ASSESSMENT OF LOCAL LEVEL AGRICULTURAL ADAPTATION PRACTICES TO CLIMATE VARIABILITY BY SMALLHOLDER FARMERS IN SODDO DISTRICT, SOUTHERN ETHIOPIA

TSEGAW LENCHA HIRPA

THESIS SUBMITTED TO

THE DEPARTMENT OF GEOGRAPHY AND ENVIRONMENTAL STUDIES

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF ART IN GEOGRAPHY AND ENVIRONMENTAL STUDIES (POPULATION, RESOURCE & DEVELOPMENT)

Addis Ababa University

Addis Ababa, Ethiopia

June 2016

ASSESSMENT OF LOCAL LEVEL AGRICULTURAL ADAPTATION PRACTICES TO CLIMATE VARIBILITY BY SMALLHOLDER FARMERS IN SODDO DISTRICT, SOUTHERN ETHIOPIA

TSEGAW LENCHA HIRPA

THESIS SUBMITTED TO

THE DEPARTMENT OF GEOGRAPHY AND ENVIRONMENTAL STUDIES

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF ART IN GEOGRAPHY AND ENVIRONMENTAL STUDIES (POPULATION, RESOURCE & DEVELOPMENT)

ADVISER

PROF. WOLDEAMLAK BEWUKET

JUNE 2016

Addis Ababa University

Declaration

I declare this MA thesis which I submitted to School of Graduate Studies, Addis Ababa University, is my original work and has not been submitted to any other university for an award of degree. I also certify that all source materials used in this thesis are fully acknowledged.

Name of Student	**Signature**	**Date**

Addis Ababa University

School of Graduate Studies

This is to certify that the thesis prepared by Tsegaw Lencha, entitled: *'ASSESSMENT OF LOCAL LEVEL AGRICULTURAL ADAPTATION PRACTICES TO CLIMATE CHANGE BY SMALLHOLDER FARMERS IN SODDO DISTRICT, SOUTHERN ETHIOPIA'* and submitted in partial fulfillment of the requirements for the degree of Degree of Master of Art in Geography and Environmental Studies, specialization in Population, Resource and Development complies with the regulations of the University and meets the accepted standards with respect to originality and quality.

Signed by the examining committee:

Advisor Wordeamlak Berhet Signature _____ Date 01/07/16

Examiner Desalegn Wana Signature _____ Date 01/07/2016

Examiner Desalegn Yayeh Signature _____ Date 01/07/2016

_____

Chair of Department or Graduate Program Coordinator

Abstract

Climate has obvious and direct effects on agricultural production. Agricultural sector in Sub-Saharan African is particularly vulnerable to climate change. Climate change is a key concern to Ethiopia since agriculture sector of the country is the most affected sector by climate change. Thus identifying different adaptation options to climatic variation is crucial in designing appropriate coping strategies. This research was conducted with the objective analyzing local level coping and adaptation strategies in the agriculture sector in responses to climate extremes impacts on agricultural production by smallholder farmers in Soddo district of SNNPR. The study employed household survey, FGD and KI interview for data collection. Quantitative data was analyzed using SPSS software. The result show that farmers are struggling with the effects of climate change and variability (98%) and attempting to adapt to its impact (66%) indicated. Smallholder farmers in the study area experienced various effects of climate change and related hazards. Climate change contributed to increased incidence and expansion of crop pests (locusts), reduced crop yield, short length of growing period, change in production season, reduce livestock weight, deterioration of cattle health and death, water scarcity, and shortage of grazing land and feed as major effects in crop and livestock production. Flood and drought were the two commonly experienced climate related hazards in the area during the past 10-20 years. Also unseasonal rainfall, snow rain, livestock and human disease, and pest infestation are experienced by households. Natural resource management is the primary adaption strategy practiced at community level. At household level range of adaptation strategies that are mainly farm-level adaptation composed production adjustment as well as land/soil and water use practices are implemented. Measures like reducing amount of food; reducing specific type of food; cash borrowing; support from relatives/neighbors and support from government are the coping mechanisms to the different climate hazards. Grain reserve and borrowing is locally devised coping mechanism that the community practices. Therefore, it is recommended that application of proper rangeland management and effective water use systems, promote and strengthen existing improved farming practices and introduce new technologies, use of reliable climate information to make crop and livestock production decisions, reducing use of synthetic fertilizers and pursuing increased use of organic soil fertilizers, and policy-practice coherence are worth considering in enhancing climate change adaptation and ensuring food security in the area.

Keywords:

Climate Change, Adaptation, Coping Mechanism, Hazard

Acknowledgement

I am extremely grateful to God for His companionship and grace. I have received various forms of assistance from many people in the course of producing this master thesis. I am glad to use this opportunity to express my indebtedness to all of them. First and for most, I want to convey my sincere gratitude to my advisor Prof. Dr. Woldeamlak Bewket for his critical comments, unreserved guidance, encouragement, and follow-up throughout this work.

I am indebted to my dear friend Mesay Berhanu for facilitating logistics in the data collection process. I thank experts from the *wereda* agriculture office and Soddo Buee-Children and Family Development Charity Organization (SB-CFDCO) as well as development agents at *kebele* for providing me information on the interview.

Further, without the kind cooperation of participants and household, this study would have not been possible and I owe them a lot. Enumerators, Solomon and Tarekegn you deserve appreciation for your hard and timely work.

I am grateful to my friends Terefe Mena, Tigist Dalelo and Mesfine Ketena for their encouragement. Also thanks to my classmate in the department for their lovely friendship and kindness in the past three years.

I would like to express my most sincere gratitude to my wife Menen Desta for her understanding, support and time. My baby boy, Nathan Tsegaw, you came to this world in the course my study. You are a blessing from above and I dedicate this work to you.

Finally, I would like to express my sincere indebtedness to my mother Brike Yilam for her care, love, support and provision. You made me to become who I am and you are my hero.

Table of contents

List of Figures

List of Table

Abbreviations

ABD	Africa Development Bank
CRAP	Climate Resilient Agricultural Practices
CC	Climate Change
CO_2	Carbon Dioxide
CH_4	Methane
CSA	Central Statistic Agency
FAO	Food and Agriculture Organization
FGD	Focus Group Discussion
FDRE	Federal Democratic Republic of Ethiopia
GHG	Green House Gas
GTP-I	Growth and Transformation Plan One
IFPRI	International Food Policy Research Institute
IPCC	Intergovernmental Panel on Climate Change
KII	Informant Interview
NGOs	Non-governmental Organizations
NMA	National Meteorological Agency
N_2O	Nitrous Oxide
UNOCHA	United Nation Office of Coordination for Humanitarian Affairs
UNDP	United Nation Development Program
UNEP	United Nation Environment Protection
UNESCO	United Nation Education, Social and Culture Organization
UN-ISDR	United Nation International Strategy for Disaster Reduction
WMO	World Meteorological organization
WVE	World Vision Ethiopia

CHAPTER ONE: INTRODUCTION

1.1 Background and rationale

Climate change has become a formidable challenge to the world than any other phenomenon despite scientific, technological and political responses sought by scholars, policy makers and practitioners. Agriculture is likely to face the severest impact from climate change with implications for national and global food security. According to the Intergovernmental Panel on Climate Change (IPCC, 2007) agricultural production and food security including access to food in many African countries and regions are likely to be severely compromised by climate change and variability. IPCC (2001) projects by 2020, in some countries, yields from rain fed agriculture could be reduced by up to 50%. This would adversely affect food security in the continent with small-scale farmers being the most affected.

Various studies (Ajibade 2013; Di Falco *et al.* 2011; Deressa 2006; Kurukulasuriya and Mendelsohn, 2008) indicate agriculture is one of the most vulnerable sectors to climate change impact in Africa and Ethiopia. Agrarian communities in many African countries including Ethiopia are particularly vulnerable to climate change as they are largely based on rain-fed farming systems. Adaptive and response capacities are the least and technological changes are the slowest (Maddison, 2006; Bryan *et al.* 2011; Ajibade, 2013; Thornton *et al*. 2006).

Climate change is posing a great threat on food security in a rain-fed, low adaptive and traditional agriculture system. Particularly food production (availability) is declining at an alarming rate. In Sub-Saharan Africa and Asia, 56 and 21 percent of crops, respectively, are expected to be negatively affected by climate change by 2050 (Smith *et al.* 2007).

Detailed prediction by IPCC (2001) indicates that by 2050, crop yields in Sub-Saharan Africa will have declined by 14% (rice), 22% (wheat) and 5% (maize), pushing the vast number of already poor people, who depend on agriculture for their livelihoods, deeper into poverty and vulnerability. It also predicts decreased food availability by 500 calories less (a 21% decline) per person in 2050 and a further increase in the number of malnourished children by over 10 million - a total of 52 million in 2050 in Sub-Saharan Africa alone.

The fourth Intergovernmental Panel on Climate Change (IPCC) states that at lower latitude, in tropical dry areas, crop productivity is expected to decrease 'for even small local temperature increases 1–2 ◦C' (IPCC, 2007: 11). In many African countries, access to food will be severely affected. 'Yields from rain fed agriculture could be reduced by up to 50% by 2020' (IPCC, 2007: 13).

As cited in Di Falco *et al* (2011), various researches have been conducted in examining the relationship between climate variables and agriculture production (Deressa and Hassan, 2010; Kurukulasuriya and Rosenthal 2003; Seo and Mendelsohn, 2008). Besides, there exist ample literatures on the estimation of the impact of climate change on food production at country, regional, and global scale (McCarthy *et al.* 2001; Parry *et al*. 2004; Pearce *et al.* 1996; Stern 2007). However, these studies are limited in exploring local level agricultural adaptation practices and their roles in enhancing household food security.

The scarcity of information on local level agricultural adaptation measures challenges the formulation and designing of appropriate strategies and programs at farm household level. This study, therefore, attempts to contribute to the knowledge base by assessing the micro level agricultural adaptation practices; the experienced effects of climate change on agricultural (crop

and livestock) production and local level suggested strategies of adaptation to improve households' food productivity in Soddo *woreda*. This will help government institutions and development partners in understanding the specific household agricultural adaptation measure to climate change and initiate interventions that promote the local practices and enhance food security. It will also serve as a preliminary work for detailed investigation and analysis of the role and relationship of agricultural adaptation practices to household food security in the study area by academicians and researchers.

1.2 Statement of the problem

Climate change is a serious threat for agriculture, food security and fight against poverty in Sub-Saharan Africa. Crop failure due to unexpected and recurrent climate shocks incidents such as drought (shortage of rainfall), flooding (excessive rain), pests and diseases increase a risk of longer period of hunger and more severe livelihood hardship of the many rural poor who rely on small-scale farming for food and income.

In Ethiopia, the agricultural sector use low capital intensive agricultural technologies that results in low productivity and income that constrain farmers' capacity and options to adaptation under climate change (Dinar *et al.,* 2008). The sector is largely rain-fed and the country's economy heavily relies upon it. Agriculture accounted for 43% of GDP in 2013. It generates over 70% export values and employs 85% of the total labour force (UNDP, 2014). Ethiopia, like many African countries, is particularly vulnerable to climate change. This vulnerability has been demonstrated by the devastating effects of the various prolonged droughts in the 20th century and recent flooding (Di Faloc *et al*., 2011). Woldeamlak *et al.* (2015) cited, particularly there is increased incidence of meteorological drought episodes, famines and climate-sensitive human

and crop diseases in the northern highland and southern lowland regions of Ethiopia (World Bank 2009, Aklilu and Alebachew 2009, Oxfam International 2010, UN-ISDR 2010).

Despite the expansion of Ethiopia's economy over the last decade, the number of food insecure and relief-assisted population in the country has been extremely high in recent years especially in 2000, 2003 and 2008/9 following the drought experienced in preceding years respectively (Alebachew, 2011). This year (2015), the country faced failure in *belg* rain and poor *kiremt* seasons as a result of El Nino marked by a warming of sea-surface temperatures in the Pacific Ocean. In effect, currently (October 2015) Ethiopia reports an increase in food aid beneficiaries from 2.9 million in January 2015 to 8.2 million today (UNOCH, 2015; Reliefweb, 2015).

Soddo district, the selected study area, experiences a climatic variability factor mainly irregular rainfall in amount and distribution that induced low productivity. Steady population growth, deforestation, poor land management and topography are the major limiting factors to household food security and local economy (WVE, 2013). This calls for proper designing, implementation and diffusion of agricultural adaptation practices to climate change factors to build resilience, enhance food security and reducing vulnerability. This paper, therefore, aims to assess how farmers cope with climate-related agriculture production shocks using local and nationally identified agricultural adaptation practices to ensure household food security.

1.3 Objectives of the study

The overriding objective of this thesis is to assess local level agricultural adaptation strategies and coping mechanisms in responses to climate extremes impacts on agricultural production by smallholder farmers in Soddo district. More specifically, the study aspires to:

- assess observed effect of climate change on crop and livestock production in Soddo district
- assess local adaptation responses by smallholder farmers to the effects of climate change
- assess climate related hazards/extremes experienced by farm households in the study district
- assess the major causes that induce and aggravate climate change in Soddo district

1.4 Research Question

This research intended to answer the following basic questions which are derivatives of the abovementioned research objectives:

- What are farm-level adaptation measures undertaken by farm households
- What are the experienced impact of climate change on crop production
- What are the climate related hazards experienced by the farm households
- What are the social and economic consequence of climate change impact
- What are the suggested strategies for enhancing climate change adaptations to improve crop production and food security in the district

1.5 Significance of the study

Various researches are conducted with regard to climate change impact on and adaptation to agriculture and food security at national, regional and global levels (Di Falco *et. al*, 2011, Gutu *et. al*, 2012, Sisay, 2013 and Woldeamlak *et. al* 2015). This study aims to contribute to the existing academic knowledge by exploring the agriculture adaptation practices and contributions to household food security at local level. The study attempted to identify knowledge gap in local and institutional responses to climate change as well as their synergies with the agriculture sector climate change adaptation strategies of the county.

1.6 Delimitation of the study

The study has limited spatial scope since out of 54 rural kebeles in the woreda only 2 kebeles representing highland and midland agro climatic zones were selected. The study also has delimitation in that it focused to investigating the issue under study only from the crop and livestock production system of the agriculture sector. The study area was selected purposively due to very limited research works on the issue. Thus, this research being one of the few preliminary works it has limitation in generalizing findings to broader scope.

1.7 Limitation of the study

This study has limitation with regard to data acquisition (in amount and time horizon) as a result of limited available financial and time resources.

CHAPTER TWO: REVIEW OF RELATED LITERATURE

2.1 Theoretical perspective

2.1.1 Causes and impacts of climate change: The global perspective

The earth's climate is naturally variable on all time scales. However, its long-term state and average temperature are regulated by the balance between incoming and outgoing energy, which determines the Earth's energy balance. When incoming energy from the sun is absorbed by the earth system, Earth warms. The earth avoids warming and gets cool as the sun's energy is reflected and released back into space respectively. Any factor that causes a sustained change to the amount of incoming energy or the amount of outgoing energy can lead to climate change. Factors that cause climate change can be divided into two categories; those related to natural processes and those related to human activity (anthropogenic).

The earth's climate changes in response to external forcing which is physical factor external to the climate system such as; variations in the earth's orbit around the sun (orbital forcing), volcanic eruptions and atmospheric greenhouse gas concentrations that force a net increase (positive forcing) or net decrease (negative forcing) of heat in the climate system as a whole (Mohanty and Mohanty, 2009; Hansen, *et al*. 2005).

According to the IPCC fourth assessment synthesis report (2007) changes in the atmospheric concentrations of GHGs and aerosols, land cover and solar radiation alter the energy balance of the climate system and are drivers of climate change. They affect the absorption, scattering and emission of radiation within the atmosphere and at the Earth's surface.

According to World Meteorological Organization (WMO, 2013) the natural climate change/variability on different timescales is caused by cycles and trends in the Earth's orbit,

incoming solar radiation, the atmosphere's chemical composition, ocean circulation, the biosphere and much more.

Human activities contribute to climate change by causing changes in Earth's atmosphere in the amounts of greenhouse gases (GHGs), aerosols (small particles), and cloudiness. Atmospheric concentrations of GHGs increase when emissions are larger than removal processes. Anthropogenic activities result in emissions of four long-lived greenhouse gases: CO_2, methane (CH_4), nitrous oxide (N_2O) and halocarbons (a group of gases containing fluorine, chlorine or bromine). The emission of these gases is attributed to human activities such as increased use of fossil fuels in transportation, heating and cooling of buildings and the manufacture of cement, deforestation, agriculture (land use, fertilizers and livestock), natural gas distribution and landfills (IPCC, 2007).

Climate change impacts are observed on the human and natural system globally and regionally on every sector. The IPCC in its recent fifth assessment summery for policymakers report indicates melting snow and ice are changing hydrological system and affecting water resources in quality and quantity; terrestrial, freshwater and marine species have shifted their geographic ranges, seasonal activities and migration patterns; more negative impact on crop yield particularly wheat and maize for many regions and in the global aggregate that affected the production aspect of food security rather than access and its other dimensions and significant vulnerability and exposure of the human and ecosystem to climate variability such as heat waves, drought, floods, cyclones and wildfire that caused disruption of food production and water supply, damage to infrastructure and settlements, morbidity and mortality, and consequences for mental health and human well-being. The change in climate has also observed positive effect for

the poor and marginalized people particularly in diversification of social networks and of agricultural practices (IPCC, 2014).

Specific to agricultural practices climate change affects plants, animals and natural systems in many ways. In general, higher average temperatures will accelerate the growth and development of plants. In a temperature above 30 °C, animals reduce their feed intake 3–5% per additional degree of temperature. Rising temperatures are not uniformly bad. They will lead to improved crop productivity in parts of the tropical highlands. Increases in maximum temperatures can lead to severe yield reductions and reproductive failure in many crops. In maize, for example, each degree day spent above 30 °C can reduce yield by 1.7% under drought conditions (Thornton and Carmer, 2012).

Table 1 Summary of impact of climate change

Bio-physical impact	Social impact	Economic impact
Increased temperature and changes in rainfall patterns	Reduced agricultural productivity (drought) Reduced marine productivity Water stress and scarcity Increased prevalence of disease Forced migration	Reduced supplies and higher prices for food Changes in arability and cropping patterns Reduced availability and higher prices for water Change in distribution of labor supply
Sea level rise and increased incidence or intensity of disasters (storms, fires)	Damage to assets and infrastructure Population displacement Conflict	High cost of insurance Disruption of supply inputs Disruption of final markets Sudden labor scarcity or influx
Cumulative bio-physical impacts	Carbon regulation Conflict	Rising fossil fuel prices Governance breakdown

Source: Adapted from Tanner and Mitchell (2008)

2.1.2 Agriculture, food security and climate change: The nexuses

Agriculture produces the food humans need to live an active and healthy life and provides livelihoods for about half the world's population. But it also has a troubling relationship to climate change – simultaneously being affected by and a cause of the problem. Climate change has the potential to damage irreversibly the natural resource base on which agriculture depends, with grave consequences for food security. Climate change also significantly constrains economic development in developing countries that largely rely on agriculture.

Agriculture brings complex links among the issues of climate change and food security. It affects and is directly affected by climate change. Climate change will likely affect agricultural production, distribution and supply of food and alter food prices. Agricultural production will need to grow in order to meet increased demand for food. This growth will almost inevitably lead to an increase in GHG emissions and in the sector's relative contribution to climate change (Campbell, 2011).

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. Although there will be gains in some crops in some regions of the world, the overall impacts of climate change on agriculture are expected to be negative, threatening global food security (Gerald *et al*., 2009).

According to the Stern Review (Stern, 2006) agriculture is a major contributor to climate change. In 2000, about 35% of greenhouse gas emissions came from non-energy emissions: 14% were nitrous oxide and methane from agriculture, 18% from land use change mainly from

deforestation for agricultural purposes, although there is a high margin of uncertainty. Those figures do not include large emissions from soil carbon losses, including peat degradation and peat fires.

The links between food security and climate change are complex, because food security involves food and its production, trade and nutrition as well as how people and nations maintain access to food over time in the face of multiple stresses. Climate change directly or indirectly impacts food security drivers such as biophysical system, socio-economic, demographic, cultural and political variables and these drivers in turn impact the four components of food security availability, accessibility, stability and utilization (Ziervogel and Ericksen, 2010). To date, the focus on the impacts of climate change on food security has been on availability and production in particular.

2.1.3 Adaptation and resilience to climate change in agriculture

Agriculture is inherently sensitive to climate conditions, and is among the most vulnerable sectors to the risks and impacts of global climate change (Parry and Carter, 1989). In this regard, adaptation is certainly an important component of any policy response to climate change in agriculture (Mizina *et al*; 1999; Reilly and Schimmelpfennig, 1999). Studies show that without adaptation, climate change is generally problematic for agricultural production and for agricultural economies and communities; but with adaptation, vulnerability can be reduced and there are numerous opportunities to be realized (Smith 1996; Mendelsohn 1998; Wheaton and McIver, 1999).

According to Liwenga *et al*. (2014) adaptation is generally perceived to include a long-term adjustment in social–ecological systems in response to actual, perceived, or expected environmental changes and their impacts. Adaptation to climate change takes place through

adjustments to reduce vulnerability or enhance resilience in response to observed or expected changes in climate and associated extreme weather events.

IPCC (2007) working group II distinguished three types of adaptations. Anticipatory/proactive adaptation that takes place before climate change impacts are observed. Autonomous/ spontaneous adaptation that does not constitute a conscious response to climatic stimuli but is triggered by ecological changes in natural systems and by market or welfare changes in human systems. And planned adaptation that is the result of a deliberate policy decision, based on an awareness that conditions have changed or are about to change and that action is required to return to, maintain, or achieve a desired state.

Regarding general adaptation practices particularly to the impacts of weather and natural climate variability on seasonal to intera-annual time scales that is El Nino-Southern Oscillation (ENSO) Sperling and Szekely (2005), as quoted by IPCC (2007: 721), stated that

> "Adaptation practices include proactive measures such as crop and livelihood diversification, seasonal climate forecasting, community-based disaster risk reduction, famine early warning systems, insurance, water storage, supplementary irrigation and so on. They also include reactive or ex-poste adaptations, for example, emergency response, disaster recovery, and migration."

Concerning agricultural adaptation option Smith and Skinner (2002) have proposed four main categories that are not mutually exclusive: technological developments, government programs and insurance, farm production practices, and farm financial management. The last two categories mainly involve farm-level decision-making by producers. Farm production practices entail adaptations in farm production system, land use, land topography, irrigation and timing of operation.

According to Muller and Niggli (2013) adaptation in agriculture need to be based on four pillars. First, increase soil fertility this is achieved by replacing synthetic fertilizers with organic one and monocultures with diverse crop rotation. Second, increase biodiversity through diverse measures such as crop rotation, use of local varieties, catch crops hedges and other landscape elements. Third, provide information and extension service to support sustainable agriculture practices and organic agriculture, agroecology and agroforestry. And fourth, create a level playing field for sustainable agriculture at the global level.

Summary of detailed adaptation measures and potentials on cropping system as indicated in the IPCC (2007) include: altering inputs (varieties and species) to those with more appropriate thermal time requirements and with increased resistance to heat shock and drought, changing fertilizer rates to maintain grain or fruit quality consistent with the climate and altering amounts and timing of irrigation and other water management practices (water harvesting, soil moisture conservation); altering the timing or location of cropping activities; diversifying income by integrating other farming activities such as livestock raising; improving the effectiveness of pest, disease and weed management practices and using seasonal climate forecasting to reduce production risk.

Resilience is used to describe the magnitude of a disturbance that a system can withstand without crossing a threshold into a new structure or dynamic. In human systems, resilience refers to the ability of communities to withstand and recover from stresses such as environmental change or social, economic, or political upheaval while for natural systems it is a measure of how much disturbance (in terms of storms, fire, pollutants, and so on) an ecosystem can handle without shifting into a qualitatively different state. Therefore, the ability of institutions and individuals to avoid potential damage and to take advantage of opportunities will be a critical factor in building

resilience to climate change. In addition, building resilience to climate change requires simultaneously building resilience in human systems and in the interlinked ecosystems on which they depend (ADB and IFPRI, 2009). Improved resilience in agriculture has outcomes such as increased adaptation of crops and livestock to climate stress, enhanced access and utilization of technology and information, increased income generation, increased use of resource-conserving technologies, open and transparent trade regimes, and improved risk sharing.

In 2007, Ethiopia's National Adaptation Program of Action (NAPA) identified 11 high priority adaptation projects and/or activities, that include a drought / crop insurance program, enhancing early warning systems for both drought and floods, small scale irrigation and water harvesting systems, better management of both rangelands in pastoral areas and wetlands, community-based carbon sequestration, and a range of capacity building and research and development works led by Ethiopia's Environmental Protection Authority, to develop a Climate Resilience strategy as part of its overall Climate Resilient Green Economy program (NMA, 2007).

2.2 Empirical perspective

2.2.1 Climate variability and change in Ethiopia

Climate variability is mainly expressed through observed changes in temperature and rainfall trends. It is often described by the statistical interpretation of precipitation and temperature data recorded over a long period of time for a given region or location. The National Metrological Agency (2001) revealed that in Ethiopia climate variability and change in the country is mainly manifested through the variability and decreasing trend in rainfall and increasing trend in temperature. Besides, rainfall and temperature patterns show large regional differences.

Ethiopia has three rainy seasons, namely, June–September (called *Kiremt*), October–January (*Bega*), and February–May (*Belg*). Kiremt rains account for 50–80 percent of the annual rainfall totals over the regions having high agricultural productivity and major water reservoirs (MEF, 2015). McSweeney *et al.* (2008) as cited in Bewket *et al.* (2015) historical climate data analysis of the country show an increase in mean annual temperature by 1.3°C between 1960 and 2006, which translating into an average rate of 0.28°C per decade. And the annual minimum temperature increased by about 0.37°C every decade between 1951 and 2006.

Source: MoFE, National Communication Plan to UNFCCC (2015)

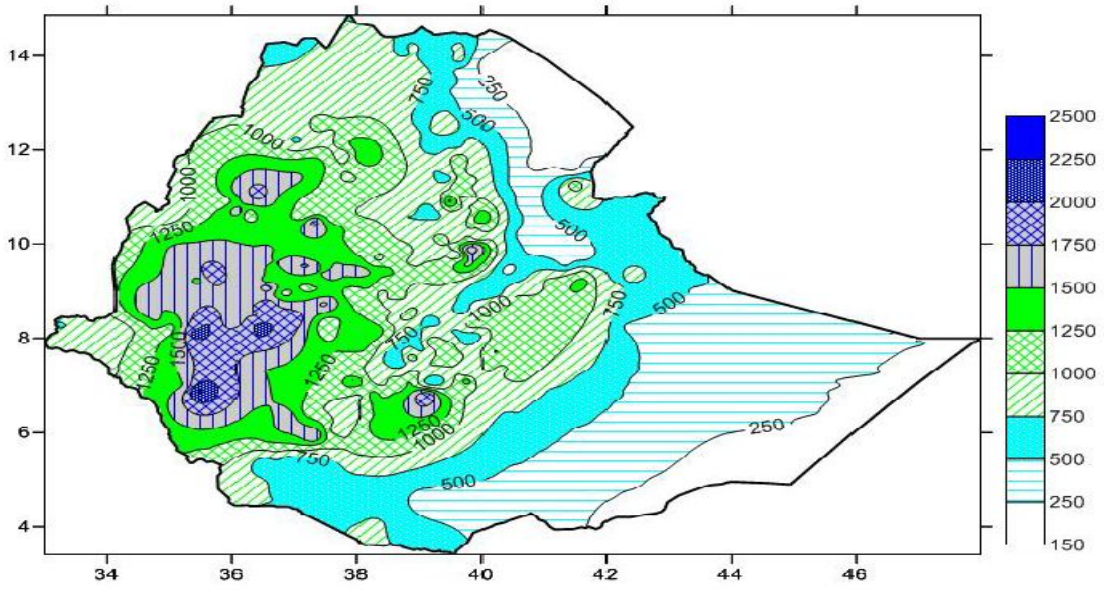

Figure 1 Spatial distribution of the mean annual rainfall in Ethiopia

2.2.2 Climate change impact on agriculture and crop productivity

Ethiopia has historically suffered from climate variability and extremes. Rain failures contributed to crop failures, deaths of livestock, hunger and even famines in the past. Even relatively small events during the growing season, like too much or too little rain at the wrong times, can spell disasters. Small farmers and cattle herders, who are already struggling to cope with the impacts of current climatic variability and poverty, face daunting tasks to adapt to future climate change.

The northern, southern and south-eastern dry land regions of Ethiopia have repeatedly faced increased frequency of meteorological drought episodes, famines and outbreaks of diseases which are believed to be linked with climatic change. The droughts have highly impacted the agriculture of the country and brought about the loss of crops, animals and above all the loss of millions of people.

Some studies have concluded that the agriculture sector of the country is the most affected sector by climate change. For instance Deressa *et al*., (2006) revealed that decline in precipitation and increase in temperature are both damaging to Ethiopian agriculture. In Ethiopia, the temperature has been increasing annually at the rate of 0.2°C over the past five decades. This has already led to a decline in agricultural production. Cereal production in Ethiopia is expected to decline still (by 12%) under moderate global warming (Yohannes and Mebratu, 2009).

According to NMA (2007) the major predicted impacts of climate change on Ethiopia‘s agriculture include frequent droughts and dry spells, shortened growing season, and increased incidence of pests and diseases. Hence, without effective adaptation, there is likely to be a decrease in the total area suitable for crop production in the country.

2.2.3 State of food security situation in Ethiopia

Ethiopia is a country that has been straggling with food security issue for several decades. Agriculture as a major means of food production is practiced for ages. Though food security is among the top priority of development and policy agenda, the country is unable to produce adequate food at household and national levels.

It has not been possible to produce adequate food (in the last three decades) to meet the needs of the fast growing population, attributed mainly to fragmented land holdings, successive droughts,

untimely and unpredictable rainfall, antiquated farm technology, lack of farm input, low producer prices and other ecological factors (Asfach and Nigatu, 2007). Despite this, food security as a problem at the national level was first felt in the 1960s, it only started influencing policy in the 1980s, when food self-sufficiency became one of the objectives of the Ten-year Perspective Plan (TYPP) in the early 1980s (Kidane *et al.* 2005).

The country has been structurally food deficit since at least 1980. During the late 1980s, 52% of its population consumed less than the recommended daily allowance of 2,100 kcal and nearly half of its population is food insecure or live below the poverty line (Devereux, 2000). However, according to Messay (2010) since 1960s, the number of food insecure households has been increasing, whilst per capita food availability decreasing. The average per capita food availability was 128.08kg for the period 1961-1974, and it declined to 119.99kg in 1975-1991. Although during 1992-2001 average per capita food availability was 125.41kg, still it remained far below (225Kg) the recommended average per capita daily requirement set by the government (2,100 kcal). This resulted over four decades of stagnation in the per capita food supply. In effect, the large gap that remained between food demand and supply was filled from food imports and food aid, the later contributing the largest share (Woldeamlak, 2009).

2.2.4 Local and institutional responses to climate change impacts

The government of Ethiopia has taken tremendous effort in responding to climate change impact in all sectors and agriculture in particularly. It has mainstreamed the issues of climate change in various national policies, strategies and programs. Bewket *et al.* (2015) noted that the Environment Policy, the Climate Resilient Green Economy (CRGE) initiative, and the Growth and Transformation Plan-GTP I are the prominent in the process. Currently, the country in its

GTP-II (2015-2020) has planned to create the foundation for Climate Resilient Green Economy by enabling the agriculture sector to adapt to climate change and reduce GHG emissions.

The Environment policy stipulates that the country needs to: demonstrate its firm and visible commitment to addressing climate change; emphasize on harnessing its hydro-, geothermal and solar energy potential as a way of reducing greenhouse gas (GHG) emissions and develop its energy sector accordingly; and maximize the standing biomass in the country through a combination of reforestation, agro-forestry, rehabilitation of degraded areas and a general re-vegetation of the land. The policy only provides for a climate monitoring program with respect to climate change adaptation (Bewket *et al.* 2015).

The Ministry of Agriculture (MOA) has developed the agriculture sector programme of plan on adaptation to climate change. The program state the already functioning policy, strategy, legislations and guidelines such as Food Security Programme, Productive Safety Net Programme, Voluntary Resettlement Programme, Participatory Watershed Management, Participatory Forest Management, Early Warning, Agricultural Extension Packages are believed to promote the sector's adaptation to climate change. Further, ongoing activities in the sector like afforestation, agroforestry, soil improvement and the use of manure as fertilizer contribute significantly in the reduction of greenhouse gases in the atmosphere making good synergy with climate change and adaptation (MOA, 2011).

Rural Development Policy and Strategy does not explicitly or directly address climate change. However, such principles as promoting agricultural development through expanding input supplies, irrigation and water management techniques, skills development, rural financing,

dissemination of technologies and natural resources management and ascertaining the participation of land users including women in the management of land resources are all relevant for climate change adaptation. In GTP-I, it is recognized that climate change presents both a threat and an opportunity for Ethiopia and it has pursued both appropriate climate change adaptation and mitigation measures in order to build a climate-resilient economy and facilitate the move towards a carbon-neutral economy (Woledamalk *et al.* 2015).

According to the Climate Resilient Green Economy (CRGE) strategy, by building a CRGE the country envision achieving a carbon-neutral middle income economic status by 2025. The strategy focuses on four pillars that will support Ethiopia's developing green economy: adoption of agricultural and land use efficiency measures, increased GHG sequestration in forestry, deployment of renewable and clean power generation and use of appropriate advanced technologies in industry, transport, and buildings. Adaptation of the agriculture sector focus is on improving crop and livestock production practices for higher food security and farmer income while reducing emissions. The strategy prioritized intensifying agriculture through usage of improved inputs and better residue management, creation of new agricultural land in degraded areas through small, medium, and large-scale irrigation and introduction of lower-emission agricultural techniques, ranging from the use of carbon and nitrogen efficient crop cultivars to the promotion of organic fertilizers as initiatives to limit the soil-based emissions from agriculture and limit the pressure on forests from the expansion of land under cultivation (FDRE, 2011).

2.3 Conceptual framework

Climate can be defined as average weather and describes the overall long-term characteristics of the weather experienced at a place. It is described in terms of the mean and variability of relevant

characteristics such as temperature, precipitation and wind over a period of time ranging from months to thousands or millions of years. Weather, whereas, is a set of meteorological conditions wind, rain, snow, sunshine, precipitation, temperature, etc. that we experience daily at a particular time and place (UNESCO/UNEP, 2011).

Climate change is the variation in earth's global climate or in regional climates over time. It involves change in the variability or average state of the atmosphere over duration ranging from decades to millions of years (Mohanty and Mohanty, 2009). It is the alteration of the world's climate that we humans are causing, through fossil fuel burning, clearing forests and other practices that increase the concentration of greenhouse gases (GHG). In this regard, the UNFCCC (1992:3) define climate change as "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods".

On the contrary, the Intergovernmental Panel on Climate Change (IPCC) uses the term for any change in the climate, whether arising naturally or from human causes. According to the working group II of IPCC climate change is "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" (IPCC, 2007:812). A similar concept related to climate change worth noting is climate variability. The IPCC in its working group two refers it as variations in the mean state and other statistics (such as standard deviations, statistics of extremes, etc.) of the climate on all temporal and spatial scales beyond that of individual weather events (IPCC, 2007). Variability may be due to natural internal

processes within the climate system (internal variability), or due to variations in natural or anthropogenic external forcing (external variability).

Adaptation is adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities (IPCC, 2007). A related concept to adaptation is resilience. In general terms, it is the capacity that ensures adverse stressors and shocks do not have long lasting adverse development consequences. The ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity for self-organization, and the capacity to adapt to stress and change (IPCC, 2007).

Source: Drawn from DFID Livelihood Framework and ADB Resilience Framework

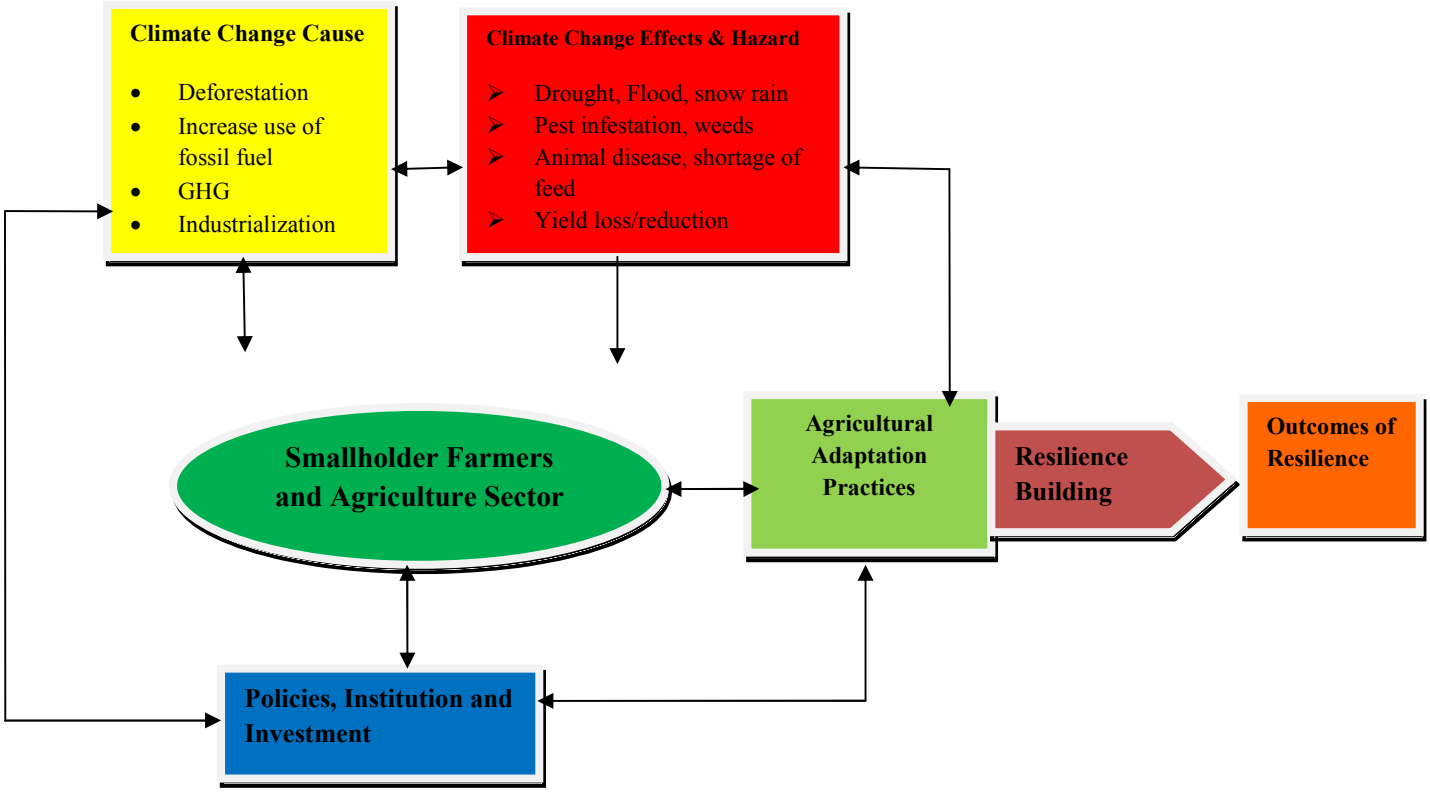

Figure 2 Conceptual Framework of Climate Change Adaptation

CHAPTER THREE: DESCRIPTION OF THE STUDY AREA AND THE RESEARCH METHODS

3.1 Description of the study area

3.1.1 Location

Soddo *Woreda* is found in SNNPRS, Guraghe Zone. The *woreda* is located between 8.09-8.45 latitude and 38.37-38.71 longitude. The *woreda* has 4 urban and 54 rural *kebeles* that serves as lower administrative units. Among these 22 *kebeles* are found in highland area and the remaining in midland. 15 *kebeles* are closer to the rift valley catchment and frequently affected by recurrent drought. These *kebeles* are considered as hot spot at national level (WVE, 2013). The total area of the Woreda is estimated to be 881.5 square kilometre. The *woreda's* town, Buee, is located 105Km from the capital of Ethiopia (Addis Ababa) and 124 from the zonal capital Wolkite.

3.1.2 Biophysical setups

The woreda has two major agro climatic zones namely, highland and midland which ranges from 1501 to 2500m.a.s.l. The average rainfall is 801 to 1200mm while the mean annual temperature lies between 12.6 and 20 degree Celsius.

3.1.3 Socioeconomic profile of Soddo *Woreda*

The dominant religious affiliation is Orthodox Christian (93%) whereby Islam and protestant accounted 3% equally. The remaining close to 1% is catholic and other. According to Woreda information Office (2012) the major ethnic composition of the district is Soddo Guraghe (85%), Oromo (11%), Amhara (1%) and other (2%). The total population of the Woreda is 165,076

where 81,843 are male and 83,233 female (CSA, 2013)[1]. The average family size of the district is 4.9 while the age structure of children from the total population is (84530) 48% (SNNPR BoFED, 2011).

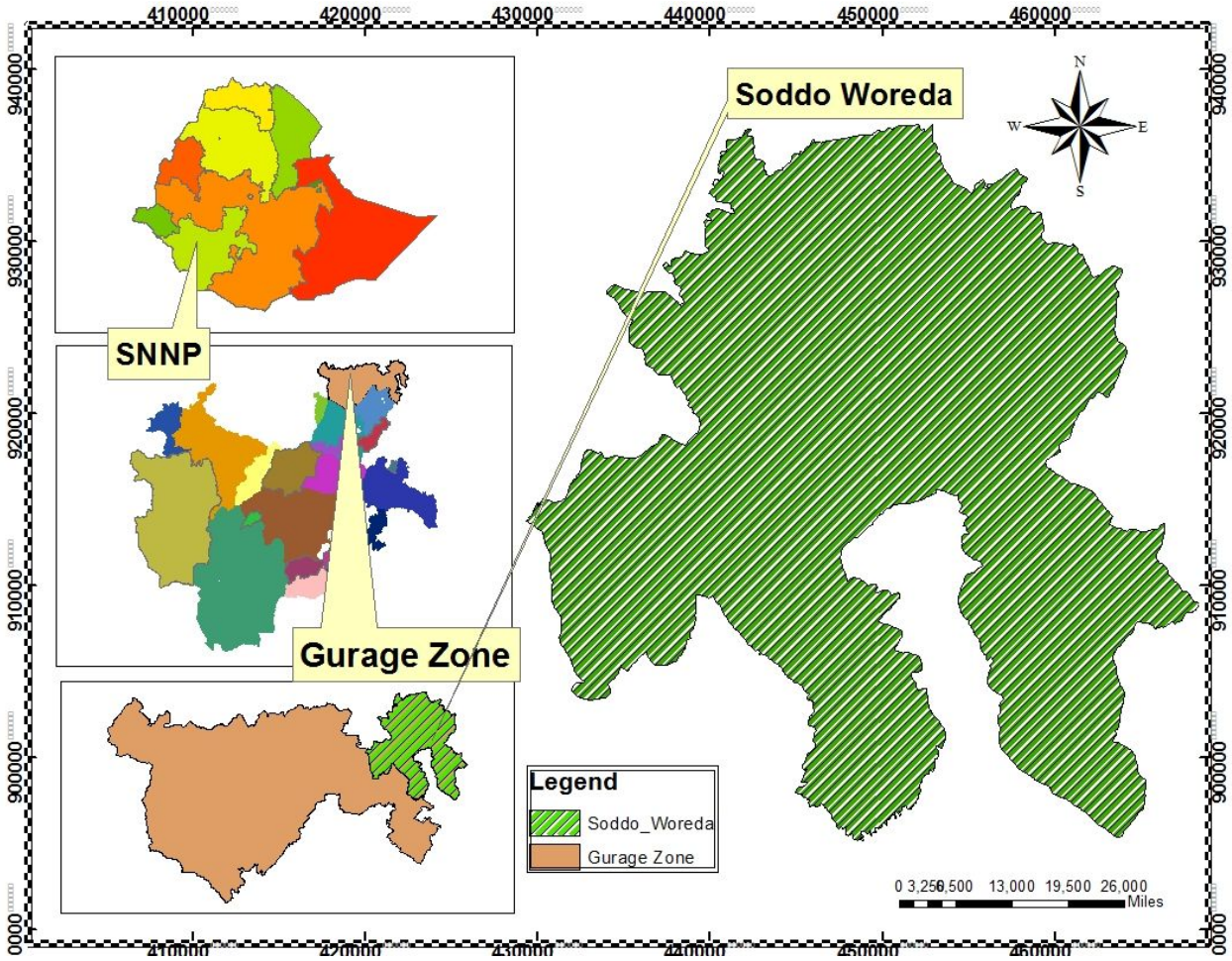

Figure 3 Location map of Soddo *woreda (Source: CSA 2014)*

3.2 Sources and types of data

The data source for this study was both primary and secondary. Primary data was collected from the field and respondents and secondary date gathered from different offices as well as available and accessible documents.

[1] Population projection values of 2015 at zonal and wereda levels by urban and rural residence and by sex. CSA (2013)

3.3 Study design

The researcher employed a mixed method approach for this study in order to accommodate qualitative and quantitative data. This approach provided an opportunity to collect diverse types of data that promoted understanding of the research problem. The study began with household survey in order to generalize results to a population and then followed interviews to collect detailed information from participants (Creswell, 2009).

3.4 Sampling design

3.4.1 Sampling procedure and sample size determination

Soddo woreda for the study was selected purposively. This is due to limited research undertakings in the woreda particularly related to climate change adaptations. The population for the study was the total households in Soddo district. The study applied multi-stage sampling with stratification. The 58 *Kebeles* in the district were stratified into midland and highland *Kebeles* based on the existing agro-ecology. Then using simple random sampling two *Kebeles* representing each agro-ecology were selected. These are namely Adazer *Kebele* from highland and Adele Kobo Borebor from midland. This ensures most homogeneous stratum than the total population and results in more reliable and detailed information (Kothari, 2004).

Considering factors such as; purpose of the study, research design, the type of population and financial limitation a simplified formula developed by Yamane (1967:886) to calculate sample size was used to determine the total sample size for this study.

$$n = \frac{N}{1 + N(e)^2}$$

Where; **n** is the sample size, **N** is the population size, and **e** is the desired level of precision. The researcher calculated the sample size assuming 90% confidence level and using 10% (0.1) precision level as a result of financial limitation to take large household sample. Further, this sample was also complemented by 2 FGD (with 22 participants) and KII with four experts at *woreda* and *Kebele* level.

The population size (N) was the household population of the two selected *Kebeles*. Then the sample size for each *Kebele* (stratum) was allocated using proportional stratified sampling method. Accordingly, a total 93 households 34 from Adazer and 59 from Borebor *Kebele* were selected to be the sample size for household survey. In order to identify the participants for the survey, using systematic random sampling the i^{th} element of the population was selected to be in the sample.

3.5 Method of data collection

The research employed household questionnaire survey, FGD, KIIs, and field observation in primary data collection. Besides, intensive desk review of published and unpublished literatures primarily from internet sources was conducted.

The number of respondents for the household questionnaire survey was determined using Yamane (1967:886) sample size determination model based on the proportion of the household population of the selected *Kebeles*.

The focus group discussions (FGDs) included a mix of participants from the communities groups; elders, women, men, and youth in mixed group settings, and from dominant livelihood systems such as crop producers and livestock keepers. Total of two FGDs (one FGD composed 8-12 participants from each kebele) was conducted.

Key informant interview was carried with the district level experts from agriculture, and local NGO offices. Besides, interview was conducted with development agents at each kebele. Accordingly, four individual were communicated for the KII.

3.6 Data quality assurance

In order to maintain the quality of data to the researcher applied scientific principles and guidelines during questionnaire designing, data collection, data filling, encoding, data entry and processing. An open response-option questions were developed and translated into Amharic. Data collectors were oriented on issues related to data collection procedures and ethics. Pilot study was undertaken for pre-testing the questionnaire in order to estimate the time needed to complete and implement it. The questionnaire was edited in the light of the results of the pilot study. The research reviewed the completed questionnaires for their clarity and truthfulness. Further computer data cleaning was carried to check for the completeness, consistency and accuracy of data and to identify errors that might have occurred during data collection or coding process.

3.7 Methods of data analysis

Quantitative data collected from questionnaire survey was analyzed using Statistical Package for Social Science (SPSS version.20) software and excel in order to describing key findings, conditions, states and circumstances disclosed from the data. Measure of central tendencies (mean) and measures of dispersion (standard deviation) was the major descriptive techniques used to summarize and compare the data. The qualitative data collected form interview and discussion went through interpretative and conversation analysis focused on providing meaning, explanation, perceptions or causal relationship from the findings.

CHAPTER FOUR: RESULTS AND DISCUSSIONS

4.1 Respondents and household characteristics

Age and Sex

As shown in figure 1, the quantitative data were collected from a total of 93 households in the two sample kebeles of Adazer and Adele Kobo Borebore. Specifically, 34 (37%) of the respondents were from Adazer and 59 (63%) were from Borebore. Of the total sample respondents 16% were female headed households.

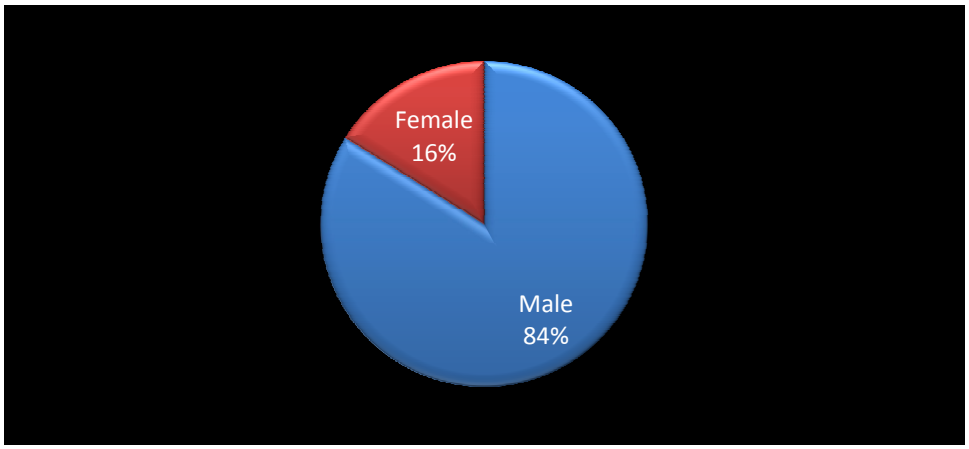

Figure 4: Sex of the sample households

The age distribution in table 1 shows that, the respondents have an age range from 32-70 with as standard deviation of 10.46 in Adazer kebele and an age range from 25-80 with a standard deviation of 16.43 in Borebor kebele. This indicates that the data is collected from a wider range of age groups in order to have representative information for the study. The mean age of the respondents is 49 and 45 in Adazer and Borebor kebele respectively.

Table 2: Age of the sample households' heads by Kebele

Kebele	Age of the respondent			
	Mean	Maximum	Minimum	Standard Deviation
Ada zer	49.03	70.00	32.00	10.46
Adele kobo borebor	45.21	80.00	25.00	16.43

Source: Household survey

Family Size and Education

The family sizes of the sample household heads are given in table 2. As the table show, a significant proportion of the respondents have large family size which is a typical characteristic of rural households in Ethiopia. About 33% of the total households have family size 4-6 members and 46% of the households have a family size of 7-9 members above the average family size of the woreda which is 4.9.

Table 3: Family size of the sample households by kebele

Family Size Categories	Kebele				Total	
	Ada zer		Adele kobo borebor			
	No.	%	No.	%	No.	%
Family Size 1-3	1	2.9%	12	20.3%	13	14.0%
Family Size 4-6	8	23.5%	23	39.0%	31	33.3%
Family Size 7-9	20	58.8%	23	39.0%	43	46.2%
Family Size 10-15	5	14.7%	1	1.7%	6	6.5%
Total	34	100.0%	59	100.0%	93	100.0%

Source: Household sample survey (March 2016)

Figure 5 give a graphic description of information with regard to educational status of the respondent household heads. Above 34% of the study household heads are non-literate referring to no formal education. Nearly 25% of the households stated that they can read and write.

Meanwhile, 41% of the respondents have had a formal schooling of primary education and above.

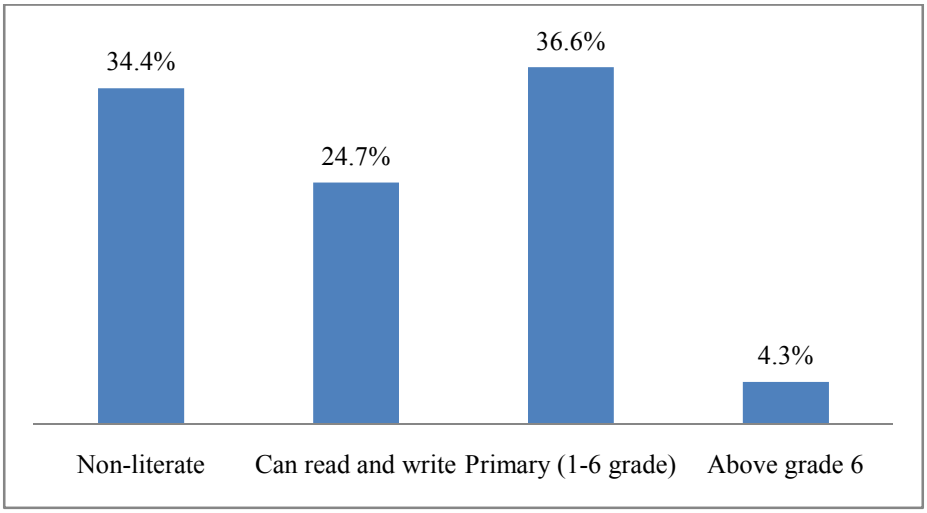

Figure 5: Sample households' education level by category

4.2 Agricultural production of the sample household

Agriculture in Ethiopia is heavily dependent on rainfall. It is traditional and resource poor with irrigation agriculture accounting for only around 1.1% of the total cultivated land in the country. In 2012/13, it accounts for about 43 percent of the gross domestic product (GDP), 90 percent of foreign currency earnings, and about 83 percent of the national employment (UNDP, 2015). It is viewed as a land use system, an economic mode of production and a way of life for many people in rural Ethiopia who drive their main livelihood incomes and subsistence from crop production and livestock herding. Despite, the increasing challenge of natural hazard and human induced climate risks, farmers try to combine their earlier mode of production with on-farm and off-farm/non-agricultural livelihood sources like petty trading, micro and small enterprise work and labor sale.

4.2.1 Crop production

Crop production in the study area assumes a similar nature as in many parts of the rural Ethiopia. It is a subsistence smallholder farming dominant source of employment and income for farmers in the study area. The overwhelming majority (99%) of the sample household indicated their main livelihood is crop production. This doesn't mean farmers are not engaged in extra type of agricultural activity. In fact they are engaged household livestock herding such as cattle, sheep, goat and poultry production and sale.

Table 4 Major crop production of sample households (2007/08 E.C)

Major crop type	Households		Area in hectare		Production Season	
	N	(%)	Mean	Total	Meher %	Belg %
Teff	71	76	.61	43.25	96	4
Maize	81	87	.50	40.13	5	95
Wheat	76	82	.58	44.13	94.7	5.3
Pea	10	11	.24	2.44	100	-
Bean	13	1	.24	3.13	100	-

Source: Household sample survey (March 2016)

As shown in table 3 above, maize is the widely cultivated cereal by the majority of (87%) of the respondent households' followed by wheat (82%). In terms of total area of production wheat (44ha) is the dominant followed by teff (43ha). Teff and wheat are mainly produced in meher whereas maize produced in belg season. Small proportion of the households also produces bean and pea indicating the small scale production of pulses in the area. The study area seems to be dominated by cereal production farming type with almost no fruit and vegetable production (as none o the household respondents indicated and seen from observation).

4.2.2 Livestock production and holding

The livestock sub-sector plays a significant role in the overall farming systems in Ethiopia. Messay (2011) cited Tilahun (1995:274) regarding the importance of livestock to the Ethiopian subsistence farmers as follows:

> They are sources of food (milk and some meat), store of wealth (especially cattle) and source of cash (especially sheep and goats). In the seed farming areas cattle are kept chiefly for tilling which provide traction power for more than five million hectares of crop land moreover, animal dung is used as the major source of fertilization in mixed farming systems, although this is decreasing due to its ever increasing use as a source of household energy associated with the virtual disappearance of forests in the rural areas. Livestock also serve as means of transport. Equines (horses, mules and donkeys) are mainly employed in transporting rural produce.

Livestock are important asset for the smallholder farmers in the study area. They are very useful in the livelihood activities of households providing food and nutrition, draught power, manure and income security in time of need.

Table 5 Average livestock possession of sample households

Types of livestock	Average number owned per household	Total number of livestock	Percentage of household	Conversion Rate	Tropical Livestock Unit
Ox	2	107	71	0.7	74.9
Calf	1	64	52	0.4	25.6
Cow	1	80	69	0.7	56
Sheep	3	100	38	0.1	10
Goat	3	103	40	0.1	10.3
Poultry	6	290	58	0.01	2.9
Donkey	1	49	48	0.5	24.5
Mule	2	8	5	0.7	5.6
Horse	1	2	2	0.8	1.6

Source: Household sample survey (March 2016)

The survey data above describes the average livestock possession of sample household computed in Tropical Livestock Unit (TLU) values for Africa. Accordingly, 71% of the sample households own 75 TLU of ox. However, the average and total possession of ox in the household is low (2 and 107 in head count respectively). This infers that there are households with no ox possession as confirmed by 32% of the total respondents.

4.3 Land holding and farming characteristics

Land is a valuable resource in agricultural production. Food security depends on a wide range of crops such as cereals, pulses, oilseeds, etc. cultivated by most of the land within the private peasant holding. According to agricultural sample survey of central statistics agency (CSA, 2014), the national average holding sizes per household is 1.14 hectares and the average cropland area was found out to be 0.95 hectares per household. The percentage distribution of land use area in 2014/2015 was 8% permanent crop, 10% grazing land and 73% temporary crop.

4.3.1 Landholding and use sample households

The researcher considers the definition of landholding as the total land in different uses that an agriculture household exercises management control over. The land can be under any crops, fallow, grazing, woodland and other land. Agricultural household meaning a household with at least one member of the household is engaged in growing crops and/or raising livestock in private or in combination with others.

Table 6 Landholding and use of the sampled households

Land use type	land holding in hectare		% distribution of area
	Mean	Sum	
Temporary crop	1.25	108.38	92
Grazing land	.34	3.69	3
Permanent crops	.16	4.81	4
bare/unused	.13	1.13	1
Total land owned	1.33	118.00	100

The sampled households hold a total of 118ha of land with an average holding size of 1.33ha. Temporary crops such as cereal and pulses possess a total area of 108ha indicating 92% of land use distribution. Permanent crops mostly coffee and Enset inhabit 4% of the total hectares of the respondents land holding.

4.3.2 Farming practices

The respondent farming households have total years of experience in agriculture/farming that ranges from 6 to 60 years. And 73% of them indicated that they have applied one or more type of improved farming practice such as intercropping, crop rotation, water harvesting, use of compost/manure, improved seed & fertilizer and others.

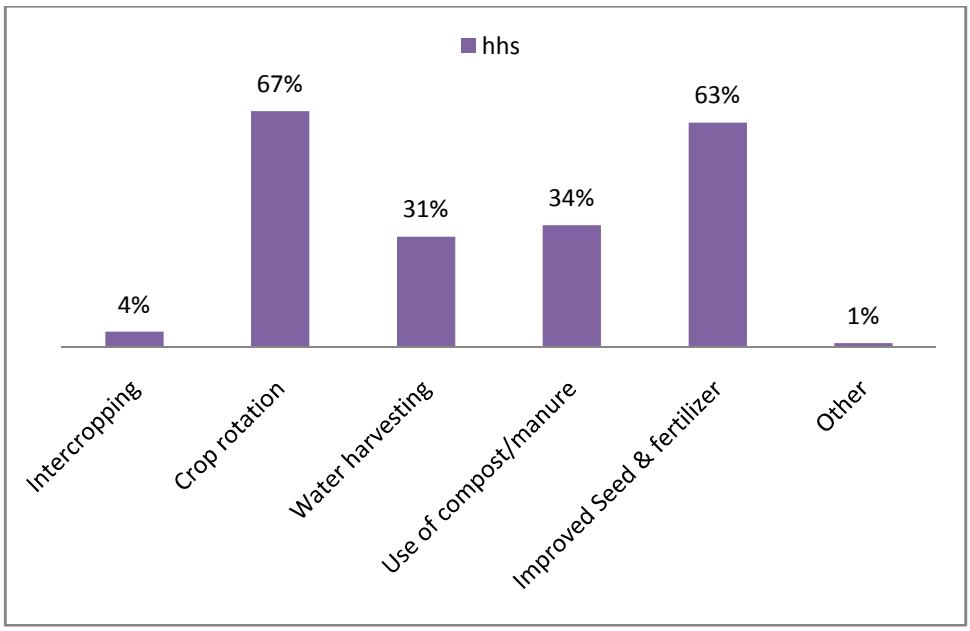

Figure 6 Improved farming practices applied by households

As indicated in figure 6 the crop rotation and use of improved seeds and fertilizer are the widely practiced improved farming systems among the sampled households. Farmers also have a considerable experience of apply compost/manure in their farming.

4.4 Major causes and local perception of climate change and variability

4.4.1 Perception of respondents on rainfall and temperature variability

Change in climate and variability is commonly indicated and measured by rainfall and temperature variability. As per the assessment of the perception of households in relation to observed climate change in their area 98% of them agreed. Further investigation of farmers perception based on rainfall and temperature parameters indicate the same proportion (98%) of them have observed change in the trend and amount of rainfall as well as temperature during the 10-30 years in their area.

The figure below illustrates a comparison of farmers' observation of the change in the pattern and amount of rainfall verses temperature change in the study area.

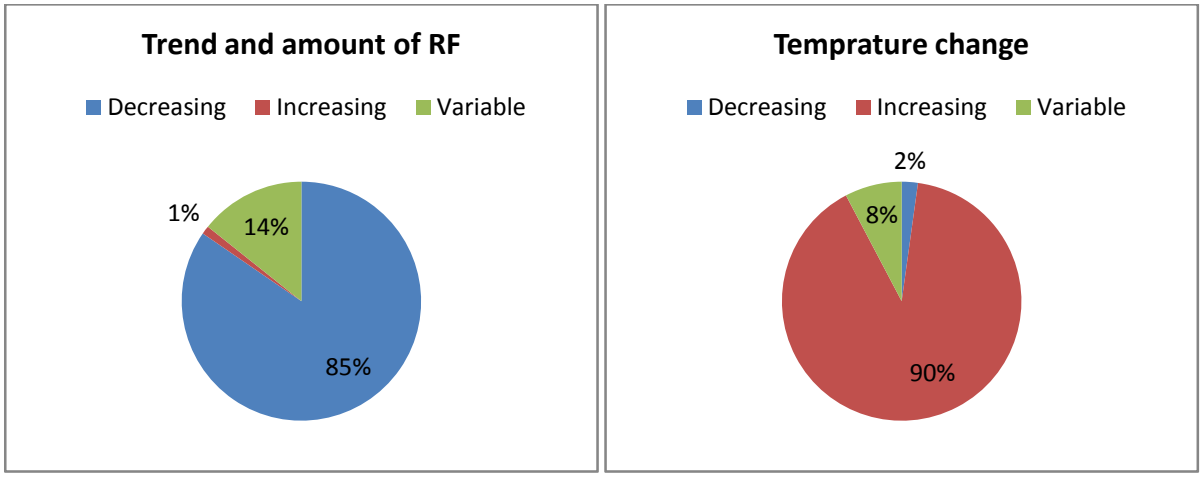

Figure 7 Farmers' observation of climate change and variability

As it can been seen clearly, 90% of the total respondent households observed increasing temperature change and 85% of them witnessed a decrease in the trend and amount of rainfall in their area. 14% told variability in rainfall and 2% a decrease in temperature. This generally tells, an increase trend of temperature that complements with the national patter (NMA, 2007) and

might correspond to higher rainfall variability in the country as concluded by Mersha (1999, 2003) cited in Woldeamlak and Conway (2007).

FGD participants mentioned that they have heard of climate change and they are aware of it. They explained climate change is the frequent occurrence of untimely or unseasonal rainfall and increased heat/sun wave. It is increase in local warming. It causes change in time of seeding and harvesting. It induces weather fluctuation and variability. They said, while they expect rain in a specific season drought happens and vice versa.

Kebele level experts noted that they understand climate change as a very serious issue. They explained climate change as a variation/distortion of climate due to different manmade and natural causes. The experts related the experienced climate change to the expansion of industries national and globally. They have observed climate variability in the area that is manifested through increase warming and shortage of rain.

Interview with woreda level experts in government and local NGO offices indicated a better understanding of climate issues. Climate change, they explained, is a variation/deviation of the weather condition from the usual (existing trend) as a result of either natural or manmade causes. They described shortage of rain; high amount of rain (excessive) at a time; increase in local warming, delayed start of rain and early off set of rain, reduced forest cover as well as variation in the amount and duration of rain as indictor of climate variability in their area. To this end, it can be seen that the study area is experiencing climate change with an erratic rainfall pattern and increased warming that call for specific adaptation strategy in agriculture.

4.4.2 Major causes of climate change in the area

The FGD participants indicated that deforestation is the prime contributor of climate change in the area. The respondents indicated charcoal burning as a driving cause of deforestation and increasing population as underlining factor. They also noted expansion of farm plots as another aggravating cause of climate change in their area.

Woreda agriculture expert stressed the loose engagement (reluctance) of community in the natural resource conservation as a cause and aggravating factor of climate change in addition to the contribution of the compound effect of population increase with deforestation.

Local NGO expert explained various complementary reasons could contribute as cause and aggravating factor to climate change in the woreda. He attributed climate change to global and local increase in warming, declining forest coverage, failure to timely response/address problems of soil degradation and production decline, climate pollution, various manmade causes and lack of coordinated mitigation works.

Further to realize climate change and variability in the area, respondent households were asked to identify and prioritize major causes that induce and aggravate climate change in their area. They were asked to identify the first three causes as primary; moderate and minor and ascribe values 3 to 1 respectively. The number of households giving a particular rank (1 to 3) to each option is counted and multiplied by 3, 2, and 1, respectively to get the total score. The result is shown in the figure below.

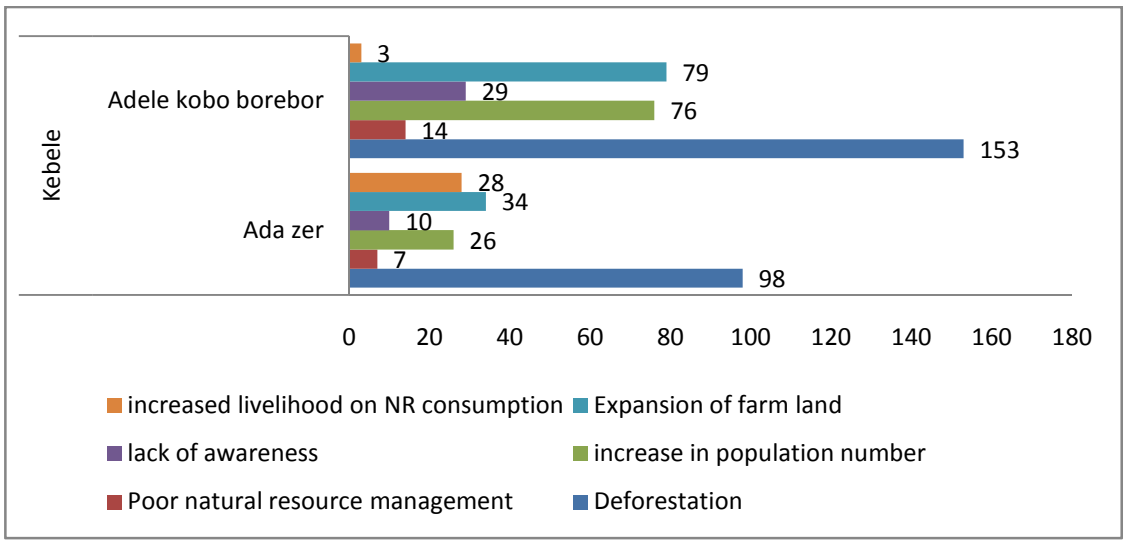

Figure 8 Major causes that induce and aggravate climate change in study area

Accordingly, respondent households both in Adazer and Borebor kebele identified and ranked deforestation (mainly for charcoal burning); expansion of farm land (leading to vegetation clearance) and population increase as the three top local causes contributing to climate change and variability. In addition to these, lack of awareness in Borebor and increased consumption of natural resource for livelihood in Adazer were also prioritized local factor promoting climate change.

4.5 Climate change effects and local agricultural adaptation practices

4.5.1 Observed effect on crop production

Climate change has various effects on crop production. Woledamlak et. al (2015) indicated effects such as increased temperatures, changes in soil water balance, changes in length of growing period (LGP), increased soil erosion and land degradation, increased incidence of floods, and increased incidence and expansion of crop pests, diseases and weeds.

In the study area, crop production is highly affected due to climate variability. Particularly in past 4-5 year farmers are experiencing occurrence of crop pest (locust) that feeds on crop and caused serious damage on production. The rainfall pattern affected the flowering and fruiting stage of crops. The rain stops in September (fruiting time of most crops) causing short length of growing period that leads to decrease in yield.

The major observed effects of climate change on crop production across the study sites from the FGDs and key informant interviews included:

- reduced crop yield that challenges the livelihood of households
- short length of growing period (LGP) as a result of erratic rainfall that leads to crop failure
- change in time of seeding and harvesting (previously sowing in midland was in April but currently it has shifted to June)
- delay in time of sowing of specific crops (e.g sorghum should have been sown in March)
- loss of fertilizers and seeds caused by dry spell that leads to production decline
- shortage of food as a result of drought causing production decline
- reduction of production season to once in a year (failure/no belg production)
- reduced volume of production as a result of variation in the amount and duration of rain

Interview with key informants indicated that shortage of rain (drought) has affected mainly cereals and pulses in 2007/8 EC production season. Teff and wheat are the cereal crops affected in Adazer kebele while pea and bean are the major pulses affected in the same kebele. In Adele

Kobo Borebore kebele perennial crops are affected in addition to cereal and pulses. Coffee production is affected by drought and increased temperature (dry spells) affected the production of Avocado and Mangoes. The woreda agriculture office confirmed that 4756 and 574 hectares of cereals and pulses (at woreda level) are destroyed due to climate change effects in the production season.

In household survey farmers were asked to rank the major experience climate change effects on crop production. In this case values (3 to 1) were ascribed to first, second and third common/widely observed effects of climate change as per respondents' qualitative ranking. Hence an effect ranked firs was given a value of three, second experience a value of two and third ranked effect a value of one. The graph below illustrates the cumulative ranking of climate change effect experienced by farmer in each kebele.

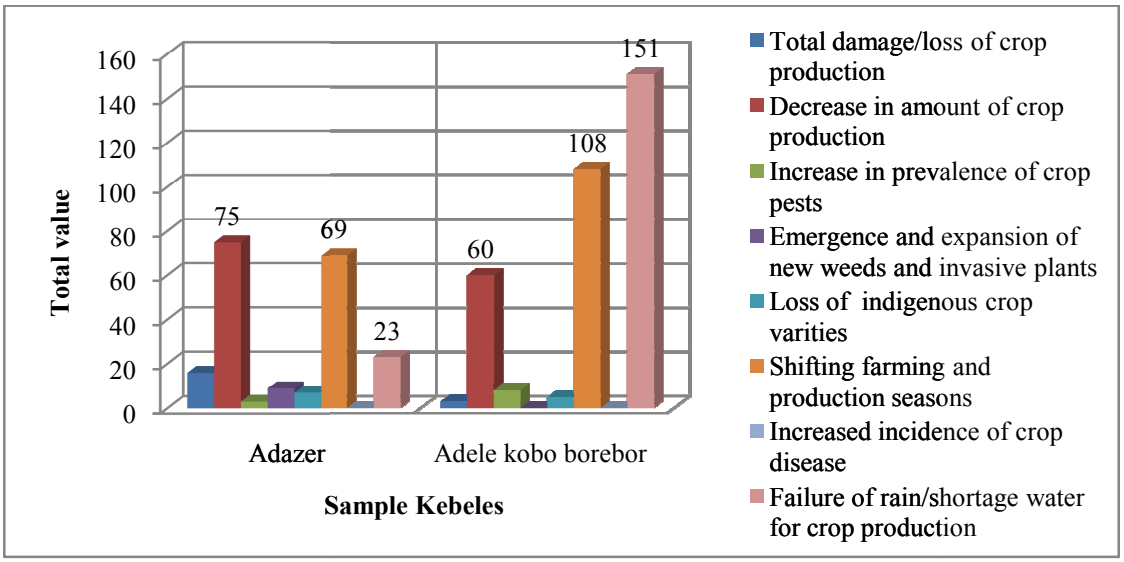

Figure 9 Experienced effect of climate change on crop production

As it can be seen from the graph, failure of rain was attributed to climate change as the major effect on crop production by farmers in Borebor kebel. Whereas, farmers in Adazer kelebel prioritized decrease in the amount of crop production as the major effect of climate change they

experience. Shifting farming and production seasons was identified as the second major climate change effect on crop production in both kebeles. The respondents in Adazer ranked shortage of rain/water as the third major effect, while farmers in Borebor kebele listed decrease in amount of crop production in the same rank.

In conclusion, water stress; shift in farming and production season and reduction in crop yield were identified to be among the three major experienced climate change effects on crop production in the study area. Crop production in Borebor kebele is serious challenged as a result of water scarcity. Farmers in Adazer seem to have relative availability of water for their crop production. In any case, farming households in both kebeles are being forced to shift and reduce their farming and production seasons as a result the rainfall pattern.

Table 7 Types of crop affected by climate change

Type of crop severely affected climate change	Kebele			
	Ada zer		Adele kobo borebor	
	Count	%	Count	%
cereals	21	61.8	-	-
Pulse	12	35.3	57	98.3
Oil crops	1	2.9	-	-
Fruits and vegetable	-	-	1	1.7

Source: Household survey

Household respondents were asked about which group of crops are severely affected in their area. As the data in the above table clearly shows, nearly 62% of the households in Adazer kebele confirmed that cereals are severely affected crop group substantiating the result from key informants. Similarly, 98% of the households in Borebore kebele affirmed that pulses are the severely affected crop types in their area as a result of climate change.

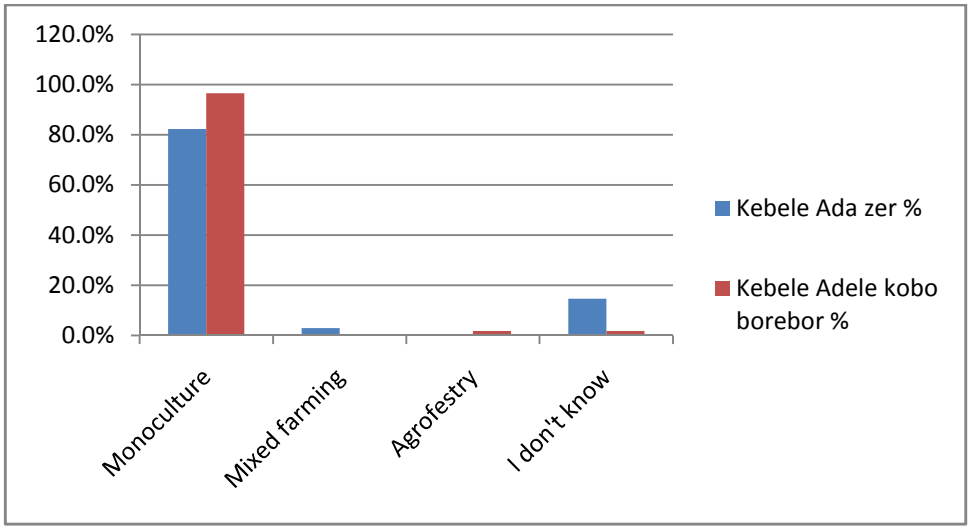

Figure 10 Agriculture/farming system affected by climate change

On the other hand, households were asked about the effect of climate change on the agriculture/farming system they are undertaking. The figure above indicates the type of farming system severely affected by climate change in the study area as per the respondents. Accordingly, significant proportion of households 82% (Adazer) and 97% (Borebore) identified monoculture as the agriculture system severely affected. About 15% of the household in Adazer kebele are not sure (don't know) the type of farming system affected in their area.

The table below is about the type of crop and livestock variety that is severely affected by climate change in the area. To this end, a total of 67% of respondents (significantly in Borebor 84%) indicted the local/indigenous variety to be severely affected by climate change. However, the result in Adaze kebele (44% of households) showed improved/commercial variety is disproportionately affects by climate change in their specific area.

Table 8 Crop and Livestock variety affected

Crop & Livestock Variety severely affected	Kebele				Total	
	Ada zer		Adele kobo borebor			
	N	%	N	%	N	%
Improved/commercial variety	15	44.1	6	10.7	21	23
local/indigenous Variety	13	38.2	47	83.9	60	67
I don't know	6	17.6	3	5.4	9	10
Total	34	100	56	100	90	100

Source: Household sample survey (March, 2016)

4.5.2 Experienced impact on livestock production

In Ethiopia, livestock production accounts for 12-16% of the GDP and 16% of foreign earning of the country. Approximately 65% of the total area of the county dominated by the pastoralists depends on livestock for their livelihood (Woldeamlak et al; 2015). Climate change has a warming effect on livestock that alter the feed intake, mortality, growth, reproduction, maintenance, and production of animals. Chickens are particularly vulnerable to climate change because they can only tolerate narrow ranges of temperatures beyond which reproduction and growth are negatively affected. Collectively, these effects are expected to have a negative impact on livestock productivity (Thornton et al. 2009 cited in EACC).

According to FGD and key informants, in the study area climate change has both direct and indirect effect on livestock. The direct effect is loss of livestock weight, deterioration of health and death of livestock (specifically cattle). Indirect effects include: shortage of feed and pasture that constrained diary and fattening activities; water scarcity that reduced productive performance of cattle; induce cheaper market price; reduce their draught power and cause physical injury during farming.

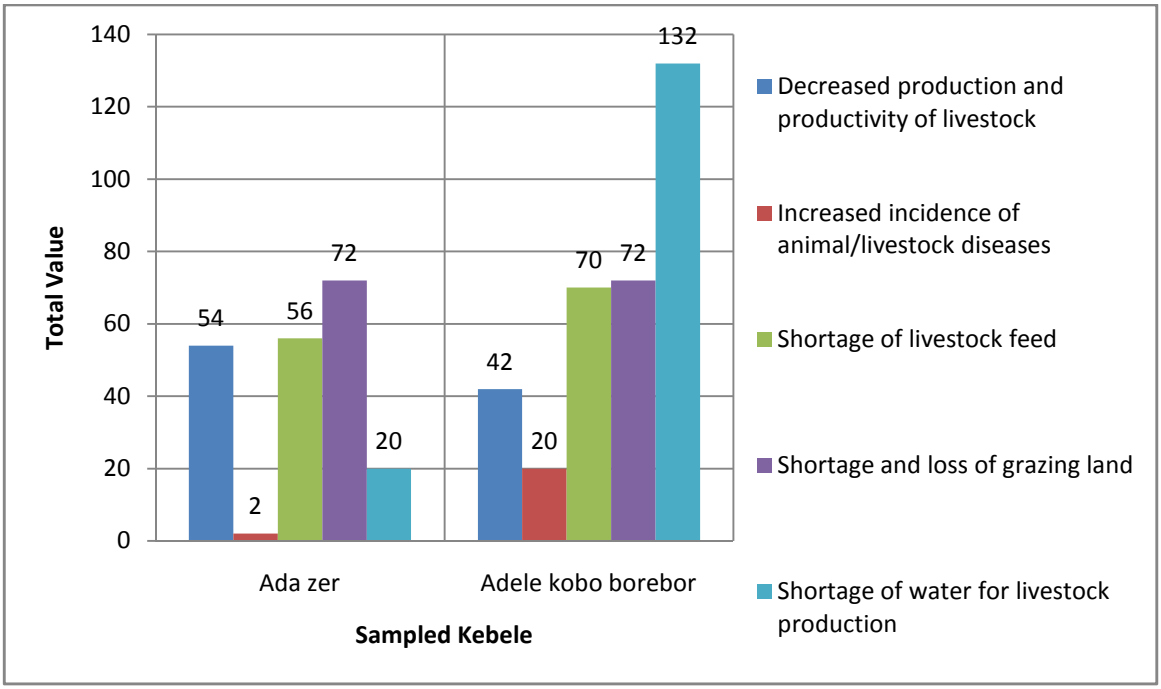

Figure 11 Experienced impacts of climate change on livestock production

Figure 11 illustrates farmers' experienced impact of climate change on livestock production in the study area. Similarly analysis technique as in the effect on crop production was followed to identify and prioritize the climate change effects in livestock. To this end, shortage of water; shortage and loss of grazing land and shortage of feed were identified and prioritize to be the three major effects on livestock production related to climate change in Borebor kebele. With regard to Adazer, the households indicated shortage and loss of grazing land as well as shortage of livestock feed respectively as the major experienced impact of climate change on livestock. Further, reduced production and productivity of livestock was identified among the major impacts.

Looking into the effect of climate change both on crop and livestock production, it is found that water stress (either shortage or scarcity) as the significant problem challenging agriculture and livelihood for household in Borebor kebele.

4.5.3 Adaptation practices in crop and livestock production

Discussion with focus groups and key informants at kebele levels revealed that farmers and local communities in the study area primarily practice natural resource management to adapt to climate variability. This includes a range of strategies such as: building terraces; rehabilitation and maintenance of natural and manmade ponds; watersheds management; forestation and reforestation works. They noted these interventions helped in water retention of the soil and recovery of soil moisture. In relation to adaptation in crop production, FGD participants told that they are broadly producing Enset as it is resistance to drought.

Meanwhile, the woreda agriculture office told that use of short maturing crop verities is the major types of adaptation practices in crop production implemented by farmers in the woreda. The agriculture office is further promoting the adoption of crop verities with adaptable characteristics to different climate situation.

Smallholder farmers in the study area have faced considerable challenges in livestock production as a result of severe scarcity of water induced by climate change. In this regard, they have made some adjustment strategies such as stocking of cattle feed from crop residue (hay and straw); giving livestock in custody to relatives; and sale of livestock with cheaper price in case of stress/shock. Other mechanisms with adaptive capacity are income diversification, local saving and migration of people to other places in search of employment.

Table 9 Households Climate Change Adaptation Practice

Climate Change Adaptation Practice		Kebele				Total	
		Ada zer		Adele kobo borebor			
		N	%	N	%	N	%
Households who applied one or more adaptation practices	Yes	34	100.0	26	45.6	60	66
	No	0	-	31	54.4	31	34
	Total	34	100.0	57	100.0	91	100
Households who think they have adapted to major climate change effects	Yes	34	100.0	14	24.6	48	53
	No	0	-	43	75.4	43	47
	Total	34	100.0	57	100.0	91	100

Table 9 above demonstrates the climate change adaptation practices and coping status of the households in detail. Total of 66% of the respondent among the household told that they have applied one or more adaptation practice in relation to agriculture while 34% have never undertook any adaptation measures. On the other hand, total of 53% of the households confirmed that they are able to coping with the effect of climate change and related hazards. However, considerable proportions (47%) of the households are not able to cope with the effect and related shocks of climate variability in the area.

Disaggregated observation by kebele indicates disproportionate results. 100% of the sampled households in Adazer have applied one or more adaptation response and reported they are able to adapt with major climate change effects. However, this is challenging to conclude as climate change effects are divers, complex and increasing and about 80% of the household respondents indicated (in the later section of this report) the adaptation practices helped to reduce climate change effect just a little.

On the contrary, majority (54%) of the households in Borebore kebele replied that they have not practiced any adaptation measures. In turn, significant proportion (75%) of the household confirmed they are not able to cope with major climate related hazards and effects. This clearly

shows the households in the kebele are more vulnerable to climate variability than their counter parts in Adazer kebele.

In relation to climate change adaptation, households were asked to identify and prioritize (1 to 3 scales among the list) the local agricultural adaptation practices they applied as very frequently, frequently and sometimes based on their lived experiences. Values (ranging 3 to 1) were attributed for each adaptation options prioritized correspondingly. The number of households giving a particular rank (1 to 3) to each option is counted and multiplied by 3, 2, and 1, respectively to get the total score. The cumulative response result is depicted in the underneath figure.

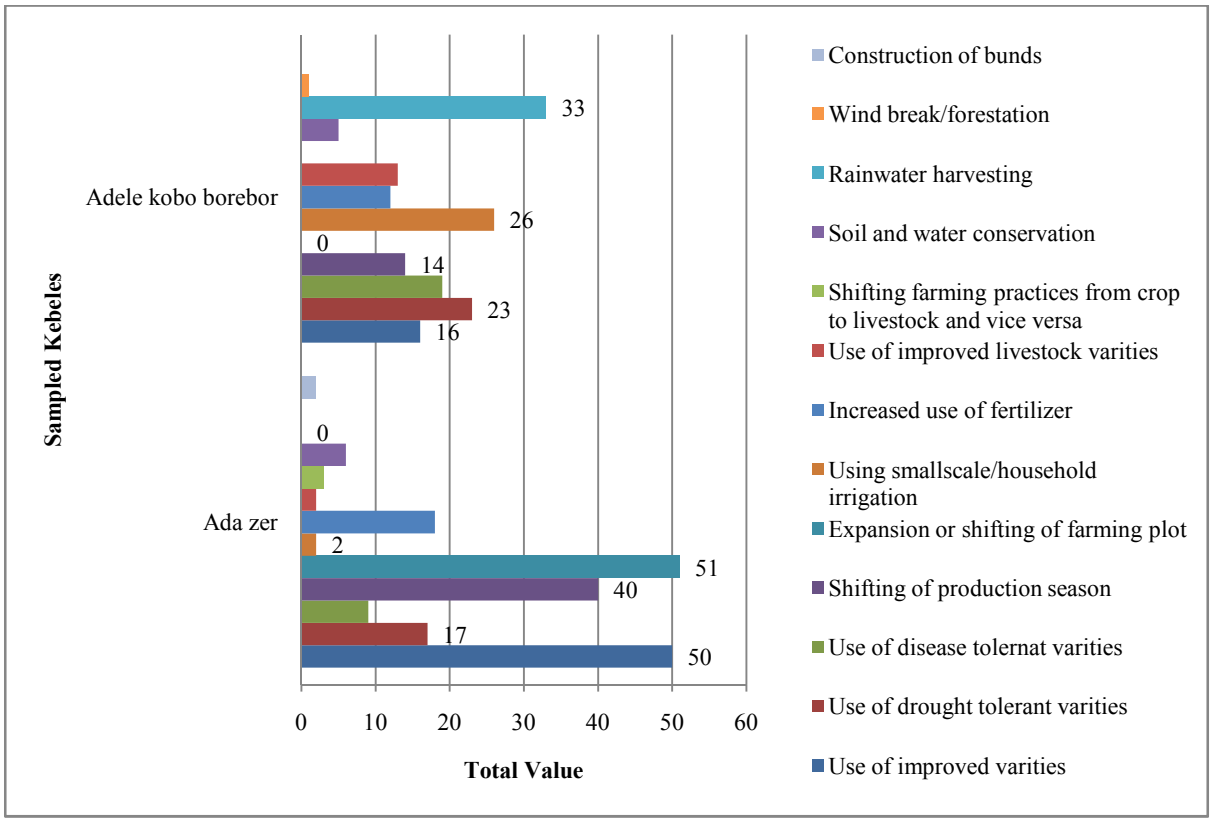

Figure 12 Local agricultural adaptation practices by smallholder farmers

As can been seen from the figure above, farmers in Adazer and Borebor kebeles used a range of strategies to adapt climate change effects. The strategies are mainly farm-level adaptation that involves production adjustment as well as land/soil and water use practices. Accordingly, farming households in Borebor kebele indicted they applied rainwater harvesting very frequently as adaptation technique to the effect of climate change. On the contrary, water harvesting was not totally mentioned as adaptation strategy by households in Adazer. This connotes for promoting water harvesting techniques as adaptation practice in Adazer kebele and strengthening its existing practice among households in Borebor.

Expansion or shifting of farming field was mentioned as the dominant adaptation measure practiced by famers in Adazer. On the other hand, this measure is not totally practiced by households in Borebor kebele. Despite the cases, this is a very critical issue that needs due attention since the practice has a counter effect and consequences with respect to climate change. In most cases, farm expansion is done by encroaching to uninhabited and protected/conserved area that lead to clearance of vegetation and forest. To this end, the practice might induce and aggravate climate variability rather than adaptation. Adaptation strategies should be low cost, no-regret and co-beneficial with environment.

Use of improved crop varieties was the frequent adaptation practice among farmers in Adazer whereas household irrigation identified for the same in Borebor kebele. This indicted, farmers in the both kebeles are implementing appropriate measure to adapt with the existing (observed effect of climate change) crop yield decline and water scarcity problems they identified. Further, use of drought tolerant (short maturing) variety is indicated as sometimes applied adaptation practices in Borebor. This is also an ideal strategy that fits to the severe water problem in the

kebele. Households in Adazer indicated they sometimes apply shifting production season as adaptation practice followed by increased use of fertilizer and drought tolerant variety.

Further into the analysis of the farm level adaptations, household respondents were asked to what extent they agree that the implemented adaptation measures have helped to reduce the climate change effect they experienced. The result is depicted in the figure below.

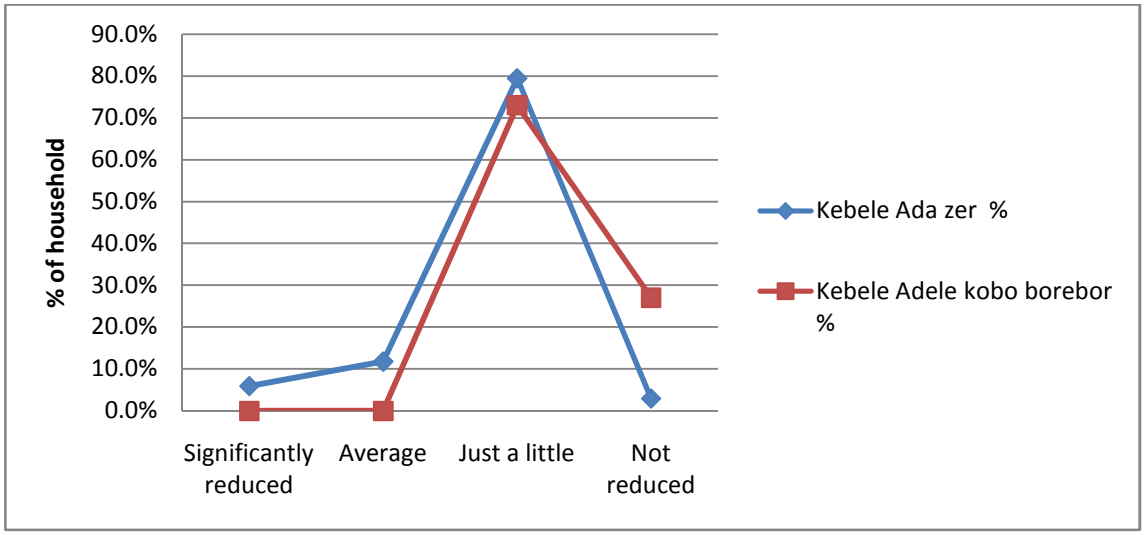

Figure 13 Farmers thought of adaptation responses in reducing CC effect

Accordingly, the majority of farmers 80% Adazer and 73% Borebor agreed that the adaptation practices applied have contributed just a little in reducing climate change effects they experienced. On the contrary, none of the households in Borebor kebele, think the adaptation measure have help neither significantly nor averagely in reducing climate change effects. Meanwhile only 6% in Adazer agreed the adaptation have helped significantly in reducing the climate effects on their agriculture. Considerable proportion (27%) of respondents in Borebor argued that the adaptation measures have not reduced the climate change effect.

Table 10 Local government support to farmers' adaptation efforts

Does the local government support your adaptation efforts?	Kebele				Total	
	Ada zer		Adele kobo borebor			
	N	%	N	%	N	%
Yes	33	97.1	20	33.9	53	57
No	1	2.9	39	66.1	40	43
Total	34	100.0	59	100.0	93	100

Farmers were asked whether or not the local government institutions supported their effort in relation to climate change adaptation. Table 10 lucidly shows, 57% of the total respondents told local government supported them in the climate change adaptation efforts. There exist disproportional differences among the kebeles in receiving support from the government as significant (97%) and minimal (34%) proportion of the responding household in Adazer and Borebor respectively reported they received one or more type support from the local government (primarily agriculture office). On the other hand, considerable number (66%) of the sampled household in Borebor told they have not received any support from the local government.

This might trigger a question why such a difference existed with regard to the local government support to these communities especially since both kebeles are located nearly at same distance from the woreda town Buee. Moreover, as Borebor kebele is with more degraded environment (field observation) government support becomes critical in helping communities to adaptation.

Figure 14 Degradation in Adele Kobo Borebor kebele

Further assessment was made to identify the types of support that local government provided to smallholder farmers in the study area. To this end, sampled households were asked to list the types of support the received from local government in relation to their adaptation effort. The figure below depicts their responses.

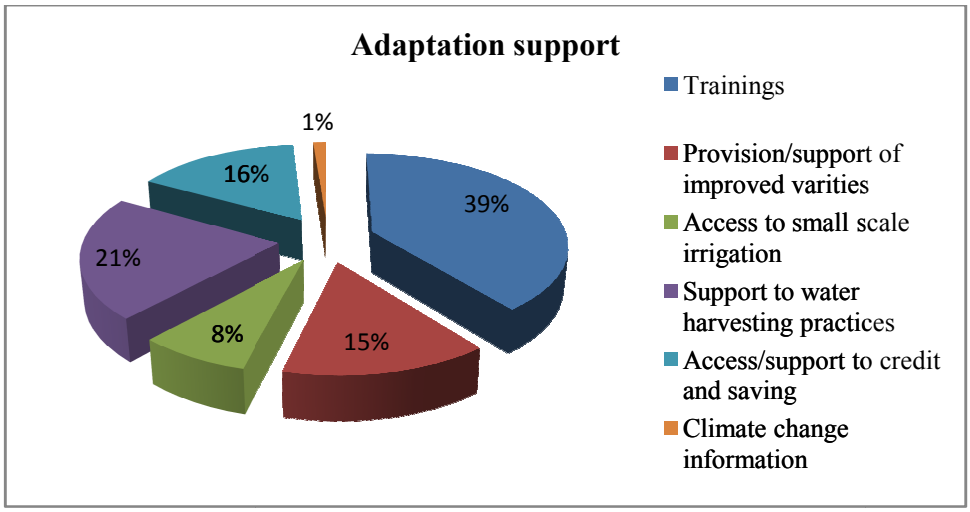

Figure 15 Local government responses to climate change adaptation

As vividly indicated in the figure, training is the dominant support that local government provided to farmers in the study area. Also government supported rainwater harvesting adaptation practice of the households. This indicates alignment in the farmers' adaption practice

and government support particularly in Borebor kebele. However, surprisingly government support in relation to climate change information seems to be completely missing in the study area.

4.6 Climate Related Hazards and Copping Mechanisms

FGD participants in both kebeles identified flood as a common hazard they experienced in the past 10-20 years. They reported increased frequency of flood some ten years back. A case in point is that, in 1988/89 EC it was raining starting from November to the next September continuously as a result the area faced with excessive flooding and famers could not produce. This had led to severe crop damage and cattle death. Furthermore, they recalled there was a time that climate relate hazard cause malaria epidemic that killed two or more people a household.

Experts interview both at the kebele and woreda level indicated an increased trend of drought in the past 10-20 years. They explained drought in the woreda has caused different hazards and effects. These include: high reduction in yield; water scarcity for human and livestock; shortage of livestock feed that led to animal death; increase vulnerability of kebeles to climate change effects and rise in the number of households that need food assistance. The woreda expert highlighted that in the past 5-10 years about 15 kebeles in the woreda are receiving more food aid.

According to household survey, only 5% of the total respondents told they have not experienced any climate related hazard within the past five to ten years in the area. The remaining households were asked to identify and rank (1 to 3 scales among the list) the major climate induced hazards in their area as most common, common and rarely experienced based on their qualitative assessment. Scores were attached for each option ranging 3 to 1 accordingly. The number of

households giving a particular rank (1 to 3) to each option is counted and multiplied by 3, 2, and 1, respectively to get the total score. Figure 8 below illustrates their responses.

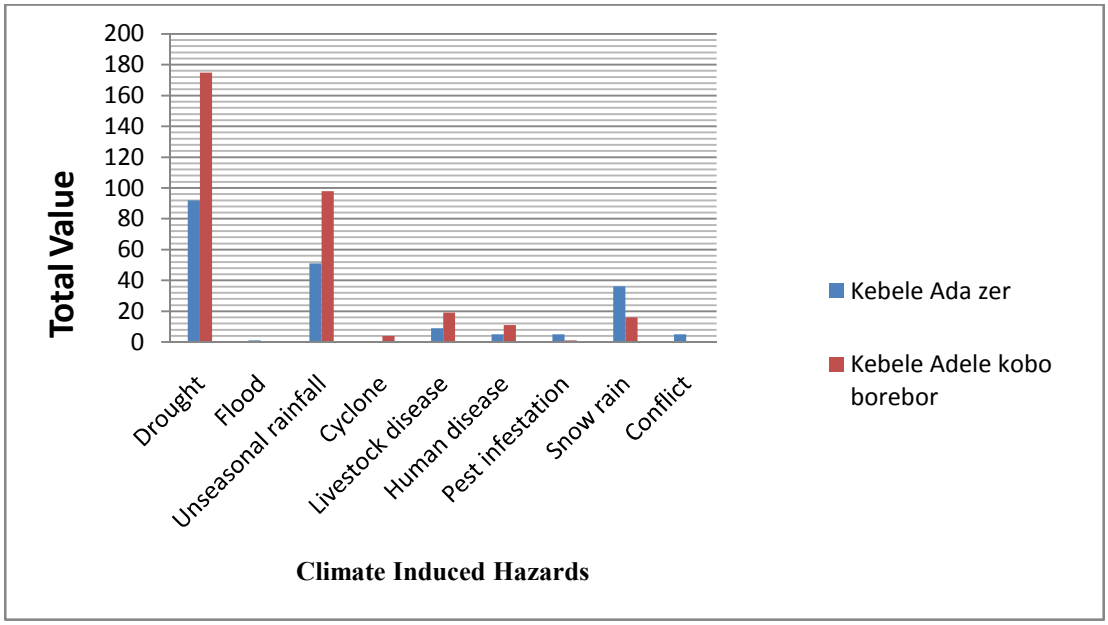

Figure 16 Major climate related hazards experienced by farmers

The experience climate related hazards identified in both kebeles following the analysis described above were drought, unseasonal rainfall, snow rain, livestock disease, human disease and pest infestation. Drought was found to be the most common hazard experience by farming households in the study area. Unseasonal rainfall happened to be the commonly experienced hazard in both kebeles. While snow rain was ranked as a rarely experienced hazard in Adazer kebele, livestock disease prioritized for the same rank in Borebor.

This qualitative information of the household was substantiated by secondary data from the woreda agriculture office and respective kebele administrations. The data from the woreda agriculture office show that 13,009 households in the woreda were affected by drought in the short rainy season (belg) of 2015 that rose to 21,000 households in the main production season (meher) of 2015/16 (2008 E.C). Data from the respective kebeles of Borebor and Adazer indicate

that a total of 2,987 and 320 people are exposed food shortage as a result of drought induced by shortage of rain.

Further assessment was conducted to understand livelihood vulnerability and magnitude of hazard effect on agriculture production of the households as per their judgment. Respondents were exposed to the following questions and replied as indicated in the table below.

Table 11 Livelihood vulnerability and magnitude of hazard effect

Livelihood Vulnerability and Magnitude of Hazard Effect on Agriculture		Kebele			
		Ada zer		Adele kobo borebor	
		N	%	Count	%
To what extent your livelihood is exposed/vulnerable to these hazards	Very vulnerable	33	97.1	21	36.8
	Vulnerable	1	2.9	20	35.1
	Less vulnerable	-	-	16	28.1
What percent of your agricultural production is affected by these hazard	Up to half proportion	-	-	5	8.5
	Up to 3/4th proportion	14	42.4	29	49.2
	Up to total proportion	19	57.6	25	42.4

Significant proportion (97%) of households in Adazer expressed that their livelihood is very vulnerable to the climate related hazards they experience. Nearly equal proportion of the households (37% and 35%) in Borebor spoke their livelihood as vulnerable and less vulnerable to the climate induced hazards they prioritized above. In relation to the magnitude of the effect of these hazards on agricultural production, 42% and 58% of the farmers from Borebor and Adazer respectively indicated up to total damage on production as a result of the climate related hazards.

Assessment of the coping mechanism that the farmers use in response to the hazard or disaster was one of the research interests. The researcher understands the concept of coping as strategies that are invoked following a decline in normal livelihood mainly food and income and these strategies are involuntary responses to disaster or unanticipated failure in major sources of

survival. And in this cases, coping are short-term measures used by farmers who experience climate related hazards/shocks. Further, the researcher agrees that there are overlaps between coping and adaptation in the sense that coping may lead to adaptation.

In order to identify the widely used coping strategies, household were asked to prioritize the local strategies as very commonly, commonly and sometimes by ascribing values 3, 2 and 1 respectively. The cumulative frequencies their priorities were analyzed using the SPPS and the finding is clearly depicted in the figure below.

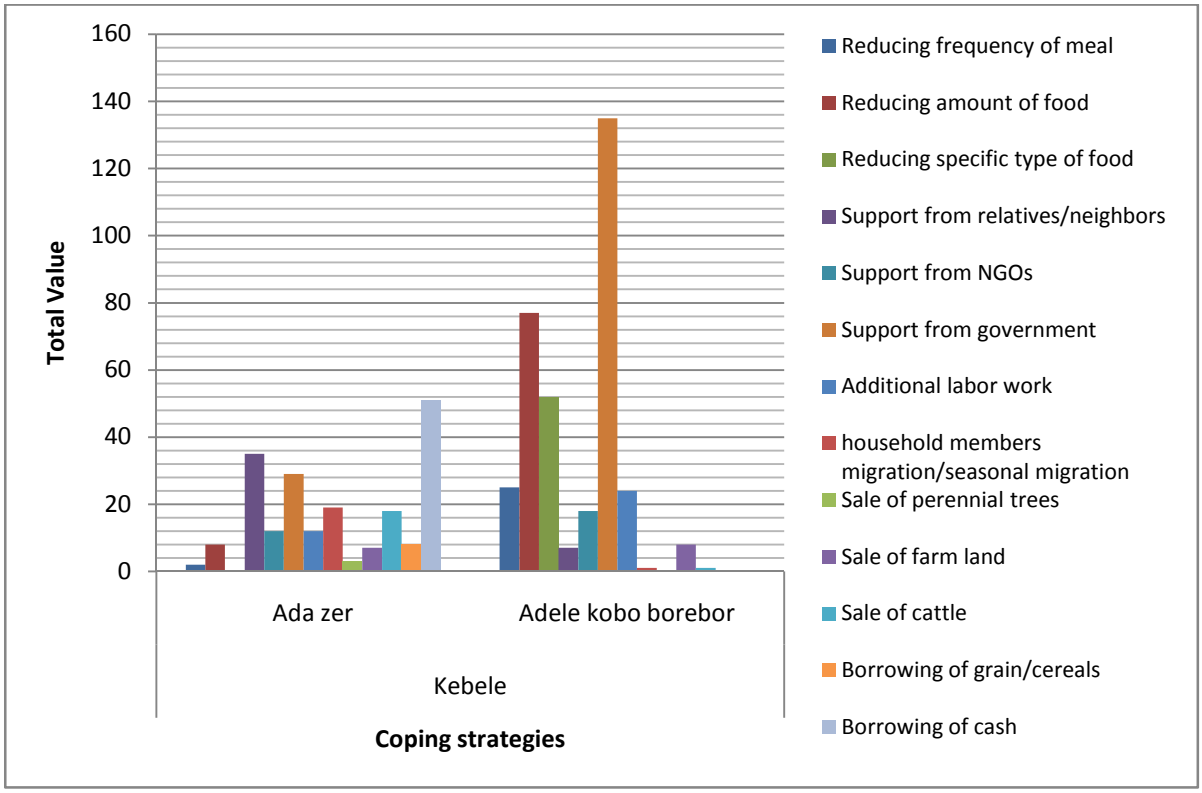

Figure 17 Coping strategies of households in response to hazards

Households were administered with question on a list of coping strategy options to identify and priorities among the alternatives. The responding farmers indicated they employ a range of coping measures some of which include: reducing frequency of meal; reducing amount of food;

support from community; support from government; support from NGOs; seasonal migration and borrowing cash.

As per the ranking of the households among the range of options, support from government; reducing amount of food and reducing specific type of food were identified to be the top three coping mechanisms widely/commonly used in order to respond to climate hazards in Borebor kebele. On the other hand, cash borrowing; support from relatives/neighbors and support from government were identified as the frontline coping strategies among farmers in Adazer in similar way. Farmers in both kebeles seem to be less dependent on NGOs support in order to cope with climate change hazards.

FGD participants indicated that they have a practice of reserving grain in custody under the local Idir leader. This serves as a local grain reserve so that vulnerable and victim households would access to borrow grain the in time of stress and repay on good harvest season.

4.7 Suggested Strategies for Enhancing Adaptation and Coping Capacity

Results from FGD indicated that farmers with better financial capacity and larger farm size are quick in implementing adaptation practices and coping capacity to climate change effects. FGD participants in the study kebeles suggest the following strategies for enhancing their adaptive capacity

- Water harvesting
- Organized and coordinated forestation and reforestation work
- Construction of new ponds
- Rehabilitation of existing ponds (from sedimentation)
- Development of water sources for livestock

- Construction of water reservoir
- Construction of additional water points
- Pipeline extension for supply/distribution of water to each village
- Scaling up the area closure (forest rehabilitation) experience
- Bridge construction for school and market access

Woreda experts from agriculture and NGO offices suggested measures such as: strengthening the adoption of short/early maturing varieties; introduction of appropriate system of irrigation utilization; strengthening environmental protection works (such as rehabilitation of forests/land, watershed development); introducing improved drought tolerant varieties and modern farming systems/practices; establish/set up coordinated information system and timely response to climate change and related hazards; support farmers adoption of water management and utilization; support alternative sources of income and promote saving culture; and integration and networking with partners to device effective and efficient systems that build resilient community to climate change.

CHAPTER FIVE: CONCLUSION AND RECOMMENDATION

5.1 Conclusion

Climate change has become a formidable challenge to the globe than any other phenomenon despite scientific, technological and political responses sought by scholars, policy makers and practitioners. Agriculture is likely to face the severest impact from climate change with implications for national and global food security.

Climate change is already a reality in Africa. There are prolonged and intensified droughts in eastern Africa; unprecedented floods in western Africa; depletion of rain forests in equatorial Africa; and an increase in ocean acidity around Africa's southern coast. Vastly altered weather patterns and climate extremes threaten agricultural production and food security, health, water and energy security, which in turn undermine Africa's ability to grow and develop.

Ethiopia already suffers from climate variability and extreme events, and future climate change poses a major development challenge. In order to identify and implement appropriate adaptation strategies at local level, it is important to understand the nature of climate change impacts, key vulnerabilities and indigenous adaptation practices.

This research primarily assesses and analyzes local level agricultural adaptation strategies and coping mechanisms in response to climate change effects on agricultural production in Soddo district of SNNPR. Further, it synthesizes an investigation on experienced effect of climate change on crop and livestock production system, climate related hazards, the major causes that induce and aggravate climate change in the study area and suggested strategies for enhancing climate change adaptations to improve crop production and food security in the district. The study was conducted in two *kebeles* of the district representing the existing agro-ecology

midland and highland. It used both qualitative and quantitative data as well as a review of relevant literature.

The major finding of the assessment is that the *kebeles* under the study, even though exist within the same *woreda*, have differences in the climate change effects they experienced and adaptation strategies applied. Most of the adaptation strategies applied by the farmers have synergy with the identified high priority adaptation activities in the Ethiopia's National Adaptation Program of Action-NAPA (NMA, 2007) and the suggested strategies in the Agriculture Sector Program of Plan on Adaptation to Climate Change by the Ministry of Agriculture (MOA, 2011).

Discussion with focus groups, key informants and household survey indicated that there is change in local climate condition manifested by observed change in the trend and amount of rainfall as well as temperature during the past 10-30 years in their area. Particularly shortage of rain, high amount of (excessive) rain, increase in local warming, delayed start of rain and early off set of rain, as well as variation in the amount and duration of rain were reported as indictor of climate variability in their area.

Deforestation driven by charcoal burning and population increase were identified as the major and underlying causes that contributed to local climate change. Expansion of farm plot (leading to vegetation clearance) was indicated as aggravating factor by the community. The woreda expert attributed climate change to the poor natural resource conservation practice of the local community. NGO expert related the observed climate change to global and local warming as a result of manmade causes. Households identified and ranked deforestation; expansion of farm land and population increase as the three top local causes contributing to climate change and variability.

With regard to experienced effect of climate change, FGD and KI interviews indicated various effects on crop and livestock production in the area. Climate change contributed to increased incidence and expansion of crop pests (locusts), reduced crop yield, short length of growing period, change in time of seed and harvest (production season), reduction of production season (failure of belg season), and loss of fertilizers and seeds caused by dry spells. Shortage of rain (drought) as result of El Nino has adversely affected the production cereals and pulses such as teff, wheat, pea and bean that led to food shortage.

In livestock production, climate change contributed to negative effects such as reduce livestock weight; deterioration of health and death cattle; water scarcity that reduced productive performance of cattle, induce cheaper market price, reduce their draught power and cause physical injury during farming.

Households in the study area identified and prioritized water stress; shift in farming and production season and reduction in crop yield among the three major experienced climate change effects on crop production. And monoculture was indicated as severely affected farming system in the area. In relation to livestock production, households identified and prioritize shortage of water; shortage and loss of grazing land and shortage of feed as the major effects of climate change.

Local communities in the study area primarily practiced natural resource management to adapt to climate variability. This includes a range of strategies such as: building terraces; rehabilitation and maintenance of natural and manmade ponds; watersheds management; forestation and reforestation works and area enclosure. Interview with experts indicated that use of short maturing crop verities' stocking of cattle feed from crop residue, giving livestock in custody to

relatives, and sale of livestock with cheaper price in case of stress/shock as the major agricultural adaptation strategies.

Households reported that they use a range of adaptation strategies that are mainly farm-level adaptation composed production adjustment as well as land/soil and water use practices. The specific strategies included: rainwater harvesting; Use of improved crop varieties; household irrigation; drought tolerant (short maturing) variety; shifting production season; and increased use of fertilizer.

In relation to local government support to adaptation efforts, the woreda agriculture office provided technical trainings, supported improved varieties, support water harvesting practices and facilitate access small scale irrigation and credit and saving. However, there seemed to be complete absence regular and structured information communication of climate change.

Flood and drought were the two major (commonly experienced) climate related hazards in the area during the past 10-20 years. Community reported there was frequent flood hazard some ten years back that had led to severe crop damage, cattle death and malaria epidemic that killed people. Experts' interview indicated increased trend of drought during the past 10-20 years in the study area. In relation to this, households indentified drought, unseasonal rainfall, snow rain, livestock disease, human disease and pest infestation as commonly experienced climate induced hazards.

In order to cope with the climate related hazards, household practiced top measures like reducing amount of food; reducing specific type of food; cash borrowing; support from relatives/neighbors and support from government. Grain reserve and borrowing is the local level coping mechanism that the community practices.

5.2 Recommendation

It is evident from the finding of this research that smallholder farmers in the area are struggling with the effects of climate change and variability. Agriculture (crop and livestock) productions are jeopardized very seriously to the extent that household failed to meet their food demand. Households and communities are using range of adaptation strategies that are mainly farm level and natural resource management practices.

The researcher agrees with most of the strategies suggested for enhancing adaptation (section 4.7) by FGD participants and experts to be specific recommendation of this research. The following recommendation are synthesized from this study and are worth considering in designing, implementation and diffusion of appropriate agricultural adaptation practices to climate change effects:

- Application of proper rangeland management and effective water use systems such as irrigation from various water sources (such as rain water harvesting, underground, surface water;
- Promote and strengthen the application of existing improved farming practices and introduce new technologies (such as diversification in to fruit and vegetable production) that has co-benefits in climate change adaptations;
- Use of reliable climate information to make crop and livestock production decisions such as variety selection; planting time adjustments; disease outbreak and market prices
- Reducing use of synthetic fertilizers and pursuing increased use of organic soil fertilizers having multiple benefits;

6. References

Ajibade, I. (2013). Climate Change and Human Rights: a Case Study of Vulnerability and Adaptation in Coastal Communities in Lagos, Nigeria. Unpublished PhD dissertation, 150-170.

Alebachew, A. (2011). Climate Change and Rural Livelihoods in Northern Ethiopia: Impacts, Local Adaptation Strategies and implications for Institutional Interventions. (M. Ayenew, Ed.) Addis Ababa: Forum for Social Studies (FSS).

Asefach, H. a. (2007). Correlates of Household Food Security in Densely Populated Areas of Southern Ethiopia: Does the Household Structure Matter? Stud. Home Comm. Sci., , 1(2): 85-91.

Asia Development Bank (ADB) and International Food Policy Research Institute (IFPRI). (2009). Building climate resilience in the agriculture sector in Asia and the Pacific. Mandaluyong City, Philippines: Asian Development Bank.

Bryan, E., Ringler, C., Okoba, B., Roncoli, C., Silvestri, S., & Herrero, M. (2011). Adapting Agriculture to Climate Change in Kenya: Household and Community Strategies and Determinants. Nairobi: World Bank.

Campbell, B., Mann, W., Meléndez-Ortiz, R., Streck, C., Tennigkeit, T. (2011). Agriculture and Climate Change: . Meridian Institute.

Central Statistical Agency. (2013). Population Projection of Ethiopia for All Regions At Wereda Level from 2014-2017. Addis Ababa: CSA.

Creswell, J. W. (2009). Research Design: Qualitative, Quantitative and Mixed Methods Approaches. London: SAGE Publications, Inc.

Deressa, T. (2006). Measuring the economic impact of climate change on Ethiopian agriculture: Ricardian approach. Centre for Environmental Economics and Policy in Africa South Africa Discussion Paper No. 25 . South Africa: University of Pretoria.

Deressa, T., and Hassan, R. H. (2010). Economic Impact of Climate Change on Crop Production in Ethiopia: Evidence from Cross-Section Measures. Journal of African Economies , 18(4): 529–554.

Devereux, S. (2000). Food Insecurity in Ethiopia: A discussion paper for DFID. Sussex.

Di Falco S., Veronesi M., and Mahmud Y. (2011). Does Adaptation to Climate Change Provide Food Security? A Micro-Perspective From Ethiopia. American Journal of Agricultural Economics , 1–18.

Dinar, A., R. Hassan, R. Mendelsohn, J. Benhin. (2008). Climate Change and Agriculture in Africa: Impact Assessment and Adaptation Strategies. London: : EarthScan.

FAO (UN Food and Agriculture Organization). (1996). Final report of the 1996 World Food Summit. Rome: FAO.

FDRE (FEDERAL DEMOCRATIC REPUBLIC OF ETHIOPIA). (2011). Ethiopia's Climate-Resilient Green Economy: Green economy strategy. Addis Ababa.

Gerald C. Nelson, Mark W. Rosegrant, Jawoo Koo, Richard Robertson, Timothy Sulser, Tingju Zhu, et al. (2009). Climate Change: Impact on Agriculture and Costs of Adaptation. Washington, D.C.: International Food Policy Research Institute.

Gutu, T. Mengistu, K. & Bezabih, E. (2012). Adaptation to Climate Change and its Impact on Food Production in North Shewa Zone, Ethiopia. Journal of Advances in Agriculture, Sciences and Engineering Research , 2 (8), 285 – 298.

Hansen, J., L. Nazarenko, R. Ruedy, M. Sato, J. Willis, A. Del Genio, D. Koch, A. Lacis, K. Lo,S. Menon, T. Novakov, J. Perlwitz, G. Russell, G. A. Schmidt, and N. Tausnev. (2005). Earth's energy imbalance: Confirmation and implications. Science , 308, 1431-1435.

Intergovernmental Panel on Climate Change (IPCC). (2014). Summary for policymakers. In: Climate Change 2014. In V. D. C.B. (Ed.), Impacts, Adaptation, and Vulnerability.Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (pp. 1-32). Cambridge and New York, NY, United Kingdom and USA: Cambridge University.

IPCC. (2001). Climate Change 2001: Impacts, Adaptation Vulnerability. In Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel. Geneva: UNEP/WMO.

IPCC. (2007b). Climate Change 2007: Impacts, Adaptation and Vulnerability. In O. C. M.L. Parry, Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (p. 976pp). Cambridge, UK: Cambridge University Press.

IPCC. (2007a). Climate Change 2007: The Physical Science Basis. In S. f. Basis., & S. D. Solomon (Ed.), Contribution of Working Group I to the Fourth Assessment

Report of the Intergovernmental Panel on Climate Change (pp. 1-18). Cambridge and New York, NY, United Kingdom and USA: Cambridge University Press.

Kabubo-Mariara, J. and Kabara, M. (2015). Climate Change and Food Security in Kenya. Discussion Paper Series . (E. D. 15-05, Ed.) Environment for Development.

Kidane, H. Alemu, ZG. & Kundhlande, G. (2005). Causes of Household Food Insecurity in Koredegaga Peasant Association, Oromiya Zone, Ethiopia. Agrekon , 44 (4).

Kothari, C. (2004). Research Methodology: Methods and Techniques. London: New Age International.

Kurukulasuriya, P. and Rosenthal, S. (2003). Climate Change and Agriculture: A Review of Impacts and Adaptations. Climate Change Series 91. Environment Department . Washington, DC.: The World Bank.

Kurukulasuriya, R. and Mendelsohn, R. (2008). A Ricardian analysis of the impact of climate change on African cropland. AfJARE , 2 (1).

Liwenga, E. T., Jalloh, A. and Mogaka, H. (2014). Review of Research and Policies for Climate Change Adaptation in the Agriculture Sector in East Africa. Working paper 103 . Future Agriculture www.future-agricultures.org.

Maddison, D. (2006). The perception of adaptation to climate change in Africa. Johannesburg: University of Pretoria.

McCarthy, J., O. F. Canziani, N. A. Leary, D. J. Dokken, and C. White. (2001). Climate Change 2001:Impacts,Adaptation,andVulnerability. In Contribution of Working Group II

to the Third Assessment Report of the Intergovernmental Panel on Climate Change. UK: Cambridge University Press.

McSweeney C, New M, Lizcano G. (2008). UNDP. UNDP Climate Change Country Profiles – Ethiopia . Retrieved from http://country-profiles.geog.ox.ac.uk

Mendelsohn, R. (1998). Climate-change damages. In R. N. Mendelsohn, & W. Nordaus (Ed.), Economics and Policy Issues in Climate Change. Washington, D.C.

Messay, M. (2010). Food Security Attainment Role of Urban Agriculture: A Case Study from Adama Town, Central Ethiopia. Journal of Sustainable Development in Africa , 12 (3), 223-249.

Ministry of Agriculture (MOA). (2011). Agriculture Sector Programme of Plan on Adaptation to Climate Change. Addis Ababa: MOA.

Mizina, S.V., Smith, J.B., Gossen, E., Spiecker, K.F. and Witkowski, S.L. (1999). 'An evaluation of adaptation options for climate change impacts on agriculture in Kazakhstan'. Miti. & Adapt. Strat. for Glob. Change , 4, 25–41.

Mohnaty S. and Mohanty B.P. (2009). Global Climate Change: A cause of concern. Science and Technology Policy Issue , 32 (5 & 6), 149-156.

Muller, A. and Niggli, U. (2013). Commentary III: The Potential of Sustainable Agriculture for Climate Change Adaptation. In In Wake Up Before It Is Too Late: Make Agriculture Truly Sustainable Now For Food Secuirty In A Changing Climate. United Nations Conference on Trade and Development (UNCTAD).

Mulugeta, M. (2011). Determinates of Agricultural Productivity and Household Food Security Case studies from Kuyu Woreda. Germany: LAP LAMBERT.

National Meteorological Agency-NMA. (2007). Climate Change National Adaptation Programme of Action (NAPA) of Ethiopia. Addis Ababa: NMA.

National Meteorological Agency-NMA. (2001). Initial National Communication of Ethiopia to the United Nations Framework Convention on Climate Change. Addis Ababa: NMA.

Parry, M., C. Rosenzweig, A. Iglesias, M. Livermore, and G. Fisher. (2004). Effects of Climate Change on Global Food Production under SRES Emissions and Socio–Economic Scenarios. Global Environmental Change , 14, 53–67.

Parry, M.L. and Carter, T.R. (1989). 'An assessment of the effects of climatic change on agriculture'. Clim. Change , 15, 95–116.

Pearce, D,W. Cline, A. Achanta, S. Fankhauser, R. Pachauri, R. Tol, and P. Vellinga. (1996). The Social Cost of Climate Change: Greenhouse Damage and the Benefits of Control. In H. L. J. Bruce (Ed.), In Climate Change 1995: Economic and Social Dimensions of Climate Change (pp. 179–224). UK: Cambridge University Press.

Reilly, J. and Schimmelpfennig, D. (1999). 'Agricultural impact assessment, vulnerability, and the scope for adaptation'. Clim. Change , 43, 745–788.

Reliefweb. (2015). Retrieved Oct 28, 2015, from Relieweb: http://reliefweb.int/report/ethiopia/millions-children-and-their-families-risk-ethiopia due-failure-rains

Seo, S. N., and Mendelsohn R. (2008). Measuring Impacts and Adaptations to Climate Change: A Structural Ricardian Model of African Livestock Management. Agricultural Economics , 38 (2), 151–165.

Sisay, B. (2013). Understanding Climate Change Adaptation Mechanisms in Agriculture in Sub-Saharan Africa: A Review Papaer. International Journal of Research in Applied, Natural and Social Sciences (IJRANSS) , 1 (2), 69-76.

Smith, B. and Skinner, M.W. (2002). Adaptation Options in Agriculture to Climate Change: A Typology. Mitigation and Adaptation Strategies for Global Change , 7, 85–114.

Smith, J. (1996). 'Using a decision matrix to assess climate change adaptation'. In N. B. J.B. Smith (Ed.), Adapting to Climate Change: An international Perspective (pp. 68–79). New York: Springer.

Smith, P., D. Martino, Z. Cai, D. Gwary, H. Janzen, P. Kumar, B. McCarl, S. Ogle, F. O'Mara, C. Rice, B. Scholes, O. Sirotenko. (2007). Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. In O. D. B. Metz (Ed.), Climate Change 2007: Mitigation. Cambridge and New York, NY, United Kingdom and USA: Cambridge University Press.

Southern Nations Nationalities and Peoples Regional State Bureau of Finance Economic. (2012). Annual Statistical Abstract 2010/2011. Hawassa: Unpublished .

Stern, N. (2006). Retrieved Nov 5, 2015, from HM treasur: http://www.hmtreasury.gov.uk/d/Executive_Summary.pdf

Stern, N. (2007). The Economics of Climate Change: The Stern Review. Cambridge: Cambridge University Press.

Tanner, T. and Mitchell, T. (2008). "Entrenchment or enhancement: could climate change adaptation help to reduce chronic poverty?". IDS Bulletin , 39 (4), 6-15.

Thornton P, a. C. (Ed.). (n.d.). Impacts of climate change on the agricultural and aquatic systems and natural resources within the CGIAR's mandate. CCAFS Working Paper 23 . Copenhagen, Denmark: CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS) www.ccafs.cgiar.org.

Thornton PK, Jones PG, Owiyo T, Kruska RL, Herrero M, Kristjanson P, Notenbaert A, Bekele N, Omolo A. (2006). Mapping climate vulnerability and poverty in Africa. Nairobi: ILRI.

UNDP. (2015). National Human Development Report, Ethiopia: Accelerating Inclusive Growth for Sustainable Human Development in Ethiopia. Addis Ababa: UNDP.

UNESCO and UNEP. (2011). Climate Change Starter's Guidebook. France: United Nations Educational, Scientific and Cultural Organization and the United Nations Environment Programme.

UNFCCC. (1992). Retrieved Oct 28, 2015, from https://unfccc.int/resource/docs/convkp/conveng.pdf

United Nation Development Program (UNDP) Ethiopia. (2014). Retrieved Sep 15, 2015, from www.et.undp.org Quarterly Key Economic and Social Indicators

UNOCHA. (2015). Eastern Africa: El Niño Snapshot (as of 23 Oct 2015). Retrieved Oct 28, 2015, from http://reliefweb.int/report/world/eastern-africa-el-ni-o-snapshot-23-oct-2015

Wheaton, E.E. and McIver, D.C. (1999). 'A framework and key questions for adapting to climate variability and change'. Miti. & Adapt. Strat. for Glob. Change , 4, 215–225.

Woldeamlak B, Radeny M, and Mungai C. (2015). Agricultural Adaptation and Institutional Responses to Climate Change Vulnerability in Ethiopia. Copenhagen, Denmark.: CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS).

Woldeamlak, B. (2009). Rainfall variability and crop production in Ethiopia Case study in the Amhara region. In H. A. Svein Ege (Ed.), Proceedings of the 16th International Conference of Ethiopian Studies. Trondheim.

Woldeamlak, B. (2009). Rainwater Harvesting as a Livelihood Strategy in the Drought-Prone Areas of the Amhara Regions of Ethiopia. Addis Ababa: OSSREA.

Woledamlak B, and Conway D. (2007). A note on the temporal and spatial variability of rainfall in the drought-prone Amhara region of Ethiopia. International Journal of Climatology , 27: 1467–1477.

World Meteorological Organization-WMO. (2013). The Global Climate 2001-2010: A Decade of Climate Extremes. Summary Report. Retrieved Nov 10, 2015, from www.unep.org/pdf/wmo_report.pdf

World Vision Ethiopia-WVE. (2013). LEAP Programme Assessment Report. Bui ADP Assessment Report and Design. Unpublished .

Yamane, T. (1967). Statistics: An Introductory Analysis (2 ed.). New York: Harper and Row.

Yohanes, G & Mebratu, K. (2009). Local innovation in climate-change adaptation by Ethiopian pastoralists. Addis Ababa: PROLINNOVA–Ethiopia and Pastoralist Forum Ethiopia (PFE).

Ziervogel, G. and Ericksen, P. J. (2010). Adapting to climate change to sustain food security. Clim Change , 1, 525–540.

7. Appendix

Annex 1: Household Survey Questionnaire

1. Household Characteristics and Structure

S.N	*Questions*	*Response*	*Remark*
Q 101	Sex of respondent	Male 1 Female 2	
Q 102	How old are you?	Age in completed year.... ….	
Q 103	Educational status of the respondent	Not read and write 1 Read and write 2 Primary education (1-6 grade) 3 Above primary education (>6 grade) 4	
Q 104	Sex of the household head	Male 1 Female 2 Child head 3	
Q 105	Could you please indicate your marital status?	Married 1 Widowed 2 Divorced 3 Separated 4 Single 5	
Q 106	What is your major livelihood occupation?	Crop production 1 Livestock production 2 Mixed farming 3 Petty trade 4 Handicraft 5	

Q.107 Family size

Family size range	Male	*Female*
1-3 members ☐		
4-6 Members ☐		
7-9 Members ☐		
10-15 members ☐		
>15 members ☐		

2. Agriculture Production

Q201 Crops

S/N	Crop Type	2007/08 EC Production		Production in bad season		Production season	Production Purpose
		Farm size (timda)	Total production (qtl)	Farm size (timda)	Total production (qtl)	1= meher 2= belg	1-mark 2- HHs consumption 3- both
A	***Cereal***						
1	Teff						
2	Maize						
3	Sorghum						
4	Barely						
5	Wheat						
B	***Pulses***						
1	Pea						
2	Horse bean						
3	chick pea						
4	Bean						
5	Lentils						
C	***Oil Crops***						
1	Nuts						
2	Nugi						
3	Selit						
D	**Fruit and vegetable**						
1	Orange						
2	Lemon						
3	Banana						
4	Avocado						
5	Guava						
6	Papaya						
7	Mango						
8	Enset						
9	Carot						
10	Red Root						
11	Poteto						
12	Tometos						
13	Onion						

Q202 Livestock Possession

S/N	Type of livestock	Owned in 2008E.C	Total sale 2008	Production in bad season	Sale in bad season	Production in bad season
1	Ox					
2	Calf					
3	Cattle					
4	Sheep					
5	Goat					
6	Poultry					
7	Donkey					
8	Mule					
9	Houses					

3. Land Use and Farming characteristics of Households

Q301	How many years experience do you have in agriculture	----------, Years	
Q 302	Have you applied/utilized improved farming practice	Yes 1 No 2	
Q 303	What type of improved agricultural/farming practice you applied More than one alternative is possible	Intercropping 1 Crop rotation 2 Water harvesting 3 Use of compost/manure 4 Improved Seed & fertilizer 5 _____ other 6	
Q 304	What amount of land size is under household ownership	----------, timad	
Q 305	To how many farm plots are this land divided	----------, timad	
Q 306	Size of land owned by	Farm land …… timad 1 Grazing land …… timad 2 Perennial crop …….. timad 3 Uncultivated …… timad 4	
Q 307	Have you contracted land?	Yes 1 No 2	
Q 308	For Q307 yes, how much land size	…….. , timad	
Q 309	Do you practice natural resource/land	Yes 1	

	management	No 2	
Q 310	If yes Q309, what type of natural resource/land management do you practice More than one alternative is possible	Soil bund 1 Fanaya juu 2 Terra 3 Planting trees 4 Planting grass 5 Area enclosure 6 Natural fertilizer/compost 7 ---------- others 8	
Q311	Do you think is there relation b/n NRM and climate change?	Yes 1 No 2 I don't know 3	
Q312	Do you access extension service concerning NRM?	Yes 1 No 2	
Q313	Have you applied improved crop varieties in 2007/08?	Yes 1 No 2	
Q314	If yes Q313, for which type of crops?	teff 1 wheat 2 Barely 3 Maize 4 Sorghum 5 Pulses 6 Oil seeds 7 Fruit & l8 Vegetable 9 …….others 10	
Q315	If you are not using improved varieties why?	Limited Financial capacity 1 Availability of local varieties 2 Fertility of soil 3 Low level of knowledge/awareness 4 Lack of interest to use improve varieties 5 Lack of access to improved varieties 6 .....Other 7	
Q316	Have you applied fertilizers in 2007/08 E.C production?	Yes 1 No 2	
Q317	If yes Q316, for which crop types?		

Crop	Farm size (timda)	Total fertilizer in K.g	
		UREA	DAP
teff 1			
wheat 2			
Barely 3			
Maize 4			
Sorghum 5			
Pulses 6			
Oil seeds 7			
Fruit & l8			
Vegetable 9			
…….others 10			

Q318	If you are not applying fertilizer why?	Limited Financial capacity 1 Type of varieties used 2 Good soil fertility 3 Unable to pay fertilizer loan 4 Resistance to use fertilizer 5 Low technical knowledge 6 Lack of access to other inputs 7 Use of compost/manure 8 ……other 9	
Q319	In 2007/8 E.C production season have used compost and manure?	Crop / Farm size (timda) / Total compost in K.g teff 1 wheat 2 Barely 3 Maize 4 Sorghum 5 Pulses 6 Oil seeds 7 Fruit & l8 Vegetable 9 …….others 10	
Q320	Do you have ox?	Yes 1 No 2	
Q321	In 2007/8 how many oxen you own?	----------	
Q322	Do you have the necessary farm tools?	Yes 1 No 2	
Q323	Do you have water resource for irrigation?	Yes 1 No 2	
Q324	Do you use/apply irrigation?	Yes 1 No 2	
Q325	If yes Q324, what size of land in timad is under irrigation?	……. timad	
Q326	Do you produce in Belg Season;	Yes 1 No 2	
Q327	How do you observe/measure/judge last year's (2007EC) Belg rain	Above the average 1 Average 2 Below average 3 Very minimum 4	
Q328	Do you produce in Mehre season;	Yes 1 No 2	
Q329	How do you observe/measure/judge last year's (2015) Mehre rain	Above the average 1 Average 2 Below average 3 Very minimum 4	

4. Observed Climate change effect on crop and livestock production

S.N	*Questions*	*Response*	*Remark*
Q401	Are there effects on your crop and livestock production as a result of climate change	Yes 1 No 2	
Q402	What are the three major (commonly experienced) effect/impact of climate change on crop production Give rank 3= very common 2= common 1= sometimes	Total damage/loss of crop production 1 Decrease in amount of crop production 2 Increase in prevalence of crop pest 3 Emergence and expansion of new weeds and invasive plants 4 Loss of indigenous crop varieties 5 Shift in farming and production seasons 6 Increased incidence of crop disease 7 Shortage of water for crop production 8 …… Others 9	
Q403	What are the three major (commonly experienced) effect/impact of climate change on livestock production Give rank 3= very common 2= common 1= sometimes	Decreased production and productivity of livestock 1 Increased incidence of animal/livestock diseases 2 Shortage of livestock feed 3 Shortage and loss of grazing land 4 Shortage of water for livestock production 5 …… Others 6	
Q404	Which type/group of crop is severely affected	cereals 1 Pulse 2 Oil crops 3 Fruits and vegetable 4	
Q405	which type of agriculture/farming system is severely affected	Monoculture 1 Mixed farming 2 Agro-forestry 3 I don't know 4	
Q406	Which type of variety (crop & livestock) is severely affected	Improved/market variety 1 local/indigenous 2 I don't know 3	
Q407	How do you measure/judge the agriculture production/yield you obtain from the same size of land in the past 5 years	Increased 1 Decreased 2 I don't know 3	

5. Local Agricultural Adaptation Practices to Climate Change Effects Implemented by Smallholder Farmers

S.N	*Questions*	*Response*	*Remark*
Q501	Have you tried to apply climate change adaptation practices	Yes 1 No 2	
Q502	Do you think you have been able to adapted with major climate change effects	Yes 1 No 2	
Q503	which adaptation practices you have applied very frequently	Use of improved varieties 1 Use of drought tolerant varieties 2 Use of disease tolerant varieties 3	

	Give rank 3= very frequently applied 2= frequently 1= sometimes	Shifting of production season 4	
		Expansion or shifting of farming plot 5	
		Using irrigation	
		Increased use of fertilizer 7	
		Use of improved livestock varieties 8	
		Shifting farming practices from crop to livestock and vice versa 9	
		Soil and water conservation 10	
		Water harvesting 11	
		wind break 12	
		Agro-forestry 13	
		Construction of bunds14	
		…….Others 19	
Q504	How do you think these adaptation practices reduced the hazards caused due to climate change	Significantly reduced 1 Average 2 Just a little3 Not reduced 4	
Q505	What is/are the major/s factor limiting you not to apply the adaptation practices	Limited extension service 1 Limited capital 2 Limited information 3 Limited agriculture inputs 4 Others 5	
Q506	Does the local government support your adaptation efforts;	Yes 1 No 2	
Q507	If Yes for Q506, what type of support is provided to you Select the three types of support you received	Trainings 1 Provision/support of improved varities2 Access to small scale irrigation 3 Support to water harvesting practices4 Access/support to credit and saving 5 Climate change information 6 Other 7	

6. Climate Induced Hazards in the Study Area and Coping Mechanisms

S.N	***Questions***	***Response***	***Remark***
Q601	Is there any incidence of hazard in the past 5-10 years as a result of climate chnage	Yes 1 No 2	
Q602	What are the climate related hazards that occurred in your area during the past 5-10 years List three major as: 3= Most Common 2= common 1= rarely	Drought 1 Flood 2 Unseasonal rainfall 3 Cyclone 4 Livestock disease 5 Human disease 6 Pest infestation 7 Land slide 8 Snow rain 9 Conflict 10 …… Others 11	

Q603	In what time difference/period did these hazards occurred (How often)	Annually 1 Every 2 years 2 Every 3 years 3 Every 4 years 4 Every 5 years 5	
Q604	To what extent your livelihood is exposed/vulnerable to these hazards	Very vulnerable 1 Vulnerable 2 Less vulnerable 3 Not vulnerable 4	
Q605	What percent of your agricultural production is affected by these hazard	1 - 25% 1 26 - 50% 2 51- 75% 3 76- 100% 4	
Q607	very commonly What copping strategies are practiced by the household List three major as: 3= very commonly applied 2= commonly applied 1= sometimes applied	Reducing frequency of meal 1	
		Reducing amount of food 2	
		Reducing specific type of food 3	
		Support from relatives/neighbours 4	
		Support from NGOs 5	
		Support from government 6	
		Sale of farming tools 7	
		Sale of household assets 8	
		Additional labour work 9	
		household members migration/seasonal migration 10	
		Extraction and sale of natural minerals 11	
		Sale of perennial trees 12	
		Sale of farm land 13	
		Sale of cattle 14	
		Borrowing of grain/cereals 15	
		Borrowing of cash 16	
		---------- Others 17	

7. Major Causes and Local Perception of Climate Change and Variability

S.N	***Questions***	***Response***	***Remark***
Q701	Have you observed climate change in your area during the past 10-30 years	Yes 1 No 2 I don't know 3	
Q702	In the past 10-30 years have you observed change in the trend and amount of rainfall	Yes 1 No 2 I don't know 3	
Q703	If yes for Q702, how do you observe the change in the amount of rainfall	Decreasing 1 Increasing 2 Variable 3 …… Others 4	

Q704	In the past 10-30 years have you observed change in temperature in your area	Yes 1 No 2 I don't know 3	
Q705	If yes for Q704, how do you observe the change in temperature in your area	Decreasing 1 Increasing 2 Variable 3 …… Others 4	
Q706	In past 10-30 years have you observed change in the moisture content of your farm land	Yes 1 No 2 I don't know 3	
Q707	If yes for Q706, how do you observe the change in moisture content of your farm land	getting more drier1 becoming more moist 2 no change3	
Q708	What is the major cause that induce and aggravate climate change in the area List three major as: 3= primary cause 2= moderate 1= minor	Deforestation 1 Poor natural resource management 2 increase in population number 3 lack of awareness 4 Expansion of farm land 5 increased livelihood on NR consumption 6 …… Others 7	

Annex 2: Focus Group Discussion

1. Have you heard about climate change? What does climate change mean in your context?
2. Have you noticed climate change and variability in your area? Could you please describe the climate changes you noticed in your area?
3. Please explain Climate Change related hazards that you experienced in the area in the past 10-20 years
4. Would you explain the effects that you observed on your crop production as a result of climate change/ that might be attributed to climate change/?
5. What are the effects on livestock production?
6. What are the social and economic consequences on your family and the community as a result of climate change effects?
7. What adaptation measures do people in your area took when confronted with climate change (temperature and rainfall) related shocks? (for crop production, livestock production and other)

8. What do you think are the major causes that induce and aggravate climate change in area?
9. Do local government and non-government institutions supported your effort to adapt and cope to climate change? (who are they, what support?)
10. Is there any local community based institution that work on climate change responses? What it does? Who participate and benefit?
11. Generally, what would be your suggestion with regard to future/further adaptation strategies (to be done) in order to cope with climate change effect and achieve food security in the area?

Annex 3: Key Informant Interview (Woreda level Experts)

1. How do you understand CC?
2. Have you observed change and variability in CC and its indicators in the woreda? Would you explain the indicators of climate change and variability you observed?
3. Could you explain major hazard experienced in the woreda as a result of CC in the past 5-10years?
4. Could you explain measure that farmers in the woreda are undertaking to cope with CC hazards?
5. What are the experienced of effects CC on the crop production of smallholder farmers (the woreda)?
6. What are the experienced of effects CC on the livestock production of smallholder farmers (the woreda)?
7. Which group of crop type is severely affected as a result CC in the woreda (cereals, pulses, oil crops or fruit and vegetable)
8. Which type of agriculture system (farming practice) is severely affected due to CC (Monoculture, Mixed farming, or Agro forestry)
9. Which type of crop or livestock variety is severely affected due to CC (Improved/commercial, local/indigenous)
10. Would you explain the major types of agricultural adaptation practices that farmers in the woreda are practicing
11. As a woreda agriculture office are you working to reduce climate change vulnerability of the farmers? What agricultural adaptation practices are you promoting?
12. Could you explain the major local level reasons that cause and aggravate CC in the woreda
13. Would you explain the El Nino effect on the woreda that occurred in 2007/8 EC
14. As a professional what further strategies do you suggest (works to be done) to cope and adapt to CC effect and achieve food security in the woreda

Secondary data

1. Number of household that faced food shortage in the past five years in the woreda

Year EC	No. of households
2008	
2007	
2006	
2005	
2004	

2. What are the CC related hazards and number of affected households in 2007/8 EC production season

Type of hazard	number of affected households		
	Belg	Meher	Total
Shortage of rain (drought)			

3. Type of crop destroyed in hectare in 2007/8 EC due to climate change

Cause	Crop destroyed in hectare			
	Cereal	Pulse	Oil crops	Fruit and vegetable
Shortage of rain	4756	574	-	-

Annex 4: Key Informant Interview (Woreda NGO Experts)

1. How do you understand CC?
2. Have you observed change and variability in CC and its indicators in the woreda? Would you explain the indicators of climate change and variability you observed?
3. Could you explain major hazard experienced in the woreda as a result of CC in the past 5-10years?
4. What are the experienced/observed effects of CC on the agriculture production, environment and smallholder farmers in the woreda
5. As an NGO are you working/responding /to reduce CC vulnerability and adaptation? Would you explain
6. Could you explain the major local level reasons that cause and aggravate CC in the woreda
7. Would you explain the El Nino effect on the woreda that occurred in 2007/8 EC
8. As a professional what further strategies do you suggest (works to be done) to cope and adapt to CC effect and achieve food security in the woreda

Annex 5: Key Informant Interview (Kebele level Experts)

1. How do you understand CC?
2. Have you observed change and variability in CC and its indicators in your area? Would you explain the indicators of climate change and variability you observed?
3. Could you explain major hazard experienced in your KA as a result of CC in the past 5-10years?
4. What are the experienced of effects CC on the agriculture production, environment and smallholder farmers in your KA
5. As a KA agriculture officer are you working/responding /to reduce CC vulnerability and adaptation? Would you explain
6. Could you explain the major local level reasons that cause and aggravate CC in the KA
7. Is there any support you have received (as a KA) from local government and non-government organization in relation/responding to CC
8. What do you suggest as further strategies (works to be done) to cope and adapt to CC effect and achieve food security

Secondary Data

1. What are the CC related hazards in 2007/8 and number of affected households

Type of hazard	number of affected households		
	Belg	Meher	Total

2. Type of crop destroyed in hectare in 2007/8 EC due to climate change

Cause	Crop destroyed in hectare			
	Cereal	Pulse	Oil crops	Fruit and vegetable