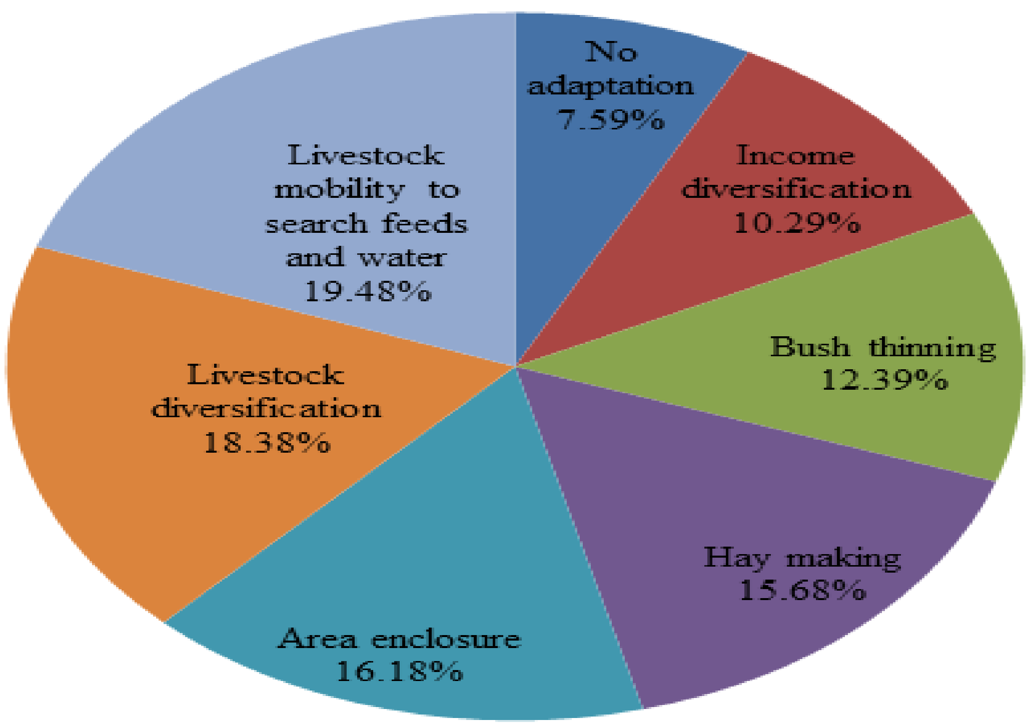

Figure 18: Climate change adaptation strategies by herders of study area

4.4.2. Determinants of herders' adaptation choice

In this topic data analysis methods of econometric models are presented. Before conducting econometric estimation different tests which are very necessary for multinomial logit model were undertaken. The MNL was employed to determine the factor that influences herders' choice of adaptation method as well as identifying different adaptation strategies of the herders in response to climate change on livestock production depending on the eleven explanatory variables of cross sectional survey results of pastorals and agro-pastorals households of Teltelle district of Borana zone. The survey results of determinants herders' adaptation choice and strategies were analyzing by using STATA version 14.2 and after testing correlation matrix methods of the final regression analysis, multi-collinearity problem was checked using Variance Inflating Factor (VIF). The VIF value of each independent variable is less than 2 with mean of 1.5. So, the results of the test indicate the presence of no severe problem of multicolinearity among the independent variables.

Table 17: Description of independent variables of the study

Variables	Parameter	Agro-past (n=102) %	Past (n=83) %	Total(n=185)%
Age	30-45 yrs	38.2	32.5	35.35
	46-60 yrs	50	51.8	50.9
	>60 yrs	11.8	15.7	13.75
Education level	Illiterate	26.5	31.3	28.9
	Adult education	43.1	49.4	46.25
	Primary school	30.4	19.3	24.85
Family size	2-5	42.2	42.2	42.2
	6-9	51	47.0	49
	10 and above	6.9	10.8	8.85
Income	Livestock	39.3	79.6	59.45
	Crop	40.2	3.6	21.9
	Bee keeping	7.8	8.4	8.1
	Petty trade	9.8	8.4	9.1
	Charcoal	2.9	-	1.45
Land holding	<2 ha	5.9	-	2.95
	2-5 ha	40.2	6.0	23.1
	> 5 ha	53.9	94.0	73.95
TLU	<10	38.2	9.6	23.9
	10-20	59.8	59.0	59.4
	>20	2	31.3	16.65
Climate information	Yes	88.2	79.5	83.85
	No	11.8	20.5	16.15
Extension services	Yes	87.3	88.1	87.7
	No	12.7	11.9	12.3
Market service	Yes	87.3	77.1	82.2
	No	12.7	22.9	17.8
Credit service	Yes	81.4	80.7	81.05
	No	18.6	19.3	18.95

Source: Survey, 2019

4.4.3. Estimation of the results of multinomial logit model

As the results of MNL model showed, there were high influences of independent variables on herders' adaptation choices to apply climate change adaptation strategies in the district and also some significant levels of the parameters estimates.

According to the result of MNL model, likelihood ratio of the ch2 statistics was (LR chi-square (66) =154.29 was highly significant Prob> chi2= 0.0000), suggesting the model had a strong independent power. The estimated coefficients of all dependent variables were taking no adaptation as base category.

The coefficient estimations from the multinomial logit model show the direction of the effect while multinomial logit model regression shows the magnitude effect of determinant variables for each category versus the base category. That means the base category was the household who did not choose any adaptation strategy. The maximum likelihood method was employed to estimate the relative importance of predictor variables on the farmers‟ decision to choose adaptation strategies. The parameter estimates of the MNL model estimates neither actual size of change nor the probabilities, but it gives only the direction of the effect of explanatory variables on the dependent variable. Therefore, we can compute the magnitude of effect by using STATA command mfx2 after MNL regression and it gives marginal effect.

Table 18: Marginal effects of MNL of study area

Independent Variable	Livestock diversifi.	Hay making	Area enclosure	Livestock mobility	Income diversif	Bush thinning	No adaptat.
Sex	. 38498	1.279	-.5915	. 579	. 9699	-.466	-.055
Age	. 037895	. 03756	.05617	. 02621	. 024	. 08	-. 059*
Education	.0072	.05059	.0656	-.0686	.0531	.057	.0146
Family size	.1118*	.074	.89**	.0358	.0107	.057	.0058
Income	.0684 **	.064*	-.0136	.086	.0010	.006	.0032
Land size	.183**	.0306	.041	.05599	.0156	.15***	-.0106
TLU	.029***	.0048	.014**	.038	.0097	.0146*	-.0213
Market	.14408	-.0703	.1659	.0132	.0914	.17**	.01695
Information	.24584 *	.03775	.104	.1205	.0851	.06766	-.19***
Credit	.096	.0566	.2189	-.0656	.12**	.07887	-.069**
Extension	.0969	.09465	.189**	-.05684	.0796	.0793	-.06**

*Notes: ***, **,* = significant at 1%, 5% and 10% probability level, respectively.*
Source: Analysis based on survey data, 2018/19

4.4.4. Interpretation of marginal effect of adaptation strategies of study area

Age of household head: Age of household head has negative and significant effect on the no adaptation to climate change. As age of household increase by one unit, the no adaptation decreases by 5.9% (p=0.054), keeping other variables constant. This result was in line with the findings of Deressa *et al*. (2008).

Family size of household: family size has positive and significant effect on adaptation strategies to climate change. As the number of family size increase by one unit, the herders' adaptation methods of livestock diversification and area enclosure increase by 11.18% (p=0.071) and 89% (p=0.044) respectively, keeping other variables constant.

Income of house hold: income of the household has also positive and significant effect on adaptation strategies to climate change. The increasing one unit of household income increases livestock diversification and hay making by 6.84 %(p=0.011) and 6.4 %(p=0.095) respectively, holding other variables constant. The impact of income on adoption found a positive correlation (Deressa *et al*., 2008). When the main source of income in pastoralists would increase, pastoralists tend to invest on productivity smoothing options.

Land holding: land holding by household has positive and significant effect on adaptation strategies to climate change. Increasing in one unit of land size increases livestock diversification and bush thinning by 18.3 %(p= 0.054 and 15% (p= 0.007) respectively, holding other variables constant.

Livestock holding: livestock holding by household has positive and significant effect on adaptation strategies to climate change. As livestock holding by household increase by one unit livestock diversification, area enclosure and bush thinning increases by 2.9 % (p= 0.000), 1.4% (p= 0.044) and 1.46% (p= 0.083) respectively, keeping other variables constant.

Market accessibility: access to market has positive and significant effect on adaptation strategies to climate change. Market accessibility increases bush thinning by 17 % (p=0.049), holding other variables constant.

Climate information: climate information has positive and significant effect on adaptation strategies while negative and significant on no adaptation strategies to climate change. As household information on climate change increase livestock diversification increase by 24.58 % (p= 0.090) and the no adaptation to climate change decrease by 19% (p= 0.012), keeping other variables constant. The availability of better climate information helps farmers 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).

Credit accessibility: credit service has positive and significant effect on adaptation strategies while negative and significant on no adaptation strategies to climate change. As credit accessibility increase income diversification increase by 12 % (p= 0.042) and the no adaptation to climate change decrease by 69% (p= 0.014), holding other variables constant. Access to affordable credit increases financial resources of farmers and their ability to meet transaction costs associated with various adaptation options they might want to take (Nhemachena and Hassan, 2008).

Extension services: also extension service has positive and significant effect on adaptation strategies while negative and significant on no adaptation strategies to climate change. As extension services increase area enclosure increase by 18.9 % (p= 0.027) and the no adaptation to climate change decrease by 6% (p= 0.030), holding other variables constant. Nhemachena and Hassan (2007) confirmed that extension on crop and livestock production and information on climate represent access to the information required to make the decision to adapt to climate change.

5. SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1. Summary

In this study, herders reported the decreasing of seasonal and annual rainfall due to too late at starting and too early at end, and increasing of temperature. Decreasing of rainfall both in amount and duration with high variability in patterns lead to increase drought frequency in study area. Meteorological data of the district also confirmed high frequency of drought due to the failures of both main rainy season (MAM) and short rainy season (SON) in last 36 years.

Effects of climate change on livestock production and productivity have been observed in the study area reported by respondents were; reduction in milk production, decreasing of production life, increasing of calving interval, reduction of lactation length, increasing of age at first calving, increasing of age at sexual maturity and livestock mortality. Pastorals household also reported the availability and quality of feed resources were decline from decade to decade and year to year due to the high rainfall variability, bush encroachment, recurrent drought and flood occurrences.

Major adaptation strategies practiced by herders' were livestock diversification, livestock mobility, area enclosures, bush thinning and income diversification, while few respondents did not. Moreover, herders who did not adapt have given many reasons for their failures to adapt which include lack of information, lack of money, shortage of labour, poor saving habit and poor in livestock owned as well as lacks of support from the governmental body. The result from the multinomial logit analysis showed that age of household head has negative and significant effect on the no adaptation to climate change. As age of household increase, the no adaptation decrease. Family size has positive and significant effect on adaptation strategies to climate change. As the number of family size increase by one unit, the herders' adaptation methods of livestock diversification and area enclosure increase. Also land holding by household has positive and significant effect on adaptation strategies to climate change. Increasing in one unit of land size increases livestock diversification and bush thinning. Livestock holding by household has positive and significant effect on adaptation strategies to climate change. Increasing livestock owned by herders' increase livestock diversification, area enclosure and bush thinning for adaptation strategies. Access to market, credit and extensions have positive and significant effect on adaptation strategies to climate change. Market accessibility increases bush thinning. Climate information has positive and significant effect on adaptation strategies while negative and significant on no adaptation strategies to climate change. As household information on climate change increase, increase livestock diversification and decrease no adaptation to climate change.

5.2. Conclusion

In general, both pastorals respondents and the 36 years of meteorological data of the district indicated the decreasing of the rainfall amount and increasing of temperature as well as high drought frequency. High drought frequency in the district affected livestock production and availability and quality of feed. To reduce negative effects of climate change on livestock production herders practiced some adaptation strategies. Whereas, age, family size, income, farm size, access to the market, access to credit, extension service, number of livestock owned by herders and access to climatic information were main factor that influences herders' choice of adaptation method to climate change in the study area.

5.3. Recommendations

Based on the findings of this study, the following recommendations were forwarded to reduce the effect of climate change on livestock production and to promote adaptive strategies. Thus, government and any concerned body better focus on:

- Improving water source management systems through encouraging harvesting of rain water, expansion of motorized water source, and modifying climate information system as well as availability of meteorological data station.
- Improving livestock management systems through identifying and promoting local breeds that tolerate to local climate, reducing number of livestock, shifting livestock bank into bank system, shifting from cattle to goat and camel, and promoting livestock insurance systems.
- Improving rangeland management system through modifying and conserving rangeland, and bush thinning then sowing grass species that has good nutritive value and supported by local climate, and also adjustment of herder settlements.
- Encouraging and improving adaptation strategies practiced by herders of the district, and improve access to roads, market systems, tele communication, credit services and extension services. Application of these recommendations should be able to minimize climatic problems on livestock production and rangeland condition in the district and tackle the barriers to climate change adaptation as well as environmental sound.

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APPENDICES

Appendix Table 1: Descriptive statistics of rainfall data of the district

Rainfall	Range	Minimum	Maximum	Sum	Mean	SD	CV%
March	75	17	93	1920	53.32	24.073	45.13
April	180	32	212	3930	109.18	45.600	41.76
May	123	18	141	2712	75.33	29.976	39.78
September	42	10	53	894	24.83	12.229	49.25
October	82	35	116	2295	63.74	17.488	27.43
November	134	13	147	2272	63.11	35.708	56.55
Main	284	113	397	8562	237.83	76.052	31.97
Short	225	36	261	5357	148.80	50.516	33.9
Annual	432	316	749	18281	507.81	103.730	20.43

Note: Unit of rainfall variables were in mm.

Appendix Table 2: 10 year's livestock population and RF data of study area

Year	Cattle	Goat	Sheep	Camel	Donkey	Mule	Annual RF(mm)	MAM RF(mm)	SON Rf(mm)
2007	149357	121448	79021	545	8247	61	435.529	180.261	128.011
2008	159685	139836	82313	606	8416	61	422.32	235.406	74.8209
2009	178692	158856	85743	873	8587	62	504.763	105.3	211.109
2010	187564	148555	94316	848	8762	62	564.772	260.702	185.361
2011	168856	148984	73037	894	8921	63	337.308	143.431	96.3702
2012	189241	160198	96914	865	9124	64	528.109	234.712	166.547
2013	190775	172256	100952	999	9310	64	527.849	220.701	215.343
2014	195878	185221	105158	1000	9500	65	542.817	270.309	154.171
2015	198025	185846	106158	1062	9704	65	549.232	248.316	179.199
2016	156557	183530	100854	1059	9256	64	344.093	131.818	35.8233

Source: ENMA and DLRD, 2019

Appendix Table 3: Coefficient Variation of rainfall data of the study area

Year	Annual RF CV%	Main rainy season CV%	Short rainy season CV%
1981	11.753	29.204	7.290
1982	8.829	12.708	40.964
1983	3.169	7.486	9.016
1984	4.778	10.190	10.380
1985	9.560	30.112	9.605
1986	6.783	15.399	22.777
1987	5.966	3.621	11.915
1988	7.682	3.503	17.955
1989	6.895	9.111	24.084
1990	5.434	12.871	16.315
1991	6.471	13.958	18.456
1992	5.840	4.444	21.910
1993	7.612	10.642	20.529
1994	7.463	5.1425	6.407
1995	12.609	30.606	45.959
1996	5.379	13.076	14.030
1997	11.575	18.061	31.888
1998	4.830	8.053	21.290
1999	7.030	9.134	12.530
2000	6.408	4.208	9.476
2001	8.421	17.158	13.976
2002	7.361	24.563	22.879
2003	7.501	12.278	9.127
2004	7.981	9.049	36.90
2005	7.68511	21.178	2.841
2006	5.35373	13.902	4.44
2007	4.96197	10.821	10.597
2008	5.56329	5.659	11.052
2009	6.79946	13.668	30.542
2010	9.5153	34.763	12.3
2011	4.22107	10.942	15.912
2012	5.83071	6.383	18.257
2013	8.61696	20.274	34.869
2014	11.1861	36.516	21.340
2015	8.28357	14.851	27.177
2016	4.72421	9.496	18.598

Appendix Table 4: SPI of analysis of the study area

Year	Annual RF SPI	Main rainy season SPI	Short rainy season SPI
1981	1.153	2.286	-5.178
1982	1.754	-0.646	1.840
1983	-11.888	-7.032	-3.089
1984	-5.907	-4.840	1.425
1985	-0.660	0.848	-3.759
1986	-2.242	-0.466	-0.382
1987	3.157	2.065	1.055
1988	2.305	6.951	-0.491
1989	1.829	1.776	-0.567
1990	-0.921	-1.544	0.331
1991	-1.367	-1.904	-1.644
1992	-1.485	-4.814	1.239
1993	0.516	2.216	-0.987
1994	1.735	6.698	-1.368
1995	3.766	1.655	1.063
1996	0.034	-0.901	-1.999
1997	4.092	3.672	2.350
1998	-6.181	-6.503	-0.052
1999	-0.259	2.073	-1.594
2000	-1.109	-8.621	-1.112
2001	1.253	2.040	-1.785
2002	-1.489	-0.656	0.129
2003	-1.344	1.445	-2.856
2004	4.1683	0.207	1.462
2005	2.363	1.115	1.643
2006	-3.557	-1.999	2.254
2007	-2.868	-2.236	-1.318
2008	-3.026	-0.180	-4.498
2009	-0.088	-1.923	1.371
2010	1.178	0.276	1.997
2011	-7.954	-3.627	-2.214
2012	0.685	-0.205	0.653
2013	0.457	-0.355	1.282
2014	0.616	0.949	0.169
2015	0.984	1.146	0.751
2016	-6.824	-4.694	-4.082

Appendix Table 5: Variance Inflation Factors of Independent Variables

Variable	VIF	1/VIF
TTLU	1.92	0.520503
Age	1.66	0.600938
Education	1.62	0.617025
La holding	1.55	0.643933
Family size	1.48	0.675956
Climate information	1.44	0.695345
Extension	1.37	0.730209
Market	1.36	0.737348
Credit	1.29	0.774618
Income	1.29	0.776262
Mean VIF	1.50	

A. Survey Questionnaires

Date: ____________ Kebele: _________Name of Interviewer_______________

Part I. Household Head Demographic Characteristics

1. Name of the Household Head (HH) _____________________________________
2. Sex of the household head: Male ☐ Female ☐
3. Age of the household head (in years)_____________________________________
4. Marital status of the household head________________________

A. Married ☐ B. Single ☐ C. Widow ☐ D. Divorced ☐

5. Educational level of household head: A. Illiterate ☐ B. Literate ☐

If literate the highest level of formal education completed is______________

6. Number of total family members_____________________________

Number of active children below 15 years_______________

Number of active household members aged between 15-64 years____________

Number of elders above 64 years _________________

Part II. Household Head Socio-Economic Characteristics

7. What is the main source of your income? Please rank it according to its importance.

Source of Income	Rank
Selling of livestock production	
Selling of crop production	
Bee keeping	
Petty trade	
Making charcoal	
Others (Please specify)	

8. What kind of agricultural activities are you undertaking?

A. Pastoral system ☐ B. Agro-pastoral system ☐

C. Others (please specify)________________________________

6. Total farm land operated including any private grazing land (in hectares)______________

7. How many of the following types of livestock did you have in the past 10 years?

(Ranges: For greater than 30 write 3, for 21-30 write 2, for 11-20 write 1 and for less than 10 write 0)

Types of livestock	Number of livestock before 10 years	Number of livestock right now	Reason for decreasing or increasing in livestock numbers
Cattle			
Goats			
Sheep			
Donkey			
Mules			
Camel			
Chickens			
Others			

8. Do you have deposit in financial institutions? Yes ☐ No ☐

Part III. Institutional Characteristics

9. How far market place from where you live? Distance in (km)____________________

10. Do you have access to any credit services? Yes ☐ No ☐

11. Did you get any training on climate change information? Yes ☐ No ☐

12. Do you receive any support from the extension workers to undertake adaptation measures?
Yes ☐ No ☐

Part IV. Perception of Climate Change

13. Comparing climate condition before gadaa Boru Madha (1994-2001) with after gadaa Guyo Goba (2010-2017), have you observed any changes?

Yes ☐ No ☐

14. If you say yes Q 13, rank local indicators you have observed in your area in last three Borana gadaa periods.

Local indicators	**Rank**
Decreasing of Rainfall amount	
Increased drought and flood frequency	
Increasing of temperature	
Decline of livestock production	
Decline of rangeland	
Prevalence of human and animal diseases	
Dry up of water sources	
Introduction of plant species those were not popular in the area	
Other (specify)	

15. Please specify the pattern of the change in rainfall you have noticed.

Highly variable ☐ Less variable ☐ No change ☐ I don't know ☐

16. Amount of rainfall gained by your *kebele* per year for your livestock or crop production is

Too little ☐ Enough ☐ Too much ☐

17. Duration of rainy season is becoming: Prolonged ☐ Too short ☐ No change ☐

18. Start of rainy season is coming: On time ☐ Too early ☐ Too late ☐

19. End of rainy season becoming

20. In last three Borana gadaa periods, have you ever experienced by drought? Yes ☐ No ☐

21. If yes Q 20, drought frequency becoming: Increasing ☐ Decreasing ☐ No change ☐

22. If yes Q 20, drought duration becoming: Increasing ☐ Decreasing ☐ No change ☐

23. If yes Q 20, drought magnitude becoming: Increasing ☐ Decreasing ☐ No change ☐

24. Is it raining during the dry season? Yes ☐ No ☐

25. If yes Q 24, describe its effects on your animals or crop ____

26. Comparing before gadaa Boru Madha with after gadaa Guyo Goba, how do you describe animal mortality due to drought? Increasing ☐ Decreasing ☐ No change ☐

27. Comparing before gadaa Boru Madha with after gadaa Guyo Goba, specify the pattern of temperature you have noticed. Increasing ☐ Decreasing ☐ No change ☐

28. What do you say about the trend of hot days over the years?

Increasing ☐ Decreasing ☐ No change ☐ I don't know ☐

29. What do you say about the trend of cold days over the years?

Increasing ☐ Decreasing ☐ No change ☐ I don't know ☐

30. When did you observe severe temperature conditions (heat stress)? Please explain its effect on your animals' ____

31. Have your livestock (body condition) ever affected by strong dry wind? Please describe its effect_____________

Part V. **Effects of Climate Change on Livestock Production and Productivity**

32. Comparing before gadaa Boru Madha with after gadaa Guyo Goba, how is the productivity of different livestock species? Please fill the table.

(Give 1 for increasing, 2 for decreasing and 3 for no changes)

Performances	**Cattle**	**Sheep**	**Goats**	**Camel**
Milk production				
Growth rate				
Lactation length				
Production life				
Age at sexual maturity				
Age at first calving/kidding/lambing				
Calving/kidding/lambing interval				
Maximum number of parity				

33. Identify the factors affecting productivity of livestock in the past three gadaa periods in your local area

No.	**Factors**	**'*x*' Mark for your choice**
1	Drought	
2	Shortage of feed	
3	Heat stress	
4	Animal diseases	
5	Shortage of water	
6	Ticks and parasites	
7	Others (specify)	

34. Identify and rank the following climate change effects on livestock production and productivity in the last three Borana gadaa periods. (Rank 1 for the most impacting, 2 to the next and so on).

No.	Climate change related effects	Rank
1	Reduction of milk & milk production	
2	Reduction of reproduction performance	
3	Reduction of lactation length	
4	Reduction of production life	
5	Increasing of age at sexual maturity	
6	Increasing of age at first calving	
7	Increasing of calving interval	
8	Livestock mortality due to drought	
9	Others (specify)	

Part VI. Effects of Climate Change on Feeds and Water Resource

35. What are the major sources of feed for your animals? Please rank the following feed resource.

Feed resource	Rank
Natural pasture	
Crop residues	
Hay	
Weeds	
Others (specify)	

36. Comparing before gadaa Boru Madha with after gadaa Guyo Goba, how is availability and quality of animal feeds resources?

Variables	Increasing	Decreasing	No change
Feed supply			
Feed quality			

37. If the supply and/or quality of feed are decreasing, what is the reason behind? Please rank it.

Reason for decreasing feed availability and quality	**Rank**
Bush encroachment	
Drought	
Rainfall variability	
Others (specify)	

38. Identify and rank the following major types of bush Species which affects the feeds resource in the last three Borana gadaa periods. (Rank 1 for the most impacting, 2 to the next and so on).

Major types of Bush species		**Rank**
Scientific name	Local name	
Acacia mellifera	Saphansa	
Acacia drepanolobium	Fulleessa	
Acacia reficiens	Sigirsoo	
Acacia senegal	Waaccuu	
Acacia nubica	Waangaa	
Dichrostechys	Jirimee	
Acacia brevispina	Hammarreessa	
Acacia horide	Caaccannee	
Acacia senegal	Hidaadhoo	

39. What are the sources of water to your animals? Please rank it.

Livestock water resource	Rank
Traditional Well	
Pond	
Motorized water	
Other (specify)	

40. Comparing before gadaa Boru Madha with after gadaa Guyo Goba, how do you describe water availability and quality?

Variables	Increasing	Decreasing	No change
Water supply			
Water quality			

41. Rank factors reducing availability and/or quality of water in your area.

Factors affecting water availability and quality	Rank
Drought	
Heat stress	
Flood	
Others (specify)	

42. Please describe if there were any water sources dried up totally in past three gadaa periods

____

VII. Adaptation Strategies

43. Have you taken any adaptation measures in order to reduce the effects of climate change on your livestock? Yes ☐ No ☐

44. If yes to Q 43, which of the following adaptation strategies have you employed in your economic activities/livelihood in past three Borana gadaa periods? (Rank 1 for the most practicing, 2 to the next and so on).

Adaptation strategies	**Rank**
Temporary migration in search of water and/or feed	
Diversification, intensification and / or integration of pasture management	
Improving animal health	
Hay making	
Income diversification practices; sell of charcoal & animal products, labour force, petty trade …	
Shifting from cattle to goat and camel	
Diversification of livestock genetics	
Area enclosures	
Improving livestock breeding	
Agro-pastoral system	
Soil and water conservation	
Bush thinning	
Others (specify if any)	

45. If your answer to Q 43 is no, why?

No.	**Reasons for not taking adaptation measures**	**Rank**
1	Lack of information	
2	Lack of capital	
3	Lack of skill	
4	Shortage of sufficient man power	
5	Shortage of grazing land	
6	Not observing the climate related problems	
7	Do not know what to do	
8	Distance to input markets	
9	Others (specify)	

B. Checklist for Key Informant Interviews

Name____________________________________

*Kebele*____________________________________

Profession/position___________________________

1. Can you explain any form of climate change you have noticed in your *kebele*/district?
2. Explain the trends of rainfall and temperature data of last three gadaa periods in your *kebele*/district?
3. Explain the extent of climate change and its effects on livestock production in your *kebele*/district?
4. Among livestock productions which are more vulnerable to the adverse effect of climate change?
5. Explain trends of livestock feeds and water resource of last three gadaa periods in your *kebele*/district?
6. What is your future plan in increasing livestock productivity under changing climate?
7. What are the local coping mechanisms used to reduce the effects of climate change at household level?
8. What are the institutional levels of coping strategies to reduce future of climate change effect?
9. Describe contributions and constraints of institutions (both GOs and NGOs) in facilitating adaptation of livestock to climate change in your district?
10. Explain about local communities' participation in making decisions with regard to adaptation mechanisms.

11. Describe the main challenges to undertake adaptation to climate change in your district with possible solutions.

C. Checklist for Focus Group Discussions

Age __________ Sex __________ Level of wealth _________________

Education level _________________

Kebele __________________________

Group __________________________

1. Is the pattern of weather changing? Please explain trends of temperature and rainfall condition of last three gadaa periods.
2. What are the manifestation of climate change and variability? Are rainfall variability, drought, high temperature and flood occurring in your village/*kebele*?
3. Is there any change on livestock number and composition in your village/*kebele*?
4. What are the effects of climate change on livestock production? Could you tell us the major effects that you perceived?
5. Which type of livestock is more resistant to climate change and variability?
6. What are the condition of livestock feeds and water resources availability in your village in last three gadaa periods?
7. What are major effect of climate change observed on rangeland which new to your village/*kebele*?
8. How do you cope up or adopt the effect of climate change on your livestock production?
9. What are the main challenges that hinder your coping mechanisms?
10. What kind of support do you want to undertake adaptation measures?

BIOGRAPHICAL SKETCH

The author was born on February 24, 1989 G.C in Sabba *kebele* of Teltelle District of Borana zone, Oromia National Regional State to his father Halake Huka and his mother Elema Halake. He attended his primary school at Brindar (1997- 2000 G.C), junior school at Teltelle (2001 – 2004 G.C) and high school and preparatory at Yabello from (2005 – 2008 G.C). After passing the Higher Education Entrance Certificate examination (HEECE), he joined Hawassa University in 2009 and graduated with a BSc degree in Geography and Environmental Studies in 2011. Soon after graduation he was employed by Teltelle District Education sector. He served as a teacher for three years and then enters to Teltelle district Environmental protection, forestry and climate change office. He joined the School of Graduate Studies of Hawassa University to pursue his MSc. in 2017/18 and study majoring in the field of Climate Change and Sustainable Agriculture.