



**EFFECTS OF CLIMATE CHANGE ON THE LIVELIHOOD OF  
SMALLHOLDER FARMERS AND THEIR ADAPTATION  
MECHANISMS: THE CASE OF ADAMI TULU JIDO KOMBOLCHA  
DISTRICT, OROMIA REGION, ETHIOPIA**

**MSc THESIS**

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**HAWASSA UNIVERSITY  
COLLEGE OF AGRICULTURE**

**HAWASSA, ETHIOPIA**

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## Advisor Approval Sheet

As thesis research advisors, we here by certify that we have read and evaluated this thesis prepared, under our guidance, by Abdissa Hatew entitled “**Effect of Climate Change on the Livelihood of Smallholder Farmers and Their Adaptation Mechanisms: The Case of Adami Tulu Jido Kombolcha District, Oromia Region, Ethiopia.**”

We recommend that it be submitted as fulfilling the thesis requirement.

_____	_____	_____
Major Advisor	Signature	Date
_____	_____	_____
Co-advisor	Signature	Date

## **DEDICATION**

I dedicate this thesis manuscript to my father Hatew Chuko and my mother Hatatu Kotu for nursing me with affection and love and for their dedicated partnership in the success of my life.

## **STATEMENT OF THE AUTHOR**

I declare that this thesis is my bonafied 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**.....

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**Date of Submission**.....

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## LIST OF ABBREVIATIONS AND ACRONYMS

<b>CGE</b>	Computable General Equilibrium Model
<b>CRV</b>	Central Rift Valley
<b>CSA</b>	Central Statistics Authority
<b>DA</b>	Development Agent
<b>EHNRI</b>	Ethiopian Health Nutrition Research Institute
<b>FAO</b>	Food and Agriculture Organization
<b>FGD</b>	Focus Group Discussion
<b>FTC</b>	Farmers Training Center
<b>GCMs</b>	Global Climate Models
<b>GDP</b>	Gross Domestic Product
<b>GHGs</b>	Greenhouse Gases
<b>GIEWS</b>	Global Information and Early Warning System
<b>IFPRI</b>	International Food Policy Research Institute
<b>IPCC</b>	Intergovernmental Panel on Climate Change
<b>m.a.s.l</b>	meter above sea level
<b>MoFED</b>	Ministry of Finance and Economic Development
<b>NAPA</b>	National Adaptation Programme of Action
<b>NMA</b>	National Meteorology Agency
<b>PSNP</b>	Productivity Safety Net Program
<b>OESPO</b>	Oromia Economic Study Project Office
<b>SPSS</b>	Statistical Package for Social Science
<b>SSA</b>	Sub Saharan African
<b>TLU</b>	Tropical Livestock Unit
<b>UNDP</b>	United Nation Development Program
<b>UNECA</b>	United Nations Economic Commission for Africa
<b>UNFCCC</b>	United Nations Framework Convention on Climate Change
<b>VIF</b>	Variance Inflation Factor

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*EFFECTS OF CLIMATE CHANGE ON THE LIVELIHOOD OF SMALLHOLDER FARMERS AND THEIRS ADAPTATION MECHANISMS: THE CASE OF ADAMI TULU JIDO KOMBOLCHA DISTRICT, OROMIA REGION, ETHIOPIA*

**Abstract**

*Climate change is a major challenge for agriculture, food security and rural livelihoods for many of people in the area. The aim of this study was to assess the effects of climate change on the livelihood of smallholder farmers and theirs adaptation mechanisms. The study was conducted in four rural kebeles of Adami Tulu Jido Kombolcha of Oromia Region, Ethiopia. Both primary and secondary data were collected and analyzed using both qualitative and quantitative (descriptive statistics and binary logit model) methods of data analysis. Primary data were collected from a randomly selected 200 sample households through interview and focus group discussion. Relevant secondary data were also obtained from National Meteorological Agency (NMA), other governmental offices, and the internet. The results obtained from the analysis of three decades meteorological data and the respondents' perception on local climate change indicate an overall increase in temperature and high variability in belg and kiremt rainfalls. Local people perceived climate change induced hazards as increasing in terms of the occurrences of frequent drought, extreme heat, livestock disease and crop yield reduction. The findings also reveal that some elements of climate (temperature and rainfall) show annual and seasonal variability with slightly increasing trend. It is found that higher temperature and decreasing precipitation levels caused by climate change depresses crop yields and livestock production. The findings indicate that climate change has led to changing the planting time, declined crop yield and decreasing livestock production. The results of binary logit model analysis identified that age, sex, education level, TLU, number of oxen, farm size, off farm activities, distance to Farmers' Training Centre and distance to market are the major determinants of households livelihoods as a measure of farmers food security. Changing planting date, implementing soil and water conservation techniques, use of improved crop varieties, use of irrigation and growing drought tolerant crops are the major adaptation mechanism employed by the farmers to adapt to climate change in the study area. In livestock production, farmers are found to decrease livestock numbers by selling the older ones, diversify livestock holdings and practice transhumance. Lack of awareness, shortage of money, poor information, shortage of land, lack or low access to irrigation, poor access to market, no or low access to credit, low access to agricultural inputs and low access to extension service as most important barriers to adaptation.*

**Keywords:-***Climate change/ variability, Farmers' perceptions, Food security, Livelihoods,*

## CHAPTER ONE: INTRODUCTION

### 1.1 Background

Today, climate change is recognized as one of the greatest challenges of our world. It is predicted to have adverse consequences for the world's ecosystems, economies and societies. But, the severity of adverse effects varies across countries, regions, and socio demographic groups due to differences in exposures, sensitivities and adaptive capacities (IPCC, 2007).

The negative effects of climate change are threatening to reverse development gains in many parts of the world especially in sub-Saharan Africa (SSA) (IPCC, 2001). It is now an accepted scientific phenomenon that the global climate is changing. In the sub-Saharan region rainfall patterns have become less predictable, precipitation has decreased on average, and temperatures are rising (Holmgren and Oberg, 2006). Evidence shows that the increasing trend of the already high temperatures and the declining of precipitation levels will increasingly result in reduced agricultural production in sub-Saharan Africa (Mano & Nhemachena, 2007).

Over the coming decades, global climate change will have an impact on food and water security in significant and highly uncertain ways, and there are strong indications that developing countries will bear the brunt of the adverse consequences, particularly from climate change. This is largely because poverty levels are high, and developing country capacity to adapt to global change is weak. Furthermore, the rural populations of developing countries for whom agricultural production is the primary source of direct and indirect employment and income will be most affected due to agriculture's vulnerability to global change processes (Ringler *et al.* 2011).

Agriculture and food security, water resources, biodiversity and ecosystems, and human health are identified as the key vulnerable sectors for Africa (IPCC, 2007). Agriculture is the most important sector particularly in sub-Saharan Africa (SSA). It employs more than 60% of active population and contributes, on average, 40% of GDPs of the region. Negative impacts of climate change on agriculture in SSA are likely to be highly significant (Kandji *et al.*, 2006). Muller *et al.* (2011) noted that the negative consequences of climate change are expected to be damaging for Africa where over 95 % of the farm production is dependent on rain-fed agriculture. Even though the impact of climate variability and change on agricultural production is a global concern, the impact is particularly significant in Africa.

Like in the other sub-Saharan countries, agriculture is the largest sector of economy in Ethiopia, accounting for about 46% of the national GDP, 85% of the labor force, 90% of the export earnings, and 90% of the poor depend on the sector for its livelihood (World Bank, 2010). It is also the major source of food for the population and the prime contributing sector to food security. In addition, agriculture is expected to play a key role in generating surplus capital to speed up the country's overall socio-economic development (CSA, 2008). The major factors responsible for the low productivity of Ethiopian agriculture are identified as reliance on traditional farming technologies, soil erosion caused by deforestation and overgrazing, poor complementary services such as extension, credit, marketing and infrastructure; and climatic factors such as drought and flooding. This has in turn has reduced the adaptive capacity or increased the vulnerability of farmers to change in climate (Temesgen, 2010).

Ethiopian agriculture is basically rain fed where the productivity and competitiveness of the sector is increasingly constrained by temporal and spatial variability of climate change. This could potentially expose millions of people to recurrent food shortages and episodic famines. Moreover, the negative impact of climate change and variability on crop and livestock production could result in a nationwide food shortage and greatly hinder the economy (Assfa *et al.*, 2008). Historically, Ethiopia has been portrayed as a food deficit country with its people and livestock suffering from recurrent droughts and floods. The great famines of 1973-74 and 1984 droughts as well as some of the recent droughts and floods that caused the death of a millions persons, of people and livestock can be cited as examples of the catastrophic impacts of climate change (NMA, 2007).

The Adami Tulu Jido Kombolcha, where the study district is located, is one of the vulnerable regions in the country which is adversely affected by climate variability and change (Kassie *et al.*, 2013). The region experiences frequent natural hazards such as recurrent droughts, sudden flooding and chronic water stress that are often aggravated by climate change and its variability. The Adami Tulu Jido Kombolcha also covers a variety of agro-ecologies characterized by extensive areas of low rainfall as well as limited areas receiving adequate rainfall (Getachew and Tesfaye, 2015). Various studies indicated that the frequency and intensity of extreme events have negative impacts on the biophysical and socio-economic assets of Ethiopia specifically in the Adami Tulu Jido Kombolcha (Gizachew and Shimelis, 2014). As a result farmers in many arid and semi-arid areas of the Adami Tulu Jido Kombolcha was more vulnerable to climate change for their economies largely depends on climate sensitive agricultural production systems. Therefore this study was designed to

investigate the effects of climate change on the livelihood of smallholder farmers and their adaptation mechanism in the Adami Tulu Jido Komblocha district.

## **1.2. Statement of the Problem**

Climate change and variability have adverse impacts on environment, human health, food security, economic activity, resources and physical infrastructures. A large part of Ethiopia is dry sub-humid, semi-arid and arid, which is prone to desertification and drought. The country has also fragile highland ecosystems that are currently under stress due to population pressure and associated socio-economic practices (NAPA, 2007). Ethiopian agriculture is not highly productive in general. This is mainly because of climatic factors and soil and land degradation (IPCC, 2007). The Adami Tulu Jido Kombolcha region, where the study area is located, has been adversely affected by climate variability and change, which is manifested in the frequency and intensity of flood and drought. In this area the fluctuations in precipitation and temperature rates are directly affecting the production and productivity of the agricultural systems (Greenstone, 2006). Climate change and variability cause negative impacts upon agriculture (Below *et al.*, 2010). Because of the size and sensitivity of the agricultural sector, the impact is relatively high in developing countries (IPCC, 2014), especially on the farming livelihoods based on it. Research on climate change and variability and local livelihood adaptation mechanism are limited in Ethiopia and no known study is reported for study area. A known study for Ethiopia is done by Deressa (2006) that used sub-regional (agro-ecology) agricultural data, not household level data. The scale of his analysis does not cover basic household specific characteristics that are potentially the key to designing effective adaptation mechanism. This study was designed, therefore, to assess the effects of climate change on

smallholder farmer livelihood and their adaptation mechanism in the Adami Tulu Jido Kombocha district.

### **1.3 Objectives of the Study**

The general objective of this study was to investigate the effects of climate change on the livelihood of smallholder farmer and their adaptation mechanisms in the Adami Tulu Jido Komblocha district.

#### **1.3.1. Specific Objectives**

The study had the following specific objectives:

1. To analyse rainfall and temperature variability and their trends overtime in the study area.
2. To analyse the effects of climate change on smallholder farmers' livelihood with particular focus on crop and animal productions in the study area.
3. To analyse the households livelihood status, as measured by food security level.
4. To identify the adaptation mechanisms of smallholder farmers in the study area in the face of changing climate.

### **1.4. Research Questions**

The study intends to answer the following questions:

1. What do the trends of rainfall and temperature show overtime in Adami Tulu Jido Komblocha district?
2. What is the impact of climate change on smallholder farmer livelihood in the study area in terms of their crop and livestock production?
3. What is the household livelihood status as measured by their food security situation in the study area?

4. What are the adaptation mechanism that farmers use in response to climate change and Adami Tulu Jido Komblocha district?

### **1.5. Significance of the Study**

The impacts of climate change on agriculture are likely to be regionally distinct and highly heterogeneous spatially, requiring sophisticated understanding of causes and effects along with careful design and dissemination of appropriate responses. These changes will challenge the livelihood of farmers and other natural resource based livelihood that are already vulnerable and food insecure. Understanding how climate change is increasing the vulnerability of the rural smallholder farming communities is essential for effective policy responses.

The findings of this study are believed to make some contribution towards the ongoing effort of combating the recurrent effect of climate change on livelihoods. It is hoped that the study increases knowledge on the problems due to drought, floods, crop failure, animal's production and other related issues in the district and raise local understanding about climate change and its effects on local livelihood thereby informing policy and local awareness creations to community. Moreover, the findings would enhance and facilitate exchange of climate knowledge and information among local communities, field experts, policy makers and researchers. It may serve as a basis for further studies on the subject and, also document local climate change trend and adaptation practices of farmers on climate change and variability.

### **1.6. Scope and Limitation of the Study**

This study is confined to the effects of key climatic variables such as rainfall and temperature, and most common adaptation mechanism on household livelihoods. Besides, it utilizes cross sectional data generated from 200 households selected from four rural *kebeles* of Adami Tulu Jido Kombolcha district in Oromia region, Ethiopia.

In addition, the study uses three decades rainfall and temperature data obtained from Ethiopian National Meteorological Agency. Hence, one of the limitations of this study is relied on four selected *kebeles* in Adami Tulu Jido Kombolcha district, for practical reasons such as time, and financial limitations, some farmers were not willing to fill questionnaires and participation in FGD because of during data collection were conduct the country where under the state emergency and shortage of adequate secondary source of data was also another problem.

Also during the data collection process extreme temperature, poor transport and in accessibility of roads, farmers 'hesitance and unwillingness of selected respondents to be interviewed and tell the right in formations, specially, with regard to their assets, source of income, family size and land size were the major limitations during the study. And the other limitation livelihoods are very wide concept including many elements and explanatory variables that are related to each other in a complex way. And climate change can affect all elements of livelihood resources (natural capital, human capital and social capital). However, this study focused only on the effects of climate change on crop and animal productions in the study area.

### **1.7. Organization of the Paper**

The study is organized into five chapters. The first chapter deals with the introductory parts including background, statement of the problem, objectives, significance, scope and limitations of the study. The second chapter presents review of related theoretical and empirical literatures. In the third chapter, methodology of the study comprising the data, model specification and methods of data analysis is presented. The empirical findings of the study are discussed in the fourth chapter. Finally, chapter five is devoted for the conclusion and policy implications based on the findings.

## **CHAPTER TWO: LITERATURE REVIEW**

### **2.1 Concepts of Climate Change and Variability**

**Climate change** in IPCC usage refers to a change in the state of the climate that can be identified (E.g. 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. It refers to any change in climate over time, whether due to natural variability or as a result of human activity.

This usage differs from that in the United Nations Framework

Convention on Climate Change (UNFCCC), where climate change refers to a change of climate that is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and that is in addition to natural Climate variability observed over comparable time periods (IPCC, 2007). Each of these two definitions is relevant and important to keep in mind.

#### **Climate Variability**

There is no internationally agreed definition of the term “climate variability”. Climate has been in a constant state of change throughout the earth’s 4.5 billion-year history, but most of these changes occur on astronomical or geological time scales, and are too slow to be observed on a human scale. For meteorologists and climatologists, however, climate variability refers only to the year-to-year variations of atmospheric conditions around a mean state (NMSA, 1996).

### **2.2. Causes and Manifestation of Climate Change**

The Earth's climate has changed many times during the planet's history, with events ranging from ice ages to long periods of warmth. During the last centuries natural factors such as volcanic eruptions or the amount of energy released from the sun have affected the Earth's

climate on a smaller scale. By the 1950s and early 1960s, it was becoming clear that human activities were releasing CO<sub>2</sub> fast enough to significantly increase its atmospheric abundance (Dessler & Parson, 2006).

Beginning since the 19<sup>th</sup> century, due to human activities associated with emissions of carbon dioxide and other greenhouse gases the composition of the atmosphere has changed. The Fourth Assessment Report of the IPCC published in 2007 stated that: ‘Most of the observed increase in global average temperatures since the mid-<sup>20</sup><sup>th</sup> century is very likely due to the observed increase in anthropogenic greenhouse gas concentrations (Pender, J.S. 2001). The scientific community has reached consensus that this changes cause a warming of the atmosphere and therefore influencing the Earth's climate. Continuation of greenhouse gas emissions can result in additional warming over the 21<sup>st</sup> century up to 4.5 °C by 2100.

Land use and land cover changes influence carbon fluxes and GHG emissions, which directly alter atmospheric composition and radiative forcing properties. They also change land surface characteristics and, indirectly, climatic processes. Established evidence links land degradation to the loss of biodiversity and climate change, both as cause and effect. CO<sub>2</sub> induced climate change and land degradation remain inextricably linked because of feedbacks between land degradation and precipitation. Climate change might exacerbate land degradation through alteration of spatial and temporal patterns in temperature, rainfall, solar radiation, and winds.

The contribution of human activities to climate change, however, is increasing. The probability that human activities are the main cause for the increase in temperature since the mid-twentieth century has risen from 66 % in 2001 to more than 90 % in 2007 (Keshav and Niraji, 2013). Rising fossil fuel burning and land use changes have emitted, and are continuing to emit, increasing quantities of greenhouse gases into the Earth's atmosphere (UNFCCC,

2007). These greenhouse gases include carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>) and nitrogen dioxide (N<sub>2</sub>O), and rise in these gases has caused raise in the amount of heat from the sun with held in the earth's atmosphere, heat that would normally be back into space. Greenhouse gases and aerosols affect climate by altering incoming solar radiation and out-going infrared radiation that are part of Earth's energy balance.

### **2.3. Impacts of Climate Change and Variability in Ethiopia**

Currently climate change and variability is already impose significant challenge to Ethiopia by affecting food security, water and energy supply, health, poverty reduction and sustainable development efforts (Abebe, 2007).

Furthermore, extreme weather events, such as droughts, floods, or landslides, may cause death to domestic animals. Livestock suffering and death often means that farmer's wealth is decreased and they lose much of their resources (Pettengell, 2010). According to IFPRI (2009), agriculture is extremely vulnerable to climate change. Higher temperatures eventually reduce yields of desirable crops while encouraging weed and pest proliferation. Changes in precipitation patterns increase the likelihood of short run crop failures and long run production declines. The overall impacts of climate change on agriculture are expected to be negative.

Agriculture plays a dominant role in the economy of Ethiopia, contributing about half of the GDP, provides employment opportunity for majority of working force and generates considerable foreign exchange earnings (MoFED, 2006). Despite its high contribution to the overall economy, this sector is challenged by many factors, of which climate related disasters like drought and flood often causing famine, are the major ones (Temesgen, 2007). As a result of this, the country becomes highly vulnerable to climate change and variability. It has been indicated that climate change and variability could have significant impact in Ethiopia for

various reasons; its economy mainly depends on small scale rain fed agriculture, which is very sensitive to climate variation. Large part of the country is arid and semiarid and is highly prone to desertification and drought. It has also a fragile highland ecosystem, which is currently under stress due to population pressure (NMA, 2001).

Abate (2009) argued that, climate change affects agriculture and its effect is pronounced on the subsistence farmers, which have low adaptive capacity. Under dry-land conditions where the biological productivity is low and majority of the poor are found, climate change is manifested not only by increasing temperature but also through changes in hydrological cycles characterized by both increased droughts and flooding (Thomas *et al.*, 2007). Generally, climate changes will most likely increase poverty in Ethiopia (Mideksa, 2010). Long term trends towards reduced rainfall, and recurring droughts, have played a role in weakening of Ethiopian economy.

#### **2. 4. Climate Change and Agriculture**

There is close interrelationship between climate change and agriculture. Agriculture is highly dependent on climate patterns while, on the other hand, it can contribute to climate change through the release of GHGs. Agriculture can also offer opportunities to mitigate climate change.

As a human activity, agriculture is directly exposed to climate change as its activities are directly exposed to climatic conditions. Higher temperatures, reduced rainfall and increased rainfall variability reduce crop productivity that would, in turn, affect food security in low income and agriculture based economies (Edwards Jones *et al.*, 2009). Thus, the impact of climate change is more detrimental to countries that depend on agriculture as the main livelihood source. Climate change causes variability in temperature conditions and

precipitation as well as the frequency and severity of weather events. Some indirect effect of climate change includes, changes in soil moisture, land and water condition, change in frequency of fire and pest infect and the distribution of diseases. The potential for a system to sustain adverse impact on agriculture is determined by its capacity to adapt to the changes (Mohan and Rob, 2005).

Climate change will have wide ranging effects on the environment, and on socio-economic and related sectors, including water resources, agriculture and food security, human health, terrestrial ecosystems and biodiversity. Changes in rainfall pattern are also likely to lead to severe water shortages and/or flooding. Rising temperatures also will cause shifts in crop growing seasons which affects food security and changes in the distribution of disease vectors putting more people at risk from diseases such as malaria. Climate change has the potential to undermine sustainable development, increase poverty, and delay or prevent the realization of development goals (IPCC, 2007b). An effective way to address the impacts of climate change is by integrating adaptation measures into sustainable development mechanism so, as to reduce the pressure on natural resources, improve environmental risk management, and increase the social well-being of the poor. Climate change can influence humans directly, through impacts on health and the risk of extreme events on lives, livelihoods and human settlements, and indirectly, through impacts on food security and the viability of natural resource-based economic activity. The biophysical effects of climate change on agriculture induce changes in production and prices, which play out through the economic system as farmers and other market participants adjust autonomously, altering crop mix, input use, production, food demand, food consumption, and trade (Oxfam, 2006).

## **2.5. Climate Change and Agriculture in Ethiopia**

Ethiopian agriculture dominates the economy which accounts for almost 46% of GDP and 85% of total employment (World Bank, 2012). Thus, the country is highly dependent on the agricultural sector for income, foreign currency, and food security, the sector is dominated by small scale farmers who employ largely rain-fed and traditional practices a state which renders Ethiopia highly vulnerable to climate variability as seen during past persistent droughts, and thus to climate change (World Bank 2007). Rainfall and temperature are important determinants of crop harvests, and unfavorable realizations of either the amount or the temporal distribution of rainfall triggers food shortages and famine. A recent mapping on vulnerability and poverty in Africa put Ethiopia as one of the countries most vulnerable to climate change with the least capacity to respond (Bezu and Holden, 2008). Indeed, Ethiopia has experienced at least five major national droughts since 1980 (Yosuf *et al*; 2008). Cycles of drought create poverty traps for many households, constantly uneasy task to build up assets and increase income. Food shortage and famine associated with rainfall variability cause a situation of high dependency on international food aid. And Ethiopia is one of the biggest food aid receipt countries in Africa that accounts to 20-30% of all food aid to sub- Saharan Africa (Bezu and Holden, 2008).

## **2.6. Impact of Climate Change on Agriculture**

Climate change can affect agricultural production in a variety of ways. Temperature and precipitation patterns, extreme climate conditions, surface water runoff, soil moisture and CO<sub>2</sub> concentration is some of the variables which can considerably affect agricultural development (IPCC, 2007). Global warming would alter natural climate and environmental systems in many ways, leading to an increased frequency of weather events, rising sea levels and changes

in precipitation patterns. These changes could impact socio-economic activities, with series implications for the well-being of humans long into the future (Zhai and Zhuang, 2009). Agriculture is one of the most vulnerable sectors to climate change. Zhai and Zhuang (2009) noted that whatever technological advancement have been reaching in the last century, agricultural production and productivity is highly dependent on the weather and climatic conditions in many areas of the world.

Determining the effect of climate change on agriculture is complex as it affects varieties of factors such as change in temperature, change in rainfall pattern and change in carbon dioxide levels (Aydinalp and Cresser, 2008). Climate change affects agricultural production and productivity both directly and indirectly. It directly affects agriculture by affecting the weather variables such as temperature, solar radiation, rainfall, wind speed and humidity (Sowunmi and Kintola, 2009) and indirectly through disease and pest outbreak as well as favoring the development of climate related diseases like malaria that affect the work force (Ngigi, 2009).

The impact of climate change on agricultural production is not uniform across regions of the world; low latitude and developing countries are expected to suffer more from global warming, reflecting their disadvantaged geographic location, greater agricultural share in their economies, and limited ability to adapt to climate change (Newton *et al.* 2010).

The concern of food security and climate change in the developing world would be threatened due to anticipated to experience significant change in temperature and rainfall patterns, their developing economy heavily rely on climate sensitive business and they totally depend on agriculture as source of food, which seriously affects by climate change (Newton *et al.*, 2010).

Ethiopia has already suffered from climate extremes, manifested in the form of frequent drought (1965, 1974, 1983, 1984, 1987, 1990, 1991, 1999, 2000, and 2002, 2008) and recent

flooding (1997 and 2006). Rainfall variability and associated drought have been major causes of food shortage and famine in Ethiopia (World Bank, 2006).

At the national scale, the link between drought and crop production is widely known. However, little evidence is available on how climate change affects crop yield and farmers' adaptation mechanism at the household level. Agriculture is mainly practiced under rain fed condition and characterized by many subsistent, small scale farmers (Temesgen *et al.*, 2009). Climate change could have a significant impact in Ethiopia economy; because the economy mainly depends on small scale rain fed agriculture, which is very sensitive to climate variations. Large part of the country is arid and semi-arid and is highly prone to desertification and drought. It has also a fragile highland ecosystem, which is currently under stress due to population pressure.

Similar to crop production, the impact of climate change and variability in the livestock production is generally negative. Heat stress and its impact on seasonal water availability have a variety of detrimental effects on livestock, with significant effects on milk production and reproduction in dairy cows, and swine fertility (Nigus, 2011).

Drought and delay in the onset of rain led to poor grass regeneration/forage deficit, water shortage and heat stress on livestock, and consequently increased the mortality of the livestock, vulnerability to diseases and physical deterioration due to long distance travel for water and pastures (Abate, 2009). Climate change affects livestock both directly and indirectly. The direct effects from air temperature, humidity, wind speed and other climate factors influence animal performance: growth, milk production, wool production and reproduction. Climate change will have far reaching consequences for dairy and meat production, especially in vulnerable parts of the world where it is vital for nutrition and livelihoods. The impact of climate change can

heighten the vulnerability of livestock systems and exacerbate existing stresses upon them, such as drought (Abebe, 2013). The most vulnerable communities to the impacts of climate change inhabit the dry lands areas. Pastoralists inhabiting dry lands have been able to survive the harsh environments practicing various sustainable livelihood approaches including seasonal movements, keeping livestock, among others (UNDP, 2010).

## **2.7. Climate Change, Agriculture and Food Security**

Agriculture is inherently sensitive to climatic conditions. It is a sector vulnerable to current and anticipated global climate change. Consequently, livelihood of the people leading agriculture dependent life is highly vulnerable to climatic shocks which result in food insecurity. Despite a good performance with high economic growth rates over the last decade, Africa has not made significant progress on some of its major challenges, especially food security and employment for the growing youth population (UNECA, 2012). Climate change has affected agriculture negatively and triggered food security problem in various regions of Africa. Higher temperatures, reduced rainfall and increased rainfall variability reduce crop productivity in many tropical areas. This affects food security in low income and agriculture based poor economies. Thus, the impact of climate change is detrimental to countries in which people depend on agriculture as their main means of livelihood (Jones *et al.* 2009).

In the Horn of Africa, food insecurity has increased in drought affected pastoral areas of Somalia, Kenya, Djibouti and Ethiopia. The recent drought of 2011-2012 has been qualified as the worst drought in 60 years, caused by a prolonged lack of rain and resulting dry conditions. South eastern Ethiopia, northern and eastern Kenya, and southern Somalia, are the worst affected areas. The severity and scale of the drought has raised concerns because 80% of the

population in this sub-region depend on crops and livestock for their livelihoods and food security, (GIEWS, 2012).

Among the horn countries, Ethiopia is one of the most poverty stricken, ecologically vulnerable country whose growing population and economy are heavily impacted by climatic change and variability. In Ethiopia, agriculture is important for food security in three ways. Firstly, it produces the food people eat and contributes about 45% of Gross Domestic Product (GDP). Secondly, it provides the primary source of livelihood for about 80% of the country's total workforce. Thirdly, it can provide income through generating about 60% of export earnings from the exports (MoFED, 2010). This implies that climate change can affect food security mostly through affecting agriculture.

According to Funk *et al.* (2005), rainfall is expected to decline in the future and also become more irregular. Drought has been an increasing occurrence in Ethiopia over the last decades affecting a significant proportion of the population. Food shortage and famine associated with rainfall variability cause a situation of high dependency on international food aid. According to African Development Bank report in September 2010, there is a strong correlation between weather conditions and Ethiopia's economic growth performance. A change of 1% in average annual rainfall is associated with a change of 0.3% in real GDP in the following year. This has a clear implication for the impact of climatic conditions on smallholders' food security in the country. Furthermore, climate change will have impact on all four dimensions of food security such as food availability, food accessibility, food utilization and food systems stability. It will have an impact on human health, livelihood assets, food production and distribution channels, as well as changing purchasing power and market flows.

A large body of empirical literature on impacts of climate change on agriculture and food security exists in various countries using different approaches. Both economy wide and micro level studies generally report negative impact of climate change on agricultural production and productivity.

Thurlow *et al.* (2009) has examined the impacts of climate variability and change on economic growth and poverty in case of Zambia under different scenarios. The result of their study indicated that climate variability has imposed significant cost to Zambian economy. Another study by Zhai *et al.* (2009) modeled the potential long term impacts of global climate change on agricultural production and trade. They employed an economy wide, global CGE model, and simulation scenarios of how global agricultural productivity may be affected by climate change up to 2080. The interesting finding of their study is that as the share of agriculture in GDP decline, the impact of climate change on the overall economy become less intense.

Similarly, Gebreegziabher *et al.* (2011) have modeled the impacts of climate change on overall economy using countrywide dynamic Computable General Equilibrium model in Ethiopia. They simulated the impacts of climate change induced variations in land productivity in the Ethiopian economy for 2010–2060 periods. The results of simulation indicated that the projected reduction in agricultural productivity may lead to 30 % less average income, compared with the possible outcome in the absence of climate change in Ethiopia. They also confirmed that climate change does have a dramatic impact on agriculture dominated Ethiopia's economy even in the high growth scenarios.

In Ethiopia, Deressa and Hassan (2009) assessed the vulnerability of Ethiopian farmers to climate change in broad region of Nile Basin by using Ricardian approach. They conducted regression of net farm revenue on climate, household and soil variables. The results indicate

that vulnerability to climate shocks is not uniform across agro-ecological zones. Lemma *et al.* (2012) examine household food security implications of climate in pastoral areas of Jigijiga district in Eastern Ethiopia. They use rainfall and temperature data from the period 1952 to 2010 and primary data collected from 140 sample households. Mann-Kendall trend test results reveal existence of statistically significant declining trend in rainfall in the rainy season and increasing trend in temperature at annual and seasonal time scale.

Abera *et al.* (2011), used panel data to investigate the effect of rainfall shocks on Ethiopian rural households food security and vulnerability over time while controlling for a range of other factors. They generate a time variant multidimensional household food security index which is developed from various indicators by using principal component analysis. Taking food security index as the dependent variable, use fixed effects instrumental variable regression model to identify determinants of households' food security over time. Their results reveal that both the level and variability of rainfall are important determinants of persistent household food insecurity and vulnerability.

In the tropics and subtropics, where some crops are near their maximum temperature tolerance and where dry land, non-irrigated agriculture dominates, yields are likely to decrease for even small changes in climate, especially in Africa and Latin America, where decreases in overall agricultural productivity of up to thirty percent are projected during the next century. Therefore, there may be increased risk of hunger in some locations in the tropics and subtropics where many of the world's poorest live (IPCC, 2001). It is established that climate change, mainly through increased extremes and temporal/spatial shifts, will worsen food security in Africa and food insecurity vulnerability patterns will be modified by climate change (IPCC, 2007).

Climate change is creating additional food insecurities, particularly for the resource poor in developing countries who cannot meet their food requirements through market access. It is imperative to identify and institutionalize mechanisms that enable the most vulnerable to cope with climate change impacts. This requires collaborative thinking and responses to the issues generated by the interaction of food security, climate change and sustainable development. Achieving food security under a changing climate requires substantial increases in food production and improved access to adequate and nutritious food. Vulnerability to food insecurity is common across the world in semiarid and arid areas where marginal groups rely on rain-fed agriculture, climate variability directly affect agricultural production, as agriculture is inherently sensitive to climate conditions and one of the most vulnerable sectors to the risk and impacts of global climate change.

Climate change will act as a multiplier of existing threats to food security: It will make natural disasters more frequent and intense, land and water more scarce and difficult to access, and increases in productivity even harder to achieve. The implications for people who are poor and already food insecure and malnourished are immense (UNFCCC, 2009). Particularly in the least developed countries and small island developing states, it is the livelihoods and lives of the poorest and most vulnerable, including women, children and marginal communities, which are also at greatest risk to suffer from to the potential impacts of climate change. This is due to their high exposure to natural hazards, their direct dependence on climate sensitive resources such as plants, trees, animals, water and land, and their limited capacity to adapt to and cope with climate change impacts. Climate change may affect agriculture through: changes in temperature and precipitation, Changes in soil moisture and soil fertility, changes in the length of growing season and increased probability of extreme climatic conditions.

According to Pearce (2009), major climate change impacts on crop production includes crop damage/loss, lower yields, reduced seeding area, income loss, harvest difficulties, increased pest activity, and delayed seeding. Global climate models (GCMs) predict that aggregate changes in world food production are likely to be small (IPCC, 2001). However there is general agreement that climate change may lead to significant reductions in agricultural productivity in developing countries. Increased CO<sub>2</sub> is expected to have a positive effect on agricultural production due to greater water use efficiency and higher rates of plant photosynthesis (Kurukulasuriya et al, 2003). It promotes photosynthesis in plants, the process that converts CO<sub>2</sub> and water into glucose and oxygen. Climate change is already affecting all four dimensions of food security: food availability, food utilization and food system stability. In Ethiopia small holder farmers produce 90% of the total yield of agricultural sector while 99% of the production comes from the rain fed agriculture which is highly sensitive to climate change and variability (MoFED, 2006).

## **2.8. Adaptations to Climate Change**

Adaptation to climate impacts is not a new phenomenon. Natural and socioeconomic systems have continuously been adapting autonomously, or in accordance with a plan, to a changing environment throughout history with various natural and socioeconomic constraints that required surmounting (Kurukulasuriya *et al.*, 2008).

Historically, people whose livelihoods depend on agriculture have developed ways to cope with climate variability autonomously. Today, the current speed of climate change modifies known variability patterns to the extent that people will be confronted with situations they are not equipped to handle. Adaptation is recognized as a critical response to the impacts of climate change, because current agreements to limit emissions, even if implemented, will not

stabilize atmospheric concentrations of greenhouse gases and climate change (NAPA, 2007).

Adaptation is adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects from community to national and international, which moderates harm or exploits beneficial opportunities (Fussel, 2007).

Decisions on the type of adaptation are often made by individuals, groups within society, and organizations and governments on behalf of society. Some adaptation measures may be taken at individual level. These time societies have inherent capacities to adapt to climate change and have developed different adaptation and mitigation mechanism to combat climate change. They have developed knowledge, skills, technology, institutional arrangements and mechanism that are important foundations for adapting to long-term climate change. Communities have always adapted to climate variations by making preparations based on their resources and knowledge accumulated through experience of past weather pattern.

The capacity to adapt to climate change also varies across countries, social groups and regions over time. Hence, adaptation measures are very much related to socio-economic conditions of the country and community given basic forms of adaptations including micro level adaptations such as diversification and strengthening of crop and livestock production, changing land use, irrigation and altering the timing of operations, market responses, institutional changes and technological developments.

## **2.9. Conceptual Framework**

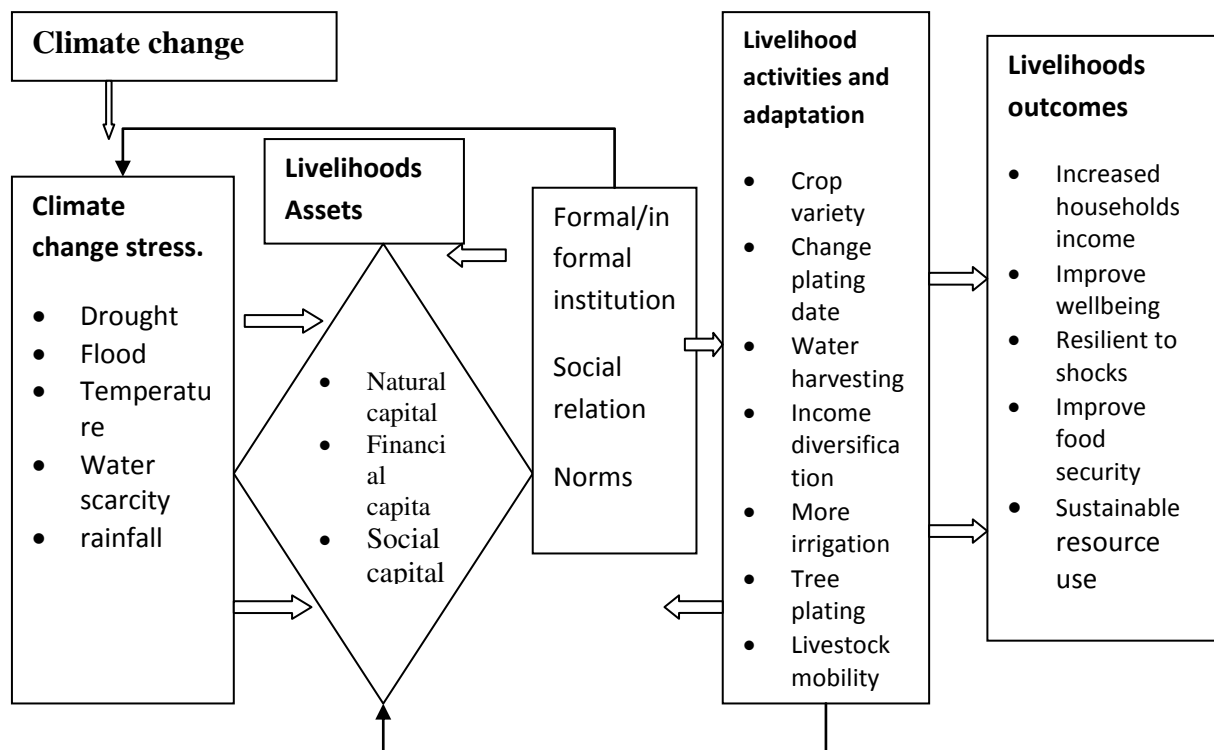
Climate change has far reaching consequences for agriculture that affect the poor disproportionately. Greater risks of crop failures and livestock deaths are already imposing economic losses and undermining food security and they are likely to get far more severe as global warming continues. Impacts of climate change on the agricultural sector are projected

to steadily manifest directly from changes in land and water regimes, the likely primary conduits of change. Changes in the frequency and intensity of droughts and flooding are expected.

Climate change is expected to result in long term water and other resource shortages, worsening soil conditions, drought and desertification, disease and pest outbreaks on crops and livestock, sea level rise. Vulnerable areas are expected to experience losses in agricultural productivity, primarily due to reductions in crop yield. Agriculture is important for food security in two ways: it produces the food people eat; and it provides the primary source of livelihood the world's total work force so agriculture is at the core of food security. In turn climate is also the most decisive factor for agriculture (FAO, 2008). Food systems exist in the biosphere, along with all other manifestations of human activity. some of the significant changes in the biosphere that are expected to result from global warming will occur in the more distant future, as a consequence of changes in average weather conditions.

Climate change variables influence biophysical factors, such as plant and animal growth, water cycles, biodiversity and nutrient cycling, and the ways in which these are managed through agricultural practices and land use for food production. Because for climate variables such as rainfall, soil moisture, temperature and radiation, crops have thresholds beyond which growth and yield are compromised. IPCC, (2007) concluded that climate variability and change would severely compromise agricultural production and access to food. In the case of an annual crop, the duration between sowing and harvesting will shorten. The shortening of such a cycle could have an adverse effect on productivity. In the long run, the climatic change could affect agriculture in several ways: productivity, agricultural practice environmental effect, soil erosion reduction of crop productivity.

Weather related disasters, crop failure, flood, and drought which resulted from extreme weather events will increase in frequency. As the result of this the livelihoods and food security status of millions of people in disaster prone areas will be adversely affected. As it is shown in figure 1, the climate change components are interrelated and their impact, directly or indirectly, feels by the livelihoods.



**Figure 1 Conceptual Framework of the study**

## CHAPTER THREE: METHODOLOGY

### 3.1. Description of the Study Area

#### Location and Size

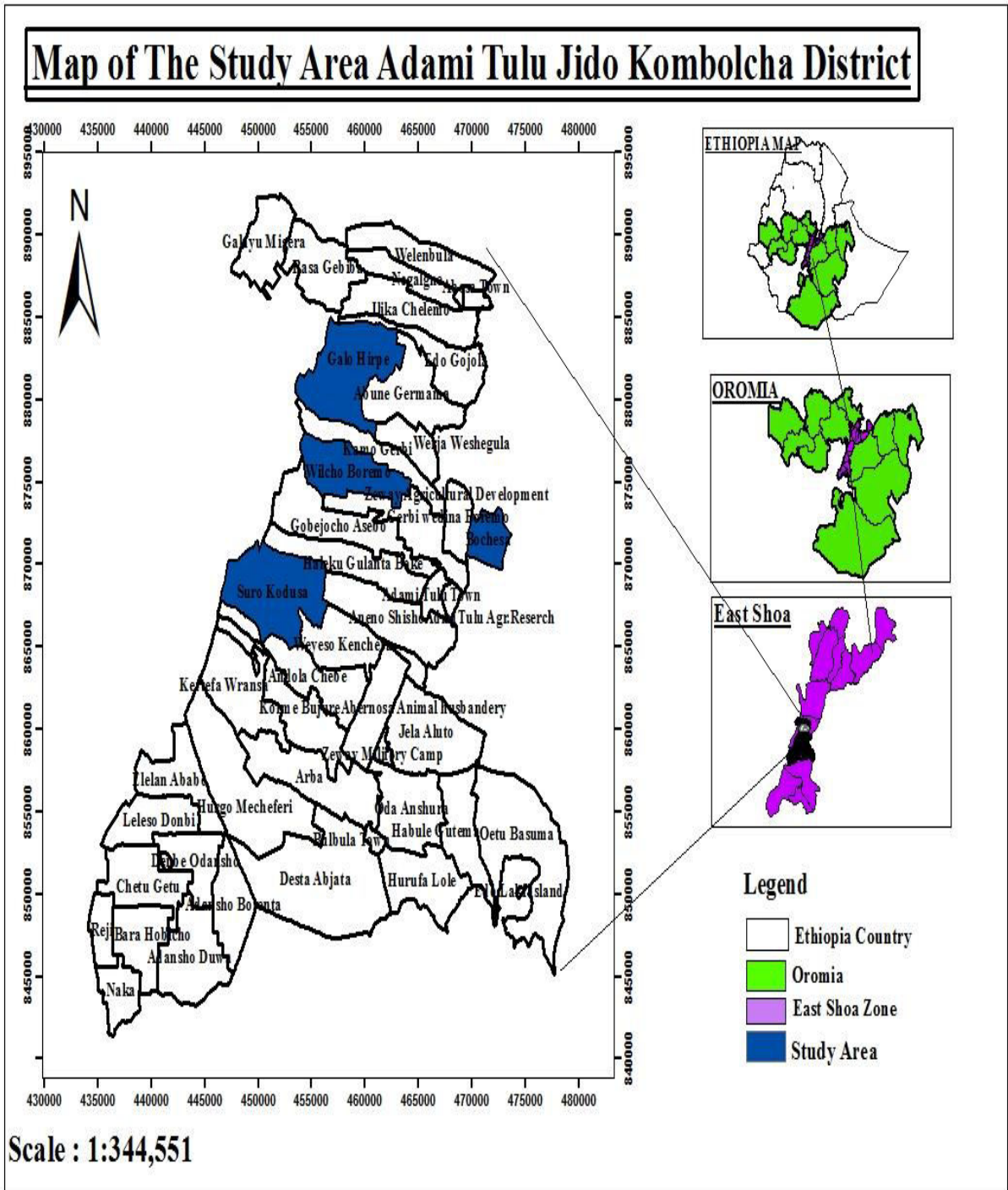
The study was carried out in Adami Tulu Jido kombolcha district situated in East Shoa Zone of Oromia Region about 160 km south of Addis Ababa. Geographically, it is situated in the Ethiopian Adami Tulu Jido Kombolcha between  $7^{\circ} 06' \text{ N}$ -  $8^{\circ} 27' \text{ N}$  and  $38^{\circ} 05' \text{ E}$  -  $39^{\circ} 25' \text{ E}$ . It is characterized by alternating topographical altitudes ranges from **1500-2328 m.a.s.l**

The district has a total area of 1403 km<sup>2</sup> which is divided into 39 administrative rural *kebeles*, four towns and total 43 *kebeles*. Batu Town is the administrative center of the district (OESPO, 2003).

#### Climate

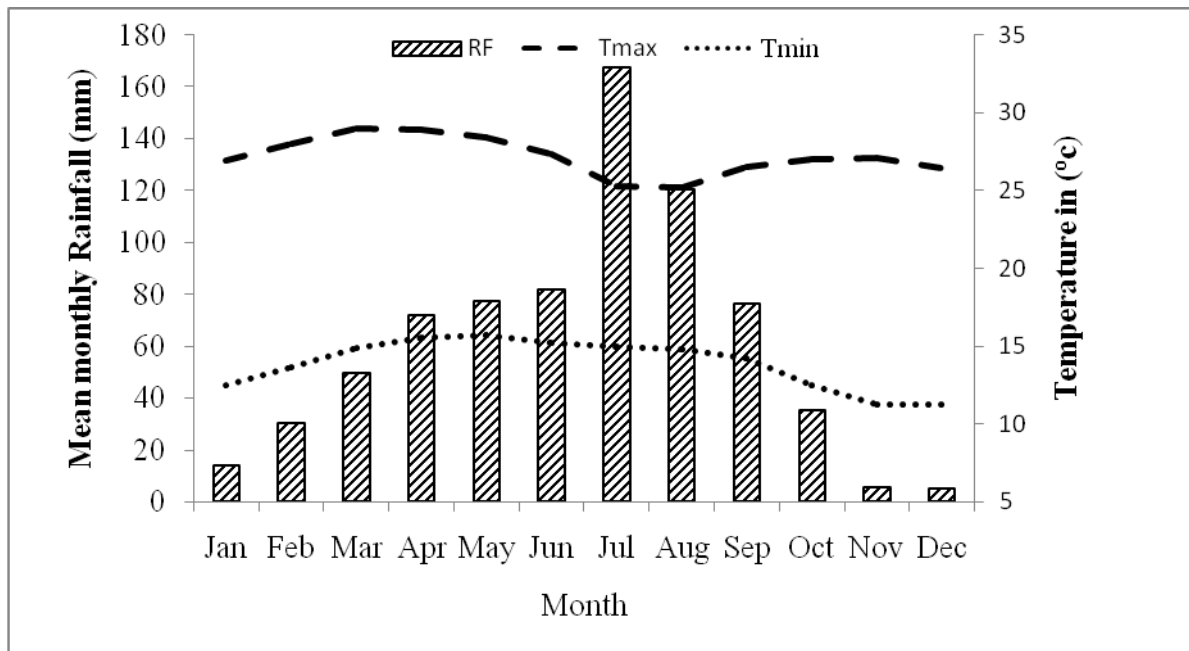
All parts of Adami Tulu Jido Kombolcha come within the sub-tropical climatic zone having semi arid and arid agro-climate zones. It is characterized by a bi-modal rainfall pattern with highly erratic distribution. According to NMA, the Adami Tulu Jido Kombolcha receives between 175–358mm rainfall during a short rainy season that extends from March–April locally known as *Belg* and 420–680mm during the main rainy season that extends from June–September locally known as *Kiremt*.

It receives on average annual precipitation of 759.7mm. The rain fall is getting vary from time to time and as a result almost all parts of the district are exposed to recurrent drought. Although the farming season is from March to July, it is not sufficient to grow *belg* crops. Therefore, farmers depend only on growing *meher* crops, once in a year.



**Figure 2** Map of the study area

The average annual minimum and maximum temperature for the district is 12°C and 28 °C, respectively (NMA 2007). The warmest period in the area is between February and May. On the other hand, the period between June and August is relatively colder. October and November are dry and windy months.



Source: Prepared from NMA, 2017 data

**Figure 3. Average monthly rainfalls, Max and Minimum temperature at Adami Tulu Jido Kombolcha district**

### Population

According to the 2007 National Census the total population for Adami Tulu Jido kombolcha district was 188612, of whom 99502 were men and 89110 women. The population was found as economically active 25-60 years are 50% of the total population.

### Soils

In Adami Tulu Jido Kombolcha district the soils are largely derived from recent volcanic rocks. The main parent materials of the soils are: basalt, ignimbrites, lava, gneiss, volcanic

ash, alluvium and pumice. The major soil units are Vertisols, Cambisols, Luvisols, Regosols, Lithosols, Andosols and Acrisols (FAO/UNESCO, 1977 cited in Itanna *et al.*, 2011). Sandy loam soil texture is the predominant of soils in area which are prone to surface crusting and erosion.

### **Vegetation cover**

Vegetation in sub-humid to semi-arid of Adami Tulu Jido Kombolcha (CRV) ranges from open woodland to bushed grasslands. According to Zerihun Woldu and Mesfin Tadesse (1990), the dominant tree species are Acacia spp are: *A. tortilis*, *A. seyal*, *A. senegal*, *A. etbaica*, *A. albida*, *Balanites aegyptica* and *Dichrostachy cinerea*. (*A. brevispica*, *A. mellifera*, *A. nilotica*, *A. reficiens*, and *A. hockii*, *A. abyssinica*), *Albizia gummifera*, *Croton macrostachyus*, *Cordia abyssinica*, *Vicus* spp *Combretum aculeatum*, *Terminalia brownie*, *Balanites aegyptium*, *Commiphora Africana*.

Acacia species provide essential browse mainly to goats and other animals. The density of acacia has been remarkably reduced. The people have been cutting acacia tree mainly for the production of charcoal. But, currently due to land conversion, the Acacia woodland and other vegetation types were reduced into 4% of the total area (Gebreslassie, 2014).

### **Farming system**

#### **Crop production**

Mixed farming is the major economic activity in the rural area of the Adami Tulu Jido Kombolcha district. Crop production, mainly rain fed production in the district. The major field crops include maize, wheat, barley, sorghum, haricot beans, *teff* and peas. Maize is used mainly for food and haricot beans are a cash crop.

## **Livestock Production**

Livestock is the major component of the farming in the Adami Tulu Jido Kombolcha district. The current number of the livestock estimated by the district agriculture and rural development office indicated, there are 141586 cattle, 39465 goats, 6424 sheep, 10631 donkey, 669 horses, and 71463 poultry (Adami Tulu Jido Kombolcha agriculture rural development organization, 2009). Cattle, goats, sheep, equines and chickens are the major livestock rearing in the area. The number of goats is more than the number of sheep; the number of donkeys is more than the number of horses because of goat and donkey were more tolerant to climate change than others. Donkeys have important role in the agriculture and transport economies of the district.

### **3.2. Research Design**

The research design used in this study is cross sectional survey where data on various socio-economic matters are collected from the sample population at a single period in time.

### **3.3. Sampling Method and Techniques**

In this study both purposive and random sampling techniques were employed for selecting study area and sampled *kebeles* and households respectively. In the first stage, the study area was purposely selected mainly with the consideration of the effect of climate change on local smallholder farmer's livelihood in the study area. There are 43 rural *kebeles* in Adami Tulu Jido Kombolcha district; out of those *kebeles* 22 *kebeles* were addressed by the safety net program. Accordingly, four representative *kebeles*, namely, Galo-rephe, Wilcho-barema, Buccessaa and Suro-kudusa were selected randomly.

The sample size was determined by using rule of thumb suggested by Green (1991). He suggested that,  $n \geq 50 + 8m$  (where  $n$  is sample size of the study and  $m$  is number independent variable).

$P_i = n_i/N$  Where:  $P_i$ = proportion of population included in stratum  $i$ ,

$n_i$ = the number of elements

$N$ = the total number of the population.

$$P_i = 200/2371 = 0.084$$

The above formula requires be greater than or equals to 170 sampled households as the total household number of the four rural *kebeles* is 2371. This study covered 200 households, selected proportional to the total number of households in each *kebele*. Accordingly, 77, 45, 44 and 34 households were selected for household survey from Galo-raphe, Wilcho-barema, Bocesa and Suro-kudusa *kebeles* respectively randomly by assuming the community is homogenous in farming practice and socio-cultural practice and similar agro ecological zone.

**Table 1. Distribution of Sample Respondent of the Selected *Kebeles***

No	<i>Kebeles</i>	Total household	Sample size
1	Galo raphe	919	77
2	Wilcho –barema	532	45
3	Bocesa	510	44
4	Suro- kudusa	410	34
	Total	2371	200

**Source:** Adami Tulu Jido Kombolcha district Administration office, (2017)

### **3.4. Data Types and Sources**

The study employed both primary and secondary data. As to the primary data sources, information were collected from household heads with a focus on socio economic and demographic characteristics of the households in the study area and essential information related to the research objectives. In support of the primary data sources, secondary data were collected from records of meteorological data, journals and office records published and unpublished materials to support primary data.

### **3.5 Method of Data Collection**

#### **3.5.1 Data Collection Instruments**

**Household survey:** Structured question was prepared to collect data on major research issues such as, perception of farmers towards trend of changes and variability in local climate, effect of climate change on farmer livelihood and adaptation mechanism of farmers in face of climate change and variability and key constraints they faced to adapt and also socio-economic and demographic characteristics of respondents and institutional accessibility were included in the questionnaire. The survey was conducted on 200 sample households and it was handled by three enumerators at each *kebele* respective, after giving orientation and training about the procedure and related issues that need to be considered in the field survey.

**Focus Group Discussions:** Focus group discussions (FGD) were conducted in the four *kebeles* and in each *kebeles* two focus group discussions were undertaken, with male and female headed households. Each focus group discussion was composed of 6-8 individuals who were selected based on the following parameters such as, age groups, sex and socio economic status (wealth status). During the focus group discussion, the perception of farmers about climate change in the area, indicators of climate change particularly rainfall variability, pattern

and reliability and the change in temperature and occurrence of extreme climate events such as drought, floods, were given an emphasis.

Focus group discussions have also discussed on effect of climate change their livelihood in the case of crop, livestock's production and food security status and adaptation mechanism which encompassed communal properties and community based adaptation being undertaken by households to the existing climate variability and change including the main challenges of the society to cope up and adapt well to the changing climate of their locality.

**Key Informant Interviews:** In addition to the focus group discussions, interview were carried out with individuals who have lived long time in the study area and had detail information about the past and present situations of the area. The key informants selected were elder peoples, four *kebeles* leaders, and two development agents from each *kebeles*. Key informants were purposively selected based on their special knowledge on the research issues and to get the general information about the study area. Primary information about the local indicators of climate change, its possible impacts on the livelihoods of the smallholder farmer's and the adaptation methods were obtained through different data collection methods. Then, key informant interview as one of data collection methods was carried with knowledgeable and experience expert such as developmental agent, *kebeles* administration and district agriculture office.

### **3.6. Methods of Data Analysis**

After the data were collected from the sample respondents, both descriptive statistics and econometrics model were employed in order to analyses and interpret the data and give meaning full analysis. Descriptive statistical tools such as percentages tables and figures were employed to

strengthen the findings of econometric methods. And also binary *logit* model was used to see the determinants of household livelihoods status, as measured by food security levels.

Comparison between farmers' perception of climate change and variability and 34 years rainfall and temperature data (1982-2015) was made by undertaking linear trend analysis. Coefficient of variation and percent of deviation were used to determine rainfall variability. IBM SPSS (Statistical Package for Social Science) version 20, Stata version 10 and EXCEL 2007 software were used as a tool for the analysis.

### **3.7. Measuring Food Security Status of the Household**

The data analysis started with the conversion of the weekly consumption data into kilocalorie using the nationally standardized food composition table manual (EHNRI, 1997). The converted data were divided into household Adult Equivalent (AE). Following this, the amount of energy in kilocalorie (kcal) available for the household was recorded. Then after, the results obtained were compared with the minimum subsistence requirement per AE per day which is 2,100 kcal. Household members which consume below this minimum requirement were categorized as food insecure and those households members which consume above the threshold were considered as food secure.

The next step involved identification of variables that are assumed to have association with food security at a household level. As the dependent variable has a dichotomous nature (food secure or insecure households), a binary logistic regression was used where the estimated probabilities lie between logical limit 0 and 1 (GUJARATI, 1995). Food security as a dependent variable, thus, assumes the value of  $Y = 1$  if a household is food secure, 0 otherwise. Following GUJARATI (1995), the functional form of logistic regression model was specified as follows:

$$1) \quad \Pi(x) = E(Y=1/x) = 1/1+e^{-(\beta_0 + \beta_1 x_1)}$$

For ease of exposition, we write (1) as,

$$2) \quad \Pi(x) = 1 + e^{-z_i}$$

Where  $\Pi(x)$  is a probability of being food secure ranging from 0 to 1 and  $Z_i$  is a function of  $n$  explanatory variables ( $X_i$ ) which is also expressed as:

$$3) \quad Z_i = \beta^0 + \beta^1 X_1 + \beta^2 X_2 + \dots + \beta^n X_n + U_i$$

In other words, the probability for a household to be food insecure can be expressed as,

$$4) \quad 1 - \Pi(x) = 1 / 1 + e^{z_i}$$

Thus,

$$5) \quad \Pi(x) / 1 - \Pi(x) = (1 + e^{z_i/1 + e^{-z_i}}) = e^{z_i}$$

Then, the expression  $\Pi(x) / (1 - \Pi(x))$  represents the odds ratio in favor of food security.

It means the ratio of the probability that a household will be food secure to the probability that it will be food insecure. After checking for multicollinearity among the continuous variables Variance Inflation Factors (VIF) and the associations computing contingency coefficient among discrete variables, the regression model was estimated. A further correlation analysis of explanatory variables and multicollinearity diagnostics was carried out to detect the presence of collinearity and the result shows the absence of serious multicollinearity.

### 3.8 Definition of Variables

#### **Dependent variables**

For this study, the dependent variable for the *logit* analysis is dichotomous variables representing the determinants of household livelihoods status as measured by food security level in the study area. Household food security status is a dichotomous variable representing the status of household food security in the model taking value of 1 if a household is food insecure and 0 otherwise. Food security status of a household is identified by comparing total kilocalorie consumed in a household per adult equivalent per day with daily minimum requirement of 2100 kcal and those getting 2100 kcal and above are food secure and food insecure otherwise.

**Explanatory variables** For this study the major variables expected to determine household livelihoods as measured by food security level are categorized under household characteristics, socio economic characteristics, physical characteristics and institutional factors.

**Age of Household Head:** It is continuous variable that is measured in year. This variable is also used as a proxy for age of household heads. Study by Nhemachena and Hassan (2007) indicated that experience in farming increased the probability of uptake of irrigation, crop diversification and different crops as adaptation measures to climate change. This study hypothesized that experience in farming increases the probability of using adjusting planting dates, irrigation and crop diversification to adapting climate change.

**Sex of the Household Head (SEX):** It is dummy variable taking the value 1 if the sex of household is male and 0, otherwise. Male-headed households were more likely to get information about new technologies and undertake risky businesses than female-headed households (Abay and Assefa, 2004). Moreover, Tenge and Hella (2004) argued that having a

female head of household may have negative effects on the adoption of soil and water conservation measures, because women may have limited access to information, land, and other resources due to traditional social barriers. The result of Nhemachena and Hassan (2007) study, however, indicated a contrary result to the above argument by showing that female headed households are more likely to use crop diversification, irrigation and water conservation practices as adaptation strategies. This study hypothesized that sex of the household head may have positive or negative relation to the using irrigation, improved crop varieties, crop diversification, adjusting planting dates and soil conservation practices as adaptation strategies to climate change.

**Education Level of a Household head (HHEDUC):** That is the number of years of schooling attained by the sampled households' heads up to the time of the survey. The possibility to adopt new methods of farming increased along with education level. That is educated farmers would more readily to adaptation's options the effect of climate change and variability on their livelihoods and other technologies, may be easier to train through extension support and have a positive impact on livelihoods . On the other hand, as the educational level of farmers is increased, their interest to work in non-agricultural activities may be increased that leads to the declining of the willingness to participate in contract farming program. According different researchers farmers with more education have been shown to adopt modern agricultural technologies sooner. Therefore, the variable will be hypothesized to influence the participation decision on contract farming and gross margin earnings of the farmers in both negative and/or positive. It is hypothesized that the educational level of household head is correlated with the food security situation positively.

**Family size (FAS):** It is a continuous variable which refers to the number of family members of the household head. This explanatory variable is included because it affects the labor supply at household level. The influence of family size on use of adaptation methods can be seen from two angles. The first assumption is that households with large families may be forced to divert part of the labor force to off-farm activities in an attempt to earn income in order to ease the consumption pressure imposed by a large family (Chilot, 2007). The other assumption is that large family size is normally associated with a higher labor endowment, which would enable a household to accomplish various agricultural tasks. For instance, Croppenstedt *et al.* (2003) argue that households with a larger pool of labor are more likely to adopt agricultural technology and use it more intensively because they have fewer labor shortages at peak times. This study hypothesized that households with large families may have either negative or positive effect on use of adjusting planting dates, crop diversification, irrigation, improved crop varieties and soil conservation practices to adapt to climate change.

**Dependency Ratio of the Household /DRHH/:** It can be assumed that if the number of productive age groups, the livelihood of the household being food insecure will be higher. Hence, it is expected that higher dependency ratio will have a negative impact on food security situation of the household.

**Total Livestock holding (TLU):** This is a continuous variable, referring to the total number of livestock (measured in Tropical Livestock Units, TLU). A household livestock size in TLU is calculated by multiplying the number of each type of animal by their conversion factors and then summing it up. Livestock is important source of cash income, food, household energy, manure and draught power for crop cultivation in Ethiopian agriculture. Livestock plays a

very important role by serving as a store of value and by providing traction especially oxen and manure required for soil fertility maintenance (Chilot, 2007). The change in the number of livestock owned is expected to influence the food security and livelihoods of community. The change in the number of livestock owned is expected to influence the food security situation positively. The livestock ownership was hypothesized to increase the probability of using irrigation, adjusting planting dates, soil conservation practices and improved crop varieties to adapt to climate change.

**Off/non-farm income (ONINCOME):** This refers to annual income obtained from an employment of the household in off-farm (laborer, wild-fruit gathering) and non-farm (hand craft, selling of fire wood, petty trading activities measured in Birr. As these activities share most of farmers' time, farmers pay little attention to their farming activity and focus on off/non-farm activities. On the other hand, access to such activities may enable the farmer to get additional income which enables the farmer to acquire purchased inputs. Aymone (2009) suggested that expanding smallholder farmers' access to off/non-farm sources of income increases the probability that they will invest in farming activities. Thus, for this study, non/off-farm income was hypothesized to affect using irrigation, improved crop varieties, crop diversification and soil conservation practices as climate change adaptation strategies negatively or positively.

**Farm income (INCOME):** This is a continuous variable which measures the amount of annual farm income obtained from sale of crop and livestock or livestock products measured in Birr. Farm income of the household has a positive and significant impact on conserving soil and using improved crop varieties adaptation options (Temesgen *et al.*, 2008). This could be apparent because adaptation to climate change is capital intensive and hence increased income

will encourage the investment capacity on adaptation options. It is regularly hypothesized that the adoption of agricultural technologies requires sufficient financial wellbeing. Thus, for this study farm income was hypothesized to affect positively the use of irrigation, improved crop varieties and crop diversification to adapt to climate change.

**Land holding of the Households (LANDHH):** This is a continuous variable measured in hectares. Hassan and Nhemachena (2008) reported that larger farm sizes were found to encourage the use of multiple cropping and integration of a livestock component, especially under dry land conditions. Large size allows farmers to diversify their crop and livestock options and help spread the risks of loss associated with changes in climate. This study therefore hypothesized that land holding has positive relation with using irrigation, improved crop varieties, crop diversification and soil conservation practices to adapt to climate change.

**Access to extension service (ACCEXTEN):** This indicates that whether the household head gets extension service from development agents (DAs) or not. Extension service provides the necessary information to acquire new skills and knowledge to farmers to improve agricultural production. Bacha et al. (2011) found significant difference between irrigators and non-irrigators in access to extension. Therefore, this variable is expected to influence the food security situation of the household positively.

**Access to credit (CREDIT):** It is a dummy variable taking the value 1 if the farmers get credit access and 0, otherwise. Availability of credit eases the cash constraints and allows farmers to buy purchased inputs such as fertilizer, improved crop varieties, and irrigation facilities. Research on adoption of agricultural technologies indicates that there is a positive relationship between the level of adoption and the availability of credit (Chilot, 2007).

Likewise, this study also hypothesized that there is a positive relationship between availability of credit and using irrigation, improved crop varieties, crop diversification, farm input and soil conservation practices to adapt to climate change.

**Distance to market (DISMKT):** This is a continuous variable measured in kilo meter. It refers to the distance between the households' home and the nearest market. As the farmer is nearer to a market, the higher will be the chance of increasing the household's income, access to purchase food from market and to sell output. It is, therefore, expected that households nearer to market improve household livelihoods. It is, therefore, expected that households nearer to market improve household food security.

**Distance farmers training center (DISFTC):** This is a continuous variable measured in kilometer. Moll (2004) argued that information is a source of knowledge, awareness and change. Different researchers argued that information is a source of knowledge, awareness and change. The necessary information can be gained from training, demonstration or workshop, and through mobile, TV and radio. The farmer training center is a source of information for the kebele resident. There are development agents in the kebele who teach the local communities about the application of the new technologies. The longer the distance from home to the farmer training centers and/or development agent offices, the lower is the probability to improve the household livelihoods and developing income source food security and adaption new technologies.

**Access to irrigation (AIRR HH).** The access to irrigation is hypothesized to have a positive effect on food security status b/c households who have access to irrigation can cultivate their irrigated land two or more times a year. So, this enables farmers to maximize agricultural

production, create opportunity, increase household income and improve livelihoods. Hence, it is hypothesized that farmers who have access to irrigation are more likely to be food secure than those who don't have access to irrigation.

**Contact with extension agents (EXTENSION):** This is a continuous variable which takes a visiting time by extension agent per year. 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. Various studies in developing countries, including Ethiopia, report a strong positive relationship between access to information and the adoption behavior of farmers (Chilot, 2007), and that access to information through extension increases the likelihood of adapting to climate change. Thus, this study also hypothesized that access to extension visit increases using irrigation, improved crop varieties, crop diversification, adjusting planting dates and soil conservation practices to adapt to climate change.

**Table 2. Description of Independent Variables**

<b>Explanatory variables</b>	<b>Description</b>
Age of household	Continuous
Sex of the house hold	Dummy
Education level of the households	Continuous
Family size of households	Continuous
Livestock owner ship in (TLU)	Continuous
Number of oxen owned	Continuous
Access of the Extension	Continuous
Access to agricultural input	Continuous
Distance to market	Continuous
Distance to FTC centre	Continuous
Farm income of house holds	Continuous
Off farming activities	Continuous
Access to credit	Dummy
Access to irrigation	Dummy

## **CHAPTER FOUR: RESULTS AND DISCUSSION**

This chapter presents the findings of the study in line with the objectives and the research questions of the study. The results are divided into five major parts. The first part presents the socio economic profile of the sample households. The second part presents rainfall and temperature trends in the study area over the last 34 years. The third part presents the effect of climate change on the livelihoods of rural farmers in terms of crop and livestock productions in the study area. The fourth part presents the findings with regard to determinant of household's livelihood status, as measured by food security levels. The final section deals with the farmers' adaptation mechanism in the face of climate change.

### **4.1 Socioeconomic Characteristics of Household Heads**

#### **4.1.1. Sex, Age and Marital Status of the Sample Respondents**

The result of the survey reveals that the age composition of the sample household heads is between 25 and 85 years. As shown in (Table 3) the age composition of sample households' heads ranges between 30-50. This indicates that most of the surveyed household heads are economically active and it can be assumed that they are well aware of their area and prevailing environmental problems very well.

**Table 3. Sex, Age, Marital status and Household size of the Sample Respondents**

Variables		Frequency	Percent
Sex	Male	140	70
	Female	60	30
Total		200	100
Age	<29	12	6
	30-39	68	34
	40-49	58	29
	50-59	37	18.5
	>60	25	12.5
Total		200	100
Household marital status	Single	-	-
	Married	182	91
	Widowed	12	6
	Divorced	6	3
Total		200	100
Households family size	1-2	3	1.5
	3-5	65	32.5
	6-8	80	40
	9-11	44	22
	12-14	4	2
	>14	4	2
Total		200	100

**Source: Own survey, 2017**

As shown in table 3. Out of the total 200 households the sex composition of the survey indicates 70% were male and 30% were female headed households. As the survey result indicates from the total respondents there is no single 91% married, 6% widowed, and 3%

divorced. The survey data indicated that the family size of the sampled households varies from 2-15 members.

**Table 4 Age and Household Family size of the Sample Respondents**

Variables	Minimum	Maximum	Mean	Std. Deviation
Age of the household head	25	85	45.91	12.3
Household family size	2	15	6.76	2.45

**Source: Own survey, 2017**

Household size and age composition affect availability of economically active labor for different activities. The survey data indicated that the family size of the sampled households varies from 2 - 15 with an average household size of 6.12, which is higher than the national average family size of 4.93 (CSA, 2007). Likewise, the minimum age of the sampled household heads 25 were as the maximum age composition was 85 years.

#### **4.1.2. Educational Status**

As the result shows in (Table 5) more than half 52% of the respondents were unable to read and write in the study area. The study shows that farmers with higher levels of education are more likely to adapt to climate change and more likely to income diversification. The result shows that an increase in the number of schooling by some year's increases the probability of crop diversification/ livestock's, involving in off-farming activity and growing drought tolerant crops and early matures crops. This can be explained as an increase in education level is an increase in knowledge and skill so the more educated farmers adapted better than less educated and uneducated farmers.

Like other developing countries Ethiopia is characterized by low level of education and high level of illiteracy. Different studies (Temesgen *et al*, 2008) state that educational level determines readiness of households to accept new ideas and technologies and enhance the ability of farmers to cope with climatic hazards. Education is understood as an indispensable tool to easily understand climate information to adjust and develop adaptive capacity to the changing climate. The empirical result of this study shows that the educational status of sample household heads was considerably low (Table 5). More than half of respondents were unable to read and write in the study area.

**Table 5 Educational status of the sampled household heads**

Variables	Frequency	Percent	
	Unable to read and write	104	52
	Able to read and write	23	11.5
Educational status of the sampled households heads	Primary school	55	27.5
	Secondary school	12	6
	College level ( diploma)	6	3
	Degree	-	-
Total	200	100	

**Source: Own survey 2017**

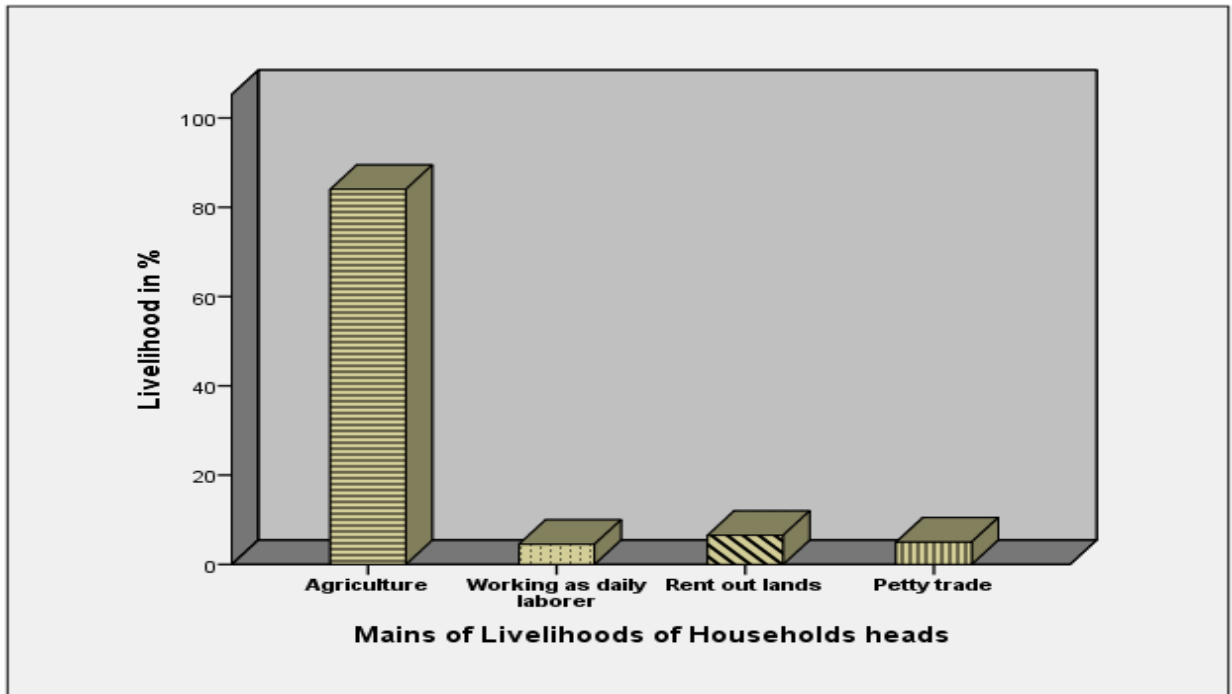
This finding indicated educated farmers have better to developing to adaptation mechanism to climate change than less educated farmers in study area. Moreover, the formal education usually does not include the able to read and write farmers with deep rooted experience and knowledge of farming practices. The survey result data shows that 27.5% of the respondents

achieved primary level and 6% of respondents achieved secondary levels. And from the total respondents 52% sample households are unable to read and write, while 11.5% can write and read and only 3% achieved above grade twelve or college levels. This entails there is illiteracy amongst the sampled households though its degree is high. Educational level determines readiness of households to accept new ideas and technologies and enhance ability of farmers to cope with climatic hazards.

#### **4.1.3. Means of the Livelihood in the Adami Tulu Jido Kombolcha District**

Household heads were also asked about their major source of livelihood and based on these principal livelihood components were grouped using clustering techniques where the majority of the households were dependent on agriculture. The result shows that the major livelihoods of community in the district depend on agriculture. As shown in (Figure 4), the main livelihoods of the household heads were 84% was found dependent on agriculture (crop and livestock productions) and 4.5%, 6.5% and 5% are dependent on daily labor, rent out land and petty trade respectively.

This result (Figure 4) indicated that agriculture is the major livelihoods of community in the district were more sensitive to climate change and variability because of this the district was more affected by climatic condition.



**Figure 4 Main means of the livelihoods of house heads in Adami Tulu Jido Kombolcha district**

**Source: Own survey, 2017**

Subsistence mixed farming (crop and livestock production) is the dominant farming system and on average a household holds 3.45 hectare of land. As shown in (Table 6), approximately of 34.5% of households have less than 1.5 ha, and 27.5% of households have land holding size of 0.25- 0.5 ha, which is followed by 12.5% and 16.5% of households who possessed 1.5ha - 1.75 ha and 2 -2.5ha respectively. Only 9% households owned >3ha of agricultural land.

The land holding of sampled households ranges from 0.25 to 6 hectares with an average size of 3.45 hectares. This indicates that farmers who have large farming size have probability to grow different crop to adapt climate change and variability and increase its livelihoods status through income and food security status. Land is the major determinant factor for applying

adaptation mechanism. Therefore, farmers' adaptive capacity also differs with average land holding they own. According to the survey data, the size of land is very fragmented and it differs among individual farmers. In different studies shortage of land is observed as a major barrier to adapt climate change (Bryan *et al.*, 2009). This study hypothesized large farm size increases the probability of using adaptation to climate change. This can be explained as, households with large farm size are motivated on farm level adaptation measures in order to increase their crop productivity and they prefer for crop diversification.

**Table 6. Land holding of the Sample Households.**

<b>Land holding in ha</b>	<b>Frequency</b>	<b>Percent</b>
0.25-0.5	55	27.5
0.75-1	69	34.5
1.5-1.75	25	12.5
2-2.5	33	16.5
>3	18	9
Total	200	100

**Source: Own survey, 2017**

#### **4.1.4. Livestock Possession of the Sampled Households.**

Another important economic variable is livestock ownership. Livestock holding size of household is one indicator of wealth. Information on the number of common types of livestock

owned by each sample household 10 years ago and currently owned was collected to see the trend of livestock ownership. Then, data on livestock holding of each household was converted into livestock units (TLU) (see appendix 3 for conversion factor used).

According to the survey result, the households own 3.11 TLU on average. The livestock ownership ranges from a minimum of 0.32 to a maximum of 8.97 TLU. While a current livestock ownership of households own 4.6 TLU on average. The current livestock ownership of households ranges from a minimum of 1.25 to a maximum of 3.7 TLU. This indicates that, in the study area livestock production declining from time to time due to climate related hazards such as disease and drought in the district. Accordingly from the surveyed households, a large number 90% of respondents perceived the effects of climate change and due to shortage of grazing land as result of farm expansion as well as changing livelihood mechanism by former cattle herders of farming as a major cause for livestock's size decrease and 10% due to sale of livestock for different purpose. The major reason for decreasing livestock's size' for last past 30 years recurrent drought, livestock's disease, shortage of pasture and shortage of grazing land are the main reason for decreasing livestock's trends in the study areas. This indicated that climate change and variability has adverse impacts on livestock compositions and compromise the return from livestock as the availability and quality of pasture availability and water are highly affected by climate variability.

## **4.2. Rainfall and Temperature Pattern of Adami Tulu Jido kombolcha District**

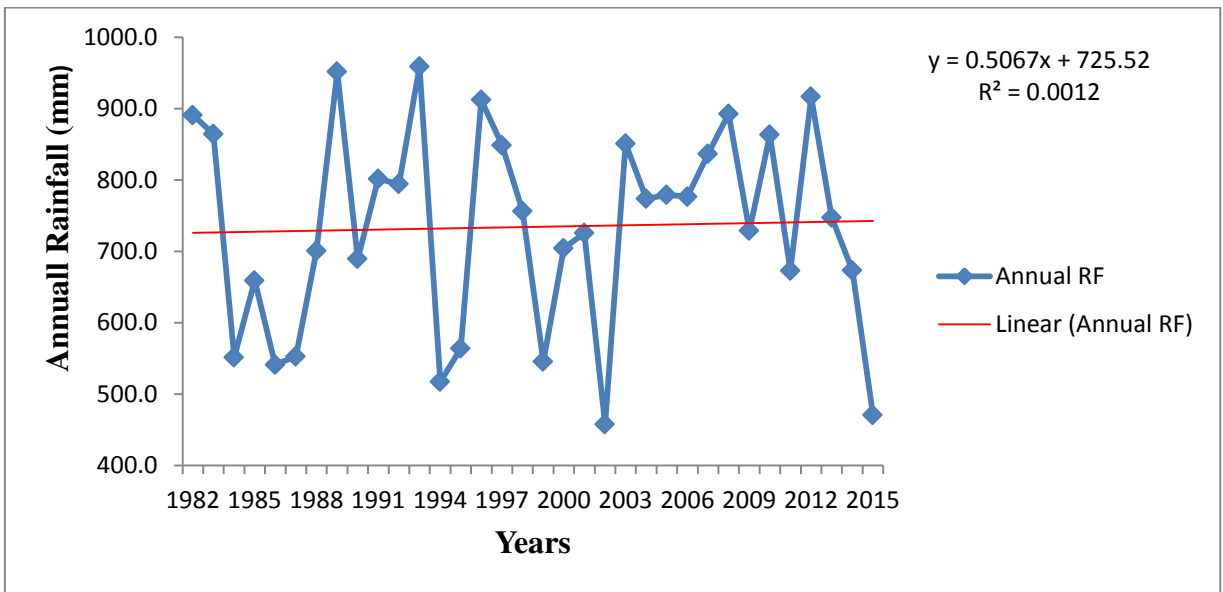
### **4.2.1 Annual rainfall Variability and trends**

Rainfall and temperature are important meteorological variables that determine water availability and production of crops and livestock rearing or food production processes in countries where agriculture is more dependent on rainfall, (Abebe, 2013). The 34 year meteorological data of station at Ziway (Figure 5) showed irregularities in rainfall. Trend however shows increasing rate of 0.506mm/year. The average annual rainfall of Adami Tulu Jido Kombolcha district in the years 1982-2015 ranges between 470.7mm to 958.9mm. The mean annual rainfall of those years is about 734.2 mm.

As shown in the (Figure 5) the rainfall of the district has shown slightly increased by 0.506mm inter annual variability and erratic over the past 34 years. This variability has also been indicated as a major problem to crop production and livestock's productions in the district.

The minimum average annual rainfall occurred is 470.7mm in 2015. The maximum average annual rainfall occurred was 958.8mm in 1993.

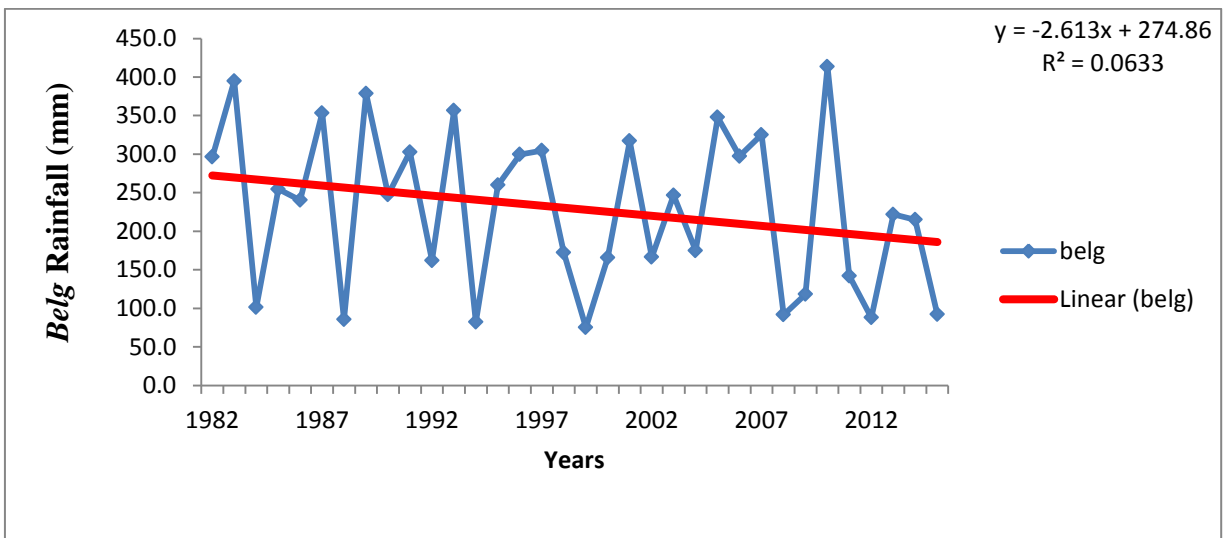
The years that recorded below average rainfall (734.2 mm) were 1984, 1985, 1986, 1987, 1990, 1994, 1995, 1999, 2000, 2002, 2011 and 2015. Therefore, agricultural production in the area was adversely affected by the variability of the rainfall for the last three decades in the district. This idea was also supplemented by the information of FGD participants.



**Figure 5 Mean annual rainfall of Adami Tulu Jido Kombolcha district (1982-2015) years**

Source: NMA, 2017 prepared by author

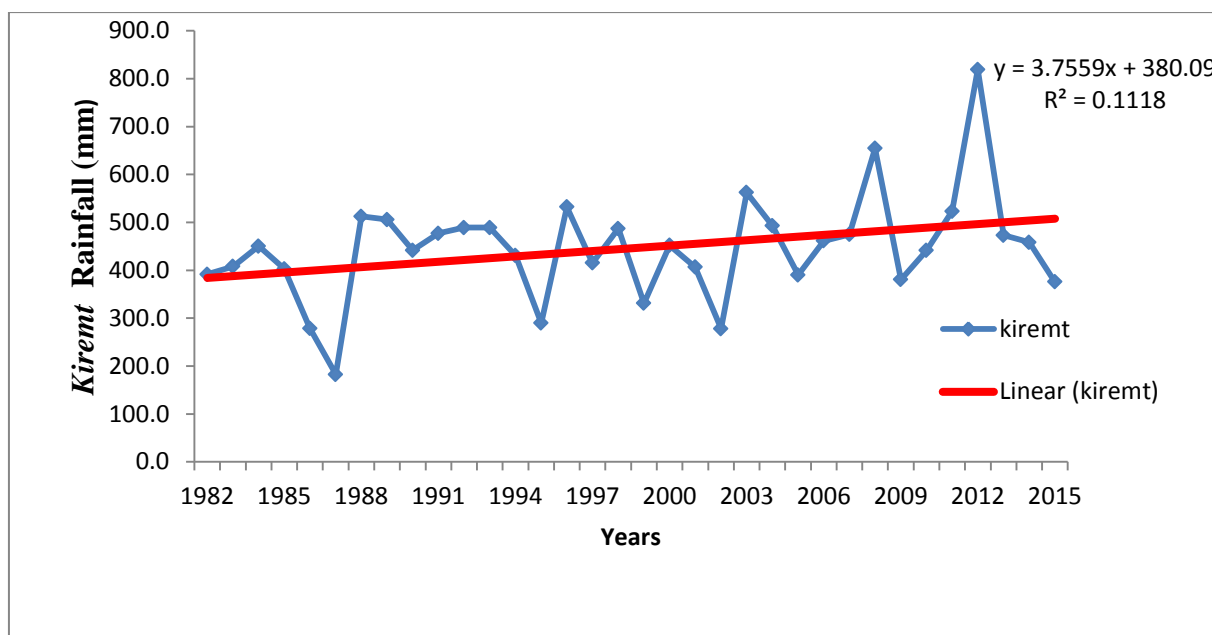
#### 4.2.2 Seasonal Rainfall Variability and trend



**Figure 6 . Belg rainfall trend and variability at Adami Tulu Jido Kombolcha (1982-2015)**

Source: NMA, 2017 prepared by author

As it's indicated in (Figure6) the *belg* rainfall was characterized with gradual decline in the district. Therefore, farmers depend only on growing *meher* crops, once in a year due late come of *belg* rain season. According focus group discussion reported that there is delaying /absence of *belg* rain season these changes pose major challenges on the rural population's livelihood especially on agriculture by changing the planting time of main crop were grown during *belg* rain season and shortage of feeds for the livestock.



**Figure 7 Kiremt rainfall trend and variability at Adami Tulu Jido Kombolcha (1982-2015) years**

**Source: NMA, 2017 prepared by author**

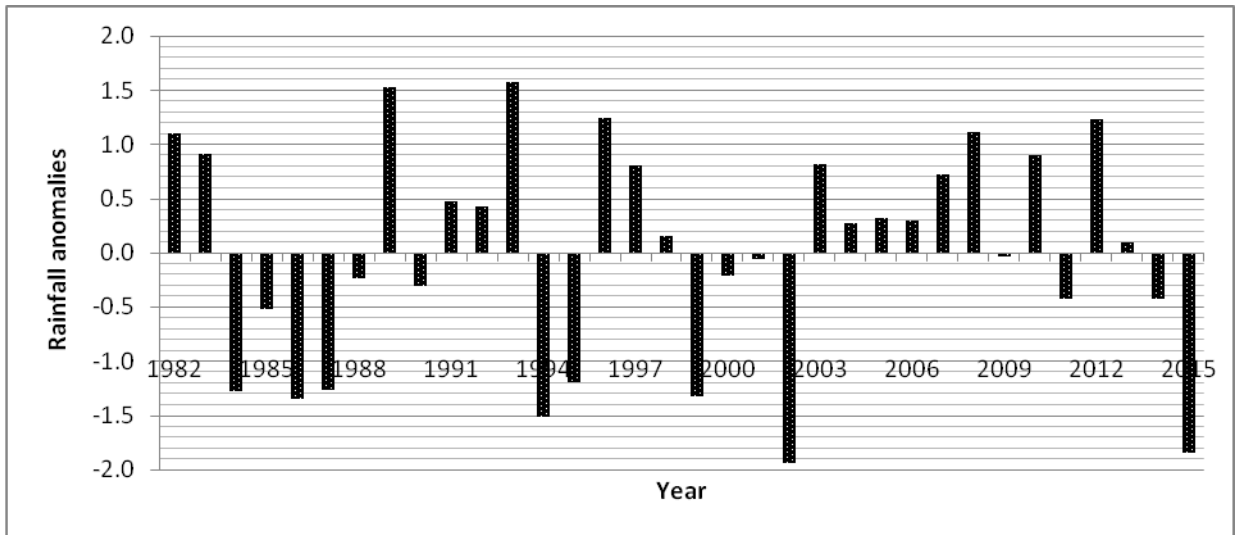
As it is shown in Table 7, Coefficients of variations were 19.45%, 45% and 25.09% for annual, *belg* and *kiremt* rainfall, respectively; which indicate that there was high inter-annual variability of rainfall between 1982 and 2015. Degree of variation in amount of rainfall was higher for *belg* season than *kiremt* season.

**Table 7. Minimum, Maximum, and Coefficient of variance, total annual, belg and kiremt rainfall at Adami Tulu Jido Kombolcha (1982-2015) years**

<b>Rainfall</b>	<b>Min(mm)</b>	<b>Max(mm)</b>	<b>Mean rainfall (mm)</b>	<b>CV (%)</b>
<b>Annual</b>	457.6	958.9	734.2	19.45
<b>Belg</b>	75.1	413.5	229.1	45
<b>Kiremt</b>	182.5	819.1	445.8	25.09

**Source:** Computed from the data obtained from NMA, 2017

The annual rainfall anomaly for Adami Tulu Jido Kombolcha district for period 1982-2015 shows that moderately wet and very wet has been observed in the year, 1982, 1986, 2008 and 2012 the area shows moderately wet while 1989 and 1993 shows severely wet. Whereas 1984, 1986, 1987, 1994, 1995 and 1999 the area shows moderately dry however 2002 and 2015 show severely dry the rest of the year shows normality (Figure 8). Both positively and negatively anomalies can affect crop yield surplus and deficit water respectively and also affect livestock production shortage of water, infestation of diseases and shortage of feeds and water. The crop requires specific amount of water at regular time interval but the anomalous behavior of rainfall poses threat to crop production targets. Under consideration the wettest year of the periods was the year 1993 and 1989 recorded 958.1mm and 951.5mm respectively. The driest years of the series was 2002 and 2015 with 457.6mm and 470.7mm rainfall respectively during the period. Time series analysis of Adami Tulu Jido Kombolcha district shows great variation in rainfall pattern which is beneficial as well as dangerous for crop and livestock production.



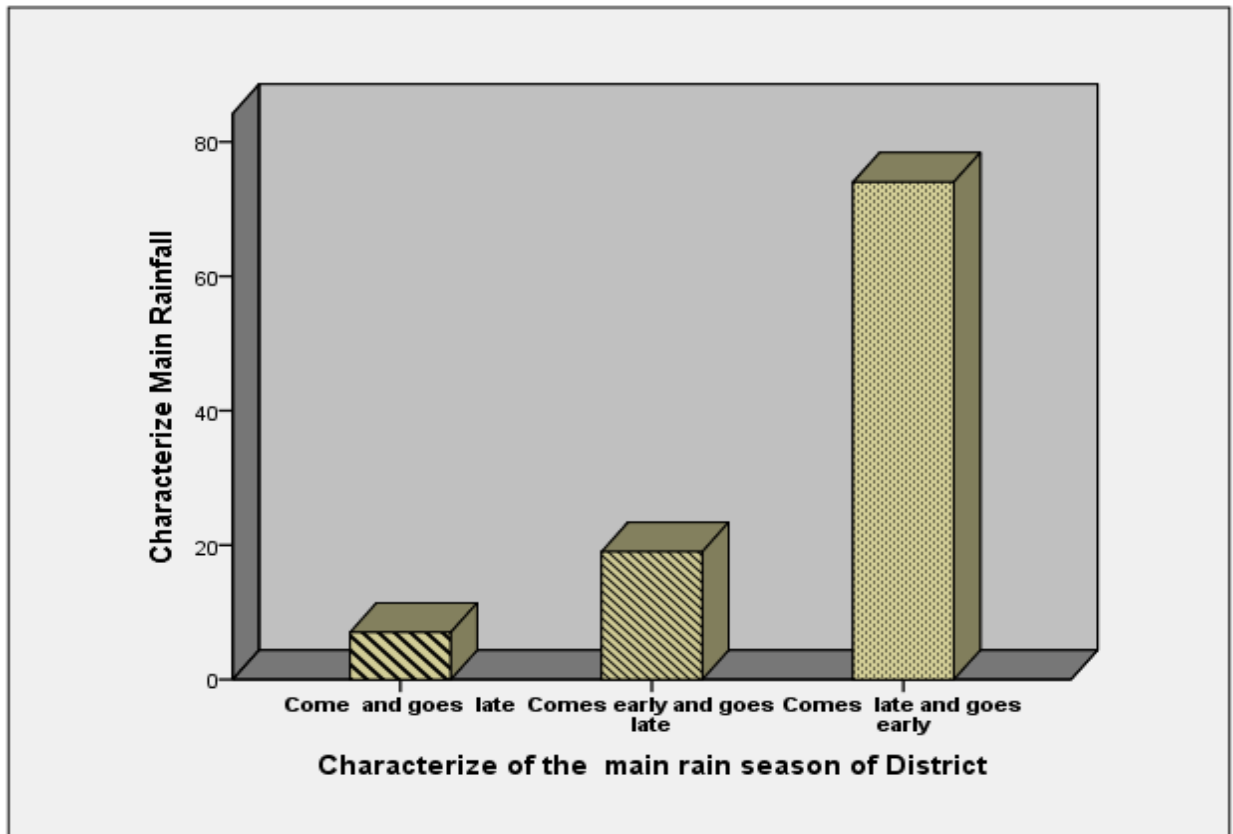
**Figure 8. Annual rainfall anomaly for Adami Tulu Jido kombolcha district (1982-2015)Source: NMA 2017 prepared by author**

#### **4.2.3. Timing of Rainfall and Variability**

Majority respondent 74% reported that the main rain comes very late,19% of the respondents said that the rain comes early and goes vey late. Only 7% of household heads responded that the rain comes and goes early. According to FGD and KI the *belg* rains, totally shows delays or absent this were making cultivation difficult and eventually causes crops. The study area has experienced frequent climatic shocks, extended drought and delay in the onset of rain, erratic and low precipitation. Based on climate data gathered from near the study area, the total number of rainfall days has decreased. But the magnitude of total annual rainfall is more or less the same.

As most studies demonstrated, changes in precipitation patterns increase the likelihood of short run crop failure and long run production declines. (Nelson.,G, 2009). As rainfall patterns become more unpredictable as climate changes, plants will be subjected to increasing fluctuations in soil moisture availability. These fluctuations are likely to have substantial impacts on plants in natural communities and on crop plants in agriculture, (Davies, .J. 2006).

The timing and reliability of rainfall in the study area has been significantly unpredictable. FGD report that before 10 years, the *belg* rain start in late March and extended up to May farmers used this rain to cultivate crops like sorghum, maize but in recent years the *belg* rain starts in end of May or absent.



**Figure 9. Timing of rainfall of Adami Tulu Jido Kombolcha district**

**Source: Own survey 2017**

#### **4.2.4 Timing of Rainfall and its Effect on Cropping Pattern**

As a result survey indicated that 83% of them said that there is shifting in planting times of main crops likes maize and sorghum because of late coming of *belg* rains and 17% of the respondent report that there is no shifting in planting time of main crop because of change

rain time. According to the key informant discussion reported that their change in planting time of major crops which is grown by *belg* rain season like maize, sorghum.

According to FAO, (2008) prediction, the wet areas are expected to be wetter and the dry areas in the tropics are expected to be drier as a result of climate change. The intensity of rain storms could increase in some areas and rain becomes more unreliable and unpredictable. It is reported by respondents that rainfall in the study area is becoming both more erratic and coming later and going earlier in the cropping seasons.

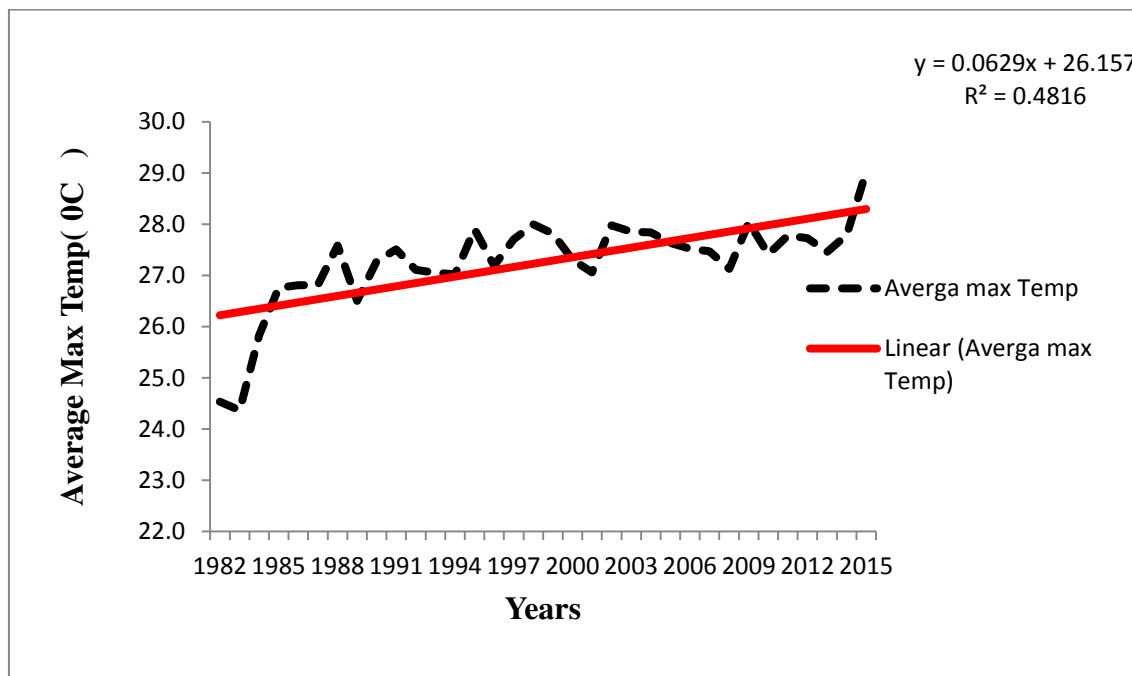
According to key informant before 10 year ago maize and sorghum crop sown during April month, but current a time those crop can sown at May end or June months. The main reason for the shifting planting time of main was due to unpredictable rainfall/ erratic rainfall. Last year's farmers used to grow crops like sorghum and maize which require lengthy rainy season to attain maturity. However, since recent times, these crops are grown as less than normal time because of the change in the timing and decreased precipitation. In all *kebeles*, the irregularity of rainfall will result in changing in planting time main crops which adversely reduce yield production

All of the members of FGD in the four *kebeles* agreed that change in timing of precipitation is adversely affecting the whole process of cultivation. The following are some of the problems raised during FGD about the impacts of the change in timing of rain fall. The delayed *belg* rain hampers sowing so that they could not prepare the land timely to grow crops using *belg*; the delayed rain often comes heavy and causes erosion and flooding on agricultural fields.

#### **4.3. Temperature Variability and trend**

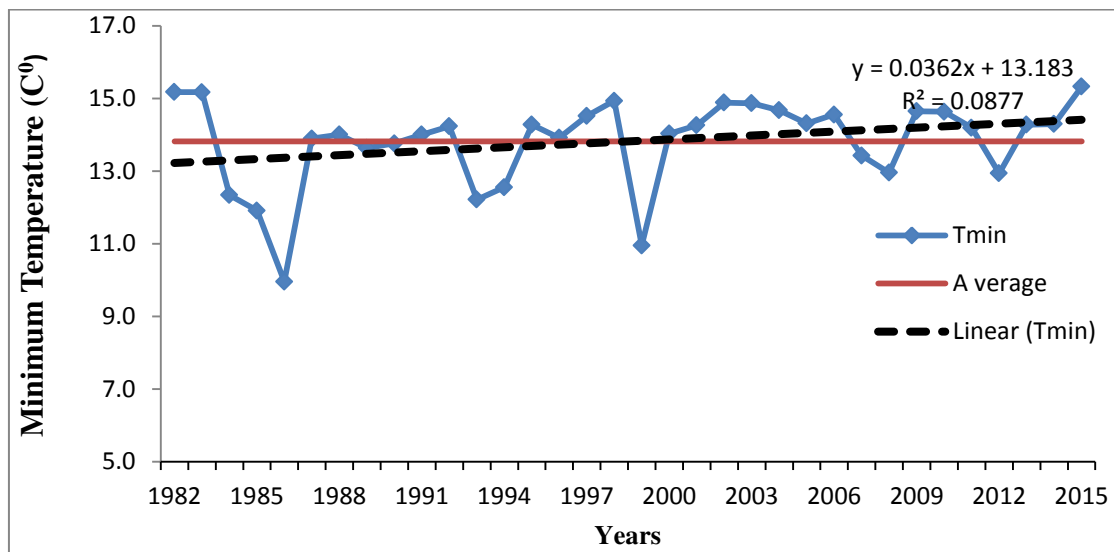
The average yearly maximum temperature of the district was to be 29.02 °C, while the average minimum temperature of 9.95°C during the period of the 1982-2015. As indicated in figure

10, the average maximum temperature of Adami Tulu Jido Kombolcha district over the past 34 years increased by about 0.062°C annually, and also the average minimum temperature increased by 0.036°C. Therefore, trend shows that the maximum temperature of the district is increasing and will continue in its increasing trend in the future.



**Figure 10.** Annual Maximum temperature trends at Adami Tulu Jido Kombolcha District (1982-2015) years

Source: NMA, 2017 prepared by author



**Figure 11. Annual minimum temperature trends at Adami Tulu Jido Kombolcha district (1982-2015) years**

**Source : prepared by author**

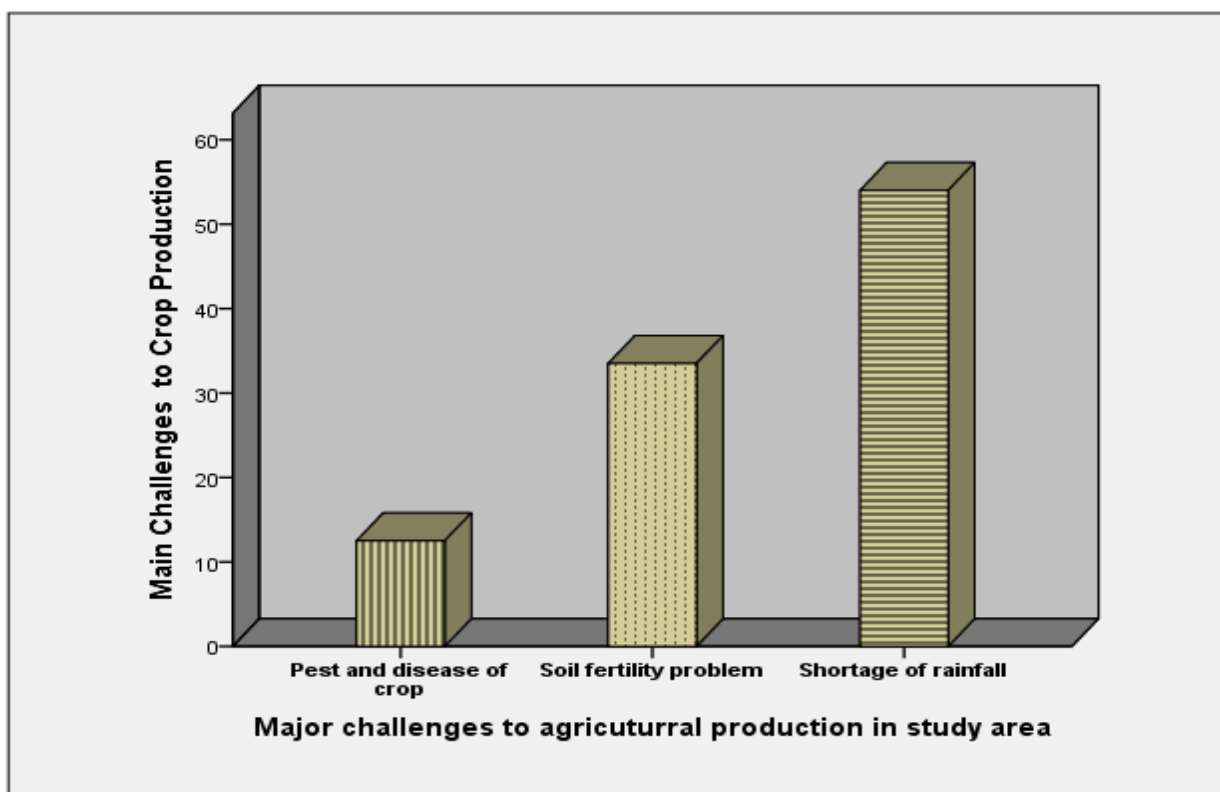
The trends result in figure 6 and 10, show decline in amount of precipitation of *belg* rain season and increase in average annual maximum and minimum temperature in the district. In conclusion, the overall analysis of rainfall and temperature for the district indicates that there was decreased seasonal rainfall and increased in maximum and minimum temperature in the district. This is expected to pose major challenges on the livelihood of the rural population especially on agriculture (crop and livestock) production.

#### **4.4 Effects of Climate Change to Smallholders farmers' Livelihood Particularly Crop Production and Livestock Production.**

##### **4.4.1 Effect of climate change on crop production**

Majority of respondents, 54% reported that the major effect that affects crop production is unpredictability of rain fall or irregularity of rainfall ,33% low soil fertility and 12.5% pest and disease are major factors influencing crop production in the area.

In the study area, since agriculture is totally dependent on rain fed practices, it is the most impacted system by climate change and variability. In this regard, the general consensus of informants and discussants was that changes in temperature and precipitation result in changes in planting time and water regimes that was subsequently affect agricultural productivity. Climate change is likely to impact crop productivity directly through changes in the growing environment, but also indirectly through shifts in the geography and prevalence of agricultural pests and diseases, associated impacts on soil fertility and biological function, and associated agricultural biodiversity.



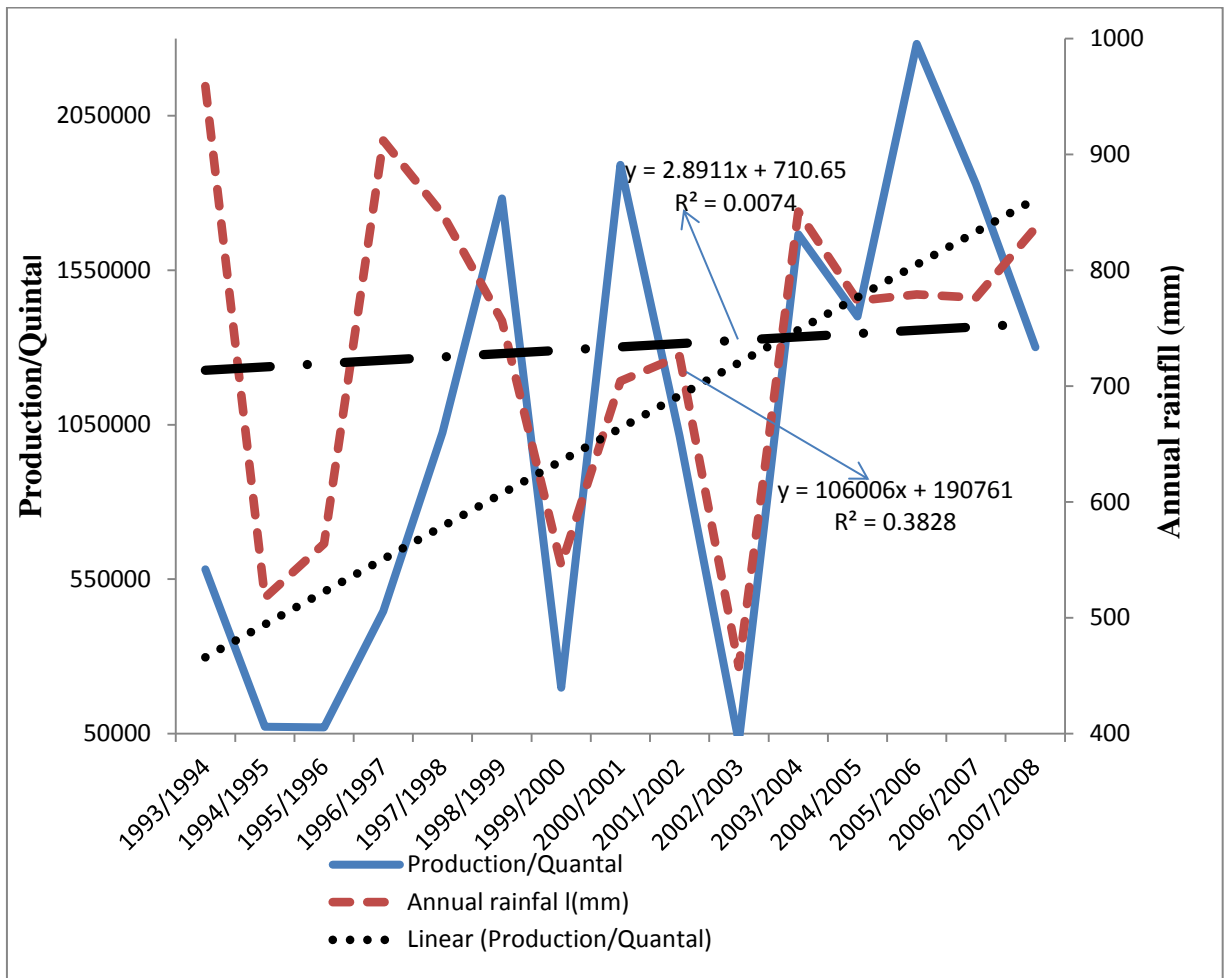
**Figure 12 Major Challenges to Crop Production in Adami Tulu Jido Kombolcha District**

Source, Own survey, 2017

#### **4.4.2 Effects of Climate Change on Crop Yield in the District**

Accordingly from the surveyed households, a large number 75% of respondents perceived the effects of climate change as a major cause for crop yield reduction, around 17.7% of the respondents said the climate change has no adverse effect on crop yield reduction. While 7.3% of the surveyed households responded that there is neither increase nor decreased in crop yield due to climate change.

According to the key informant and focus group discussion climate change was the main cause for the reduction of crop yield in the district. The main reasons for reduction of crop yield were irregularity or shortages of rainfall were major one for reduction of yield production in the district. And also the crop yield production was variable with the amount of rainfall in the district. The crop yield over last 15 years in the district has shows highly variability with the amount of annual rainfall received in the district. That means crop yield varies with amount of rainfall received. See Figure 13 below.



**Figure 13. Crop yield of the Adami Tulu Jido Kombolcha and annual rainfall (1993-2008) years.**

**Source: Adami Tulu Jido Kombolcha Agriculture office, 20017 and National Meteorological Agency**

#### **4.4.3. Effects of Climate Change on Livestock Production**

Most of the households used livestock as source of livelihood in addition to crop cultivation. In all *kebeles* majority of households are practicing crop-livestock production system. As the survey result indicated the majority of respondent reported that 85% the livestock size of the household were declined and 15% of the respondent reported that there is increased in livestock size of the households in the study area. The respondent reported that the main

reason for reduction of livestock size of the households was shortage grazing land, death of livestock as result of drought, livestock disease, and shortage water for animals a was the major reason for declined of the livestock size of household's at all sampled *kebeles* of the study area.

**Table 8 Livestock size of households and reason of decrease in livestock production**

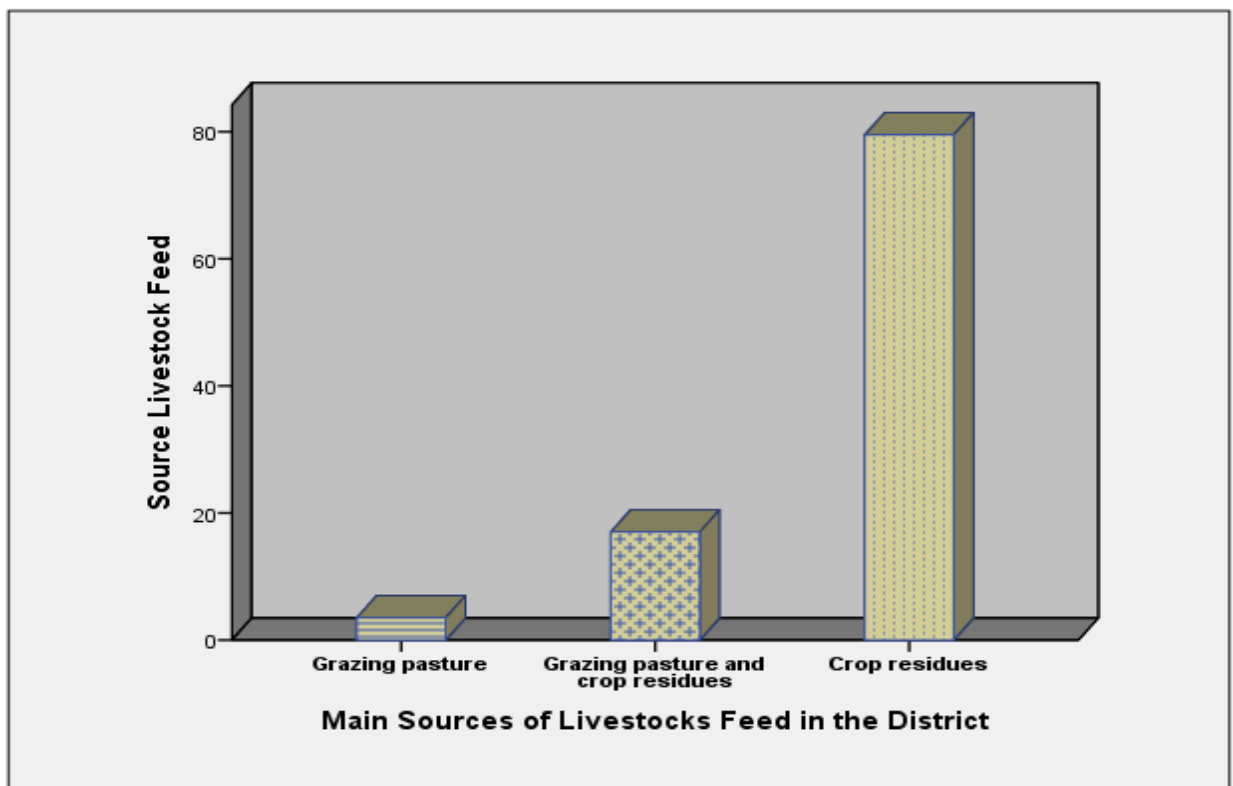
Variables		Frequency	Percent
Is there is decreased or increased in yours livestock size?	Increased	30	15
	Decreased	170	85
Main Reason for decrease of livestock			
Livestock disease		47	23.5
Shortage of grazing land		64	32
Shortage of water for animals		15	7.5
Death as result of drought		63	31.5
Sale of livestock		11	5.5
Total		200	100

Source: Own survey, 2017

#### **4.4.4 Effects of Climate Change on Livestock Feeding**

According to the survey data, 87% of the sample household heads said that the source of cattle feed before some 15 years ago was pasture, while 9% responded crop residue and the remaining 4% combined pasture and crop residue. However, at currently 79.5% of the responded reported that feeds of livestock were depended on crop residue for cattle feed while 17% on pasture and crop resides combined. The remaining 3.5% replied that they still depend on pasture for livestock feed. Drought and delay in the onset of rain fall led to poor grass

regeneration/forage deficit, water shortage and heat stress on livestock, and consequently increased the mortality of the livestock, vulnerability to diseases and physical deterioration due to long distance travel for water and pastures(Abate,2009). Members of FGD also pointed out that shortage of adequate fodder and underfeeding of livestock have increased the vulnerability of livestock to disease risks and death associated with drought and climate stress and shortage of grazing land as results of expansion farming activities.



**Figure 14 Main Source of the Livestock Feeds in Adami Tulu Jido Kombolcha district**

**Source: Own survey, 2017**

#### 4.5. Local Indicators of Climate Change and Variability

Local indicators by which people perceived local climate change and variability includes loss of some plant and animal species, increased drought and flood frequency, increased in temperature, change in timing of rain, decline of agricultural yield, decline of soil productivity, decreased water availability, prevalence of human and animal disease not familiar to the area, introduction of new plant species and dry up of water resource.

Accordingly, from the total surveyed Households, 31% of the respondent's perceived increase in temperature as an indicator of climate change and variability and this is followed by 25% households who responded the unpredictable rainfall and 21% household responded recurrent drought as the major indicator of climate change. While 9%, 8.5% and 5.5% of the households claimed unpredictable rainfall and recurrent drought, increased in temperature and unpredictable rainfall and decrease river volume respectively the households assumed indicators of climate change and variability in the study area.

**Table 9 Local indicator of the Climate Change in the Study Area**

<b>Local indicators of climate change</b>	<b>Frequency</b>	<b>Percent</b>
Unpredictable rainfall	50	25
Increased in temperature	62	31
Recurrent drought	42	21
Unpredictable rainfall and increased in temperature	17	8.5
Unpredictable rainfall and recurrent drought	18	9
Decreased in river volume	11	5.5
Total	200	100

**Source:** Own survey, 2017

#### **4.5.1. Farmers Perception of Climate Change and Variability**

According to the information obtained from sample households concerning change in climate, all of the respondents perceived change in local climate, mainly in terms of increased temperature and highly variability of rainfalls. About 84% and 16% of the respondents perceived increased temperature and decreased temperature respectively in the study area. The majority of respondents noticed decreased in annual rainfall (87.5% of total) and 83% increase in frequency of drought (Table, 10). According to FGDs conducted in both *kebeles*, farmers were reported observing a shortening of the main rainy seasons; rains start later and goes early which result in shifting cropping patterns of crops in the study areas. In addition, they said that rainfall amount, frequency and distributions have changed. This can lead to changing the plating time of main crops that were growing, to scares or no pasture growth, increased water scarcity and depletion of resources. And they had noticed that, *belg* rains declined more and has become variable than rains of *kiremt*. In this regard, analyses of meteorological data agree with perception of farmers on climate change and variability. These indicate that there was lack of enough moisture for plant growth, forage for livestock and it affects crop production due changing of plating time. As the farmer start sowing with the coming of *belg* rain, moisture stress and high temperature can affect the germination capacity as well as growing performance of crops.

**Table 10. Farmer’s Perception on Local Climate Change in Adami Tulu Jido****Kombolcha District**

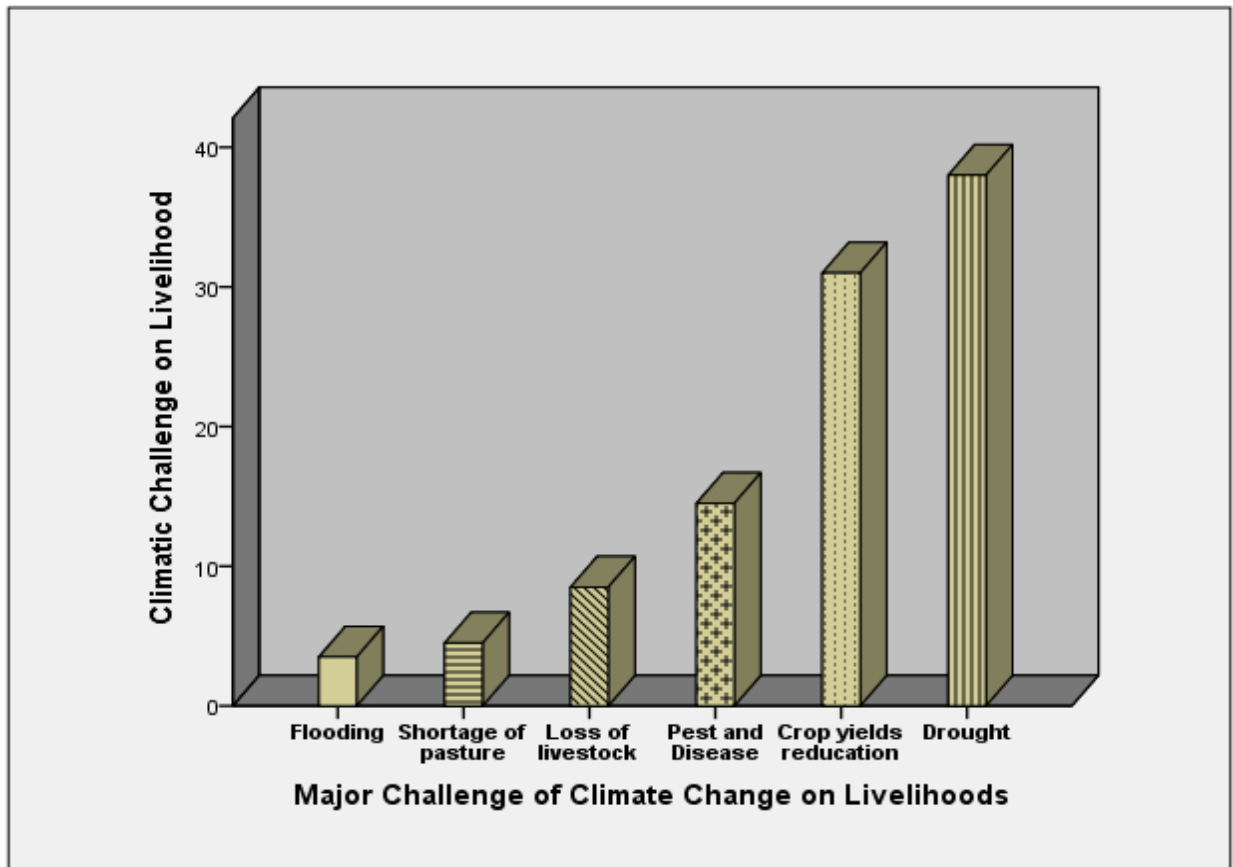
Variables		Frequency	Percent
Information about climate change	Yes	181	90.5
	No	19	9.5
Total		200	100
Is there is any change in temperature over last three decade	Increased	174	87
	Decreased	23	11.5
	No change	3	1.5
Total		200	100
Total annual rainfall	Increased	25	12.5
	Decreased	175	87.5
Total		200	100
How do you see amount rainfall in locality	Increased	184	92
	Decreased	16	8
Total		200	100
Is there is changing in timing and duration of rainfall last three decades	Yes	193	96.5
	No	7	3.5
Total		200	100
Drought occurrence over last 30 years	Increased	166	83
	Decreased	18	9
	No change	16	8
Total		200	100

**Source:** Own survey, 2017

**4.5.2. Farmers perception on Climate Change impact on Livelihood Resources**

The main climatic hazard affecting the communities in the Adami Tulu Jido Kombolcha district where is found is drought (Figure 15). Hence, 38% of the respondents ranked drought as the main climatic hazard affecting their livelihood and 31% ranked crop yield reductions as

the second significant hazard affecting their livelihood and pest and disease, loss livestock, shortage of pasture lands, and flood were also identified as significant hazards affecting their livelihood reported by 14.5%, 8.5% and 4.5% and 3.5% of respondents, respectively.



**Figure 15** Types of shocks that affecting livelihoods of Farmer in Adami Tulu Jido  
Kombolcha district

**Source:** Own survey, 2017

As shown in the (Figure 15) above, the shocks experienced by communities vary among the sampled *kebeles* in terms of frequency and intensity. Accordingly, a large number of respondents that, 40.3%, 38.6%, 38.2% and 27.3% claimed that drought is the major concern in all *kebeles* respectively. And also in all *kebeles* about 32.5%, 29.5%, 44.1% and 45% of the

respondents were concerned to crop yields reductions respectively in the study areas. This was followed by pest and disease 13%, 22.7% 8.8% and 13.6% in all *kebeles* are the major challenges in sampled *kebeles*. This implies that vulnerability to climate extremes greatly vary across different agro-ecologic environments. Generally, rain variability is the major concern in all agro ecologic conditions with far reaching adverse effects on rural livelihoods in general and agriculture in particular.

According to the information obtained from interview of farmers and DAs, those poor households with limited financial assets are suffering from increase of price commodities. Furthermore, the price of crop yield is not consistent whereas the price of inorganic fertilizer is consistently increasing from time to time and government's intervention is not sufficient. Unless the government could take better supportive intervention, climate change would put our food security at risk. As it is stated in literature review, extended increase in temperature, combined with dependency on rain fed agriculture the declining of the rain fall and the frequency of the drought, resulted in decline of agricultural production. FGD reported that impact of drought on agriculture includes decreased pasture availability and water, decreased capacity of livestock to resist disease and productivity in terms of milk and meat and death of livestock. Generally, drought causes crop failure, leading to food insecurity, increased conflict over scarce resources, migration of people for search of labor work and increased school dropout.

#### **4.5.3. Households Sources of Climatic Information**

Getting reliable climatic information increases the probability of adaptation. According to survey data and participants of group discussions, the most important source of climatic information for the communities is media (radio) and DAs. These indicates that their sources

provide information by giving emphasis on different techniques of soil and water conservation methods and the community have better information and knowledge to implement it at their farm land and communal lands. Table, 12 indicates that, from the sampled households about 38% 30, 16%, 3.5% of respondents get climate information from radio, DA, community decision and friends about temperature and rainfall (weather forecast) and from DAs, about adaptation, respectively. And 12.5% of the respondents were not obtained any climatic information from any source. In line with this, participants of FGDs were also stated that, the information they obtained from the two sources includes weather forecast, cause and consequence of climate change and about coping and adjusting the problem resulted by climate change and variability.

**Table 12 Main source of climatic information to households in the study area**

<b>Source of information</b>	<b>Frequency</b>	<b>Percent</b>
Radio	76	38
DAs	60	30
Community discussion	32	16
Friends	7	3.5
Radios and DAs	25	12.5
Total	200	100

**Source:** Own, survey 2017

#### **4.6 Analysis households' Livelihoods Status as Measured by Food security**

This section briefly reports the association between the food security status of the households in the study area and their related demographic characteristics. Among household characteristics sex of the household head, age, household size and education level of the

household head are included. Since food is the most basic of human needs for survival, health, and productivity and thus the foundation for human and economic development. The rate of food insecurity in any given area is often used as a measure of welfare of households in that area. In this study the categorization of households into food secure and food insecure is based on an assessment of whether household current consumption is above or below the minimum recommended food energy consumption measured in kilocalories (Table 13). The calculated household available energy was compared with the minimum subsistence requirement per adult equivalent per day i.e. 2,100 kcal. Based on the calorie requirement of 2100 Kcal per day per person, out of the 200 sample rural households of the Adami Tulu Jido Kombolcha district 111(55.5%) and 89(44.5%) were found food insecure and food secure households, respectively.

As it has been clearly discussed in the methodology part acquired food items by the households which is converted to kilo calories using food to energy conversion factor table as shown in appendix table 4 is used as a measure of food security status and the households in the study area are classified in to food secure and food insecure based on the comparison of their calorie acquisition per adult equivalent and the minimum recommended level of food energy consumption (2100 kilocalories) in this case following MoFED (2002) .

<b>Variables</b>	<b>Frequency</b>	<b>Percent</b>
Food secure	88	44
Food insecure	112	56
Total	200	100

**Table 13** Food Security Category of the Households

**Source:** Own survey 2017

It is well known that in Ethiopia the head of household strongly influences the household livelihood and their demographic features would then influence, to some extent type and source of income hence acquisition of food available from different sources. For this reason an attempt has been made to assess the difference in food security status that exists between different household head characteristics.

Logistic regression model was used to identify determinants of food security. Accordingly, variables assumed to have influence on household food security in different contexts were tested in the model and out of 18 variables ten of them were found to be significant. Among variables fitted into the model age of the household head, sex, educational level of household head, family size, off-farm activities, size of cultivated land, livestock ownership, oxen ownership, distance to FTC and distance to market were found to be significant in determining household food security. The model reveals that age of the household head has positive and significant at ( $p < 5\%$ ) relationship with household food security.

**Table 14. Logistic Regression models result of factors determinant household Food Security at Adami Tulu Jido Kombolcha District**

<b>Variables</b>	<b>Estimated Coefficient</b>	<b>Odds Ratio</b>	<b>Significance level</b>
AGE	0.2548	1.28	0.003**
SEX	5.9475	3.82	0.000***
EDUC	7.3397	1.54	0.000***
FSIZE	-0.1617	1.17	0.0051**
TLU	0.4886	1.63	0.051*
NOXEN	1.5677	4.79	0.021**
TCULTLAND	2.5960	1.34	0.013**
OFF/ONACTV	0.040	1.004	0.014**
DISTANCE FTC	-2.825	0.592	0.003**
DISTANE MARKET	-1.7707	0.17	0.004**

Source: Own survey, 2016

\*\*\*, \*\*, \* Significant at 1 %, 5%, and 10% significance level

**Age of the household head:** The possible explanation for such positive association is that an older household head devotes his/her time on farming activities compared to young farmers. Young people spend much time in towns and prefer urban life than the rural for a number of reasons. Moreover, as age increases, one can acquire more knowledge and experience becoming effective in exploiting these experiences. This variable affects food security status positively and significantly at ( $p < 5\%$ ) probability level in the study area.

The positive relationship implies that when household heads get older, they are expected to have stable economy in farming. Moreover, older household heads are expected to have better access to land than younger heads, because younger men either have to wait for land redistribution, or have to share land with their families. If all other things are held constant, the odds ratio of 1.28 for household age size implies that, the odds ratio in favor of being food secure increases by a factor of 1.28 as household age increase by one year. This result confirms with Frehiwot (2007) findings.

**Male-headed households** are in a better position to pull labor force than the female headed ones. Moreover, with regard to farming experience males are better than the female farmers. The result was found to be consistent with showing positive influence of sex of household head on food security status at less than five percent probability level. This result is consistent with the findings of Genene (2006).

### **Educational status**

Educational status of the household is positively related with household food security and statistically significant at ( $p < 0.1$ ). It is an important determinant of household food security because an educated household is more sensitive to adopt technology to maximize the output he/she generated from farm activities. This contributed directly for household food security.

The odd ratio in favor of food secure is increased by 1.5 as the household is educated. This study is in line with the previous studies (Amsalu, 2013)

**Family size** was hypothesized to have negative influence on household food security. It is significant at 5 % probability level and has negative association with household food security. The negative sign in the model output is an indication of probability of being food insecure with an increase in family size. The odds ratio in favor of food security decreases with increasing family size and was found to be 1.17. This implies, the odds ratio in favoring food security decreases by 1.17 as family size increases by one. Households with large family size, when composed mainly of non productive population could face the probability to be food insecure due to high burden imposed on active labor. This result coincides with the findings of Beyene, *et.al* (2010) and Guled (2006).

**Total Livestock Unit of the households (TLU):** Most households in the rural communities in Ethiopia accumulate their wealth in terms of livestock. Results here support such a practice where households with relatively large livestock size (larger TLU) were found to be less vulnerable to food insecurity. In this case, the odds ratio in favor of food security increases by factor of 1.63 for a unit increment in TLU.

**Number of oxen owned:** oxen are among the most important factor of production and hence, determine the household food security status. This variable is significant at a probability of 5% and has positive association with household food security. As hypothesized, this variable affects household's food security. The more the number of oxen available to household, the larger is the probability of being food secured. The positive significance of this variable indicates the contribution of this resource towards ensuring food security. The interpretation of the result indicates that, if all other things are held constant, the odds ratio of 4.7 for the farm

oxen household holding size implies that, the odds ratio in favor of being food secure increases by a factor of 4.7 as the farm oxen household holding size increases by one hectare.

**Total cultivated land size:** Land size owned by household heads was found to have significant 5% and positive relationship with food security status of households suggesting the larger the land size, the better food secure state of the household. The possible explanation is that the major source of food in the study area comes from own production and there was limited access to other means of income generating activities. So the household who have large size of land has better production which gives a better chance for the household to be food secured. The odds ratio of 1.3 for farm size indicates that, other things being constant, the odds ratio in favor of farmer's food security status by a factor of 1.3 as the farm size increases by one hectare. This result is in agreement with the findings of (Tesfaye, Yilma, 2005).

**Off farm activities:** The model also reveals the important role of off-farm/non-farm income in contributing to household food security as expected at ( $p < 5\%$ ). In this circumstance, smallholders who solely depend on farm activities have inadequate income to purchase farm inputs and fulfill family needs and thus, they are found to be food insecure. The odds ratio in favor of food security increases by a factor of 1.004 when off-farm/non-farm income increases by one birr.

**Distance to farmers training centers (FTC)** is also among the significant explanatory variable in this model. This variable is negatively associated with the food security status and significant at probability level of 1%. This negative relationship indicates that the odds ratio in favor of the probability of being food secure decreases as distance to farmer training center increases. As compared to the farmers who have no access to farmers to farmer's extension service, the probability of using crop variety adaption methods to climate change decreased by

0.5% for farmers' who have access farmers-to-farmers' extension service, keeping other variables constant. Moreover, As compared to the farmers who have no access to farmers to farmer's extension service, the probability of use improve crop and livestock adaption methods to climate change increases by 0.5% for farmers' who have access farmers to farmers' extension service, keeping other variables constant. Different farmers have different skills, working habits, and experience. Therefore, sharing of experience among farmers is very important to build up the knowledge of the farmers and will help them to take the adaptation measures. This result is also similar with the finding of Deressa *et al.* (2010).

**Distance to the market:** Distance to the market center is also significantly and negatively affect these farmers who are not use an adaptation method to climatic change. Market is an important determinant for adaptation method because it serves as a means of exchanging information with other farmers (Maddison, 2006). A one kilometer increase in average distance to market center, the probability of farmer's not to use adaptation mechanism to climate change decreased by 1.7 at 5% level of significance, holding other variable constant. Because if farmers' are far away from the residence to the market center, they would not obtain better information, experience sharing and it is difficult farmers to buy new adaption technologies and other important inputs.

#### **4.7 Climate Change Adaptation Mechanism used by farmers in Adami Tulu Jido**

##### **Kombolcha district**

Due to the impact of climate change and variability on agricultural production in particular, sample farmers in the study area used different adaptation mechanism to adapt to the impacts of climate change and variability. Based on the information obtained through FGD, the local communities use the following mechanism. In relation with change in rainy time they use

early and late planting or changing planting date depending upon the situation, with the increasing depletion of grasses, local communities tend to change the type of livestock to small ruminants, livestock selling. In addition to these, different adaptation measures are undertaken by farmers in the study area with the support of different organization. Such as different physical and biological soil and water conservation, agronomic and natural resource management practices.

According to the participants of FGD, the communities participate in physical soil and water conservation measures. As indicated in table 15 changing cropping date is the most commonly used method by local community to adapt impact of climate change in the study area

**Table 15 Adaptation to Climate Change used by Sampled Households**

<b>Mechanism</b>	<b>Frequency</b>	<b>Percent</b>
Early and late planting /change in planting date	94	47
Use of improved and early maturity crop varieties	74	37
Apply soil and water conservation.	24	12
Use of irrigation	8	4
Total	200	100

**Source:** Own survey, 2017

#### **4.7.1. Barriers to Climate Change Adaptation in Adami Tulu Jido Kombolcha District**

Despite all efforts to minimize the changes in climate, the world needs to adapt to the upcoming changes as well. This adaptation to climate change is necessary to prevent societies from disasters and disruption. However, several socio economic obstacles have been hindering farmers' effort to undertake various adaptation mechanisms to in response to the existing climate change and variability effects on their livelihoods. The data from survey questionnaire

reveals that the major factor that impeded farmers' endeavor to adjust themselves and their livelihood to climate change and variability include; 38.1% poverty (shortage of money), 21.6% lack of awareness of the local population about climate change and its impacts, 17.5% is fluctuation of price of agricultural products while increasing cost of fertilizers and other commodities to be bought from markets, 15.5% shortage of infrastructure ( FTC, veterinary services, roads and markets and health centers) , 5.2% absence of markets in the nearby areas to sell our agricultural products and the remaining 1% is other reasons such as poor management of resources, lack of institutional capacity as mentioned by respondents.

## **CHAPTER FIVE: SUMMARY, CONCLUSION AND RECOMMENDATION**

### **5.1. Summary and Conclusion**

Climate change is a major challenge for agriculture, food security and rural livelihoods for many of people in the area. Climate change affects agriculture and agriculture also affects climate change. Adverse climate change impacts are considered to be particularly strong in countries located in tropical Africa that depend on agriculture as their main source of livelihood. The fact that climate has been changing in the past and continues to change in the future implies the need to understand how farmers perceive climate change and adapt in order to guide strategies for adaptation in the future. Identifying factors influencing farm level adaptation can facilitate the formation of policies and investment strategies that help moderate potential adverse consequences of long-term climate change. Because smallholder farmers tend to have a low capacity to adapt to changes in climatic conditions, policies that help these farmers adapt to global warming and associated climatic extremes are particularly important. A better understanding of the local dimensions of adaptation is therefore essential to develop appropriate adaptation measures that will mitigate these adverse consequences.

The knowledge of the adaptation methods to climate change enhance policy towards tackling the challenges that climate change is imposing on smallholder farmers. In relation to this, the study attempted the effect of climate change the livelihoods of smaller holder farmers and their adaptation mechanism. In the case of Adami Tulu Jido kombolcha district, Oromia Ethiopia.

From the whole surveyed households, 84% depend on mixed farming systems (crop-livestock production) and 4.5%, 6.5%, and 5% depend on daily labor, rent out land and petty trade respectively. However, majority of the respondents possess a land size which extends from 0.25-6 ha, while very few of the respondents possess a land holding of 2 to 3ha.

The result of local meteorological data analysis shows there was inter-annual variability of rainfall and that this variability is increasing. Similarly with the annual rainfall there was also inter-annual variability in the amount of *belg* and *kiremt* rainfalls. Accordingly, both *belg* and *kiremt* rain show decreasing and marginally increasing trends respectively. In addition to these both average maximum and minimum temperature show increasing trends. Due to increased temperature and erratic nature of rainfall, the area has become prone to drought and has experienced a number of drought years.

Most of the local people perceive that change in local climate has been occurring in terms of increasing in maximum and minimum temperature, decreasing in amount of annual rainfall, shortening of rainy season, increased frequency of drought, increased number of hot days and decreased number of cold days. In addition it is felt that there is seasonal variability in the pattern and distribution of rainfall. This is confirmed by the analysis of the local meteorological data.

The local communities have been facing different impacts of climate change and variability which have become more serious currently. Drought is the major climatic hazard that has affected livelihoods in the area. Drought is affecting the key livelihood assets on which the communities depend for their survival. Crop yield reduction, loss of livestock and shortage of grazing land are the most important effects of climate change and variability in the study area.

The decrease in crop yield and livestock production are attributed to highly unpredictable rainfall, late onset and early offset of rainfall, low fertility of the soil, low agricultural inputs. In addition, shortage of irrigation and drinking water, loss of livestock due to lack of fodder, pests and diseases, dry spells were mentioned. Drought has become a common phenomenon in the study area; it has become more frequent and intense in recent years and its reoccurrence interval has become shorter. As a result, crop failure, decreased availability of pasture and water, decreased capacity of livestock to resist diseases and declined livestock productivity and scarce resource have become common.

The result from the binary logit analysis shows that age, sex, education level, household family size, farm size, TLU, numbers of oxen, off farming activities, distance to FTC and distance to market have a significant impact on farmers livelihoods as measured by food security level.

Concerning the adaptation mechanism, sample households have applied different adaptation mechanisms. Some of them used shifting planting date, use of improved seeds and early maturing crop varieties, employing soil and water conservation techniques, diversifying their income source, growing drought tolerant crops and planting trees and afforestation. With regard to livestock production, households have listed out various adaptation mechanisms, decreasing the number of livestock, sale of old animals, and herd mobility account the highest share. Adaptation mechanisms such as livestock diversification, seasonal migration, herd mobility cattle fattening are practiced in a limited basis. Lack of awareness about climate change, lack of information about climate change, lack of money to purchase agricultural

input , poor access to irrigation water, shortage of land and labor are the main constraint to farmer to adapt to climate change.

## **5.2. Recommendations**

Based on the findings of the study, the following intervention measures are recommended so as to enhance resilience and adaptive capacity of the farming communities in the study area:

The community in Adami Tulu Jido Kombolcha district are facing declining trend of crop productivity because of variability of rainfall, intensified occurrence of pest and diseases, weed, insect, environmental degradation and temperature variability. With the ever increasing climate variability, the problem shall continue in the future unless appropriate measures are taken. Hence, intervention that enhance crop diversification, selection of variety of crops that are diseases resistant, early maturing and high yielding, improving the method of cultivation and agricultural technologies and promote traditional pest management are areas of critical concern.

Build on existing people's knowledge and practices: Reviving traditional practices and improving indigenous knowledge on how to harvest rainwater, forest management, crop and livelihood diversification, provide one way of coping with different climatic variability. Interventions need to build on existing knowledge and coping mechanism in order to insure sustainability of their activities. Therefore, before planning interventions, a proper assessment of peoples available adaptations options and coping mechanism should be considered and build upon indigenous knowledge.

Protect assets and diversify income sources: Protect vital livestock, environmental resources and community water shade in order to enhance people's adaptive capacity and awareness

creation. Diversification of household income sources is also necessary to minimize exposure to climate variability shocks.

**Empowering peoples with information and education:** Creating and expanding awareness among the population and policy makers about climate variability, its impact on their livelihood, causes and consequences by providing reliable and up to-to-date information to take appropriate adaptive measures.

**Environmental rehabilitation:** An area of immediate intervention is the rehabilitation of degraded wasteland that could be rehabilitated if enclosed for some time without human and animal intervention. Resettlement programs would pave the way for such interventions on the one hand and ease population pressure on the other.

In the future, similar studies should be conducted which adequately address the issue of vulnerability to climate variability, adaptation and the relative merit of each adaptation option to better guide policy options for adaptation to climate variability and to develop a peoples specific adaptation menu, which is able to account for impacts of climate variability.

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## APPENDIX 1

### Questionnaire for Household Survey

The objective of this questionnaire is to collect information which will be used for the study on the effects of climate change on the livelihoods of smallholder farmers and their adaptations mechanisms: the case of Adami Tulu Jido Kombolcha District, Oromia Region, Ethiopia. This study is going to be conducted for the partial fulfillment of MSC degree in Climate Change and Sustainability Agriculture Studies at Hawassa University. Your full support and willingness' to respond to the question is very essential for the success of the study. Therefore, you are kindly requested to answer all questions and give clear, appropriate and reliable information on the issues. Be sure that the information you provide is only for the purpose of this study.

#### PART I

##### Household composition

1. Name of Respondent -----
2. Age-----
3. sex-----
4. Level of educational:
  - 1) Unable to read and write
  - 2) Read and write (Informal education)
  - 3) Primary school
  - 4) Secondary
  - 5) College level
5. Household marital status:
  - 1) Single
  - 2) Married
  - 3) Widowed
  - 4) Divorced
6. Household family size: \_\_\_\_\_

#### PART II Household Resource

1. What is your means of livelihood or how do you get your livelihood?
  - 1) Agriculture (Crop production)
  - 2) Livestock rearing
  - 3) Working as daily laborer
  - 4) Renting out lands
  - 5) Petty trade
2. Do you or your family member have another source of livelihood other than agriculture?
  - 1) Yes
  - 2) No,
- 3) If your answer to Q 7 is 'yes', what could be that activity, Please specify-----  
--
- 4) Do you have agricultural land?
  - 1) Yes
  - 2) No
- 5) If your answer for Q, NO 4, is 'yes', How much do you have agricultural lands (ha)?

7) Do you have livestock? 1) Yes 2) No if yes, how many livestock do you own?

No_	Livestock	Before 10 years	Current 2009
1	Cow		
2	Oxen		
3	Heifers /bull		
4	Goat		
5	Sheep		
6	Donkey		
7	Horse		

### III. Farmers' perception of Climate Change based on the past 30 years experiences

1). Have you ever heard of climate change? 1). Yes 2). No

2). In your opinion, do you think that there is climate change in your locality? 1) Yes 2) No

3) What are the local indicators of the observed climate change?

- A). Un predictable rain fall B). Recurrent drought C) Increase in temperature  
D) Decrease in river volume.

3) What are the major challenges that climate change/posed on your livelihood?

- A). Shortage of pasture land B). Loss of livestock C). Crop yield reduction  
D). Drought E). Flooding

5. Do you feel temperature of the area is changing? 1) Yes 2) No

4). How do you perceive the temperature pattern of your locality or Village?

- A. Increased B. decreased C. No observable change

5). Is there a change in the timing of main rain season last three decades rain in your area?

- 1) Yes 2) No

6). If your answer is 'Yes', how do you characterize it?

A. comes early and goes late. B. Comes late and goes early C. Comes and goes early

7). If your answer for Q N6, is comes late and goes early, what changes have you observed in crop production?

- A. Decrease in crop yield B). Increase in crop yield C). No change in production

8) Is there any change on the onset of rain in this village? 1) Yes 2) No

9). Is there change to planting date as a result of change in the onset of rain? 1) Yes 2) No

10). Do you think that livestock production has increased or decreased in your village or locality?

A) Increased B) Decreased C) No change

11). If your answer for Q No10 is decreased, what do you think is the reason?

A). Livestock disease B). Shortage of grazing land C). Shortage of water for animals

12). Have you ever faced any climate related disaster over the last ten years? A) Yes B) No

13). If your answer for Question No12, is 'yes', what type of climate shock is your Concern?

A). Recurrent drought B) .Erratic rain fall & flooding C). Crop pests and diseases  
D). Rain fall variability

14). what do you think is the main cause for the climate change related problem that you?

15) What was the main source of feed for your livestock at present time?

A. grazing pasture B. Crop residues C Both

16). What is your main source of animal feed at the before 10 years?

17). what are the challenges to agricultural production? Give a ranking per order of severity?

A) Weather condition variability B) Pests & disease, C) Feed for livestock

D) Lack of seeds and fertilizer E) Low soil fertility F) Land shortage

18). Did you encounter food shortage for your family in this years?

1) Yes 2) No

19). Did you get information on local weather condition? 1) Yes 2. No

20). What are the main sources of information on the local weather condition?

1. Radio 2. Television 3 .news paper

21). Do you have access to irrigation water? 1). Yes 2). No

22). Do you have access to veterinary services? 1) Yes 2) No

23). Do you have access to credits service? 1). Yes 2). No

24). Do you have access to extension services? 1). Yes 2). No

25). Do you have access to agricultural inputs? 1). Yes 2). No

26). Do you have access to year round road? 1) Yes 2) No

27) Do you have access to market? 1) Yes 2) No

28) Do you have access to FTC? 1) Yes 2) No

PART IV:

**Adaptation methods to impacts of climate change**

1. Do you think that it is possible to adapt the impacts of climate change hazards?
  - 1, Yes      2, No
  
2. How do you adapt the impacts of climate change related with crop production?
  - A) Change in cropping pattern    B) Growing short maturing crop    C) Soil and water conservation
  - D) Use of improved and early maturing crop varieties
  - E) Use of irrigation                      F) Planting trees
  
3. What are major adapt mechanism you used *to overcome* climate change impacts on livestock production?
  - A. Increase livestock diversification
  - B. Seasonal migration with your cattle in search of pasture & water
  - C. Sale of weak and old animals before the dry season.
  - D. Decreasing the number of livestock
  - E. cattle fattening
  
4. What are the major constraints that you in adapting to the impacts of climate change on your livelihood?
  1. Lack of accessibility to infrastructure    2. Lack of awareness
  3. Shortage of labor    4) Shortage of money      5) Shortage of lands
  - 6) Poor potential for irrigation

**Household Food Consumption**

- 1) What food items were used for consumption during the last **seven days** in your household?

Type food	Total Consumed		Source					
			Home produced		Purchased		Gift/loan	
	Unit	Qt	Unit	Qt	Unit	Qt	Unity	Qt
<b>Staple</b>								

---

**foods**

Maize

Sorghum

Wheat

Teff

Bean

Lentils

Field

peas

**Meat & Other animal products**

Cow

milk

**Goat**

**milk**

Cattle

meat

Sheep

meat

Goat

milk

Butter

**Beverages & drinks**

Coffee

Drinking

water

Beverage

**Fats, oils, sweeteners, snacks**

Edible oil

Sugar

Salt

Macaroni

Past

**Vegetables**

Potato

Onion

Pepper

Garlic

---

Unit example: Kg, Liter, Packet, bundle

## Appendix, II

### Interview Questions for Focus Group discussions (FGD)

1. What do you think are the local indicators of Climate change in your *kebele*?
2. . Do you think climate change posed negative effects on your livelihood? If Yes, Please explain it.
3. What are the more vulnerable livelihood sectors in your *Keble (peasant association)*?
4. Is there any change on water, grazing land, the quality of pasture over the past years in your village?
5. What do you think is the major causes for the changes on the resources mentioned above?
6. Do you think any measure to avert climate change? Who should have the main responsibilities to do this?
7. Is there any change on livestock number, composition and feeding village?
8. How do you perceive your crop production? Increasing /decreasing
9. How do you adopt the impacts of impacts of climate change on your livelihood?
10. Have there been climate extremes (drought and flooding) in the last 20 years? Which one is your main concern?
11. Have you ever been participated in community based environmental participation in your *Keble*?
12. What are the main challenges that hinder your adaption mechanisms?
13. What is the role of traditional institutions in adaptation climate related hazards?

### Appendix 3

#### Conversion factors used to estimate Tropical Livestock Unit (TLU)

<b>Animal category</b>	<b>TLU</b>
Calf	0.50
Weand calf	0.34
Heifer	0.75
Cow and Oxen	1
Donkey (adult)	0.7
Horse ( adult)	0.7
Horse	1.10
Donkey (young)	0.35
Sheep and Goat (adult)	0.13
Sheep and Goat (young)	0.06
Chicken	0.013
Camel	1.25

Source: Stock, *et. al.* (1991)

### Appendix 4

#### Conversion factors used to estimate Kcal of food items

<b>Food item</b>	<b>Unit</b>	<b>kcal/100 gram</b>
Teff	Kg	341
Barely	Kg	354
Wheat	Kg	351
Maize	Kg	362
Sorghum	Kg	347
Lentil	Kg	353
Bean	Kg	344
Field peas	Kg	341
Guaya	Kg	347
Finger millet	Kg	312
Coffee	Kg	2
Sugar	Kg	400
Pepper	Kg	318
Salt	Kg	0
Oil	Lt	884
<b>Onion</b>	Kg	42
<b>Garlic</b>	Kg	149
<b>Potato</b>	Kg	87
Tomato	Kg	18

Milk	Lt	39
Cheese	Lt	132
Beef	Kg	235
Rice	Kg	140
Egg	No	40
Spaghetti/Macaroni	Kg	3550

**Source:** Ethiopian Nutrition and Health Research Institute (ENHRI, 1997) and World Health organization

### **Appendix 5**

#### **Variance inflation factors (VIF) of the explanatory variables**

<b>Variables</b>	<b>VIF</b>	<b>1/VIF</b>
Age	1.141	0.87
Family size	1.26	0.792
Livestock ownership	1.107	0.903
Farm size	1.48	0.674
Off-farm income	1.23	0.81
Distance to FTC	1.28	0.78
Distance to market	1.18	0.84

**Source: Field survey data, 2017**

## **BIOGRAPHICAL SKETCH**

The author was born in 1989 in Gindebert district, West Shewa zone of Oromia Regional State of Ethiopia. He attended his elementary education at Irjajo Elementary School. He also attended his junior education and preparatory school at Ambo Secondary Schools. After successful completion of his preparatory school education, he joined Haramaya University in 2006/2007 and graduated with B.Sc. degree in plant science in July 2009. Soon after his graduation, he joined Fenatale agriculture office and served as agronomist expert from November, 2010 to September 2012 in the Agriculture office. 2013-20014 he joined nongovernmental organization in the different position. After five year of professional experience, he joined the School of Graduate Studies of Hawassa University to pursue his MSc degree in climate change and sustainable agriculture.