SOCIO-ECONOMIC IMPACTS OF CLIMATE CHANGE AND VARIABILITY ON HOUSEHOLDS AROUND HARAMAYA AND ADELE LAKES, EASTERN HARARGHE ZONE, OROMIA REGIONAL STATE, ETHIOPIA.

M.A. THESIS

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POSTGRADUATE PROGRMA DIRECTORATE(PGPD)

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DEDICATION

I dedicated this Thesis manuscript to my father **Kene Yadete** and my mother **Letu Lemi**, for nursing me with affection and love and for their dedicated partnership in the success of my life

STATEMENT OF THE AUTHOR

By my signature below, I declare and affirm that this thesis is my own work. I have followed all ethical and technical principles of scholarship in the preparation, data collected, data analysis and compilation of this Thesis. Any scholarly matter that is included in this Thesis has been given recognition through citation.

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BIOGRAPHICAL SKETCH

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The research was carried out in four *kebeles* of Haramaya Woreda, Oromia Regional State. I would like to acknowledge Agricultural office of Haramaya Woreda, and sample household heads for their support by providing necessary information and relevant data collected from the study sites.

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ACRONYMS AND ABBREVIATIONS

BoFED	Bureau of Finance and Economic Development
CCV	Climate Change and Variability
CRGE	Climate Resilient Green Economy
CSA	Central Statics Agency
El Niño	The little boy' in Spanish refers to a periodic heating-up of the surface of the tropical Pacific Ocean
EPACC	Ethiopia's Programme of Adaptation to Climate Change
FAO	Food and Agriculture Organization
FDRE	Federal Democratic Republic of Ethiopia
FGE	Federal Government of Ethiopia
HLPE	High Level Panel of Experts on Food Security and Nutrition
HWAO	Haramaya Woreda Agricultural Office
IISD	International Institute for Sustainable Development
IPCC	Intergovernmental Panel on Climate Change
NAPA	National Adaptation program of Action
NGO's	Non Governmental Organizations
NMSA	National Meteorological Service Agency
NSF	National Science Foundation
OECD	Organization for Economic Co-operation and Development
SPSS	Statistical Package for Social Sciences
SSA	Sub-Saharan Africa
UNDP	United Nations Development Programme
UNECA	United Nations Economic Commission for Africa
UNFCCC	United Nations Framework Convention on Climate Change
USDA	United State Development Agency

USDS	United States Department of State
WAZ-FS-DPPO	West Arsi Zone Food Security- Disaster Prevention and Preparedness Office
WHO	World Health Organization
WMO	World Meteorological Organization

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ABSTRACT

The main objective of this study was to assess socio-economic impacts of climate change and variability on households in four kebeles of Haramaya woreda*, Eastern Hararghe Zone, Oromia Regional State. The study relied on both quantitative and qualitative methods of data collection and analysis. The primary data were collected by using questionnaire (from 135 sample households), key informant interviews (15 participants), Focus Group Discussion (8 participants) and field observation. The study also used temperature and rainfall data from 1986 to 2016 to examine trends and changes of rainfall and temperature. The data obtained* *from questionnaire were analyzed by using Percentage for description of data, T-test and F-test for statistical differences. The finding of the study showed that there was a general trend of increasing in average maximum and mean annual temperature in the past three decades while the minimum one showed variation in the past two decades; annual rainfall had showed inter annual and seasonal variation. The analysis also indicated that cooling of temperature damaged crops and many types of vegetables and this in turn adversely affected livelihood of the households and made them vulnerable to external intervention through aids. According to perception by the sample households, it was identified that current agricultural yields were low when compared to that of past 10 years mainly due to the impacts of climate change and variability. Different adapting and coping strategies including using underground water for irrigation and changing growing and harvesting time were applied. However, the impacts of recent drought and cooling of temperature were beyond the resilience capacity of the community and made them vulnerable to external aids. It is therefore, depending on the results of finding and existing literatures, the investigator recommended that there should be unreserved efforts to address socio-economic challenges of climate change and variability through short term and long term adaptation and mitigation measures*.

Key words: Climate change and Variability, Socio-economic impacts, Adaptation.

1. INTRODUCTION

This chapter deals with background of the study, statement of the problem, objectives of the study, research questions, significance of the study, delimitation of the study, limitation of the study, definition of key terms and organization of the thesis.

1.1. Background of the Study

It is now well recognized and established in science that the global climate is already changing towards higher temperatures. Much of the analysis by climatologists and in public debate focus on the average global temperature change, which increased by 0.74º C per century in the period 1906-2005 (Collins et al., 2013). More recently, the World Meteorological Organization (WMO, 2015) announced the likelihood that the planet has already warmed by 1º C since the pre-industrial era. The bulk of warming occurred in recent decades in an accelerating trend but one of the ten hottest years since records began have occurred between 2000-2010 years while the period 2011–2015 was the warmest five-year period on record globally (WMO,2011).

The Intergovernmental Panel on Climate Change (IPCC, 2013), reported that warming of the climate system is unequivocal that since the1950s many observed changes are unprecedented over decades to millennia. Due to climate change, the atmosphere and the ocean have warmed, the amounts of snow and ice have diminished, sea level has risen, and the concentrations of greenhouse gases' effects have increased. According to the same report, human-made causes are taken as the largest contribution to increase the atmospheric concentration of CO_2. It was projected that there will be temperature change by 2100 of between 1.5°C (2.7^{0}F) and 4.8°C (8.6^{0}F).

Recent evidence and predictions indicate that global climate changes are accelerating and will lead to wide-ranging shifts in climate variables. There will be changes in the mean and variance of rainfall and temperature, extreme weather events, food and agriculture production and prices, water availability and access, nutrition and health status (Tyler, 2010). The most adverse impacts are predicted in the developing world because of geographic exposure, reliance on climate sensitive sectors, low incomes, and weak adaptive capacity (Zhang and Liu, 2012).

African countries are among the most affected parts of the world by climate change because of their reliance on rainfed agriculture, lower financial, technical, institutional capacity to adapt, land degradation and desertification (Signgh and Purohit, 2014; Rose and Hummel, 2015). East African countries such as Burundi, Eritrea, Ethiopia, Kenya, Uganda, Tanzania, Rwanda, and Somalia and Sub-Saharan Africa (SSA) are among the regions of African where effects of climate change are being felt (Feyssa and Gemeda, 2015). Particularly, in the SSA, climate change affected food and water resources that are critical for livelihoods where much of the poor population rely on local supply systems that are sensitive to climate variation (Kadi et al., 2011).

Climate change will have major effects on precipitation, evapotranspiration, and runoff. This fluctuation can affect use of agricultural land associated with irrigation systems and also cause drying of Lakes (Lijalem *et al.,* 2007). For instance, Lake Chad basin has affected economic livelihood of millions of people (Masari, 2008), fluctuation of Lake Victoria in Uganda and Lake Zeway in Ethiopia in turn affected small and large scale agriculture, floriculture and horticulture around them (Goulden, M., 2008, Olaka et al., 2010).The aim of this study was to assess socio-economic impacts of climate change/variability on households around Haramaya and Adele Lakes, Eastern Hararghe Zone, Oromia Regional State, Ethiopia.

1.2. Statement of the Problem

The direct impacts of climate change and variability include extreme precipitation, heat stress, pluvial and fluvial flooding, landslides, drought, increased aridity, and water scarcity with widespread indirect impacts on people, economies and ecosystems (IPCC, 2014a). These impacts are severe in developing countries like Ethiopia, where rain-fed agriculture of production is predominant and population growth rate is over 2.8% to double itself within 25 years. The erratic and declining pattern in mean annual rainfall and steady rise in mean air temperature in the region adversely affected crop production (Solomon, 2013).

Ethiopia is one of the most vulnerable countries to climate changes due to its dependence on rainfed agriculture; natural resources, under-developed water resources; low level of economic development; low adaptive capacity; weak institutional role; and low levels of awareness on climate change (FDRE, 2011a). Rising temperatures and increased rainfall variability are the most evident signals of climate change in the country, the impact of which is manifested through extreme events of droughts and floods with increasing frequency and intensity (Epsilon, 2011).

Currently Ethiopia has been hit by disturbed rainy seasons that have been linked to long-term climate change and now El Niño. First the *belg* rains, February to April, failed across the north (including Afar, Wollo and Tigray) and have been declining in quantity for nearly two decades. This has been linked by scientists to long-term climate change. According to this analysis, rising sea surface temperatures in Indian and Western Pacific Ocean from which rain bearing winds rise and create the *belg* rains are weakened instead of reaching the country. In 2014 poor *belg* rains have been associated with record warm west Pacific, and in 2015, with extremely warm Indian Ocean (FGE, 2015).

Numerous scholars like Solomon (2002), Chalachew (2004), Abdulaziz (2004), Wagari (2005), Siraj (2013), Solomon (2013), Solonon (2016) and others conducted studies in different ways on Lake Haramaya watershed. Most of these studies have been devoted to analyzing and investigating the causes of the deterioration and ultimate degradation of the Lake. Moreover, recent studies focused on impacts of disappearance of the lake on the surrounding community as well as on socio-economic and livelihood impacts of the disappeared Lake of Haramaya (Demissie, 2008, Seifemichael et al., 2014).

Likewise, few scholars have conducted studies on climate change related impacts in the study area. Some of these include Solomon (2013) who analyzed on environmental resources, climate change and livelihood strategies around the Dried Lake Haramaya Catchment; and Liambila and Kibebew (2016) conducted study on impacts of Climate Change on Land Suitability for Rainfed Crop Production in Lake Haramaya Watershed. However, none of these made study on socio-economic impacts of climate change on households. So to fill the aforementioned research gap, this study was designed to assess socio-economic impacts of climate change and variability on households inhabiting in the catchment of Haramaya and Adele Lakes.

1.3. Objectives of the Study

1.3.1. General Objective

Basically the research aims at assessing socio-economic impacts of climate change and variability on households around Haramaya and Adele Lakes.

1.3.2. Specific Objectives

In line with the above aforementioned general objective, the specific objectives of the study are to:

1. Identify the observed temperature and rainfall changes;
2. Assess impacts of temperature and rainfall variability on agricultural income;
3. Analyze impacts of temperature and rainfall variability on selected socio-economic variables such as crops, livestock, health, education and housing amenities;
4. Identify livelihood adaptation and copying strategies devised by households in response to impacts of climate change.

1.4. Research Questions

Based on the above objectives, the following key research questions are set including:

1. What is the trend of observed rainfall and temperature changes?
2. What impacts of temperature and rainfall variability are on prevalent agricultural income?
3. What are impacts of temperature and rainfall variability on the selected socio-economic variables?
4. What are livelihood adaptation and copying strategies devised by households in response to impacts of climate change?

1.5. Significance of the Study

Finding of this study may provide households with deep and organized knowledge about climate change and variability and its negative impacts on their economic and social aspects in the study area. The finding may help the investigator and academic and research community of Haramaya University (HU) in particular and others in general to learn more about climate change and its socio-economic impacts and thereby look for further intervention to minimize vulnerability and enhance resilience. Moreover, it may be used for better understanding about a kind of training to be given for the households on means of adaptation and copying of impacts of climate change.

The finding may also initiate HU and NGOs to give necessary financial or technical supports for the households to practice effectively the adaptation and copying strategies. Besides, it may contribute some latest and new information and knowledge to the existing literatures for academicians and researchers, enrich Post Graduate library in the university and help policy and decision makers at national level. Finally, the finding may be significant for researchers and academicians who are interested to undertake further research in related topics as well.

1.6. Delimitation of the Study

This study was designed to assess socio-economic impacts of climate change and variability on households around Haramaya and Adele Lakes in four selected *kebeles*, Eastern Hararghe Zone, Oromia Regional State. This was because farmers of these *kebeles* were highly dependent on rainfed agriculture and underground water for irrigation. Another principal reason was limitation of time and financial resource. The study could have been much more interesting had it been possible to include more *kebeles* in Haramaya Woreda and beyond. However, due to the mentioned reasons, the study was undertaken only in selected four *kebeles*.

1.7. Limitations of the Study

The study relied on four selected *kebeles* in Haramaya Woreda, for practical reasons such as time and financial limitations; some sample farmers were not willing to give correct information concerning their current income and did not remember about it before ten years in relation to climate change and its impacts. The other limitation of the study was that, Haramaya woreda does not have full functional sub Meteorological Station and consequently getting recorded data of temperature and rainfall for the study area was difficult. In spite of these short comings, however, it was attempted to make the study as complete as possible by further gathering adequate information from annual reports of socio-economic aspects of the respondents in Haramaya woreda Agricultural Office (HWAO) and historically recorded climatic data from National Meteorological Service Agency (NMSA), Jigjiga branch.

1.8. Definition of Key Terms

Climate Change: refers to a statistically significant change in measurements of either the mean state or variability of the climate for a given place or region (UN/ISDR, 2004).

Climate Variability: refers to changes that occur within smaller timeframe such as a month, a season, or a year in a given area (WMO, 2011).

Socio-economic Impacts: refer to effects of climate change on lives, livelihoods, health, economies, social aspects, cultures and services of the local community (IPCC, 2014).

Vulnerability: refers to the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes (IISD, 2012).

Adaptation: is a process by which strategies to moderate, cope with and take advantage of the consequences of climatic events are enhanced, developed, and implemented (UNDP, 2005).

Mitigation: refers to the intervention of local community to reduce the rate of impacts of climate change and variability through management of its causal factors (Smith et al., 2007).

Resilience: refers to capacity of community potentially exposed to hazards to adapt, by resisting or changing in order to reach and maintain an acceptable level of functioning and structure (UN/ISDR, 2004).

1.9. Organization of the Thesis

The major study is organized in to five chapters. Chapter one presents introduction including background of the study, statement of the problem, objective of the study, research questions, significance of the study, delimitation and limitation of the study, definitions of key terms, and organization of the thesis. Chapter two reviews important literatures related with climate change, its impact and adaptation mechanisms. Description of the study area and data gathering method is presented in chapter three. Chapter four presents results and discussion of the survey while, summary, conclusion, recommendations are presented in chapter five. Finally, references and appendices are attached at the end of the thesis for further references.

2. LITERATURE REVIEW

This section provides review of related literatures about socio-economic impacts of climate change and variability (CCV). The principal issues discussed here are definitions and concepts; overview of global climate change variability; current overview of climate change and variability in Ethiopia; impacts of climate change and variability on crops, livestock, health, education and housing amenities; challenges and opportunities of CC in different parts of the world; livelihood strategies towards CCV; and conceptual frame work of the study.

2.1. Definition and Concepts of Climate Change and Variability

Climate change refers to a change in the state of the climate that can be identified by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcings such as modulations of the solar cycles, volcanic eruptions, and persistent anthropogenic changes in the composition of the atmosphere or in land use (UNFCCC, 2015).

Climate change is a reality; it has changed in the past, it is changing at the present, and it will change in the future (Burroughs, 2007). The change of climate could be slow and gradual, rapid and catastrophic, short-term or long term could be at local, regional and global scales; and it could be due to natural factors or anthropogenic factors. The overwhelming majority of climate change researchers have reached the understanding-based on decades of evidence, modeling, and debate-that it is extremely likely that human activities are responsible for the rising temperatures on Earth. Human behavior will continue to be a major factor in climate change (NSF, 2009).

Climate Variability is variations in the mean state and other statistics (such as standard of deviations, the occurrence of extremes, etc.) of the climate on temporal and spatial scales beyond that of individual weather events. Variability may be due to natural internal processes within the climate system (internal variability), or to variations in natural or anthropogenic external forcing (Levina and Tirpak, 2006). Climate variability is a reality; it has changed in the past, it is changing at the present, and it will change in the future (Burroughs**,** 2007). The variability's of climate could be slow and gradual, rapid and catastrophic, short-term or long term could be at local, regional and global scales; and it could be due to natural factors or anthropogenic factors.

The human factors that contribute to climate change are in the form of greenhouse gases (GHGs) emissions and land-use/cover changes (Aklilu and Alebachew 2009a; World Bank, 2008; FAO, 2008). Most important GHSs are emitted from electric power station, various industries, the transport sector and deforestation due to human activities. These activities increase the concentration of different greenhouse gases. The relative share of carbon dioxide, chlorofluorocarbons, methane and nitrous oxides to GHGs emission up to 1990 were 51%, 20% 16% and 16% respectively (Singh and Sweta, 2008).

In recent decades, changes in climate have caused impacts on natural and human systems on all continents and across the oceans. Impacts are due to observed climate change, irrespective of its cause, indicating the sensitivity of natural and human systems to changing climate. Evidence of observed climate change impacts is the strongest and most comprehensive for natural systems. Some impacts on human systems have also been attributed to climate change, with a major or minor contribution of climate change distinguishable from other influences. Impacts on human systems are often geographically heterogeneous because they depend not only on changes in climate variables but also on social and economic factors. Hence, the changes are more easily observed at local levels, while attribution can remain difficult (IPCC, 2014).

2.2.1. Global Overview of Climate Change and Variability

Climate change is a widespread challenge affecting many parts of the world. This change will not occur without marked impacts upon various sectors of our environment, and consequently of our society (Chavas et al., 2009). The change in climate will appear and will have important positive or negative impacts on rainfed crop production. Climate change has raised much concern regarding its impacts on future global agricultural production varying by region, time, and socio-economic development path (Liambila and Kibebew, 2016).

According to the Intergovernmental Panel on Climate Change (IPCC, 2013), human influence has been detected in warming of the atmosphere and the ocean, changes in the global water cycle, reductions in snow and ice, global mean sea level rise, and changes in some climate extremes. It is extremely likely that human influence has been growing and is the dominant cause of the observed warming since the mid-20th century.

Future projections of climate change depend upon the path of future emissions. Even if all emissions of GHSs were ended today, the world would continue warming over the next few decades because the ultimate environmental effects of emissions are not realized immediately. Based on a wide range of models with different assumptions about future emissions, the IPCC (2013) estimates that: increase of global mean surface temperatures for 2081–2100 relative to1986–2005 is projected to likely exceed 1.5°C (2.7^{0}F) and might be as high as 4.8°C (8.6^{0}F).The Arctic region will warm more rapidly than the global mean, and mean warming over land will be larger than over the ocean.

2.2.2. Current Overview of Climate Change and Variability in Ethiopia

Climate change will be manifested through changes in climatic and atmospheric factors (rainfall, temperature and CO_2 concentration), and a host of other changes and interactions. Temperatures across the African continent will rise, and it is likely that under high emission scenarios the mean annual temperature increase will exceed 2 °C by the middle of the twenty-first century (Niang et al., 2014).

Changes in precipitation will be less uniform across the continent, with a varying degree of consensus between models across the regions. For southern Africa, most projections suggest a drying of the climate. For eastern Africa, however, an opposite trend is projected, with the

Ethiopian highlands in particular likely to witness an increase in average and extreme rainfall. In many areas of West Africa, the changes predicted by different climate models are divergent (Niang et al., 2014). Besides trends in the mean climate, changes in weather variability and frequency of extreme events are expected, with still low but increasing confidence in the projections (Porter et al., 2014).

Ethiopia's topography is characterized by large regional differences which are the main factor for high annual variation of precipitation. The country has three rainy seasons: June–September (*kiremt*), October–January (*bega*), and February–May (*belg*). *Kiremt* rains account for 50–80 percent of the annual rainfall totals and most severe droughts usually result from failure of the *kiremt*. The lowlands in the southeast and northeast are tropical with average temperatures of 25°–30°C while the central highlands are cooler with average temperatures of 15°–20°C. Lowlands are vulnerable to rising temperatures and prolonged droughts, while highlands are prone to intense and irregular rainfall (NCEA, 2015).

Ethiopia is currently faced with serious challenges arising from climate change, which include erratic rainfall, severe droughts, and floods, among others. The country is indeed rated as among the most vulnerable to climate change as a result of its high dependence on rain-fed agriculture, natural resources and low adaptive capacity (FDRE, 2011a).

The country has frequently experienced extreme events like droughts, floods, and other climate-related hazards. The variability of rainfall and the increasing temperature are blamed for the frequent droughts that at times lead to famine and affect livelihood of the people. Since the early 1980s, Ethiopia has suffered seven major droughts, five of which led to famines in addition to dozens of local droughts. Major floods also occurred in different parts of the country in 1988, 1993, 1994, 1995, 1996 and 2006 (World Bank, 2010; FDRE, 2011c; FDRE, 2011e).

According to Oxfam International (2016), climate changes can result in numerous extreme events like drought mostly in developing countries including Ethiopia, which experienced worst droughts for 50 years and also has left many poor and vulnerable families with nothing. The El

Niño weather system, exacerbated by climate change, comes off the back of 12 to 18 months of erratic or failed rains. It led to crop failures of the 2015 *meher* harvest of between 50 and 90 percent, particularly in the eastern part of the country including Oromia Regions; the El Niño has dried up many water sources. Hundreds of thousands of livestock have died and malnutrition is at alarming levels.

Crop agriculture is dominated by small-scale subsistence farmers who remain heavily dependent on rain, employ low-intensive technologies and lack access to services. This leaves the sector highly vulnerable to changing rainfall and other climate patterns. Limited water storage capacity further increases vulnerability to climate risks. Crop productivity may increase in the short term due to warmer temperatures, but continued high temperatures will result in heat stress and crop failure. By one estimate, Ethiopia will forgo more than 6 percent of each year’s agricultural output if the current decline in average annual rainfall levels continues in the medium term (Aragie, E. 2013).

2.3. Economic Impacts

2.3.1. Impacts on Crops Production

Climate change is exacerbating the challenges faced by the agriculture sector. Climate change-induced increases in temperatures, rainfall variation and the frequency and intensity of extreme weather events are adding pressure on the global agriculture system, which is already struggling to respond to rising demands for food and renewable energy (OECD, 2015). Besides, agriculture is sensitive to climate, even under current conditions. All types of farming, from highly mechanized capital intensive farming to manual subsistence agriculture have the potential to be significantly impacted by current climate variability, as well as by future climate change (UNDP, 2010).

According to UNDP (2010), farming can be impacted by a multitude of environmental issues that may influence agricultural production in the future. These include:

a) **Temperature:** Higher winter temperatures and less frost days may mean that some crops benefit. However, other crops may suffer from higher summer temperatures. The shifts in temperatures may shift the ideal planting and harvesting times for some crops or shift the type of crop varieties which should be grown. Temperature can also have a direct impact on livestock health and reproduction.

b) Precipitation and soil moisture: an increase in average global temperatures will also mean an increase in the intensification of the global water cycle. Higher temperatures will mean more evaporation, and possibly more intense rainfall in some regions – which can lead to flooding. Other regions may however experience longer spells of drought. The changes to the water cycle are critical to consider when examining the agricultural sector.

c) Climate change and extreme events: while long-term changes in the average climate may require adaptation measures, greater risks to food security may be posed by changes in year-to-year variability and extreme events. Extreme temperatures, droughts and floods may result in greatly reduced productivity, and in some cases crop failure.

The observed effects of past climate trends on crop production are evident in several regions of the world (Porter *et al.,* 2014), with negative impacts more common than positive ones, including several periods of price spikes following climate extremes in key producing regions. There is evidence that climate change has already negatively affected wheat and maize yields in many regions and also at global level (Lobell et al., 2011).

Climate change has been found to pose risks to producer incomes in other areas as well. Bárcena *et al*., (2014), summarize the results of a series of studies of projected impacts of climate change on agricultural revenues. They stated that impacts of climate change are generally found to be negative across a wide range of locations, temperature increases and assumptions. In another recent study modeling the potential effects of climate change on agricultural incomes across a wide range of farming systems in Central Asia, the authors found positive income gains for large-scale commercial farmers in northern Kyrgyzstan, but negative impacts for small-scale producers in arid areas of Tajikistan.

According to Gaillard (2010), agricultural production in many African countries and regions will likely be severely compromised by climate change and climate variability. This would adversely affect food security and exacerbate malnutrition. Agricultural yields and dependence on natural resources constitute a large part of local livelihoods in many African countries. Agriculture is a major contributor to the current economy of most African countries, averaging 21% and ranging from 10% to 70% of GDP with indications that off-farm income augments the overall contribution of agriculture in some countries.

In Niger and Ethiopia, both rainfall and maximum temperature variability appear to exert a negative impact on consumption expenditure, household income and food security, which points towards the absence of income-smoothing behavior. In Uganda, however, the limited impact of climate shock on household welfare together with highly significant effects of other socio-demographic and wealth indicators could indicate a consumption and income-smoothing behavior. In most of the East African countries, the most vulnerable rural households are more adversely affected by a rainfall deficit compared with the households in the top income quintile (Erickson et al., 2011).

2.3.2. Impacts on Livestock Production

According to Thornton et al., (2009), direct effects of climate change on livestock production are manifested through impacts of increased temperature on feed intake and animal physiology, affecting growth, health, fertility and milk production. Although the exact impact of heat stress in animals is not well established for the tropics it is likely that with increased temperatures, African livestock keepers may have to shift to more heat tolerant breeds or species. Livestock are indirectly affected by changes in forage and crop residue production and grazing resources.

Livestock are a major asset among rural communities, providing a range of essential services, including saving, credit and buffering against climatic shocks and other crises. Beyond agriculture and food security, the income from livestock thus directly contributes to education and human health. In SSA, more than one person in two keep livestock and one in three can be considered as poor livestock keeper (FAO, 2012). Livestock, especially small ruminants and chicken, are also key to women's empowerment and gender equity.

In Italy, Crescio et al., (2010), reported that high temperatures and air humidity could lead to a 60 percent increase in cattle mortality. Likewise, in countries of SSA, 20 percent to 60 percent losses in animal numbers were recorded during serious drought events in the past two or three decades. Moreover, Niang et al., (2014), reported that dairy yields may decrease by 10 to 25 percent under certain climate change scenarios. In South Africa, another case study reported by the same authors estimated a 23 percent rise in the cost of supplying water to animals from boreholes in Botswana.

According to FAO (2010), climate change affects livestock production in multiple ways, both directly and indirectly. The direct effects of climate change will depend very much on the livestock production and housing system, with high-output breeds in confined systems being better protected from natural adversities than breeds in extensive grazing systems. The need for increased production efficiency while reducing the environmental footprint of livestock will continue to be major future challenges. The same report indicates that climate change will increase the need for resource-efficient livestock production and may thus intensify current trends with a growing dichotomy between livestock kept in extensive and those in intensive systems.

2.3.3. Impacts on Households Amenities

Climate change directly bears social impacts on farming households, limiting their capacity to face other expenditures, such as health and education. At national level, they can trigger an increase in agricultural commodities' prices (food and feed), which impact the economic and social status of the whole population, particularly in countries where an important part of the household budget is spent on food. This triggers macro-economic effects for agriculture-dependent countries for which agriculture is an important part of GDP, and/or for which agriculture constitutes an important part of employment (Arslan et al., 2015a).

Climate change impacts can also bring more people into poverty every year due to increased frequency and intensity of the events that destroy physical, human, social, and natural assets, such as floods and droughts. And if climate change leads to a general increase in real or perceived risk, it can push households toward low-risk activities that offer limited opportunity for income growth, thereby expanding poverty traps and reducing the number of households escaping poverty every year. These effects are largely independent of any impact on GDP because they tend to mostly fall upon people and regions too poor to materially affect such aggregate figures (Skoufias et al., 2011).

The Economic Consequences of Climate Change (OECD, 2015) investigates the consequences of a range of climate impacts on the different sectors and regions of the global economy. In the vast majority of regions, market consequences from climate change are projected to be negative. These include changes in crop yields, coastal zones (capital and land losses from sea level rise), some extreme events (capital losses from hurricanes), health (labour productivity losses from heat stress; costs of diseases; health expenditures) and energy and tourism demand. Heat stress, extreme precipitation, inland and coastal flooding, landslides, air pollution, drought, and water scarcity pose risks in urban areas for people, assets, economies, and ecosystems (IPCC, 2014).

2.4. Social Impacts

2.4.1. Impacts on Education

Educational system should be oriented towards resolving socioeconomic constraints of the country or region. However, during climate change induced impacts such as prolonged droughts and flooding, schools would become victims of climate shocks and hazards, hence vulnerable to climate change impacts. Consequently, schools teaching-learning processes will be interrupted, educational facilities and institutions will be destroyed, and in the final analysis will bring about either complete school shut down with whole educational processes to cease or leading to a significant increasing in number of student dropouts (BoFED, 2008).

As study conducted, for example, in west Arsi zone revealed that 35 schools in Siraro district depicted high student dropouts, and school dropout has increased from 2% during normal time to 21.76% during the drought event (WAZ FS-DPPO, 2008). Moreover, low class attendance, late coming and early departure, low educational achievement and high teacher turnover was also indicated in the report. In addition, another study reported by Senbeta (2008) has showed that more student dropouts and poor educational performance took place during the drought events due to climate change imposed drought and famine or malnutrition.

Considering the importance of child health and education for long-term prospects, productivity and income, even a moderate impact of climate change on these dimensions could affect poverty visibly over the long-term. Moreover, since poor households are suffering disproportionally from impacts, it would increase the poverty legacy and reduce the chance for children from poor families to escape poverty, reducing further social mobility. Climate change impacts are expected to disproportionately affect the welfare of the poor in rural areas, such as female-headed households and those with limited access to land, modern agricultural inputs, infrastructure, and education (IPCC, 2014).

2.4.2. Impacts on Human Health

Climate variability will affect human health and well-being through a variety of mechanisms. Climate variability can adversely affect the availability of fresh water supplies, and the efficiency of local sewerage systems (WHO, 2000). Africa is vulnerable to a number of climate sensitive diseases including malaria, tuberculosis and diarrhoa (Guernier, 2004). Under climate variability, rising temperatures are changing the geographical distribution of disease vectors, which are migrating to new areas, and higher altitudes, for example, migration of the malaria mosquito to higher altitudes will expose large number of previously unexposed people to infection in the densely populated east African highlands (Boko, 2007)

Health challenges are not limited to shocks: malnutrition can be a chronic condition linked to usual economic and climate conditions. Climate change may reduce future agricultural yields and threaten food security by accelerating the risk of malnutrition and stunting. Lloyd et al., (2011), estimated that climate change will lead to an increase in moderate stunting of 1-29% by 2050 in compared to a future with no climate change while severe stunting could increase by up to 23% in SSA, and 62% in South Asia even.

Climate change also causes scarcity of water resources and severe floods that leads to outbreaks of waterborne diseases. African countries suffer serious health problems because of climate change (UNECA, 2011). Moreover, UNECA also justified that, Africa is the most susceptible continent to climate change related to health problems due to the existing poverty and weak institutions to deal with health challenges posed by climate change.

In Oromia National Regional State, existing linkages between impacts of climate change and human health related diseases show strong relationships, where with increased droughts and climate stresses, human diseases occurrence and prevalence marked increasing trend. Accordingly, ORHB (2010) indicated that 65% of Oromia's population was troubled by Malaria with 1 million clinical cases every year. In an effort to curb the hitch, the regional health bureau implemented the national malaria prevention and control strategies. Nonetheless, lack of adequate human resources, analytical skills, and inadequate and inconsistent reporting hindered the region from further attainment.

2.5. Predicted Negative and Positive Effects of CCV

2.5.1. Predicted Negative Effects

According to report of IPCC (2013), scientists have modeled the effects of a projected doubling of accumulated carbon dioxide in the earth's atmosphere. Some of the predicted effects are: (a) loss of land area, including beaches and wetlands due to sea-level rise, (b) loss of species and forest area, including coral reefs and wetlands, (c) disruption of water supplies to cities and agriculture, (d) health damage and deaths from heat waves and spread of tropical diseases (e) increased costs of air conditioning, (f) loss of agricultural output due to drought, (g) disruption of weather patterns, with increased frequency of hurricanes and other extreme weather events,(h) sudden major climate changes, such as a shift in the Atlantic Gulf Stream, which could change the climate of Europe to that of Alaska and (i) positive feedback effects,18 such as an increased release of carbon dioxide from warming arctic tundra, which would speed up global warming .

Climate change is expected to affect food and water resources that are critical for livelihoods in SSA where much of the population, especially the poor rely on local supply systems that are sensitive to climate variation. Thus, climate change would have a profound effect on food security in SSA, as increasing temperatures and shifting rain patterns reduce access to food (Kadi et al., 2011).

Climate change will has huge effects on rainfed agriculture such as for instance, in Ethiopia, crop productivity, among other agricultural activities, continued high temperatures will result in heat stress and crop failure. By one estimate, Ethiopia will forgo more than 6 percent of each year's agricultural output if the current decline in average annual rainfall levels continues in the medium term (Aragie, E., 2013).

2.5.2. Predicted Positive Effects

Positive effects of climate change and variability might include: increased agricultural production in cold climates, lower heating costs, less deaths from exposure to cold, modest reductions in cold-related mortality and morbidity in some areas due to fewer cold extremes, geographical shifts in food production, and reduced capacity of vectors to transmit some diseases. But globally over the 21st century, the magnitude and severity of negative impacts are projected to increasingly outweigh positive impacts (IPCC, 2014).

As a result of climate change, changes in agricultural productivity, with gains in some places will affect the income of workers in the agricultural sector, and therefore poverty in countries such as Burundi, Burkina Faso, Ethiopia, Mozambique, Sierra Leone, and Tanzania. World Bank household survey data indicate that more than 75% of workers are in the agricultural sector and between 75 and 95% of poor adults are farmers. The income growth of workers in the agricultural sector is therefore a key determinant of poverty eradication (Nelson et al., 2014).

2.6. Adaptation and Mitigation Strategies to Climate Change & Variability

Adaptation and mitigation are used to increase food security through increased agricultural productivity through strategies of risk management, diversification and sustainable intensification. Risk management typically aims to reduce the variance of an outcome (e.g. crop yield), whereas intensification primarily aims at increasing the mean of the outcome. Diversification may lead to a shift in both the variance and the mean. In other words, mitigation can be conceived as a co-benefit of increased productivity and adaptation. To this end, crop, livestock and rangeland management options, while indicating some important institutions that could enable the adoption of these options (Campbell et al., 2014).

Risk management strategies, such as choosing adapted animal types and breeds, may decrease greenhouse gas emissions rates because of a smaller proportion of non-productive animals in the herd. Agro forestry is a diversification option providing improved feed from (often leguminous) trees or shrubs, while at the same time sequestering carbon (Mbow et al., 2014).

Non-agriculture-based livelihoods are likely to play an increasingly important role in building resilience among agricultural populations due to projected population growth patterns as well as potential climate change impacts to consider how to improve pathways for low-income and food-insecure people in both the agriculture and non-agriculture sectors to access resilient livelihoods (HLPE, 2013).

According to Deressa et al., (2009), adaptation to climate change has many barriers, which emanate from different social, economic and institutional situations. The most important factor mentioned as barrier to adaptation is lack of information about climate change and adaptation strategies. This is attributed to various factors including lack of institutional support mechanisms and failure to mainstream the issue of climate change in the public extension system of the country.

Lack of farm inputs including seed, chemical fertilizer and oxen are the second most important impediments. Diversification of both on-farms with increased number of varieties, through mixed systems such as crop/livestock, or processing products, and off-farm, by getting a non-agricultural job, is an important element of climate change adaptation (Thornton and Herrero, 2014).

As reported by IPCC (2014), in Africa, the primary concern is adapting to the negative impacts of climate change. In the short term, integrating climate change adaptation and disaster risk reduction will help withstand shocks to human security and economic development. The same report indicates that, African governments, businesses and communities can do much to anticipate and reduce risk, rather than reacting after impacts have occurred. Support for effective disaster relief and recovery needs to continue, along with proactive efforts to reduce risk, such as integrating comprehensive risk assessments and risk reduction measures into national economic and development policy.

The bulk of climate change impacts and thus adaptation costs will occur after 2030. For example, the annual costs for Africa in 2030, based on current policy projections, is expected to be 15 USD 2012 billion, but it is expected to grow to 35 USD 2012 billion in 2040, and to 70 USD 2012 billion in 2050. Agricultural production and wages provide a large share of household income for all farm sizes (Thornton and Herrero, 2014).

Migration can be one of ways of solving weather events and climate change impacts, and thus of reducing welfare impacts (Jülich, 2011; Black et al., 2011b; Adger et al., 2014). In that case, migration increases the set of opportunities available to an individual or household, improving well-being and prospects. However, there is some evidence that the poorest households have lower capacity to migrate, and may therefore be unable to use this option. This is also the case for households in conflict and fragile areas, or those facing exclusion.

Ethiopia is already implementing the adaptation options as reflected in its draft Climate Change Adaptation Action Plan of Water and Energy Sector, the Ethiopia's National Adaptation Programme of Action (NAPA) and Ethiopia's Programme of Adaptation to Climate Change (EPACC), the Water Sector strategy and also in the 5-year Growth and Transformation Plans (GTPs).

The following are further examples of adaptation options that Ethiopia needs to scale up to increase the resilience of the people and ecosystems by improving access to water and ecosystem services for sustainable environments and livelihoods: expansion of rainwater harvesting for groundwater recharge for cultivation through irrigation; adoption of water transfer schemes; increased storage capacity by building reservoirs and improvement of water-use efficiency (NAPA, 2007).

Ethiopia needs to adapt to climate change since its mainstay economic sector, agriculture, is highly susceptible to climate shocks. Currently, the country is implementing the Climate Resilient Green Economy (CRGE) strategy to achieve the vision of becoming a low carbon; middle income economy by 2025. This strategy will also enable the country to strengthen its capacity to adapt to the effects of climate change. The CRGE strategy is considered to be an additional positive step to resist the adverse effects of climate change and build an economy that will provide sustainable development (FDRE, 2011b, 2011f).

2.7. Conceptual Framework

Climate change has far-reaching consequences for livelihood of the households who are reliant of rainfed agricultural activities. Greater risks of crops and livestock production as a result of drought, cooling as well as heavy rain are already imposing economic losses and undermining food security. The change in frequency and intensity of drought, flooding and cooling can result in long term water and other resource shortage, worsening soil condition, diseases and pest out breaks on crops and livestock. Due to these extreme events and their subsequences vulnerable areas are expected to experience losses in agricultural productivity, primarily due to reductions in crops yields (Kurukulasuriya et al., 2003).

Climate variability is one of the all-encompassing global environmental changes that have deleterious effects on natural and human systems, economies and infrastructure. The risks associated with it call for a broad spectrum of policy responses and strategies at the local, regional, national and global level. UNFCCC highlights two fundamental response strategies: mitigation and adaptation. While mitigation seeks to limit climate variability by reducing the amount of emissions of GHG and by enhancing sink opportunities, adaptation aims to alleviate the adverse impacts through a wide-range of system-specific actions (Fussel and Klein, 2002).

The impacts of climate change on smallholder farmers, who depends only on rain-fed agriculture are among the most disadvantageous and vulnerable groups (Tetteh et al., 2014). Similar to crop productions, climate change also adversely affects livestock's productions. According to Getu (2015), agriculture is among climate sensitive sectors. The negative impacts of climate change are more severely felt by poor people in developing countries who mainly depend on the natural resources base for the livelihoods.

Climate Change and Variability

Temperature (^{0}C)

- Maximum Temp. increasing
- Minimum Temp. fluctuation
- Average Temperature

Rainfall (mm)

- Seasonal fluctuation
- Onsets late and ends early
- Decreasing in amount
- Small rain in the area

Extreme Events

- Drought
- Floods
- Frost

Social and Economic Impacts

Social Impacts

- CCV related Diseases and health problems
- Obstacle for educational services

Economic Impacts

- Failure in crop products
- Reduction of livestock products
- Income reduction

Livelihood Strategies of HH

- Diversifying income & agricultural products
- Harvesting rainwater
- Using irrigation
- Adapting to climate change and Variability
- Improving usage of water

Figure 1. Conceptual Framework for Socio-Economic impacts of CCV of the Study Area

Source: Adapted from reviewed literatures of Siraj (2013); IPCC (2013, 2014) and Nelson et al (2014)

3. RESEARCH METHODOLOGY

This chapter includes description of the study area, biophysical and socio-economic characteristics of the study area, research design, types and sources of data, sample size determination and sampling procedures, methods of data collection, methods of data analysis and ethical consideration.

3.1. Description of the Study Area

3.1.1. Location and size

Haramaya Woreda is one of the 17 Woredas of East Hararghe Zone of Oromia National Regional State in Ethiopia. It is located at a distance of 510 km Southeast of Addis Ababa along the main road to Harar town. Astronomically, the Woreda is located between 9^{0}05'00"- 9^{0}32'00" North Latitudes and 41^{0}50'00" - 42^{0}09'30" East Longitudes (Fig.2). The Woreda comprises of 35 *kebeles* and 5 urban and 30 rural *kebeles* (HDAO, 2011).

The Woreda has a total area of 521.63 km^2 and comprises three towns; namely Haramaya, Aweday and Adele. Its capital town is Haramaya which is located at 16 kms Northwest of Harar town (HDAO, 2011).

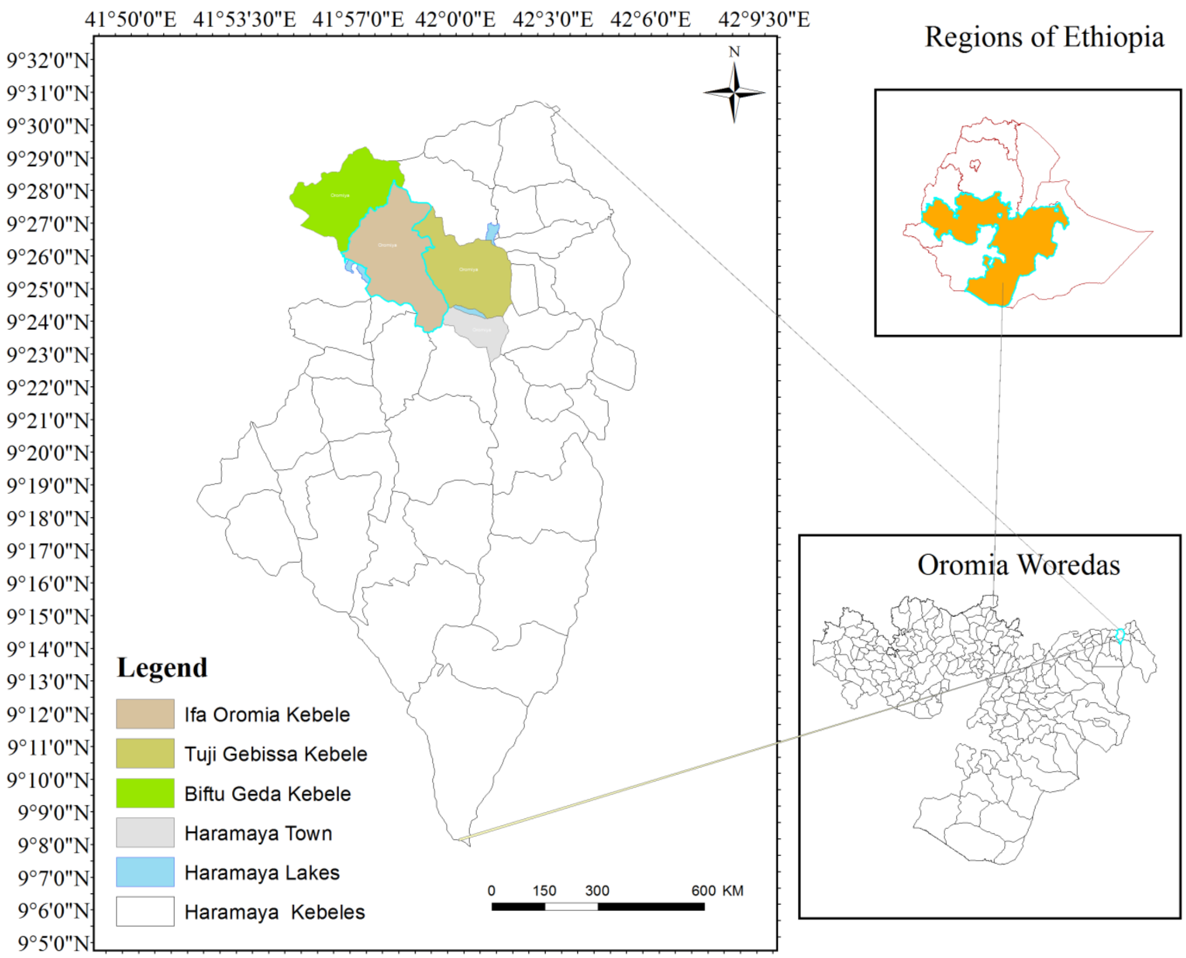

Figure 2. Map of the Study Area

Source: Own construction using Ethiopian Geographic Information System (GIS), ArcMap, Version 10.0

3.1.1.2. Relief and Soil

Haramaya woreda lies between 1900 to 2450 meters above sea level. Much of the agricultural soils in the catchments are very shallow. The texture of the soils in the watershed is grouped into four different classes: clay (14.6 km^2), clay-loam (25.7 km^2), sandy clay loam (6.1 km^2) and sandy loam (5 km^2) (Tadesse and Abdulaziz, 2009; USDA, 2014). There are five major types of soils in the catchments; namely, Lithosols, Regosols, Cambisols, Fluvisols and Vertisols. The Regosols are the dominant in the catchments while Cambisols cover larger areas around the lake from the southwest to west (Solomon, 2002; Eshetu et al., 2014).

Table 1. Area of the Woreda by Soil Texture

S. N	**Texture**	**Area(km^2)**
1	Clay	14.6
2	Clay- loam	25.7
3	Sand clay loam	6.1
4	Sandy loam	5
	Total	**51.4**

Source: USDA, 2014

3.1.1.3. Climate and Drainage

The altitudinal ranges gave the woreda *Dega* and *Woina dega* agro-ecological zones. The mean annual temperature and rainfall are 18.2^{0}C and 811.9mm respectively (Fig.3). The dry season, with relatively less than 30mm of rainfall per month, extends from October to February. The main autumn rain occurs from September to November while the smaller spring rain occurs from March to May (NMSA, 2017). Similarly, the climate of study area or *kebeles* around the Dried Lake Haramaya watershed is characterized by *Woina-dega* agro-ecological zones.

Figure 3. Average monthly Temperature and Rainfall distribution of Haramaya Woreda

Data source: NMAS, 2017

There are numerous highland lakes in Haramaya woreda, which make it unique in Eastern part of the country. These lakes are Haramaya, Adele, Tinike and Haro Jitu. Despite this fact, most of them are degraded and some are extincted and even disappeared during dry season (*bega* mostly) since last decade. However, they seasonally emerge during summer and any rainy time. Among these lakes, Lake Haramaya was the main, which was utilized for irrigation, drinking, and other domestic and industrial consumption for rural and urban communities in the woreda and nearby urban and rural (Solomon, 2002).

3.1.1.4. Wildlife

Haramaya woreda has different kind of wildlife both vegetation (natural and man-planted) and wild animals. The remnants of different types of natural and man-planted vegetation are found in the woreda. The wild animals include hyena, fox, monkey, apes, tiger, rabbits, and different species of birds, which are mostly found in the Edo Belina, Hamuma, Biftu Geda and Gobele *kebeles* of the woreda. Besides, so many different types of plant species are found in scattered way (HWAO, 2017). However, the most widely grown in the woreda is Khat (Catha edulis). This stimulant plant has many socio-economic benefits for the whole community of rural and urban areas. Farmers are expanding their farm in order to increase the income. So farmers are interested to cultivate chat instead of other crops.

3.2. Socio-Economic Characteristics

3.2.1. Demographic characteristics

The current total population of Haramaya woreda is projected 341,927 on the base of Population and Housing Census (CSA, 2007) of Ethiopia. Out of the total population, 81.2% live in rural areas while the remaining 18.8% lives in urban. In terms of sex distribution, 51% of the populations were male while 49% were female and the crude population density was 405 persons /km^2.

The majority of the inhabitants were Muslim (95.82%) followed by Orthodox Christians (3.71%) and others comprise 0.47 %. The two largest ethnic groups reported in Haramaya woreda were Oromo (96.04%), and Amhara (3.12%); the remaining made up 0.84% of the population. Afan Oromo is spoken as a first language by 95.82%, 3.62% speaks Amharic while 0.56% speaks such languages as adarigna, somaligna and guragigna (CSA, 2007).

3.2.2. Economic activities

3.2.2.1. Agriculture

The livelihood of the community in the study area is mainly based on smallholder mixed farming with crops and livestock production and to lesser extent off-farm activities, more of urban dwellers. The dominant crops grown in the study woreda are sorghum (*Sorghum bicolor* L.), and maize (*Zea mays*, L.) that are intercropped with legumes, and bread wheat (*Triticum aestivum* L.) and sweet potato (*Ipomoea batata* L.) are grown in small areas. Sorghum and maize, wheat and haricot beans are cultivated under rain-fed conditions (Liambila and Kibebew, 2016).

The major crops grown under irrigated conditions are: Khat (Catha edulis), vegetables (lettuce, carrot, onion, tomato and cabbage), and Irish potato. Khat and vegetables are the two major cash crops grown in the area. The smallholding households are highly dependent on rainfall and their farm productions are mostly for subsistence but few are and aimed at marketing by cultivating Chat and vegetables. In addition to various impediment such as high population pressure, natural disaster like frost and environmental degradation resulting to drought and poor infrastructure development have hampered the development of the sector in the Woreda (Limbila and Kibebew,2016).

3.2.2.2. Livestock husbandry

Livestock plays a great role in the social and economic life of the people of the Woreda. The livestock components are cattle, donkey, goats, sheep, and poultry. They serve as source of food and as saving asset, for draft power in agricultural activities especially for plowing, transportation, as a source of natural fertilizer (manure) for soil fertility, as a means of wealth accumulation and economic benefits. Regarding use of agricultural man power and oxen, about

44% of farmers of the woreda possessed no oxen, while 32% owned one ox, 12% owned 2 oxen, 5% owned 3 oxen and 2% of them owned 4 oxen (HWAO, 2017).

Table 2. Current Total number of livestock in Haramaya Woreda

Type of Livestock	Sheep	Goat	Donkey	Camel	Cattle	Poultry
Total	69,950	106,145	31,385	480	111,528	120,250

Source: HWAO, 2017

3.2.2.3. Non-farm activities

Non-farm is any income generating activity, which can be obtained by the households from non-agricultural activities mainly petty trade in the form of micro shops in the villages, deriving cars, brokering cattle, building houses, daily laborer and salary of government or private workers (civil servants).The households practice this activity as supportive and additional income. However, in the woreda, the number of households who are engaged in this activity is not more than 24.6% (Solomon, 2013).

3.2. Research Design

This study adopted a mixed approach, which enabled the investigator to collect relevant and adequate quantitative and qualitative data at the same time in research procedure. The design helped to analyze the quantitative and qualitative data separately and compare or combine the results so as to interpret the data and draw conclusion.

3.3. Types and Sources of Data

The data required for the study was obtained from both primary and secondary sources. The original information has been collected through questionnaire, interview, focused group discussion and personal field observation. Secondary data were collected using available sources of information such as published and unpublished documents. This includes data from Haramaya Woreda Agricultural office, National Metrological Agency, Haramaya Woreda and

Town education Administrative offices, government health office and Hospital, Central Statistical Agency, and published and unpublished documents in Haramaya University.

3.4. Sample size Determination and Sampling Procedures

Purposive sampling technique was used to select four *kebeles,* out of 35 in Haramaya woreda. In these sample *kebeles*, smallholding farmers might have been affected by climate change and variability for their agricultural activities than the rest *kebeles* because they were the most users of surface and underground water in the Lakes of Haramaya and Adele for irrigation purpose. This was the reason why the investigator was interested to focus on these *kebeles*.

Before selecting representative sample, the investigator identified total household heads in collaboration with the Woreda's Agricultural Extension Office as shown in Table 3.

Table 3. Total Population and drawn Sample Size of Household Heads by *Kebeles*

S.N	*Kebele* Administration	Total Users (N)	HHs (N)	% of Sample to total population
1	Tuji Gebissa	668	100	15
2	Ifa Oromia	155	23	15
3	Biftu Geda	146	22	15
4	Haramaya Town 02 *kebele*	25	5	20
Total		**994**	**150**	**65**

Source: Own Field Survey, 2016

Out of total users of the Lakes (Haramaya and Adele) for irrigated agriculture in the targeted *kebeles*, 150 household heads were selected using simple random sampling technique taking into account probability of samples included proportional to size of population (Table 3). This study applied a simplified formula provided by Godden (2004) to determine the required sample size.

$$SS = \frac{Z^2 x(P) x(1-P)}{C^2}$$

Where, **SS** is the Sample Size for Finite population (where the population is less than 50,000),

$$\text{New SS} = SS/\left(1 + \frac{(SS-1)}{Pop}\right)$$

Z is confidence level of Z-value (e.g.1.96 for a 95 percent confidence level);

P is percentage of population picking, expressed as decimal (0.15); and

C is confidence interval expressed as decimal (0.05).

$$\text{New SS} = SS/\left(1 + \frac{(SS-1)}{Pop}\right)$$

$$SS = \frac{Z^2 \text{ x } (p) \text{ x } (1-p) =}{C^2} \quad \frac{(1.96)^2 \text{ x } (0.15) \text{ x } (1-0.15) =}{(0.05)^2} \; 166.5$$

The above formula required a minimum of 166 respondents but due to homogeneity of household heads in their socio-economic aspects, this study was carried out on 150 respondents.

3.5. Methods of Data Collection

3.5.1. Questionnaire

Questionnaire was one of the principal tools used to gather data from respondents. It was prepared in English and translated in to Afan Oromo language in which both open and closed-ended format of questions have been incorporated and has been distributed to predetermined 135 respondents to collect quantitative and qualitative data. Pilot study was undertaken in a *kebele* inside of the study area before distribution of the main questionnaire and helped the investigator to get socio-economic information in the targeted *kebeles* and to modify the instrument based on the experience gained during the pretest.

The instrument helped the respondents to select responses from the provided alternatives and also it provided them with opportunities to express their long experiences, opinions and views regarding socio-economic impacts of climate change (Kothari, 2004). Besides, the investigator has used the instrument because it was easy to administer, less expensive and provided a wide coverage of data.

3.5.2. Interview

This study has used an interview as another principal tool to extract information upon face-to-face basis between an interviewee or a respondent and the interviewer. It is a straightforward and less problematic way of finding things out (Robson, 1995). The interview (both structured and semi-structured) was made with 15 households heads (12 educated farmers and 3 civil servants) based on their educational status. The reason for purposely selecting these respondents was that they were believed to have better understanding about climate change and variability and its socio-economic impacts. The discussion has been conducted about socio-economic impacts. The main purposes of conducting interview were to clearly understand the perception of the sample household heads on socio-economic impacts of climate change and variability the responses of the community, government and NGOs. In addition, it was used to triangulate the household survey.

3.5.3. Focus group discussion

Focus group discussion (FGD) was another instrument used to collect quantitative and qualitative data from predetermined 8 key informants (selected from the targeted *kebeles* proportionally), who were believed to have better knowledge on the issue and different from an interview. The discussion has been conducted about socio-economic impacts of CCV on the households among 2 elders, 2 officials (chairmen) of *kebeles*, 2 model farmers, 2 staff of the agriculture and rural development in the same time.

3.5.4. Field observation

Transect walks across the selected *kebeles* were conducted in order to obtain all necessary physical information. This technique involved semi structured interviewing with villagers meet during transect wakes and helped to acquire useful and detailed information. So the investigator has systematically and carefully observed physical socio-economic aspects of the households in relation to climate change and Variability. The investigator has used check list during field observation (Appendices IV).

3.6. Methods of Data Analysis

After have been collected, data were organized, tabulated, and presented in climagraphs. Then quantitative data have been edited, coded and entered into Statistical Package for Social Sciences (SPSS) 20.0 version in order to analyze by using descriptive statistics like percentages.

Inferential Statistics was applied to conduct paired t-test to compare amount of variation of crops, vegetables and livestock products before 10 years and current time in relation to effects of local climate change and variability. In other way, one way ANOVA analysis (independent F-test) was applied to check whether there was significant difference among crops between past 10 and current year (2016/17). The qualitative data were analyzed by using narrative quotes, words and sentences and interpreted.

3.7. Ethical Consideration

According to Bell (2004), research ethics is a type of agreement that researcher enters into with his or her research respondents. In this case, he or she has to reach on an agreement with respondents based on the objective and propose of data collecting. All participants are offered the opportunity to have adequate awareness and that information they give is treated with restricts confidentiality. Based on this theoretical framework, the investigator has attempted to contact sampled households in order to keep prior permissions to administer all types of data collection instruments. For this effect, the investigator has provided the respondents with all necessary respect and has given them full assurance that the information was used strictly for academic purpose.

4. RESULTS AND DISCUSSION

This chapter deals with presentation, analysis and interpretation of the collected data from sample household heads, key informants and participants of focus group discussion by employing questionnaire, interview and FGD. In addition, some relevant data were gathered through field observation. An attempt has been made to identify the observed temperature and rainfall changes and their impacts. Finally, efforts were made to display the data by using climagraphs, tables and figures, which made the results more clear and precise, so that it could be easily understandable.

4.1. Background of Sample Household Heads

4.1.1. Demographic Characteristics of Sample Household Heads

According to Table 4, about 97.3% of sample Household heads were male-headed and the remaining 2.7% were female-headed household heads (HHs). Age distribution of the respondents ranged from 25-73 years and the average age was 43 years old. Although the average family size of the sample household heads is 6, the absolute size of them ranged from 1 to 12 members. According to report of CSA (2012), the average size of family members is slightly greater than that of Oromia (4.8) and the national (4.7) ones.

Table 4. Demographic Characteristics of Sample Household Heads

Variables		Frequency	Percent
Sex of HHs	Male Female	146 4	97.3 2.7
	Total	**150**	**100**
Age of HHs	20-30 31-45 46-65 Above 65	5 82 56 7	3.3 54.7 37.3 4.7
	Total	**150**	**100**
Family Size of HHs	1-3 4-6 7-9 Greater than 10	25 91 27 **7**	16.7 60.7 18 4.7
	Total	**150**	**100**

Source: Own Field Survey, 2017

4.1.2. Socio-Economic Characteristics of Sample Household Heads

As depicted in Table 5, out of the total, 94.7% of the sample household heads were married, 1.3% were equally widowed and divorced while 2.7 % of them were single. Regarding ethnic composition, 98% of the sample household heads were follower of Islam and 2% Orthodox

Christianity. In terms of educational status, the great majorities of the sample household heads (82.7%) were illiterate with no formal education, while 8.7% of them were able to read and write. On the other hand, 4.7% and 1.3% of the household heads have completed grade 1-8 and 9-10 education respectively, whereas,1.3% of them were equally diploma and 1st degree holders.

Regarding income of the sample household heads, it was difficult to establish because the household heads could hardly tell sincerely their household earnings. However, an attempt had been made to know their income by asking the current amount of agricultural production (crops, livestock and vegetables) per year and converting it into Ethiopian birr based on the current market price. Accordingly, the income distribution of the sample household heads ranged from 12,000-170,000 Ethiopian birr with an average income of 38,870 and 3,239 birr per year and month respectively.

Table 5. Socio-Economic characteristics of Sample Household Heads

Variables	Frequency	Percent

Marital Status of HHs	Married Single Divorced Widowed	142 4 2 2	94.7 2.7 1.3 1.3
	Total	**150**	**100**
Ethnicity of HHs	Oromo Amhara	148 2	98.7 1.3
	Total	**150**	**100**
Religion of HHs	Muslim Orthodox	147 3	98 2
	Total	**150**	**100**
Educational levels attained by HHs	Cannot read and write Read and Write Grade 1-8 completed Grade 9-10 completed Diploma holder 1st degree holders	124 13 7 2 2 2	82.7 8.7 4.7 1.3 1.3 1.3
	Total	**150**	**100**
Current annual income of HHs	12,000-36,000 36,012-60,000 60,012 and above	13 118 19	8.6 78.7 12.7
	Total	**150**	**100.00**

Source: Own Field Survey, 2017

4.1.2.1. Types of Crop Production

As indicated in Table 6, of total sample respondents, 98%, 87.3% and 93.3% regularly and mainly cultivate chat, maize and sorghum as food crops on their farms respectively. Moreover, as additional responses obtained from the interviewed groups reveal, the sample household heads sometimes grow pea, wheat and soybean and among these crops, chat is grown as cash crop and use as main source of family's income. These crops shared 70% of households' income (HWAO, 2017). Regarding earning, average monthly and annual income derived from crop products was 3,300 and 40,000 Ethiopian birr respectively.

Table 6. Distribution of Sample Respondents by growing Crops

S. N	Type of crop cultivated	Number of Households (N=150)	Percent *
1	Sorghum	140	93.3
2	Maize	131	87.3
3	Chat	147	98
4	Wheat	5	3.3

Source: HWAO and Own Field Survey, 2017; *NB: percent include multiple responses

4.1.2.2. Types of Major Vegetables Production

As can be seen from Table 7, the sample household heads reported that they have been growing different type of vegetables on their farm plots by using irrigation mainly for purpose of cash. They also stated that their interest was increased in the past 10 years than before 10 years due to availability of farm land on dried parts of the nearby lake and high demand of the products on the local markets. According to report of HWAO (2017), before 10 years, the household heads produced potato, sweet potato and onion but in the past 10 years the production was diversified in kind and increased in amount due to the stated factors. Average monthly and annual income derived from vegetable products was 128 and 1,540 Ethiopian respectively.

The above finding is similar with other studies, for instance, Alemayehu et al., (2010) reported that various types of vegetable crops are grown in Ethiopia under rain-fed and/or irrigation systems. The major economically important vegetables include hot and sweet peppers, onion, tomato, carrot, garlic and cabbage. In 2013 for example, Ethiopia exported 220,213 tons of vegetables and generated USD 438 million (Ethiopian Revenue and Customs Authority, 2013).

Table 7. Major Types of Vegetables grown by the Sample Household Heads

S. N	Types of Vegetables grown	Average amount of production in kg
1	Carrot	15
2	Potato	21
3	Cabbage	7
4	Onion	13
5	Beet root	15
6	Sweet potato	1.5
7	Salads	10

Source: HWAO and Own Field Survey, 2017

4.1.2.3. Livestock Husbandry

Table 8 depicts that the sample household heads rear different types of livestock. Out of the total sample household heads, 59%, 85%, 39%, 64.7% and 81% rear/have oxen, cow, sheep, goat and donkey respectively. On average, monthly and annual income gained from livestock products was 1,468 and 17,620 Eth. Birr respectively. Moreover, this economic activity shared 23% of the households' annual income (HWAO, 2017). This finding is in contrast with study report of Leta and Mesele (2014) in terms of proportion of possessing livestock and its share of annual income in the study area. The researchers stated that livestock keeping is of large importance for both the livelihoods and the national economy of Ethiopia.

Table 8. Major Types of Livestock of the Sample Household Heads

S. N	Livestock	Number of Households (N=150)	Percent
1	Oxen	89	59
2	Cow	128	85
3	Sheep	59	39
4	Goat	97	64.7
5	Donkey	122	81

Source: HWAO and Own Field Survey, 2017

4.1.2.4. Types of Non-Fram Activities

Respondents were also asked to identify what type of non-farm activity they practiced. Accordingly, the activities were: Petty trading 14%, daily laborer 4%, possessing cars 2.7%, broker (commissioner) 2 % and civil servants 2%. Of these activities, petty trade together with wage labour shared 7 % of annual income of the households (HWAO, 2017).

Table 9. Sources of Non-farm Income of Sample Household Heads

S. N	**Non-farm income**	**Frequency**	**Percent**
1	Petty trading	21	14
2	daily laborer	6	4
3	Driving cars	4	2.7
4	Broker	3	2
5	Civil servant	3	2
	Total	**37**	**24.7**

Source: HWAO, Own Field Survey, 2017

4.1.2.5. Types of Housing Amenities possessed by Sample Household Heads

As an assessment reveals that most of the sample households (91%) had water pumping motors for the sake of irrigated vegetables production and followed by Television, tractor, car and refrigerator and fixed line phone.

Table 10. Types of Housing Amenities of the Sample Household Heads

List of the households' amenity	**Number Households (N=150)**	**Percent**
Tractor	3	2.2
Water pump motors	123	91
Car	3	2.2
Fixed line phone	1	0.7
Refrigerator	3	2.2

TV	9	6

Source: Own Field Survey, 2017

4.2. Temperature and Rainfall Patterns of Haramaya

In general, meteorological stations in Ethiopia are few in number and data for most of the stations like that of Haramaya is very scant and incomplete. There is one meteorological station in Haramaya Woreda which is found in campus of Haramaya University. Since recording instruments are not fully functional, for its completeness the station sends climate information to National Meteorological Service Agency (NMSA), Jigjiga branch, which is located in southeast of the study area at 119 km distance. Thus, for this study, monthly rainfall and maximum and minimum temperature data of 31 years (1986 - 2016) were obtained from this branch.

4.2.1. Temperature Variability and Trends

According to NMSA (2007), the average annual minimum temperature over the country has

increased by about 0.37°C, whereas, average annual maximum temperature has increased by

about 0.1°C every decade (NMSA, 2001). Similarly, temperature distribution in Haramaya

woreda was characterized by a general trend of increasing in average maximum and annual temperature in the past three decades while the minimum one shows variation in the past two decades.

As depicted in figure 4, the average of maximum temperature was increased by about 0.43^0C within a decade (1996-2005) based on baseline of the past decade (1986-1995) and followed by 0.56^0C (2006-2016), while average of minimum temperature has decreased by about 0.61℃ within a decade (1996-2005) and increased by about 0.12^0C (2006-2016).Therefore, from this trend analysis, one can say that average increment of maximum temperature is above, whereas, the minimum one is below the national ones.

In Haramaya woreda, temperatures shows significant increment in its average maximum, minimum and mean annual temperature by about 0.56^0C, 0.12^0C and 0.32^0C respectively over the last decade when compared with the previous two decades. As shown in Table 11, a cooling of air temperatures in late November to December occurred per year for instance in 1986, 1988, 2005,2007,2009,2011, and 2016 which was less than 2^0C in monthly average while few days within the months experienced up to -2^0C such as in 2016 (Appendix Table 4).

Table 11. Minimum Average Monthly Temperature Recorded in the past three Decades

Year	Month	Average Monthly/daily Temperature(^{0}C)
1986	December	-1.3
1988	November	1.1
2005	December	1.7
2007	December	1.6
2009	November	1.4
2011	December	1.8

2016	December 31 day	-2

Source: NMSA, 2017

Figure 4. Annual Temperature Patterns and Trends of Variability

Source: Computed from data NMSA, 2017

4.2.2. Annual rainfall variability and trends

As reported by NMSA (2017), the distribution in the average annual rainfall of Haramaya woreda over the last three decades (1986-2016) was uneven. The total annual rainfall ranges between 116.8mm as the minimum and 1176.6mm as maximum for the past 31 years respectively. Analysis of bar graph trends of annual rainfall indicates variability and yearly fluctuation in the woreda. The inter-annual patterns of rainfall distribution show that annual amounts were far above and below the average in 2013 and 2012 respectively (Figure 5).

The same report revealed that there was high annual, seasonal and monthly variation or fluctuation of rainfall within the past three decades. Particularly, on average, it was decreased by 10.12mm from 797.52mm (1996-2005) to 787.4mm (2006-2016). In the study area, the common dry seasons were winter and autumn, while summer and parts of spring were the wettest seasons. In terms of annual distribution, the highest amount was reported 1176.6mm in 2013 followed by 1011.8mm in 1997 and in contrast, the area experienced the lowest amount 116.8mm in 2012 (Appendix Table 4).

Rainfall variability is the major source of risk for farmers who depend on crop production. There are two important rains in Ethiopia- the 'Kiremt' and 'belge'. The belge rains usually begin in March and May in South West and advancing northwards affecting most of the country from July through September. The kiremt rain constitutes about 90% of the crop production harvested during October -December (CSA, 2011).

Figure 5. Annual Rainfall Patterns and Trends of Variability

Source: Computed from data NMSA, 2017

In the case of pattern of mean monthly rainfall distribution, 7/12 months (MAMJJlAS) received relatively higher amount of mean monthly rainfall (56-142mm) whereas the other 5/12 (42%) of months received relatively low amount of mean monthly rainfall (14-45mm) in the last three decade (Figure 6).

Figure 6. Distribution of Mean Monthly Rainfall of Haramaya Woreda

Source: NMSA, 2017

The pattern of seasonality was determined by computing the value of rainfall concentration (RC) for each month based on the method employed by Daniel (1977). According to Table 3, Haramaya woreda received small rains in 6/12 (FMMAON) as the RC is 0.6-0.9 (50%); big rainy months were April, June, July and September (RC>1) whereas, dry months <0.6 were December and January which require additional water supply to supplement life and livelihood activities of the community. In general, the majority of months for 31years (FMMAON) were small rainy periods for their RC >0.6. Only four of them (AJJlS) were with relatively big rainy months as their RC=>1.0. Haramaya area received small rains with moderate concentration during April, June, July and September for their RC>1 while summer (JJA) season experienced relatively high concentration of big rains.

Table 12. Mean Monthly Rainfall Concentration of Haramaya

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
P	14.24	23.23	58	126	104	57.6	112	142.3	126	46.2	26.04	20.64
RC	0.5	0.9	0.9	1.0	0.9	1.0	1	0.9	1	0.9	0.7	0.5
Desg	Dry	Rainy	Rainy	BRM	Rainy	BRM	BGM	Rainy	BRM	Rainy	Rainy	Dry

Source: NMSA, 2017

When the seasonal distribution of rainfall of Haramaya concerned, the summer season received about 38% followed by spring received 35% of the total rainfall while the rest autumn and winter season received 23 % and 4% respectively.

Figure 7. Percentage Distribution of Seasonal Rainfall of Haramaya Woreda

Source: NMSA, 2017

Regarding rainfall variability, the average annual rainfall of Haramaya woreda ranged between the 116.8mm (the lowest) and in 2012 to 1176.6mm in 2013 (the highest) with the difference of 895mm. There was great deviation of rainfall from decadal mean which ranged between 20.49mm (February) and 95.65mm (December). On other hand, based on Coefficient of Variation (CV), there was high variability of rainfall of months. According to COMES et al (2009), 58.3%, 25% and 8.8% of a year experienced high, medium and low rainfall variability respectively over the study period (1986-2016). This is further substantiated by observing the distribution of CV, which ranges from 0.4 (March and August) to 4.6 (December) and the yearly average was 1.2 (Figure 8).

Figure 8. Monthly Coefficient of Variation of Rainfall of Haramaya Woreda

Source: NMSA, 2017

4.3. Perceived Features of Climate Change and Variability by Respondents

4.3.1. Major Features of CCV as Perceived by Respondents

Regarding rainfall pattern of the study area, most of the respondents (86%), perceived well that the current amount of rainfall is decreasing while the remaining (14%) reported as it is decreasing significantly. In other way, about 91.3% of the sample households replied that rainfall onsets late and ends up early whereas the remaining 8.7% said it onsets on time but ends up early. These statistically analyzed results were strengthened by additional information gathered through semi-structured interview (under the same questions) that the interviewees stated that:

> "*We do not know what is happening to our area, many things are changing .Of these, the size of lakes have also reduced and disappeared ; rain has been reduced and changed its pattern. This means rainfall does not come on time; it is very small which can not support our agricultural activities and in contrary to this, sometimes unusual heavy rain was seen. Overall its time was disturbed".*

Therefore, one can conclude from the given responses and analysis of rainfall data (appendix Table 4) that the shortage and fluctuation of monthly, seasonal and annual rainfall had great impact on the socio-economic aspects of the households in the study area.

Table 13. Perceived Feature of Changes in Rainfall by Sample Household Heads

Options	Frequency	Percent
It is decreasing in amount	129	86
It is decreasing significantly in amount	21	14
Total	**150**	**100**
It onsets on time but ends up early	13	8.7
It onsets late and ends up early	137	91.3
Total	**150**	**100**

Source: Own Field Survey, 2017

4.3.2. Perception of Sample Household Heads on Extreme Events of CCV

As shown in Table 14, there was general consent among a great majority of sample household heads that about 98%, 88%, and 78% of them strongly agreed upon existence of frost, drought and shortage of animal feed respectively while 80.7%, 95.3% and 84.7% of them agree upon occurrence of pest and disease, siltation of lake water, flooding of vegetables respectively. Additional information obtained from interviewees and participants of FGD also reveal that drought and frost were the two dominant weather events which occurred repeatedly in the study area.

Table 14. Perception of Sample Household Heads on Extreme Events of CCV

S.N	Climatic Variable	Strongly Agree		Agree	
		Frequency	Percent	Frequency	Percent
1	Siltation and shrinking of lake water	-	-	143	95.3
2	Pest and disease	-		121	80.7
3	Drought	132	88	-	-
4	Frost occurring	147	98	-	-
5	Covering of vegetables by the lake water	-	-	127	84.7
6	Shortage of animal feed	117	78	-	-

Source: Own Field Survey, 2017

4.3.3. Respondents' Awareness about Socio-Economic Impacts of CCV

The survey data in Table 15 depicts that about 92% of the sample household heads reported that there was impact of climate change and variability around their living environment. In contrast, the remaining (8%) had no understanding of the change and its impacts. The result of this study goes with the finding of the World Bank (2010), i.e., Ethiopia is socio-economically vulnerable to climate change. Rapid population growth and expansion of agriculture in a potentially drier and certainly warmer climate could dramatically increase the number of people at risk. Just as the country is heterogeneous in topography and climate regime, it is also heterogeneous in social, cultural and economic factors. The degree of vulnerability of different localities and their livelihoods varies accordingly.

In addition to interview conducted with predetermined respondents, the key informants narrated that there was great change in households' livelihood in general and agricultural yield variation in particular in the past 10 and current year. For instance, two key informants (an elder and a model farmer) stated about the past as:

> "*Since lived for more than 65 years here in Haramaya Woreda; we are eye witness that before 10 years this environment was very attractive and provided the surrounding communities and others with very cheap service such as recreation through swimming and washing in the lake. Moreover, we had gotten more agricultural products with low efforts and cost because there was good rainfall; suitable climate and lake water. But in the past years, we harvested agricultural yields by great production costs such as digging underground water up to12 meters and then pumping it over a distance by motors; cooling of temperature this year and drought last year affected our products and exposed us to receive aids. So we can say that we never get the past life again".*

Table 15. Awareness on Impacts of Climate Change by Sample Household Heads

Options	Frequency	Percent
Yes	138	92
No	12	8
Total	**150**	**100**

Source: Own Field Survey, 2017

4.3.4. Economic Impacts of Climate Change and Variability

4.3.4.1. Impacts on Crops Production

As it is depicted in Table 16, a great majority of the sample household heads (90%) replied that they gained low amount of yields from crops in this year (2016/17) when compared to the past 10 years. The remaining (10%) said that the amount of the yields were medium. The reason, as they stated, was occurrence of severe frost which damaged almost all chat plants and partly sorghum. Moreover, additional responses obtained from interviewees and FGD participants strengthen the analyzed results that current year was unique within 10 years in that the main livelihood of the households (chat and vegetables) were devastated by frost and made them vulnerable to aids.

Table 16. Comparison of Current Agricultural Yield with that of Past 10 Years

Options	Frequency	Percent
Medium	15	10
Low	135	90
Total	**150**	**100**

Source: Own Field Survey, 2017

An attempt was also made to compare the amount of products in the past 10 years and the current year (2016/17). Accordingly, all respondents stated that relatively good productions were obtained from different types of crops in the past 10 years than before 10 years due to improvement of different agricultural infrastructures. But currently (2016/17) low amount of yields except maize, which was harvested before occurring of frost, was harvested due to impact of local climate change and variability (Table 18). But, one way ANOVA indicates that there is no significant means difference among products of the main three crops ($F=2.810$, $P=0.205$, Appendix Table 5).

In Haramaya woreda in general and study area in particular nearly half of sorghum and almost all chat crops were highly damaged by severe frost which was -1.0^{0}C to -2^{0}C (Table 17). When compared the past 10 years crop products with that of the current year, high percentage of difference was identified. This means extreme events made sample household heads to loss their product of sorghum and chat by about 43% and 67% respectively (Table 18).

Table 17. Minimum Temperature recorded in December of 2016

Day	10	11	12	13	31
Temperature (^{0}C)	-1	-1	-1.5	-1.5	-2

Source: NMSA, 2017

The above finding is similar with reports of other studies on the issues of frost. For instance, the incidence of frost damage to field and vegetable crops in the lower positions of the sub-catchments in the highlands of East Hararghe is often taken for granted with varying degrees of severity from year to year. The first incidence occurred between late October and mid to late November with some deviations depending on localities, and caused severe damage on field crops (mainly sorghum and late planted beans) and some vegetable crops (Alemaya University, 2005).

Regarding earning, respondents were asked to compare their average income derived from crop products; as a result they told that they had gained 12,395 and 19,710 Ethiopian birr in the past 10 years and current year respectively. This statistical data was supported by report of HWAO (2017).

Table 18. Comparison on Crop Products between Past 10 Years and Current Year

S.N	**Type of crop**	**Average amount in quintal**	**F-independent test**

		In the past 10 years	Current year (2016/17)	F-value	p-value
1	Maize	15	11	2.810	0.205**
2	Sorghum	30	13 (decreased by 43%)		
3	Chat	52 kg	17 kg (decreased by 67%)		

Source: HWAO and; Own Field Survey, 2017 NB** Insignificant at p>0.05

4.3.4.2. Impacts on Production of Vegetables

As indicated in Table 19, about 94% of sample household heads said that frost occurred late October to December of 2016 damaged many types of the vegetables. In contrast, about 6% of the respondents reported as no frost damaged their vegetables. Moreover, interviewed group and FGD participants reported that frost caused severe damage on almost all vegetables. The same result was obtained from field observation.

Table 19. Responses of Sample Household Heads to Occurrence of frost and its effect

Options	Frequency	Percent
Yes	141	94
No	9	6
Total	**150**	**100**

Source: Own Field Survey, 2017

In relation to the above responses, survey data in Table 20 show that there was difference in average amount of vegetable products between the past 10 years and a current time as a result of effects of frost and also statistical test at confidence interval of 95% indicates that there is significant mean difference between average amount of vegetable products (t=6, p= 0.001, Appendix Table 6). However, the households gained 1,235, and 1,540, Ethiopian birr in the past 10 and current year respectively.

Table 20. Comparison between Past 10 and Current Year Products of Vegetables

S. N	Vegetable type	Average Amount in kg		Paired T-Test	
		In the past 10 years	Current year (2016/17)	t-value	p-value
1	Carrot	23	15	6	.001**
2	Potato	32	21		
3	Cabbage	11	7		
4	Onion	20	13		
5	Beet root	22	15		
6	Sweet potato	3.5	1.5		
7	Salads	15	10		

Source: Own Field Survey, 2017; **Significant at $p<0.05$

According to report of HWAO (2017), frost occurred in the late November and December caused severe damage on vegetables. Although these data were reported as woreda, the study area shares more than 90% because; the production of vegetables was mainly practiced by using irrigation around Haramaya and Adele Lakes.

Table 21. Frost affected Type and Amount of Vegetables in Haramaya Woreda

S.N	Vegetable type	Land in hectar	Estimated Amount damaged in quintal/kg	No of HHs affected		
				M	F	T
1	Chat	1022	478	4150	128	4278
2	Potato	511	239			
3	Beet root	83	15kg			
4	Cabbage	60	24.15kg			
5	Sweet potato	46.5	7050 kg			
6	Salads	10	15kg			

Source: HWAO (Irrigation), 2017

4.3.4.3. Impacts on Livestock Husbandry

Regarding an average number and type of livestock reared by the sample households; field observation and record report of the woreda (HWAO, 2017) showed that the respondents reared a few number of livestock due to shortage of grazing land and experience of the community. As revealed in the Table 21, there is small difference in average number of livestock before 10 years and current time due to aforementioned reasons but the current market price of this product is greater than that of the past years. Moreover, statistical test at confidence interval of 95% (independent paired t-test) indicates that there is significant mean difference between average number of livestock owned by the sample households in the past and current year (T=4, P= 0.016, Appendix Table 7).

According to responses of the respondents, an income obtained from livestock product was not free from impact of climate change particularly during dry seasons (winter and autumn) due to shortage of animal feeds (Appendix Table 4). The average income the sample household gained from this product before 10 years and in the current year was about 11,800 and 17,620 Ethiopian birr respectively.

Therefore, from overall analysis, one can say that impact of climate change and variability on livestock production was relatively low when compared with that of crops and vegetables. This finding is consistence with that of Gashaw et al., (2014), that limited resources and higher temperatures directly impact livestock's health and productivity and indirectly can magnify existing tensions over land and water. Loss of livelihoods and forced migration are also concerns, as crop and livestock mortality are expected to decrease incomes by 19–30 percent.

Table 22. Comparison between Past and Current Year Products of Livestock

S.N	**Livestock type**	**Average Number of livestock**				**Paired T-Test**	
		Before 10 years	**Average income**	**Current year(2016/17)**	**Average income**	**T-valu e**	**P-value**
1	Oxen	2	11,800	1	17,620	4.000	0.016**
2	Cow	3		2			
3	Sheep	3		2			
4	Goat	4		3			
5	Donkey	1		1			

Source: HWAO, 2017; NB** Significant at p<0.05

4.3.4.4. Impacts on Households' Amenities

As an assessment reveals in Table 24, most of the sample respondents (91%) had water pumping motors for the sake of irrigated vegetables production and followed by TV, tractor, car, refrigerator and other assets. Concerning impacts of climate change and variability on these assets and others, about 64 % of the sample respondents said the great impacts of CCV that faced them were directly related to income. In contrast, about 36% of the participants had no information about the impacts (Table 23). Besides, the interviewed respondents and FGD participants said that sever frost had all rounded negative effects on their livelihood in general and assets in particular.

Table 23. Responses of Sample Respondents to Effect of frost on Housing Amenities

Options	Frequency	Percent
Yes	96	64
No	54	36
Total	**150**	**100**

Source: Own Field Survey, 2017

As the majority stated, in a year of good income obtained from different agricultural products, they would have a lot of assets and vice versa. Besides, the interviewees and FGD participants stated that:

> "*Although we had many different types of agricultural instruments, water pumping motors by which pump underground water for the sake of irrigation were the primary tool for our livelihood. So without adequate income we could not buy these motors and other assets*".

The above finding is consistence with that of Asfaw et al., (2015a), they conclude that the effects of climate change can result in changes in agricultural incomes, food markets, prices and trade patterns and investment patterns. At farm level, the impacts can reduce incomes and even affect physical capital by forcing farmers to sell productive capital, for instance cattle, to absorb income shocks.

Table 24. Types of Housing Amenities of the Sample Household Heads

List of the household amenity	Number of HHs (N=150)	Percent
Tractor	3	2.2
Water pump motors	123	91
Car	3	2.2
Fixed line phone	1	0.7
Refrigerator	3	2.2
Television(TV)	9	6

Source: Own Field Survey, 2017

4.3.5. Social Impacts of Climate Change

4.3.5.1. Impacts on Human Health

As survey shows, out of the total, 69% of the sample respondents reported that climate change had significant impacts on their health through spearing of climate change related diseases. For instance, pneumonia and common cold were very common particularly during cooing of temperature and rainy times followed by diarrhea and asthma. Moreover, discussants said that climate change affected their health which range from bad feeling to death.

Table 25. Perception of Sample Household Heads on CCV induced Health Problems

Options	Frequency	Percent
Presence of health problem	104	69
No response	46	31
Total	**150**	**100**

Source: Own Field Survey, 2017

According to record report of Haramaya Hospital (2017) and local clinics, climate change had considerable impacts on health of the surrounding communities in different age groups and in different seasons and/or throughout the year (Table 26). Climate change related problems of human health include sever acute pneumonia and malnutrition, diarrhea, common cold and so no. Therefore, from these evidences, one can infer that CC had direct negative impacts on health and indirect effects on socio-economic life of the surrounding households.

The current finding is consistence with other studies, for instance WHO (2015), stated that Ethiopia has a high incidence of climate-sensitive diseases. Roughly 70 percent of the population lives in malaria-endemic areas and outbreaks that occur every 5 to 8 years account for up to 20 percent of deaths for children under the age of 5. Increased temperatures will likely expand the range of malaria to highland areas and increased flooding which will facilitate the spread of waterborne diseases like diarrhea. More than 70,000 deaths annually are tied to indoor and outdoor air pollutants, which a hotter, more drought-prone climate will aggravate.

Table 26. Some of Top Ten Diseases affecting Health of Surrounding Communities

Common types of diseases	Month of a years	Season of Occurrence and Reasons	Number of in patients Treated (2016-17)
Sever acute pneumonia	June, July, August	During summer by cool temperature	52
Sever acute malnutrition	Dec. Jan. and February	During winter by lack of food	25
Diarrhea	Throughout the year	All seasons due to water born diseases	37
Measles	Throughout the year	All seasons because of lack of environmental sanitation	32
Common cold	Winter	Raised by cool weather conditions	46
Asthma	During summer and winter months	During summer and winter arisen by cool weather conditions and presence of dust particles respectively	23
Malaria(acute fever)	Throughout the year	Due to presence of stable Korke river	18
Tuberculosis	Summer and autumn months	During rainy times due to lack of personal hygiene	11

Source: Record of Hospital of Haramaya, 2017

4.3.5.2. Impacts on Education

In the study area, survey was done in some schools (two elementary and one secondary) both in town and rural area to identify impacts of climate change and variability on education. In these sample schools, three directors said that:

> " *there were climate change related problems on the process of teaching and learning such As late coming and absenteeism of the students were widely observed particularly during cooling of temperature, rainy and relatively high temperature occurring months".*

Regarding weight of impact of local climatic conditions, about 55% of the students were out of the class in the first and second periods as a result of cooling from October–December and absent from January-April because of increasing of temperature (Table 27). Likewise, absenteeism in the afternoon shift from March-May due to sowing times that the students help their family and also May-June late coming and absenteeism was experienced due to presence of rain which sometimes makes the road too muddy and difficult to come to schools.

In addition, participants of FGD stated that impacts of relatively high temperature forced some schools to change shift from afternoon to morning. Therefore, from this survey result, one can conclude that impact of local climate conditions had negative effects on the process of teaching and learning in general and academic achievements of the students in particular.

Table 27. Months of Local Climate Change and Variability Its impacts on Education

Month	Type of problems on education	Nature of Local climate change	Estimated Percent of students
Late October to December	Late coming to school	Cooling of temperature(frost)	55
January to April	Absenteeism(particularly afternoon shift)	High temperature	35
March to May	Absent to help family (sowing time)	Rainy times	45

May to June	Late coming and absenteeism	Rainy condition	30

Source: Own Field Survey, 2017

4.4. Adaptation and Mitigation Strategies Designed by Sample HHs

An assessment on adaptation and mitigation strategies designed by sample household heads indicates that the sample household heads have well developed experiences of applying different means of adapting and copying socio-economic impacts of climate change. Among the main strategies, about 74.7%, 58.7% and 50.7% were using underground water, changing growing and harvesting time and growing short maturing crops and vegetables respectively while considerable number of sample households used different methods as indicated in Table 28.

The above finding is similar with other studies, for instance, Thornton and Herrero (2014), stated that non-agriculture-based livelihoods are likely to play an increasingly important role in building resilience among agricultural populations due to climate change impacts. Diversification of farms with increased number of varieties, using mixed systems such as crop/livestock, off-farm, by getting a non-agricultural job is an important element of climate change adaptation. Farmers can adapt to shorter and more variable growing seasons by choosing drought resistant or shorter maturing crops and varieties and adjusting planting dates (Niang et al., 2014).

Table 28. Adaptation and Mitigation Strategies Designed by Sample Household Heads

S.N	Adaptation Methods	Frequency	Percent
1	Using underground water	112	74.7
2	Changing growing and harvesting time	88	58.7
3	Growing short maturing crops and vegetables	76	50.7
4	Using improved seeds	41	27.3
5	Diversifying agricultural production	21	17
6	Harvesting rain water	19	12.7
7	Spraying pesticides	17	11.3

Source: Own Field Survey, 2017

Since the impacts of climate change and variability was beyond the usual adapting mechanisms in this year (2016/17) in the study area; some of the sample farmers were vulnerable to external intervention through aids or supports like seeds of maize and that of different types of vegetables from CARE Ethiopia (Canadian NGO) and Haramaya University so as to recovery and reproduce the crops. Accordingly, about 333 quintal potato, 153 kg seeds of different vegetables and 46.6 kg of maize were distributed to 923 and 733 farmers respectively. Since the impact of climate change was severe in the study *kebeles* and other *kebeles* around Haramaya and Adele Lakes, they shared more than 90% of the reported aids.

Table 29. Distribution of Aids for Affected Farmers

Seeds of vegetables and maize distributed as Aids	**Donor**				**Total aids provided**	**Total supported farmers**
	Haramaya University		**CARE Ethiopia**			
	Amount in quintal/ KG	**No of supported Farmers**	**Amount in Quintal/kg**	**No of supported Farmers**		
Potato	133 qu	253	200 qu	100	333 qu.	**353**
Brussels sprouts	12.6 kg	-	12 kg	570	24.6 kg	
Beetroot	7 kg	133	20 kg		27 kg	
Cabbage	11.3 kg	253	40 kg		51.3 kg	
Salads	7 kg	-	-		7 kg	
Onion	20 kg	253	16 kg		36 kg	
Carrot	-	138	-		-	
Tomato	-	-	4 kg		4 kg	
Red pepper	-	-	4 kg		4 kg	
Total	**57.9 kg**	**253**	**96 kg**	**670**	**153 kg**	**923**
Maize	16.6 qu.	253	30 qu.	480	**46.6 qu.**	**733**

Source: HWAO, 2017

5. SUMMARY, CONCLUSION AND RECOMMENDATIONS

This chapter has two sections. The first section presents summary and conclusion of the study which briefly reflects the overall summary and conclusion of the finding and the last section forwards recommendation emanated from the finding of the study.

5.1. Summary

Climate change is causing the greatest environmental, social and economic threats to all of mankind and across borders in many nations. In view of this fact therefore, the main objective of this study was to assess socio-economic impacts of climate change and variability on households around Haramaya and Adele Lakes. The study was conducted in four *kebeles* of Haramaya Woreda found in Eastern Hararghe zone, Oromia Regional State, Ethiopia.

The study relied on both quantitative and qualitative methods of data collection and analysis. The primary data were collected by using questionnaire, interview, Focus group discussion and field observation. The study also used historically recorded and temperature rainfall data from 1986 to 2016 to examine trend of temperature and rainfall changes. The finding of the study showed that there was trend of increasing in average maximum and mean annual temperature in the last three decades while average minimum temperature showed fluctuation in the past two decades and similarly within the three decades annual rainfall had showed inter annual and seasonal variation.

Most of the sample household heads practiced mixed farming system. Particularly for crops and vegetables they used rain and irrigation respectively. Chat is grown as cash crop and use as main source of family's income. On other way, the household heads rear a few number of livestock due to shortage of grazing land and experience of the community. From these agricultural activities, they gained relatively high amount of yields in past 10 years but the current year's products were low. In addition to on-farm activities, a few household heads practiced non-fram activity and gained considerable additional income.

In study area, there was impact of climate change and variability in the form of frost, drought and flooding which affected most of crops and vegetables products. For the impact, the most common adaptation and mitigation strategies designed and applied by the sample household heads include: using underground water, changing growing and harvesting time, growing short maturing crops and vegetables, diversifying agricultural production and particularly took aids from different stakeholders in this year92016/17). Finally, conclusions and recommendations were made based on the findings of the study.

5.2. Conclusion

Trend analysis of climatic data revealed that the study area received small rain in a year for most of months and experienced increasing average maximum, minimum and mean annual temperature in the last decades. In addition, the sample household heads perceived that rainfall onsets late and ends up early. This trend caused extreme events mainly drought and frost which had impacts on physical resources like fresh water and socio-economic activities of the surrounding communities.

As survey result and analysis on trend of climatic data shows; communities of study area have been facing impacts of climate change and variability since the last decade particularly recent years; the impacts have become increased as there has been more climate change and variability induced events like frost and drought as compared to the situations in the past two decades. Generally, the sample household heads in the study area were more facing repeatedly occurrence of frost and drought which brought reduction in agricultural products and income of family.

The finding of the study reveals that climate change and variability had caused severe damage on crops and vegetable productions and consequently reduced overall income of the households. In other way, the impacts were extended to human health including wide spread of sever acute pneumonia, common cold, diarrhea and asthma. Moreover, the changes in climate had negative effects on educational services like late coming and absenteeism of students in the surrounding schools and housing amenities of the sample household heads through income reduction.

Since climate change and variability has long lasting effects on socio-economic life, the sample household heads had designed adaptation and mitigation strategies to the impacts and were implementing. Among these strategies were: pumping water from underground, changing growing and harvesting time, growing short maturing crops and vegetables, diversifying agricultural production and income sources and demanding aids from different stakeholders.

5.3. Recommendations

Depending on nature of the data, the finding obtained and the conclusion drawn from the study, the following recommendations are suggested to minimize the socio-economic impacts of climate change and variability on households around Haramaya and Adele Lakes catchment.

- **Improve Agricultural Production:** The possible methods include diversifying crops, selecting appropriate variety of crops i.e. diseases resistant, early maturing and high yielding, improving the method of cultivation and agricultural technologies and promote traditional pest management are areas of critical concern.

- **Build on existing people's knowledge and practices:** Reviving traditional practices and improving indigenous knowledge on how to harvest crop and diversify livelihood provide one way of coping with different climatic change. Interventions need to build on existing knowledge and adapting strategies in order to insure sustainability of their activities. Therefore, before planning interventions, a proper assessment of households available adaptations and mitigation strategies should be considered and build upon indigenous knowledge.

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

- **Protect assets and diversify income sources:** Protect vital livestock, environmental resources like lake water in order to enhance households' adaptive capacity and resilience through awareness creation etc. Diversification of households' income sources is also necessary to minimize exposure to socio-economic impacts of climate change and variability. For this effect, the households should be encouraged to expand off-farm activities such as petty-trading and others.

- **Institutional capacity:** developing institutional capacity to generate and apply climate information at local level; make climate information products available timely in a format that can easily be understood and utilized by target communities; enhance the operational and technical capacity of national institutions to develop and disseminate regularly updated climate knowledge, products and adaptation plans.

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

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7. APPENDICES

Appendix Table 1. Average Monthly Maximum Temperature in ^0C

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Aver.
1986	22.9	24.3	25.1	22.7	23.3	22.4	21.6	22.7	21.9	23.6	23.6	21.9	**21.2**
1987	21.3	24.0	24.1	23.9	23.5	24.6	23.0	23.0	24.0	24.7	24.1	23.3	**23.6**
1988	23.3	25.4	26.2	25.1	26.5	24.2	22.2	22.6	22.4	23.3	22.6	21.9	**23.8**
1989	20.7	23.5	24.9	22.1	24.5	24.5	22.0	23.1	23.0	24.1	23.2	22.5	**23.2**
1990	22.9	24.4	24.2	23.9	25.7	25.4	24.5	23.3	23.8	23.8	23.7	22.3	**23.9**
1991	22.9	24.4	24.2	23.9	25.7	25.4	24.5	23.3	23.8	23.8	23.7	22.3	**23.9**
1992	22.9	23.0	26.3	26.0	26.1	24.8	24.5	23.4	23.5	24.2	23.8	23.2	**24.3**
1993	22.4	24.1	24.9	23.9	25.0	24.5	23.2	23.1	23.2	23.9	23.5	22.5	**23.7**
1994	22.3	24.1	24.9	24.1	25.3	24.8	23.4	23.1	23.4	23.9	23.5	22.6	**23.8**
1995	22.5	24.1	25.1	24.1	25.4	24.8	23.5	23.1	23.3	23.9	23.4	22.5	**23.8**
1996	22.4	23.9	24.9	24.0	25.4	24.9	23.7	23.2	23.4	23.9	23.5	22.6	**23.8**
1997	23.5	23.6	25.9	23.6	24.5	23.9	23.5	24.0	24.7	22.8	21.9	21.7	**22.8**
1998	22.1	24.4	25.5	26.9	26.1	26.9	23.9	23.0	23.4	23.3	23.0	22.1	**24.2**
1999	23.2	25.6	23.6	26.0	25.3	24.9	22.8	23.3	23.1	22.2	22.3	21.8	**23.7**
2000	23.0	24.8	26.0	25.9	24.5	25.0	24.0	23.1	23.4	23.5	22.7	22.2	**24.0**
2001	22.7	24.4	25.0	26.3	25.2	24.6	22.2	23.6	24.3	23.4	23.4	22.2	**23.9**

2002	21.5	25.0	24.8	24.8	26.4	25.7	25.3	23.7	23.5	24.8	24.5	22.8	**24.4**
2003	23.0	25.4	26.2	25.6	27.0	24.4	23.1	23.0	23.5	25.3	24.0	22.0	**24.4**
2004	24.2	23.7	25.7	23.9	26.3	24.7	24.0	24.1	23.5	23.1	23.7	22.4	**24.1**
2005	23.6	26.2	25.7	25.2	24.3	24.0	23.2	24.0	23.9	24.1	23.9	22.8	**24.2**
2006	23.6	25.3	25.4	24.0	24.9	25.0	23.7	22.9	22.9	23.6	23.2	21.5	**23.8**
2007	22.1	25.6	26.7	25.1	25.7	25.0	23.9	23.6	23.7	24.5	23.6	22.4	**24.3**
2008	24.1	23.8	27.1	26.7	25.2	24.4	22.8	22.5	24.0	24.2	22.4	22.3	**24.1**
2009	22.7	25.1	26.5	25.2	26.4	26.1	24.0	23.9	33.1	24.1	24.5	22.4	**25.3**
2010	23.3	24.4	24.0	24.8	25.6	25.7	23.0	22.7	23.5	25.7	23.7	22.9	**24.1**
2011	23.9	25.2	26.1	27.2	25.3	25.3	24.6	23.1	23.4	24.8	24.6	21.9	**24.6**
2012	27.4	29.8	31.3	25.8	26.3	24.7	23.2	24.4	24.2	24.8	24.7	23.6	**25.9**
2013	23.7	25.6	25.7	24.6	25.3	24.4	22.0	23.1	24.3	24.0	29.4	22.0	**24.5**
2014	23.3	24.7	25.6	25.2	24.6	25.9	25.6	23.5	12.8	23.3	23.7	22.6	**23.4**
2015	22.5	25.8	26.6	27.3	25.3	25.7	25.4	24.8	25.5	26.8	24.6	22.4	**25.2**
2016	23.1	25.1	28.2	24.9	25.0	24.4	23.5	22.8	23.6	24.4	24.6	23.2	**24.4**

Appendix Table 2.Average Monthly Minimum Temperature in ^{0}C

Year	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Aver**
1986	1.5	7.5	8.2	11.0	11.6	11.3	10.1	10.1	9.5	4.0	0.1	-1.3	**6.9**
1987	3.2	7.7	13.0	11.5	12.5	14.0	13.6	13.7	12.4	9.0	3.7	4.0	**9.9**
1988	7.4	10.4	9.3	13.5	12.8	14.3	13.7	13.4	12.7	8.0	1.1	1.9	**9.9**
1989	4.1	6.7	10.9	12.8	12.2	13.1	12.4	12.4	11.9	7.3	4.6	8.5	**9.7**
1990	4.7	11.7	8.6	11.9	12.9	13.6	13.0	13.0	13.2	6.4	4.3	2.1	**9.6**
1991	5.8	9.2	12.7	12.1	12.6	14.2	13.4	13.2	12.6	5.5	2.4	4.6	**9.9**
1992	7.9	10.4	11.4	13.0	14.2	13.9	13.6	13.1	11.8	7.5	5.6	8.3	**10.9**
1993	4.9	9.1	10.6	12.3	12.6	13.5	12.8	12.7	12.0	6.8	3.1	4.0	**9.5**
1994	5.4	9.3	10.9	12.4	12.8	13.8	13.2	13.1	12.4	7.2	3.5	4.7	**9.9**
1995	5.7	9.5	10.6	12.6	12.9	13.7	13.2	12.9	12.4	6.9	3.5	4.8	**9.9**
1996	5.5	9.4	12.0	12.4	12.9	13.7	13.1	12.9	12.3	6.8	3.8	5.3	**10**
1997	6.9	2.8	10.8	11.6	12.8	13.7	13.2	13.5	13.0	10.5	9.1	6.4	**10.4**
1998	9.5	11.0	12.4	11.8	13.2	13.8	13.2	13.5	13.5	8.6	2.9	4.6	**10.6**

1999	4.6	5.1	11.3	11.3	13.2	13.9	13.3	13.4	12.5	10.0	3.4	2.8	**9.6**
2000	2.6	3.4	7.9	11.9	14.1	13.9	13.2	13.2	13.4	8.1	6.8	4.8	**9.1**
2001	6.8	6.4	12.8	11.7	13.9	13.5	13.4	12.2	8.7	3.6	4.8	5.0	**9.4**
2002	8.3	5.6	10.8	13.2	14.2	14.0	13.8	13.7	12.8	8.9	3.3	8.8	**10.6**
2003	6.4	8.7	9.9	13.5	13.5	13.8	13.7	13.6	13.4	6.2	5.6	4.4	**10.2**
2004	9.4	5.0	8.4	14.0	12.2	14.0	13.3	13.5	12.4	7.7	3.6	5.0	**9.9**
2005	6.0	7.5	12.3	11.6	13.8	14.4	13.7	13.8	13.2	6.8	4.2	1.7	**9.9**
2006	6.6	9.5	11.8	12.1	13.4	14.0	13.7	13.9	13.1	11.9	4.5	7.4	**10.9**
2007	5.7	7.6	9.2	13.8	13.7	13.8	14.0	14.0	12.9	5.9	3.2	1.6	**9.6**
2008	3.9	5.2	5.0	12.3	13.9	14.0	13.5	13.6	12.7	7.8	5.1	1.6	**9.1**
2009	5.3	6.9	10.0	12.5	13.4	13.5	12.5	12.3	11.6	7.5	1.4	6.0	**9.4**
2010	3.8	8.6	9.6	12.9	14.1	15.0	13.9	14.1	23.5	6.8	5.5	2.7	**10.8**
2011	4.9	5.7	7.6	13.4	13.7	15.1	13.9	13.9	13.3	5.2	4.7	1.8	**9.4**
2012	2.5	2.3	6.0	12.2	12.1	14.1	13.9	14.0	13.1	6.1	4.7	4.7	**8.8**
2013	5.6	4.6	11.7	14.0	14.4	14.2	13.2	13.5	12.5	9.4	7.1	2.2	**10.2**
2014	4.2	9.3	11.9	13.1	13.2	13.4	14.0	13.9	23.3	8.7	5.8	2.5	**11**
2015	4.1	6.2	10.5	10.7	13.7	14.6	14.1	14.3	13.5	7.3	5.6	3.3	**9.8**
2016	7.0	13.7	15.1	14.7	15.7	16.6	17.5	13.7	14.7	7.2	4.2	4.3	**12.0**

Appendix Table 3. Average Temperature for 31 years

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ave.
1986	12.2	15.9	16.7	16.8	17.5	16.9	15.9	16.4	15.7	13.8	11.8	10.3	**14.9**
1987	12.3	15.8	18.6	17.7	18.0	19.3	18.3	18.3	18.2	16.8	13.9	13.6	**16.7**
1988	15.3	17.9	17.8	19.3	19.6	19.2	17.9	18.0	17.5	15.6	11.9	11.9	**16.8**
1989	12.4	15.1	17.9	17.4	18.4	18.8	17.2	17.8	17.4	15.7	13.9	15.5	**16.5**
1990	13.8	18.1	16.4	17.9	19.3	19.5	18.7	18.2	18.5	15.1	14.0	12.2	**16.8**
1991	15.1	16.9	18.6	18.3	19.0	20.1	17.7	18.5	18.2	14.9	13.0	13.4	**16.9**
1992	15.4	16.7	18.9	19.5	20.1	19.4	19.1	18.3	17.6	15.9	14.7	15.8	**17.6**
1993	13.7	16.6	18.7	18.1	18.8	19.0	17.8	17.9	17.6	15.4	13.	13.2	**16.7**
1994	14	16.7	18.1	18.3	19.0	19.3	18.1	18.1	17.9	15.6	13.5	13.7	**16.9**
1995	14.2	16.8	18.1	18.4	19.2	19.3	18.1	18.1	17.8	15.5	13.5	13.7	**16.9**

1996	14.1	16.7	18.1	18.2	19.1	19.3	18.1	18.1	17.9	15.4	13.7	13.9	**16.9**
1997	15.2	13.2	18.3	17.6	18.7	18.8	18.3	18.7	18.8	16.7	15.5	14.1	**16.9**
1998	15.8	17.7	18.9	19.3	19.1	20.2	18.2	18.3	23.4	15.9	12.9	11.6	**17.6**
1999	13.9	15.3	17.4	18.6	19.3	19.4	18.1	18.3	17.8	16.1	12.9	12.3	**16.6**
2000	12.8	14.1	17.0	18.9	19.3	19.5	18.6	18.1	18.4	15.8	14.7	12.9	**16.6**
2001	14.4	15.4	18.9	19.0	19.5	19.1	17.8	17.9	16.5	13.5	14.1	15.5	**16.8**
2002	14.9	15.3	17.8	19.0	20.3	19.8	19.6	18.7	18.1	16.8	13.9	15.8	**17.5**
2003	14.7	17.1	18.0	19.5	20.3	19.1	18.4	18.3	18.4	15.7	14.8	13.2	**17.3**
2004	16.8	14.3	17.0	19.0	19.3	19.4	18.6	18.8	18.0	15.4	13.7	13.7	**17**
2005	14.8	16.8	19.0	18.4	19.0	19.2	18.4	18.9	18.6	15.5	14.0	12.2	**17**
2006	15.1	17.4	18.6	18.0	19.1	19.5	18.7	18.4	18.0	17.7	13.9	14.4	**17.4**
2007	13.9	16.6	18.0	19.5	19.7	19.4	19.0	18.8	18.3	15.2	13.4	12.0	**16.9**
2008	14.0	14.5	16.0	19.5	19.5	19.2	18.2	18.0	18.3	16.0	13.7	12.0	**16.6**
2009	14.0	16.0	18.2	18.8	19.9	19.8	18.3	18.1	22.3	15.8	13.0	6.0	**16.7**
2010	13.5	16.5	16.8	18.9	19.9	20.4	18.4	18.4	23.5	16.2	14.6	12.8	**17.5**
2011	14.4	15.5	16.8	20.3	19.5	20.2	19.3	18.5	18.3	15.0	13.7	11.9	**16.9**
2012	15.0	16.1	18.7	19.0	19.2	19.4	18.5	19.2	18.7	15.5	14.7	14.2	**17.4**
2013	14.6	15.1	18.7	19.3	19.8	19.3	17.6	18.3	18.4	16.7	18.3	12.1	**17.4**
2014	13.8	17.0	18.7	19.2	18.9	19.7	19.8	18.7	18.0	16.0	14.8	12.6	**17.3**
2015	13.3	16.0	18.5	19.0	19.5	20.2	19.8	19.5	19.5	15.2	13.5	12.6	**18.4**
2016	13.9	16.0	21.0	20.0	19.9	20.1	20.1	20.1	18.6	19.5	13.5	12.6	**18.2**

Appendix Table 4. Haramaya Station Monthly Rainfall Data of 31 Years

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1986	0	38.6	14.1	153.9	110.1	80.8	66	161.4	96.7	34	5.8	0	**765**
1987	0	8.1	180.2	148.6	248.2	29.6	63.3	123.2	111.9	31	2.7	0	**946.8**
1988	9.8	43.8	30.4	154.3	31.3	54.1	101.5	180.7	212.1	41.9	0	6	**865.9**
1989	0	14.4	154.9	114.5	69.4	52.6	104	146	104.4	41.2	3.6	45	**850**
1990	1.7	73.	45.4	137.	59.6	54.1	80.9	154.	133.	53.3	0	7	**807**

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1991	0	51.7	136.2	73.2	58.6	25.7	109.1	107	120.1	25.8	0	52	**759.4**
1992	3.9	11	18.2	85.2	65.1	68.3	77.5	97.6	107.1	36.6	10.4	4.1	**585**
1993	0	0	0	79.2	61.9	47.0	34.5	106.4	136.2	59.7	0	1.2	**526.1**
1994	0	0	17.0	223.5	172.0	57.7	281.4	96.0	59.7	3.5	15.7	0	**926.5**
1995	0	24.6	112.2	318.1	67.1	55.3	114.6	108.4	38.9	2.4	0	25.3	**866.9**
1996	9.2	2.4	83.1	83.8	171.5	131.0	114.1	175.2	181.0	0	9.6	0	**960.9**
1997	0	0	78.1	124.6	155.9	59.8	148.7	102.7	61.7	203.8	60.4	16.1	**1011.8**
1998	86.5	51	33.7	59.9	55.4	24.8	128.5	110.4	175.7	54	21.3	0	**801**
1999	0	3.7	68.3	71.3	77.4	30	95.2	238.6	139	135.7	15.6	4.9	**879.7**
2000	0	0	6.3	137.6	95.1	18.9	82.7	141.5	109.4	16.6	104.2	na	**712.3**
2001	Na	18.8	56.6	94	146.2	111.3	217.7	54.6	24.9	0	na	na	**724.1**
2002	17.9	0.6	56.3	84.4	47.9	43.3	64.8	165.3	83.4	21.7	0	21.5	**607.1**
2003	3.6	16.4	25.1	142.2	19.2	62.5	106.6	272.4	77.2	0.2	0	40.7	**766.1**
2004	38.2	0	27.4	215.1	39.7	25.3	74.2	116.4	126.7	43.8	33.6	4.5	**744.9**
2005	0.5	2	39.9	119.5	198.3	23.5	68.1	132.2	154.4	17	11.9	0	**767.3**
2006	4	35.9	49.2	187	71.4	74.1	108.6	191.4	180.4	111.6	1.6	88.4	**923.2**
2007	0	3.5	19	132.7	55.7	61.4	185	110.5	123.6	26.9	6.5	0	**724.8**
2008	5.5	0	0.2	25.9	180	106.3	136	120.6	170.2	14.1	120.6	0	**879.4**
2009	23.6	5.3	5.7	78.2	127.8	53.8	163.5	96.5	65.2	139.9	12.4	26.2	**798.1**
2010	2.7	44.1	82.3	123.8	73.1	24.6	144.9	179.6	170.4	5.6	10.8	0	**861.5**
2011	0	0	0	79.4	113.	115.	119.	227	323.	0	0	0	**978.3**

					4	4	5		6				
2012	0	0	0	0	0	0	0	0	105	4.6	0.5	6.7	**116.8**
2013	6	0	159.3	171.6	122.1	15.8	215.4	185.1	142.1	71.4	81.6	0.8	**1176.6**
2014	0	0	50.3	85.7	110.6	18.8	101.4	166	150.2	87.9	3.6	0.4	**774.9**
2015	0	0	32.7	77.4	199.8	86.1	17.3	163.6	53.6	7.9	0	0	**638.4**
2016	0.4	15.5	41.5	168	120.8	87.9	149.2	38.3	165.8	1	23.5	0	**811.9**

Appendix Table 5: ANOVA Test for Variation of Crop Products in the Past 10 and Current Year

Source of Variance	SS	Df	MS	F	Sig
Between groups Within groups	15865.333 8468.000	2 3	7932.667 2822.667	2.810	0.205**
Total	24333.333	5			

Appendix Table 6: Paired T-Test on Vegetables Products in the Past 10 Years and Current Year

	Paired Difference					t	df	sig(2-tailed)
Pair 1 Before 10 year Current year	Mean	Std. Deviation	Std. Error Mean	95% confidence interval of the Difference		5.68	6	0.001
				lower	Upper			
	6.286	2.927	11.10	3.578	8.99			

Source: Own field survey data, 2017

Appendix Table 7: Paired T-Test on Number of Livestock in the Past 10 Year and Current Year

	Paired Difference	t	df	sig(2-tailed)

Pair 1 Number of livestock in the past - Number of livestock in the current year	Mean	Std. Deviation	Std. Error Mean	95% confidence interval of the Difference		4.00	4	.016
				lower	Upper			
	.8000	0.4472	0.2000	0.2447	1.3553			

Source: Own field survey data, 2017

APPENDEX I

Code No ------------

QUESTIONNAIRES TO BE COMPLETED BY SAMPLE RESPONDENTS

General Instructions:-

- No need of writing your name.
- For each of the statements (questions) below, please put tick mark (√) in the box corresponding to the appropriate information about yourself.
- For the items presented in a multiple choice form; choose the response/s you think is/are right, for the open ended questions write your response in the space provided.

Part I: General Background information of Sample Households

Kebele---------------------------------------, Zone/*Ketena*-------------------------

1. Sex of household head: A. Male B. Female

2. Age of household head -------- years old.

3. Family size (including household head): Male---------, Female-----------, Total-----------

4. Religion of household head

A. Muslim B. Orthodox C. Protestant

D. Wakeffata E. If any other, specify -------------------.

5. Ethnicity: A. Oromo B. Amhara C. Others, specify -------------------.

6. Marital status: A. Married B. Single C. Divorced D. Widowed

7. Educational status/level:

A. Illiterate B. Read and write

C. Primary education completed D. High School education complete

E. Higher education complete F. Others specify--------------------------

8. Average monthly income--.

Part II: Socio-economic Characteristics of Sample Household Heads

1. What is your source of current livelihood? (Multiple choices, more than one answer is possible).

A. Livestock rearing B. Crop or chat production

C. Mixed (A & B) D. Petty trade

E. Remittance F. Daily laborer

G. Civil servant H. If any other, specify ------------------.

2. Among the listed choices in question No1 above, which one is your primary livelihood activity?________________________________.

3. What kind of farming do you practice? (Multiple choices, more than one answer is possible).

A. Crop farming B. Livestock rearing

C. Mixed farming (A & B) D. Growing vegetables

4. What kind of agriculture are you practicing? (Multiple choices, more than one answer is

possible).

A. Rainfed agriculture B. Irrigated agriculture

C. Both rainfed and irrigated agriculture D. Others, specify-------------?

5. If your answer to the above question includes **B** what is the major source of water? (Multiple choices, more than one answer is possible).

A. Lake water B. Harvested water from rainfall

C. Underground water D. Others, specify-----------------

6. Which of the following cereals or cash crops do you cultivate on your farm? Put your answer from the list in the Table below in ranking order (means from the most to least important).

S. N	**Type of crop**	**Amount in quintal or kilogram**	
		Before 10 years	**Current year**
1	Pea		
2	Sorghum		
3	Wheat		
4	Maize		
5	Chat		
	If any other, specify		

7. On average, how many birr do you earn/year from crop products before ten years ----------?
8. On average, how many birr do you earn from crop products in the current time---------------?
9. Do you grow vegetables? A. Yes B. No
10. If your answer to question **number 9** above is "**yes**" what type of vegetables you grow? Put your answer from the list in the Table below in ranking order (means from the most to least important).

S. N	**Vegetable type**	**Amount in kilogram**	
		Before 10 years	**Current year**
1	Carrot		
2	Potato		
3	Sweet Potato		

4	Cabbage		
5	Onion		
6	Salad		
7	Beet root		
8	Green pepper		
9	If any other, specify		

11. On average, how many birr do you earn/year from vegetables before ten years ------------?

12. On average, how many birr you earn from vegetables in the current time-------------------?

13. Do you have or rear livestock? A. Yes B. No

14. If your answer to question **number 13** above is "**yes**", how many do you have? Put your answer from the list in the Table below in ranking order (means from the most to least important).

S.N	Livestock type	Number of livestock	
		Before 10 years	Current year
1	Oxen		
2	Cow		
3	Sheep		
4	Goat		
5	Donkey		
6	If any other, specify		

15. On average, how many birr you earn/year from livestock products before ten years (2006-2016) ---------------------?

16. On average, how many birr you earn/year from livestock products currently (2016) -------?

17. How is the current agricultural yield when you compare with previous ten years?(Choose one of them)

A. Very high B. Medium

C. Low D. No change

18. What is the reason for your answer in the above question? ---.

19. Do you have non-farm source of income? A. Yes B. No

20. If your answer is **yes** to the above question, please indicate your source in the following table by putting **X** mark on the spaces provided(Multiple choices, more than one answer is

possible).

S . N	Non-farm income	Your real non-farm income source
1	Petty trading	
2	daily laborer	
3	Driving cars	
4	Broker	
5	Civil servant	
6	If any other, specify	

21. Do you have any of the following house amenity or property/asset? Respond by putting **X** from the list in the Table below on the spaces provided.

S . N	House amenity list	House amenities you have	
		Before 10 years	**Current year**
1	Tractor		
2	Water Pump motors		
3	Any type of car		
4	Villa house		
5	Fixed line phone		
6	Modern quality Refrigerator		
7	Modern Quality TV		

Part III: Socio-economic Impacts of Climate Change and Variability

22. Did you face variation in your agricultural production in the past ten years?

A. Yes B. No

23. If your answer to question number **22** is "**yes**" what are the main causes of the variation? (Multiple choices, more than one answer is possible).

A. Temperature and rainfall change,

B. High cost of pumping underground water,

C. Impacts of frost on crops and vegetables,

D. Shrinking and disappearance of the lakes water,

E. Shortage of animal feeds during dry season,
F. If any other, specify----------------------.

24. How do you describe the current amount of rainfall compared to the rainfall amount in the past ten years ?
    A. Increasing significantly
    B. Neither increasing nor decreasing
    C. Increasing
    D. Decreasing
    E. Decreasing significantly
25. Do you think that the timing of rainfall is a problem?
    A. Yes, it onsets late and ends up late
    B. Yes, it onsets early and ends up early
    C. No, there is no problem on timing of rainfall but on its amount
    D. Yes, it onsets on time but ends up early
    E. Yes, it onsets late and ends up early
26. Based on question **number 24** and **25** was there any impact of the climate change in the past ten (10) years? A. Yes B. No
27. If your answer to question **number 26** is **"yes"** what are extreme events induced by climate change and variability you have encountered in the past ten (10) years? (Tick your answer by this mark"✓" under the provided options).

S. N	Climatic variable	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
1	Shrinking and siltation of lake water					
2	Pest and disease					
3	Drought					
4	Frost occurring					
5	Flooding or covering of vegetables by the lake water					
6	Shortage of animal feed					
7	If any other, specify-------------.					

28. What are impacts caused by extreme events of climate change and variability on your socio-economic aspects? (Multiple choices, more than one answer is possible).
    A. Reduction of family's income

B. Change of production variety

C. Obstacle to educational services

D. Loss of crops and vegetable by frost

E. Human health problems

F. If any other, specify-------------------.

29. How do you adapt the impacts of climate change and variability? Put your answer from the list in the Table below in ranking order.

S.N	Adaptation and Mitigation Methods	Rank of its implementation
1	Growing short maturing crops	
2	Using improved seeds	
3	Using underground water	
4	Being daily laborer in the towns	
5	Change cropping pattern	
6	Diversifying agricultural production	
7	If any other, specify---.	

30. Would you suggest the best livelihood strategies for impacts of climate change and variability on social and economic aspects of households?

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APPENDEX II

INTERVIEW TO BE CONDUCTED WITH SAMPLE RESPONDENTS

Identification

Name of the Enumerator---------------------------------

Date of interview --

Name of the *Kebele* ---

Name of village or Ketena ---------------------------------

Part I: Background information of Sample Respondents

1. Sex ----------------------------------
2. What is your age?
3. How many family members (including you) do you have?
4. What is your religion?
5. What is your ethnicity?
6. What is your marital status?
7. Your educational status?
8. What is your average monthly income?

Part II: Socio-Economic Aspects of Sample Respondents

1. What is your current occupation/work?
2. What kind of farming do you practice mainly?
3. What kind of agriculture are you practicing?

    Rainfed agriculture

    Irrigated agriculture

    Both rainfed and irrigated agriculture

4. What kind of agriculture do you practice?

    Rainfed agriculture
    Livestock rearing
    Irrigated agriculture
    rainfed and Livestock rearing

5. If you use irrigation system of farming, what is the source of water?

Underground water
Rain water
Harvested rain water

6. Do you cultivate different types of crops? If yes, list down

7. On average, how many birr you earn/year from crop products before ten years ------------?

8. On average, how many birr you earn from crop products in the current time-------------------?

9. Do you grow vegetables? If yes, list down

10. On average, how many birr you earn/year from vegetables before ten years ----------------?

11. On average, how many birr you earn from vegetables in the current time--------------------?

12. Do you have or rear livestock? If yes, list down kind and amount.

13. On average, how many birr you earn/year from livestock products before ten years (2006-2016) ---------------------?

14. On average, how many birr you earn from livestock products currently (2016) -------------?

15. How is the current agricultural yield when you compare with previous ten years?

Very high
Medium
Low
No change

16. What is the reason for answer to the above question?

17. Do you have non-farm source of income? If yes, list down

18. Do you have any one of the following house amenity or property/asset?
Tractor
Water pumping motor
Any type of car
Villa house
Fixed line phone
Modern quality refrigerator
Modern Quality TV
Others

Part III: Socio-economic Impacts of Climate Change and variability

19. Did you face variation in your agricultural production the past ten years? If yes, would you explain the main causes.

20. Did you face any extreme events of climate change and Variability in the past ten (10) year in your area?

    Frost occurring

    Drought

    Flooding or covering of vegetables by the lake water

    Crop pests

    Human and animal diseases

    Drying up of or siltation the lake water

21. Is there any impact of climate change and Variability in the past ten (10) years? If yes" what are its main socio-economic impacts?
22. What are the main strategies you applied for impacts of climate change on social and economic aspects?
23. Would you suggest some of the best additional livelihood strategies help to remove social and economic impacts of climate change?

APPENDIX III

QUESTIONS FOR FOCUSED GROUP DISCUSSION (FGD)

Date-----------------, time-----------------------

1. Do you think that there is climate change and variability in your area?
2. What are the local indicators of climate change and variability?
3. Is there any impact of climate change and variability on social and economic aspects of households?
4. What are the major impacts of climate change and variability up on households'?
   - Crop production
   - Livestock rearing
   - Vegetables production
   - Households' income
   - Educational services
   - Health condition
   - House amenities or properties
5. To adapt climate change and variability what are the responses of household heads, government and non-governmental organization?
6. What do you think the best ways to adapt or mitigate the impacts of climate change and variability on social and economic aspects of households?

APPENDIX IV

CHECK LIST FOR FIELD OBSERVATION

1. Land cover and land use,
2. Major household heads' economic activities in the study area,
3. Types of crops grown on the farms,
4. Types of vegetables grown in the farm plot,
5. Types of livestock in the grazing fields,
6. Source of water HH's use for irrigation,
7. Government and Non government activities on environmental conservation,
8. Means of adaptation and mitigation strategies applied by the household heads in response to climate change and variability.