CLIMATE CHANGE, ADAPTATION STRATEGIES AND THEIR DETERMINANTS IN RURAL LOKA ABAYA WOREDA, SIDAMA REGION, ETHIOPIA

MSc THESIS

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HAWASSA UNIVERSITY COLLEGE OF AGRICULTURE

HAWASSA, ETHIOPIA

SEPTEMBER, 2020

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MSc THESIS

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A THESIS SUBMITTED TO FACULTY OF ENVIRONMENT, GENDER AND DEVELOPMENT STUDIES FOR THE PARTIAL FULFILLMENT OF MASTER OF SCIENCE DEGREE IN CLIMATE CHANGE AND SUSTAINABLE AGRICULTURE

HAWASSA, ETHIOPIA

SEPTEMBER, 2020

ADVISORS' APPROVAL SHEET

SCHOOL OF GRADUATE STUDIES

HAWASSA UNIVERSITY (Submission Sheet-1)

This is to certify that the thesis entitled " Climate Change, Adaptation Strategies and their determinants in rural Loka Abaya woreda, Sidama Region, Ethiopia" submitted in partial fulfillment of the requirements for the degree of Masters of Science in Climate Change and Sustainable Agriculture Program, Hawassa College of Agriculture, and is a record of original research carried out by Adisu Petros, under our supervision, and no part of the thesis has been submitted for any other degree or diploma. Therefore, the assistance and help received during the courses of this investigation have been duly acknowledged. Therefore, we recommend that the student has fulfilled the requirement, and hence here by can submit the Thesis to the Program.

Approved by Advisors:

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ACCNOWLEDGEMENT

First of all, I would like to thank almighty God through which he has streng then me to face all stresses, up and downs while doing my study. Nextly, I would like to express my sincere thanks to my major supervisor **Kinfe Asayehegn (PhD)** and co-supervisor **Zerhun Ganewo (MSc)** for their commitment and willingness to accept me as their student and their constructive advices, guidance and endless support without which this thesis would not have been completed. I am very grateful for them valuable contribution and the help they provided all through.

I want to exert my heartful thank to my father for his supporting in research fund for the completion of my study work.

I am highly appreciating the Sidama Region, Environment, Forest and Climate change Authorty at large for granting me the opportunity to pursue my Master education for two years in Hawassa University Collage of Agriculture under the Platform on Climate Change and Sustainable Agriculture.

I am grateful to the Loka Abaya woreda Council for accepting, allowing and supporting me to carry out my study in their area, as well as providing me with relevant information regarding this study. The support provided by Agricultural Office, Livestock Resource Office and Environment Protection Office during research field study in Loka Abaya can’t be forgotten. My special thanks are also go to extension workers at wards, village leaders and farmers whom I worked hand in hand with, and for their willingly contribution through valuable information contained in this report.

Finally, I would like express my deepest gratitude to my parents for their great support, encouragement and guidance in my life.

STATEMENT OF THE AUTHOR

I declare that this thesis is the result of my own work and that all sources of materials used for writing it have been duly acknowledged. This Thesis has been submitted in partial fulfillment of the requirements for the Degree of Masters of sicence in Climate Change and Sustainable Agriculture at Hawassa University College of Agriculture and is deposited at the library of the University to be made available to borrowers under the rules and regulations of the library. I solemnly declare that this dissertation has not been submitted to any other institution anywhere for the award of any academic degree, diploma, or certificate. Brief quotations from this dissertation are allowable without requiring special permission provided that an accurate acknowledgment of the source is made. Request for permission for extended quotations from or reproduction of the manuscript in whole or in part may be granted by the Head of the Program of Climate Change and Sustainable Agriculture or by the Dean of the School of Graduate Studies when in his or her judgment, the proposed use of the material is for a scholarly interest. In all other instances, however, permission must be obtained from the author.

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Date of submission: _____________________

DECLARATION

I dedicate this Thesis to my mother Belaynesh Deboche and father Petiros Desalegn.

ABREVIATIONS

CSA	Central Statistical Agency
CV	Coefficient of Variation
FAO	Food and Agriculture Organization
FDRE	Federal Democratic Republic of Ethiopia
FGD	Focused Group Discussion
GDP	Gross Domestic Product
IFAD	International Fund for Agricultural Development
IPCC	Intergovernmental Panel on Climate Change
KII	Key Informant Interview
LADANRB	Loka Abaya District Agriculture and Natural Resource Bureau
LAWAO	Loka Abaya Woreda Administration Office
MoA	Ministry of Agriculture
MNL	Multinominal logit Model
NAPA	National Adaptation Programme of Action
NMSA	National Meteorological Services Agency
NGO	Non-Governmental Organization
SNNPR	Southern Nation Nationalities and Peoples Region
SPI	Standard Precipitation Index
SPSS	Statistical Package for Social Sciences
TLU	Tropical Livestock Unit
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change

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Climate Change, Adaptation Strategies and their Determinants in Rural Loka Abaya Woreda, Sidama Region, Ethiopia

By: Adisu Petros (BSc.)

ABSTRACT

*Many studies have shown that climate change has adverse impacts on human welfare, agriculture, natural resources and development activities in Ethiopia in general and sidama Region in particular (Deressa et al., 2011; Kassie et al.,2013; Hamesso, 2013; Seyum, 2014). The objectives of study were: 1) to explore effects of climate change and variability on agricultural based livelihood systems***,** *2) to analyse trends of climate variability in terms of temperature and annual rainfall in the study área, 3) to assess the existing responses and adaptation measures being practiced to climate change and variability, and 4) to identify determinants of climate change adaptation strategies. Three-stage sampling technique was employed to select 188 study sample respondents. Both primary and secondary data was collected. Primary data were collected from the household survey; Key informant intervew and Focus group discation. Secondary data were reviewed from offices and published sources. Both descriptive and econometric model were used to analyze data collected SPSS version 20 and STATA 14.2 version software were used for data entry and analysis. Based on the study result 95.2% agreed the state of climate is changing, 90.4% reported decreasing rainfall, 93.9% indicate the increasing temperature. On the other hand, the households replied that extreme heat, drought, and increasing change in wind intensity, respectively. Moreover, time series data revealed that both mean rainfall and temperature were decreasing and increasing, respectively. The climate change impacts experienced by respondents in resulted reduced productivity/yield, increases pests/insects/diseases, use of traditional crop varieties decreased (, cropping pattern has changed , traditional irrigation sources like pond has reduced, and reduced cultivated land . Sample households agreed that climate change increased scarcity of forages, grass species composition, decreased productivity (mainly milk and its products), decreased livestock number, and shortage of drinking water availability. Moreover, results revealed, out of the total studied households(74.58%) agreed that climate change reduced income, while 69.17% believed it affected business items (increased price of food), and 26.34% reported climate change increased dependency on relief programs. The identified main adaptation strategies in response used by sample respondents were, crop diversification, improved crop varieties, reducing livestock number, tree plantation, crop rotation and intercropping, soil and conservations practices and non-farm incomes. According to marginal effects of MNL result the significantly determining factors for a choice of adaptation strategies were age, family size, education status of household, farm size, livestock ownership, extension service, access to credit service, climate change information and non-farm income of household. The study recommends that farmers, local government, and research instititutitions ought to work on collectivelly about the socio-economic and institutional factors challenging farmers in the study area to encourage use of available opportunities to adapt and enhance their long term resilience to climate change.*

Key words: Adaptation, Climate Change, Crop, Livestock, Livelihood, MLN

1. INTRODUCTION

1.1 Background of Study

Climate change is a global concern as it severely affects the livelihoods of the world community in general and agricultural production and food security of the farming community in particular. Adverse effect on various biophysical and economic activities like agriculture, water resources, forestry, human health, biodiversity, and wildlife. Its consequences are severe in developing countries in which agriculture is the primary source of livelihood (IPCC, 2014; FAO, 2016; Imbach *et al.*, 2017).

Climate change affects agriculture and agriculture also contributes to climate change. The impact of climate change on agriculture in developing countries has been increasing. Higher temperature and changing precipitation levels caused by climate change depress crop yields. This is particularly true in low-income countries, where adaptive capacities are perceived to be low. Many African countries which have economies largely based on weather-sensitive agriculture are vulnerable to climate change. However, the rapid pace of climate change, along with increasing socioeconomic pressures, threatens to overwhelm their ability to cope. It is worried that Africa is especially vulnerable to climate change and variability because large proportions of the population are poor and depend on agricultural activities, which is highly sensitive to rainfall variability and change in temperature ((Ford *et al.,* 2015; Eshetu *et al*., 2014; Niang *et al.* (2014).

The vulnerability of Ethiopian agriculture to climate change impact is a function of several biophysical and socioeconomic factors (Bewket, 2010). In Ethiopia, agricultural production and food security of smallholder farmers are likely to be severely compromised by climate change and variability (Temesgen, 2007). Because, the sector is dominated by small-scale mixed crop and livestock production with low economic development, lack of institutional capacity, inadequate infrastructure and with very low productivity. The major factors responsible for low productivity include reliance on traditional farming techniques, soil degradation caused by overgrazing and deforestation, poor complementary services such as extension, credit, marketing, infrastructure and climatic factors such as drought and flood. These factors reduce the adaptive capacity and increase the vulnerability of farmers to future shocks, such as climate change, which negatively affect the performance of the already weak agriculture (Aemro *et al.*, 2012). Frequent drought, shortening of growing season and increased occurrence of pest and disease are the major predicted impact of climate change on Ethiopian agriculture (Seid *et al.*, (2016).

Loka Abaya woreda is one of the potential agricultural producer areas of Sidama Region. Farmers in the woreda practice mixed farming in most parts of woyna-dega agro-ecological zone and agro-pastoralism in kolla agro-ecological zone of the woreda (LAWAO, 2018).

Nowadays, like in most rural areas of Ethiopia, the Woreda is characterized by deterioration of natural resource base, shortage of agricultural land and speedy deforestation which resulted in land degradation in most mid lands of the area. Since recent past, farmers in the woreda are facing adverse impacts of climate change and variability on their livelihood. As a result of this, it affected farmer’s livelihood, crop and livestock production has decreased and the woreda has become significantly vulnerable to the impacts of climate change and variability. In addition to this, due to the change in the pattern and timing of rain fall, there is change in the cropping pattern of the study area.

In spite of the long term local farmers endeavor to adapt to the changing climate, their effort to achieve resilient livelihood is constrained by various factors. This might be partly because, their adaptation strategies are not well organized, not integrated with development polices, may not be in accordance with community priorities and needs. Furthermore, it could be assumed that their attempt to adapt to climate variability and attain more resilient livelihood lacks, collective action and social capital and does not emphasize local decision making processes.

But, it is possible to reduce adverse effects of climate change and variability by formulating effective and efficient adaptation strategies. Climate change impact assessment research conducted so far in the study area is very limited and most of it focuses on policy responses to climate change leaving out the efforts made to adapt in household and community level. Therefore, to fill this gap, this study attempts to evaluate the effects of climate change and variability on rural livelihoods' and their adaptation strategies in Lokka Abaya woreda Sidama Region, Ethiopia.

1.2 Statement of the Problem

Sub-Saharan African countries including Ethiopia are extremely vulnerable to climate change. According to Climate Change Vulnerability Index, Ethiopia is one of the countries in extreme risk category and ranks 7th in the list of countries most at risk from climate change (Admassu *et al.*, 2013). Ethiopia is an agrarian country which is challenged by both social and natural problems. The main social problem is poverty which is largely associated with high population growth, a low level of institutional and infrastructural development and a limited use of agricultural technology (Bryan *et al.*, 2013). Widespread land degradation associated with deforestation and soil erosion and loss of biodiversity coupled with climatic variability and recurrent drought in many places has severely damaged agricultural productivity and the livelihood of the farming community; and the cumulative effect has been manifested in food insecurity,(Gebrehiwot *et al.*, 2013).

Agriculture which is the dominant livelihood in most parts of the world is believed to be most sensitive to climate change impacts, and this equally applies to Ethiopia. Loka Abaya district in Sidama region is not different from what already explained. In the Loka Abaya district of Sidama region, climate change and variability manifest through frequent droughts and floods, erratic rainfall and fluctuating mean temperature (LADANRB, 2018). Smallholder farmers are highly dependent on rain fed agricultural and/or livelihood which is very sensitive to climate variability and change. Besides the study area has climate-induced risks such as shortage of water and increased incidences of pest and diseases. Some Changes in the distribution and amount of rainfall which have resulted in low precipitation and frequent drought have been affecting agriculture and livelihood of farmers in the district. This situation calls for scientific investigations which would enable to design local specific intervention and help to improve the communities' adaptive capacity against the present and future challenges of climate change-related hazards.

Many studies have shown that climate change has adverse impacts on human welfare, agriculture , natural resources and development activities in Ethiopia in general and sidama Region in particular (Deressa *et al.,* 2011; Kassie *et al.*,2013; Hamesso, 2013;

Seyum, 2014). In addition, most of the previous studies were carried out at macro-levels aggregated at the district and national levels. However, unless, the effects of climate variability and change are known and understood at the micro-level by the local people through establishing the right perception, it would be difficult to convince and motivate local leaders and communities to undertake mitigation and adaptation actions.

Thus, there was need to proactive adaptation strategies are needed to reduce the impact of climate change on agriculture/livelihood and to improve the resilience of smallholder farmers. This study aimed at, the effect of climate change and variability on rural livelihood and farmers adaptation measure in Loka Abaya woreda of Sidama Region, Ethiopia.

1.3 Objective of the study

1.3.1. General Objectives

The general objective of the study was to assess the effects of climate change and variability on rural households and the adaptation responses being undertaken in Loka Abaya woreda, Sidama region.

1.3.2. Specific Objectives

The specific objectives of the study are:

1. To analyse trends of climate variability in terms of temperature and annual rainfall in the study area;

2. To assess the existing responses and adaptation strategies being practiced to climate change by small holder farmers;

3. To identify determinants of climate change adaptation strategies by farmers in Loka Abaya woreda, Sidama Region.

1.4 Research Questions

The Research questions are;-

- What do you know about climate change in Loka Abaya woreda?
- What are the trends of local climate variability (Temperature and annual rainfall) in the study area?
- What are indicators of climate change over long period in Loka Abaya woreda?
- What are major adaptation strategies you exploit to reduce the impact of climate change?

1.5 Significance of the Study

The findings could contribute to deepen the knowledge of rural communities' perception and attitudes on climate change effect on rural livelihood and adaptation mechanisms used in the study area in particularly. Therefore, the outcomes of the study would be used in formulating future environmental policies and strategies at the local level. In addition, it could be used to identify the gap that can fill by material or by training which is required by people in the study area. Moreover, this kind of study was done for the first time specifically in the area and suits to dig out basic knowledge about the issue.

1.6 Scope of the Study

The study aimed to assess the effect of climate change and variability on rural livelihood and farmer's adaptation measure in Loka Abaya woreda, in Sidama region, but does not represent other woredas in the region.

1.7 Limitation of the Study

The study could have been much more interesting if it includes more additional *kebeles* in Loka Abaya woreda. However, the study relied on four selected *kebeles* only, for practical reasons such as time and financial limitations, some farmers were not willing to fill questionnaires and participation in FGD and shortage of adequate secondary source of data was also another problem. Thus, to narrow the earlier mentioned discrepancy the study identified the effect of climate change and variability on rural livelihood and farmer's adaptation measure in selected woredas.

1.8 Organization of the Thesis

This thesis comprises five chapters; the chapter one includes introduction, statement of the problem and objectives of the study. Chapter two and three to occupy literature review and methodology,respectively. Eventually chapter four and five comprises results, discussion, conclusion and recommendations.

2. LITERATURE REVIEW

2.1. Theretical Review on Climate change

2.1.1. Climate Change at a Global Level

The increased concern of the international community on challenges of climate change is based on the scientific understanding of the climate system. The Sun's energy enters the atmosphere as light wave then heats up the Earth (Mitchell, 1989). Some of the energy warms up the Earth and some of it is re-radiated back into atmosphere in form of infrared waves (Mitchell, 1989). Under normal conditions, some of the outgoing infrared waves are trapped by atmospheric greenhouse gases, which keep the Earth's temperature around moderately warm, making the Earth comfortable and habitable as well as maintain the balance between natural and social systems (Al Gore, 2008; Houghton, 2009, 2009; McMullen, 2009; Mitchell, 1989). Thus, temperatures on Earth have always been right for living. The current problem is on the thickening of the atmospheric greenhouse gases layer through deposition of huge quantities of human induced atmospheric carbon-dioxide and other greenhouse gases (Mitchell, 1989). As the thickness increases, it traps more infrared radiation that would otherwise escape from the atmosphere (Al Gore, 2008). As a result, the temperature of the Earth's atmosphere and oceans are getting quickly and dangerously warmer (Houghton, 2009; Al Gore, 2008; McMullen, 2009). It is this understanding that led the IPCC in its Third Assessment Report released in 2001 to identify five reasons for concern about climate change (portrayed in a diagram called burning embers), namely, the risk to unique and threatened ecosystems; the risk of extreme weather events; distribution of impacts; scale of aggregate impacts; and risks of large-scale discontinuities (IPCC, 2001).

Climate Change is one of the biggest global problems posing challenges to sustainable livelihoods, food security and economic development, particularly for developing countries (Eshetu *et al.,* 2014). Climate change, whether driven by natural or human forcing, can lead to changes in the likelihood of the occurrence or strength of extreme weather and climate events or both (Cubasch *et al.,* 2013). Human influence on the climate system is clear, and recent anthropogenic emissions of greenhouse gases are the highest in history. Recent climate changes have had widespread impacts on human and natural systems (IPCC, 2014a). Increase in population size, economic activity, lifestyle, energy use, land use patterns, technology and climate policy had been the mainly drivers of anthropogenic emissions of greenhouse. Since 1950 extreme weather and CC events have been observed, whereby more than half of the observed increase in global average surface temperature from 1951 to 2010 was caused by the anthropogenic increase in GHG concentrations and other anthropogenic forcing (IPCC 2014b). Heat waves, droughts, floods, cyclones and wildfires are recent climate related extremes impacts that reveal significant vulnerability and exposure of some ecosystems and many human systems to current climate change and climate variability (IPCC, 2014a). Moreover, according to the contribution of Working Group II to the Fifth Assessment Report (FAR), the continued emission of greenhouse gases will cause further warming and long-lasting changes in all components of the climate system, increasing the likelihood of severe, pervasive and irreversible impacts for people and ecosystems. Moreover, future climate will depend on committed warming caused by past anthropogenic emissions, as well as future anthropogenic emissions and natural Climate variability .

As a continent, Africa contributes the least to GHG emissions, yet it is the continent that is and will continue to be impacted most by climate change (IPCC, 2007e; Global Humanitarian Forum, 2009; Conway, & Schipper (2011). For Africa, climate change is a serious threat to development and poverty reduction efforts because with its impacts, small scale African agriculture is and will severely be compounded (IPCC 2007b; Müller, 2011). In addition, other key economic sectors are affected by the frequent climate variability, and extreme weather events such as drought and flooding thereby increasing risks to livelihoods. The African continent is said to be at high risk of water scarcity and stress, which may lead to intensified conflicts (IPCC, 2007b; Bates *et al*., 2008; UNFCCC, 2007). The continent is also facing various health risks associated with climate variability and change including malaria. All these may threaten to reverse decades of development efforts and subject the continent into risks of long-term poverty. In a general sense, vulnerability of the African continent to climate change is a function of many factors including long-term poverty, illiteracy, lack of skills, weak technical institutions, poor and probably limited infrastructure and poor technological development. Others include health risks due to HIV/AIDS and other health related stresses and poor information access to many particularly those in rural areas where transport and communication are also in poor conditions, just to mention a few.

2.1.2 Climate Variability and Change: The Ethiopian Context

Ethiopia is one of those countries that are extremely vulnerable to climate change. Its geographical location and topography, coupled with low adaptive capacity due to low level of development and dependence on agriculture, explain its vulnerability to the impacts of climate change (World Bank, 2010). Agriculture is the mainstay of its economy contributing 42 % of its GDP and employing close to 80% of its population (FDRE, 2014; EfD, 2012).The majority of farmers are smallholders that depend on rain-fed agriculture for subsistence production, which makes them highly exposed to climate variability and consequently to both transient and chronic food insecurity (Conway & Schipper, 2011).

Ethiopia has a wider range of climatic zones that vary in altitude and location. Altitudinal variation induces temperature changes and is a factor for the formation of three main climatic zones –cool (Dega), temperate (Weyna Dega), and hot (Kola). The mean annual rainfall distribution in the country ranges from a maximum of more than 2000 mm over the South Western highlands to a minimum of less than 300 mm over the South-Eastern and North Western lowlands. Similarly, mean annual temperature varies considerably, from lower than 15^0C over the highlands to over 25^0C in the lowlands. This climate variability is used to classify the three seasons in the country mainly based on rainfall regimes. These are the dry season (Bega) from October to January; the short rainy season (Belg) from February to May and the long rainy season (Kiremet) from June to September (FDRE, 2015; Livelihoods Integration Unit (LIU), 2011).

In Ethiopia, climate variability is common and has caused several droughts and floods, undermining food security and even causing famine for decades. Drought and floods are the major climatic hazards in Ethiopia and occur every 3 to 5 years. Since the early 1980s the country has suffered five major droughts that caused famines (FEWS NET, 2012); World Bank, 2009). Over the last two decades, the frequency and severity of droughts has increased in many parts of the country and are likely to continue with increasing trend in global warming (Williams & Funk, 2011; Shiferaw *et al.,* 2014). These droughts have caused livelihood breakdowns, aggravated poverty and triggered major catastrophes such as the 1972/73 and 1984 Wello famines (Webb & Braun, 1994). Likewise, flooding caused considerable damages to lives and livelihoods by destroying crops and infrastructure in different parts of the country in 1988, 1993, 1994, 1995, 1996, and 2006 (ICPAC, 2007 cited in World Bank, 2010).

2.3. Impact of Climate Change on Rural Livelihoods

The major and almost the exclusive livelihood activities of the rural Ethiopia are crop production, livestock rearing, natural resource extraction, and only less than small percentage engaged in off-farm activities. Hence, given the inherent link of these livelihood activities to natural resources, they are largely at the mercy of uncertainties driven by climate change, including extreme events such as flooding and drought. Over the last decade or so, climate change (in terms of long-term changes in mean temperature or precipitation, as well as an increased frequency of extreme climate effects) has gradually been recognized as an additional factor which, with other conventional pressures, will have a significant weight on the form, scale, and spatial and temporal impact on rural livelihood activities. The distribution of impacts will vary as both the ability to respond to impacts and resources with which to do so vary across nations. In other cases, impacts will be unexpected, and appropriate responses may not easily be known or implemented in advance (Seyum, 2015).

Climate change impacts on livelihood activities are elaborated below

2.3.1. Impacts of Climate Change on Crop Production

Climate change will impact the crop, animal and grazing resources of mixed farming systems in different ways, altering also the interactions and resource flows between them, and as such the functioning and performance of the entire system. The tropical crops such as maize, soybean and cotton may experience greater sensitivity to warming, compared to temperate crops such as wheat, barley and potato, especially when they are grown at the edge of their natural range (Alcamo & Olesen, 2012). The changes in precipitation and temperature can directly influence crop production. Climate change will affect the crop component of mixed systems through impacts on primary biomass production (grain and crop residues), and on crop suitability. Precipitation patterns determine the availability of freshwater and the level of soil moisture, which are critical inputs for crop growth. Moderate precipitation may reduce the yield gap between rain-fed and irrigated agriculture by reducing crop variability (Calzadilla *et al.,* 2009 and 2013). However, heavy precipitation is very likely to result in soil erosion and difficulty to cultivate land due to water logging of soils. Higher temperatures accelerate plant phenology, leading to decreased yield potential (Schlenker and Lobell, 2010; Sultan *et al.,* 2013). Temperatures above or below thresholds may trigger plant senescence, and reduce leaf area growth and photosynthesis. Conversely, a shorter growing period may help to avoid drought during grain filling. Furthermore, changes in temperature and rainfall affect biomass production through their effects on transpiration and water stress (Asseng *et al.*, 2011).

Crop suitability is affected by changes in the length of the growing period and changes in the frequency of crop failure as weather variability and the frequency of extreme events increase. Although the magnitude and even the direction of change vary tremendously between regions, crops and cultivars, an overall negative impact of climate change on crop yields is expected (Müller, 2013; Niang *et al.*, 2014). Notable exceptions to these negative projections include maize in highland areas, which may benefit from increased temperature (Thornton *et al.*, 2010) and cassava, which, being a starch crop resistant to high temperature and low rainfall, may benefit from CO2 fertilization (Liu et al., 2008).

The yields of most European crops are stimulated by the increased atmospheric CO2 concentration. The effect is mostly pronounced to the crops with C3 photosynthesis pathway which most of these crops are grown in Europe (Alcamo & Olesen, 2012). The yield of these crops can be increased to 20-40% in response of doubling of atmospheric CO2 concentration (Olesen, 2014). Plants with C4 photosynthesis pathway which include warm season plants like maize, sorghum, sugar cane, miscanthus, amaranth and millet, the response is noticeably lower (Jalloh *et al.*, 2013). The consumption of water by plants is also reduced by higher CO2 concentration, and therefore, in drier conditions, the tolerance of plants might be improved, consequently leading in higher yields under dry conditions. This is mainly due to the fact that, the amount and the openness of stomata will be reduced with higher CO2 concentration for both C3 and C4 plants. Thus, under dry or drought conditions, the transpiration will be reduced and more water use efficiencies, leading into higher yields (Sheffield *et al.*, 2012). The same authors highlighted that the quality of plant biomass is also affected by higher CO2 concentrations; this is mainly due to fact that, plants accumulate more sugar resulting to leaves, stems and reproductive organs to have higher carbon contents. Consequently, this might have some negative impacts on the quality of the food and feed.

And therefore, there might be a need of some adjustments in farm management, for instances; changes in the timing of harvesting grape in to get the optimal quality as well as the way cattle are fed. Also, the increased CO2 concentrations can results into a more trouble weeds. Though, there might be some changes in the attraction of plants for pests and diseases, whereby plants can be more resistant to attack (Teka *et al.*, 2012).

2.3.2. Impacts of climate change on Livestock Production

Similar to crop production, the impact of climate change and variability in the livestock production is generally negative. Heat stress and its impact on seasonal water availability have a variety of detrimental effects on livestock, with significant effects on milk production and reproduction in dairy cows, and swine fertility (Nigus, 2011). Drought and delay in the onset of rain led to poor grass regeneration/forage deficit, water shortage and heat stress on livestock, and consequently increased the mortality of the livestock, vulnerability to diseases and physical deterioration due to long distance travel for water and pastures (Abate, 2009).

Climate change affects livestock both directly and indirectly. The direct effects from air temperature, humidity, wind speed and other climate factors influence animal perf romance: growth, milk production, wool production and reproduction. Climate change will have far-reaching consequences for dairy and meat production, especially in vulnerable parts of the world where it is vital for nutrition and livelihoods.The impact of climate change can heighten the vulnerability of livestock systems and exacerbate existing stresses upon them, such as drought (Abebe, 2013). The most vulnerable communities to the impacts of climate change inhabit the dry lands areas. Pastoralists inhabiting dry lands have been able to survive the harsh environments practicing various sustainable livelihood approaches including seasonal movements, keeping livestock, among others (UNDP, 2010).

2.3.3. Impacts on Water Resources

Water is an essential resource for all life and a requirement for good health and sanitation. It is a critical input for industry and essential for sustainable growth and poverty reduction. Climate change will alter patterns of water availability by intensifying the water cycle. Droughts and floods will become more severe in many areas. There will be more rain at high latitudes, and less rain in the dry subtropics (IPCC, 2007 & 2014).

Observed warming over several decades has been linked to changes in the large-scale hydrological cycle such as: increasing atmospheric water vapor content; changing precipitation patterns, intensity and extremes; reduced snow cover and widespread melting of ice; and changes in soil moisture and runoff. Precipitation changes show substantial spatial and inter-decadal variability (Haggar and Schepp, 2012; IFRC, 2016).

Climate change is also likely to intensify the current challenges of water scarcity and water competition within and between communities and nations, linked by hydrological flows across watersheds and basins. By the middle of the 21st century, annual average river runoff and water availability are projected to increase as a result of climate change at high latitudes and in some wet tropical areas, and decrease over some dry regions at mid-latitudes and in the dry tropics.

Poor and vulnerable populations of SSA are likely to face the greatest risk. Moreover, there is recognition that climate change, mainly as a result of human action, is impacting

SSA more than other continents because its economies are largely based on weather sensitive crop-livestock and agro pastoral production systems and also due to the low adaptation capacity of SSA countries to climate change and variability (FAO, 2011).

2.3.4 Climate Change Impact on Forest Resources

Ethiopia Climate change is expected to have adverse ecological, social and economic impacts. So far, there have only been limited numbers of quantitative climate change impact assessments for the various socio-economic sectors in Ethiopia. According to Ethiopia's NAPA (Federal Democratic Republic of Ethiopia, 2007), the major impacts of climate change on forests include the expansion of tropical dry forests and the disappearance of lower montane wet forests, and the expansion of desertification. One of the specific impacts of climate change is the increased fire risk: drier conditions will increase the risk of fire, making forest fires more frequent and intense, resulting in degradation. Further impacts of climate change include land-use change; increase in invasive species such as Prosopis juliflora and Acacia drepanolobium in Afar and Somali regions, where they are causing considerable socio-cultural damage; and changes in forest-dependent livelihoods due to changes in forest extent. Furthermore, the changing climate will impact species with a narrow ecological range (e.g. highland bamboo, alpine species), which are likely to be threatened.

Climate change has the potential to affect both timber and Non timber forest products as well as wider ecosystem services (water and soil, catchment management and flood protection) and rural livelihoods, which depend on forests for a large proportion of their income and as a coping strategy during times of drought – by damaging the products and services obtained from the forest and causing species extinction. This will particularly affect people who depend on timber production and Non timber forest products such as forest coffee, honey, beeswax, medicinal herbs, bamboo, mushrooms, latex, gums and resins. Changing climatic conditions make agriculture more precarious in current agricultural production areas, driving farmers to move into higher rainfall areas (woodland and forest areas). Increased demand on forests to diversify sources of livelihood (as agricultural systems become more precarious as a result of climate change) may increase the pressure on forests. There are a limited number of quantitative studies in Ethiopia on the specific impacts of climate change, but hazards such as outbreaks of pests and diseases and forest fires (which are already affecting forest areas) are likely to increase in frequency and intensity. Further, although models are not yet sufficiently developed to predict the future climatic trends in Ethiopia, anecdotal evidence suggests that climate variability is already occurring (Kefiyalew, 2016).

2.4. Climate Change Adaptation Strategies

Adaptation measures always seek to reduce the risks and impacts of climate change, to moderate the negative effects, and to exploit beneficial opportunities .In many rural communities indigenous knowledge developed over the years is the foundation for decision-making at local level. Indigenous knowledge has value not only for the cultural scenario in which it evolves, but also for intellectuals and planners striving to improve conditions in rural localities (Ford *et al.,* 2015). Integrating   indigenous knowledge into policy frameworks for climate change can lead to the development of effective adaptation strategies that are profitable and sustainable (Ford *et al.,* 2015; Nyong *et al.,* 2007). Communities and farmers in Africa always strive to withstand the changing environments.

They have the knowledge and practices to cope with basic environmental conditions and climatic and other natural shocks:

Crop diversification as a reaction to reduced productivity. This strategy was not considered very sustainable or efficient, as it can only help marginally (Gbetibouo, 2009; Gebre *et al.*, 2014).

Fallowing, as a reaction to reduced productivity of soils. This is sustainable, but requires sufficient possession of land (EfD, 2012).

Conservation agriculture: promotes soil quality through minimum soil disturbance, mulching and residue management which can increase soil fertility and the availability of nutrients to plants. Soil organic matter has been found to increase significantly over time in conservation agriculture systems, primarily due to the introduction of organic matter as crop residues or mulch and to the minimal disturbance of soil (FAO, 2016). Soil organic matter not only provides nutrients for the crop but is also a crucial element for the stabilization of soil structure. Presence of organic matter improves soil fertility and reduces soil erosion by improving the aggregate stability of soil. Minimum disturbance of soil results in less soil compaction which lowers the bulk density. High bulk density restricts root growth, movement of air and water through the soil resulting in poor plant growth that affects crop yield.

Agroforestry: Agroforestry is land use management system that involves the integration of trees and shrubs into farmland either through planting or natural regeneration. Agroforestry have a high potential for climate change mitigation, adaptation and crop productivity. Agroforestry enhances SOM, agriculture productivity, carbon sequestration, water retention, agro-biodiversity and farmers' income (Zomer *et al.,* 2016; Singh, 2017).

Trees provide cover for soil that prevents erosion which is one of the main causes of soil degradation. Agroforestry improves agricultural yield by enhancing soil fertility through nutrient cycling, improved SOM and creation of favorable microclimate for certain crops.

Soil and Water conservation (SWC): SWC is the combinations of the appropriate land use and management practices that promotes the productivity and reduce erosion and other forms of land degradation (Roobroeck *et al.*, 2016). A SWC practice reduces soil erosion, enhances soil fertility, improves soil moisture and ultimately improves system productivity.

Livestock management: Adaptation to climate change in field-based livestock includes altering animal species and breeds, giving adequate water supply, producing pasture, altering rotation of pastures, and modifying the time of grazing and reproduction. Furthermore, using different and/or adapted forage crops, supplementary feeds, and concentrates are agricultural adaptation options (Homann *et al.*, 2008). Mixing animal and cropping systems is another adaptation option which diversifies the farm and thus increases the farmers' adaptive capacity. Especially changing the animal species or breed can be an effective adaptation options, since some animal species and breeds are better suited to heat stress than others (Gebrehiwot & van der Veen, 2013). However, more heat-tolerant livestock breeds often show lower levels of productivity (Hoffmann, 2008).

Diversification of incomes: through livestock, bees and poultry, against reduced incomes. This is sustainable, but not very effective, as these activities are difficult to put in place. - Petty trade (grain and other sales), as a reaction to reduced incomes. This strategy was considered efficient and sustainable.

2.5. Empirical Studies

Farmers' Adaptation Strategies to Climate Change

There are a few studies conducted on Ethiopian farmers' climate change adaptation strategies. Economists have done a research work on understanding farmers' awareness of climate change, options for adaptation to climate change and the factors influencing choice of adaptation methods to climate change in Ethiopia. There has been mixed evidence about climate adaptation strategies. Some of the relevant studies conducted in Ethiopia are presented here as follows.

ACCCA (2010) employed a multivariate Probit model in northern Ethiopia and found that access to extension service, livestock ownership by female farmers and access to climate change information have positive and substantial impact on adaptation to climate change. In analyzing options and constraints in adapting to climate change in Ethiopia and South Africa. Bryan *et al* (2009) insisted on farmers' better understanding of climate change as the way of reducing its negative impacts. The study found that government farm support, farmers' income, and access to fertile land and credit influence the choice of adaptation methods in South Africa while access to extension and credit, fanners' income and information about climate change influence the choice of adaptation methods in Ethiopia. The study further found that the main barrier to uptake of other adaptation methods in both countries was lack of access to credit.

Yesuf *et al* (2008) used probit regression model to factors affecting adoption of climate change adaptation strategies and the impact of climate change adaptation on food production using plot- level data from 1,000 farm households producing cereal crops in the Nile Basin of Ethiopia. They found that climate change adaptations, namely, changing crop varieties, adopting soil and water conservation measures, water harvesting, tree planting, and changing planting and harvesting periods have significant impact on farm productivity. Extension services, access to credit and information on future climate changes, affect adaptation positively and significantly. Farm households with larger access to social capital are more likely to adopt yield-related adaptation strategies. On the other hand, lack of information and shortages of labor, land, and money were identified as major reasons for not adapting. Some studies identified the use of different crops or crop varieties, tree planting, soil conservation, changing planting dates, and irrigation as common adaptation strategies; and level of education, gender, age, and wealth of the head of household; access to extension and credit; information on climate, social capital, agro-ecological settings, and temperature all influence farmers choices; lack of information on adaptation methods, financial constraints, and lack of access to land as main barriers to adapt (Temesgen *et al*, 2008; Bryan *et al*., 2009).

According to Temesgen *et al.* (2009), household characteristics such as education, farm, and nonfarm incomes have significant impact on adaptation to climate change. The study further revealed that institutional factors such as extension on crop and livestock production, access to information on climate change and access to credit enhanced adaptation to climate change. Social capital, which was represented by farmer-to-farmers extension and the number of relatives in local area, also affect adaptation to climate change positively. In addition to this, environmental factors such as agro ecological setting (kola, woyna dega and dega), temperature and precipitation significantly affect adaptation to climate change. Furthermore, the study in the analysis of farmers' perceptions of climate change indicates that most of the farmers in the Nile basin of

Ethiopia are aware of the fact that temperature is increasing and the level of precipitation is declining.

Tadesse (2011) revealed that male headed household, those educated and those with large family size tend to adapt crop diversification adaptation method to cope with adverse impacts from climate change. Likewise, households with larger land size, TLU and higher farm income have higher probability of preferring soil and water conservation as an adaptation method. Access to credit, extension services and climate change information among the households are positively associated with preferring adjusting planting date adaptation method.

Bewket (2010); Bewket *et al*., 2013) indicated that most of the farmers who perceived changes in climate employed local adaptation options in response to climate signals. The most common adaptation options include: implementation of soil conservation practices, cropping calendar adjustment, tree planting, and change of crops, crop diversification and adjustment to crop and livestock management. However, lack of knowledge and information, lack of inputs, inappropriate policy, land scarcity, shortage of labor, lack of market, water scarcity, poverty and lack of extension services were identified as barriers to adaptation. The multinomial logit model result highlighted the frequent extension visit, resource endowment, access to climate information, large size of productive labor and increased farming experience as positive influences on farmers' adaptation to climate change.

Hassan and Nhemachena (2008) in their study of actual adaptation choices made by farmers in 11 African countries based on a cross-sectional survey using MNL model, found farming experience to promote adaptation. Experienced farmers usually have better knowledge and information on climate change and agronomic practices that they can use to cope with changes in climate and other socioeconomic conditions. The results of the empirical analyses confirmed the role of improved access to information (climate and production) and credit in enhancing farmers' awareness, which is crucial for adaptation decision making and planning. Combining access to extension and credit ensures that farmers have the information for decision-making and the means to take up adaptation measures. Better access to markets reduces transport and other market related transaction costs and enhances the uptake of farm-level adaptation measures. Larger farm sizes were found to encourage the use of multiple cropping and integration of a livestock component, especially under dry land conditions. Large farm sizes allow farmers to diversify their crop and livestock options and help spread the risks of loss associated with changes in climate. This suggests that availability of labor may be a critical factor constraining the switch away from the risky mono-cropping systems.

2.6. Conceptual Framework

This study draws upon the conceptual framework developed by Connolly-Boutin *et al.* (2015), which explains that the vulnerability of a farming community depends on two interrelated factors: The first is related to shocks such as climate change and socioeconomic factors and the second on the capacity to adapt to the shocks. Climate change/shocks include high temperature and rainfall intensity (Thomas *et al.,* 2007), droughts and floods (Niang *et al.,* 2014; Tschakert *et al.,* 2010), spread of animal and human diseases (Chen *et al.,* 2006). Socioeconomic factors such as population growth, policies and institutions are also important drivers of vulnerability (Adger *et al.,* 2006; Scoones, 2009). Climate shocks and socioeconomic factors systematically interact (overlap) to affect the food security of a community and are regarded as hazards (Gentle *et al.*, 2012).

Adaptation to climate change on rural livelihood systems is determined by local institutions and polices as well as by the interaction between climate and socioeconomic conditions (seesFigure.1).

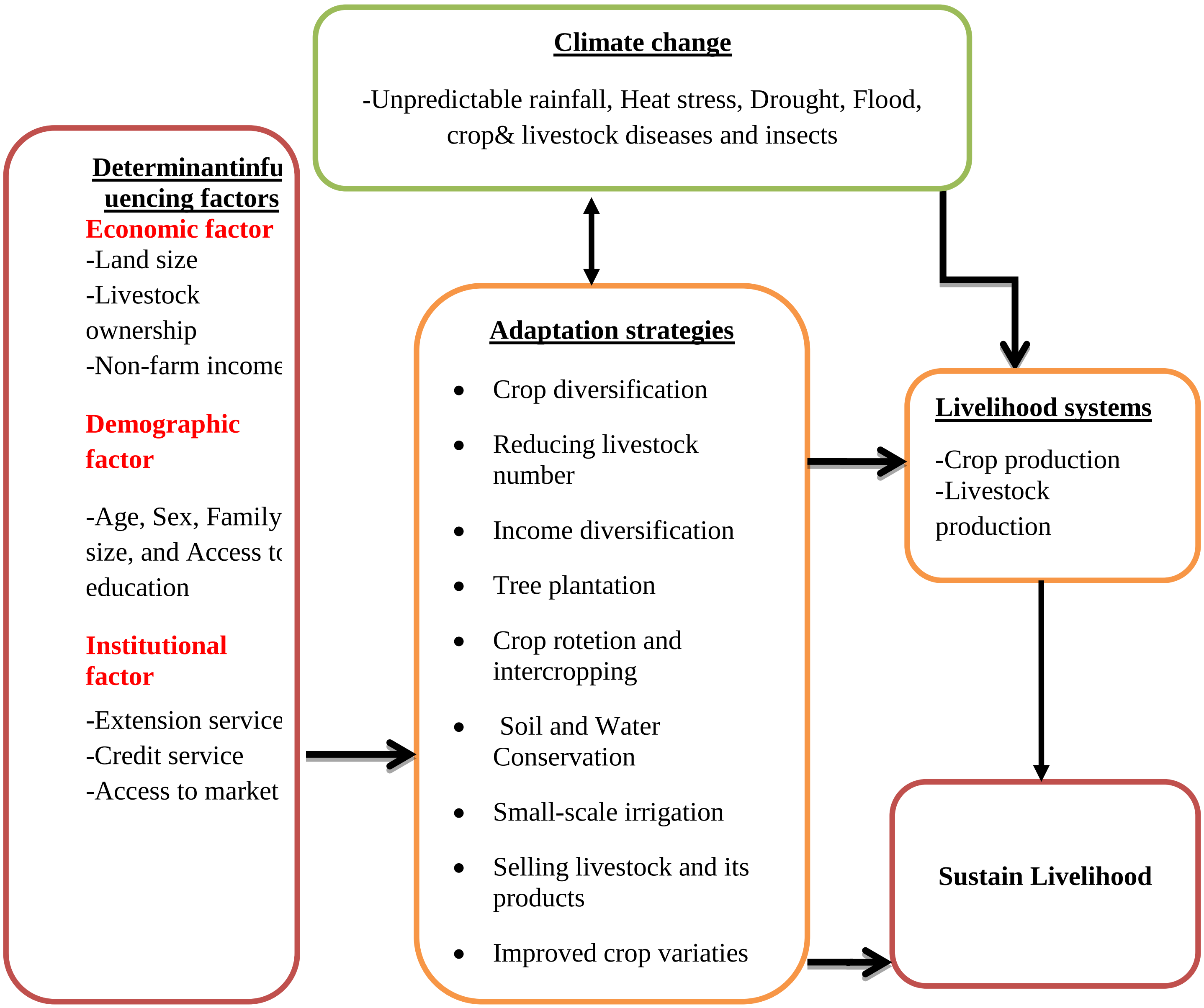

Figure1. Conceptual framework of study

Source: Developed based on Literature review (2020).

3. METHODOLOGY

3.1. Description of the Study area

Loka Abaya woreda is found in Sidama Region, Ethiopia. The area is located at East of Lake Abaya. Geographically it lie between 6° 42´- 6º 83´ N and 38° 01´- 38° 36´E, The total area of the woreda is about 878 km2. Its altitude ranges from 1001-2000 meter above sea level. The major part of the woreda is characterized by semi-arid which constitutes fifteen kebeles along with a few sub-humid areas which includes about ten kebeles. Based on the census conducted by the CSA (2013) this woreda has a total population of 124,771 of whom 63,050 are men and 61,661 women. The agro-ecology of woreda can be considered as Woyna dega and Kolla. It is characterized by a warmer climate following the traditional classification of agro ecological zones in Ethiopia. The woreda is characterized by hot condition and experienced recurrent drought in recent years .The mean annual minimum and maximum temperature of the area ranged from 17.6-25ºC, annually. The rain fall distribution of the woreda lies between 1001-1400mm per annum which is characterized by erratic distribution (LAWAO, 2018).

According to the District Rural and Agricultural Development Office, (2016), the topographic feature of the district is rugged and its plateau is dissected by various gorges and river valleys that flow west ward with abrupt cliffs that form the Great Rift Valley. The woreda consists of steep slopes and rivers like Bilate, valleys as well as protected area like Loka Abaya Park with its diverse fauna and flora. The district encompasses 25 kebeles.

Both crop production and animal husbandry are commonly practiced. Farming system of the study area generally depends on rain fed agriculture. The major crops cultivated in study area are maize, haricot bean, coffee, horticultural crops and teff. The main livestock species reared in the district are cattle, goats, sheep, poultry, donkey, horse and mule. There are two cropping seasons in the study area, i.e., Belg (short rainy season) which runs from March to May and Meher (main rainy season) which occurs in the months of June to September. Belg rains are mainly used for land preparation and planting long cycle crops such as maize. The Meher rains are used for planting potato, green paper, haricot bean, sweet potato and to some extent teff (LAWAO, 2018)

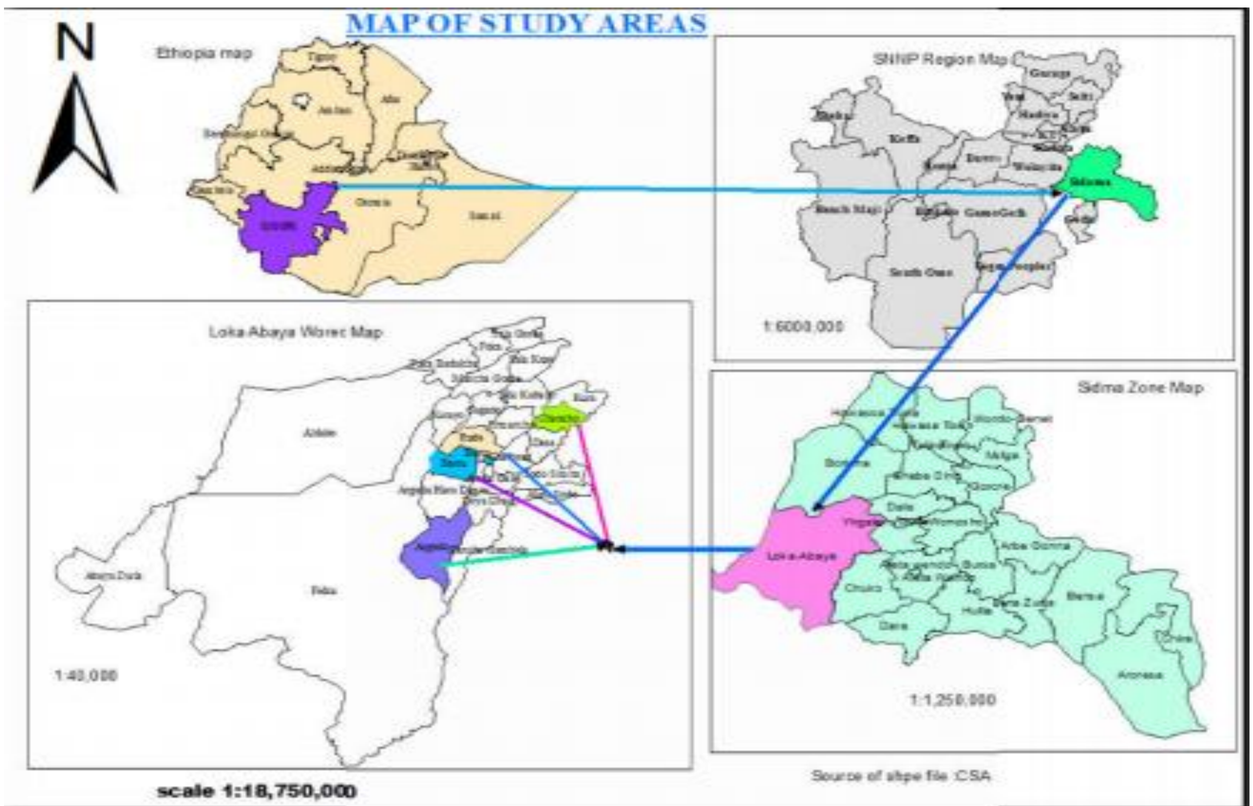

Figure 2 Map of study area

Source developed by ARC GIS (2020)

3.2. Research Design

The study used cross sectional survey design to assess overall activities at one shot and to maintain triangulation of the findings, this design manifests the basic features of both the qualitative and quantitative researches.

3.3 Sampling Procedure and Sample Size Determination

The study employed a three stage sampling techniques. In the first stage, Loka Abaya district was selected purposely from Sidama Region because it is one of the most affected areas by extreme climate induced shocks, by considering farming/livelihood system, characterized by two distinct agro-ecological zones namely Woyna dega (mid-altitude) and Kolla (low-altitude).

In the second stage, four Kebeles (two from each agro ecological zone) were selected randomly (Table 1) with the assumption that smallholder farmers within each agro-ecological system may have differences in their traditional knowledge and skills, and that this may result in different adaptive capacities in the communities. As climate change may have different effects in different agro-ecological zone, the farmers in the respective agro-ecologies may practice different adaptation strategies. These strategies are also determined by socioeconomic status of the areas.

In the third stage, total numbers of households in each target kebeles were identified then, out of those selected kebeles, 188 sample households were selected using systematic sampling techniques with probability proportional to size. Simplified formula provided by Yamane (1967) was used to determine the required sample size at 95% confidence level and 7% level of precision as shown below

$$n = \frac{N}{1 + N(e)^2} = \frac{2458}{1 + 2458(0.07)^2} = 188$$

Where n is sample size,

N is the total number of households in study kebeles and

e- is level of precision

Table1 Distribution of Sample household in each study kebeles

Study Kebeles	Agro ecology Zone	Total number of HHs	Number of Sample households
Argada	Woyna Dega	727	57
Bartu	Kolla	486	37
Chancho	Woyna Dega	615	46
Rude	Kolla	630	48
Total		2458	188

3.4 Sources of Data and Methods of Data Collection

To achieve the objectives of the study, both primary and secondary data were collected. Primary data were collected by using household questionnaire, key informant interviews and FGD. Secondary data sources which include district profile were obtained from published and unpublished sources, district offices, and Monthly rainfall and temperature records (1988-2017) were obtained from the National Meteorological Agency (NMA) of Ethiopia. Various data collection tools that was used in this study were as described below;

Household survey

A semi structured questionnaire having both close-ended and open-ended questions was delivered to 188 households through trained data collectors that aimed at obtaining information on important demographic and socio-economic information, farmers' perceptions on the local climate status; climate change effect in their farming practice/livelihood activities overtime; and adaptation measures in response to changing climatic condition as well as factors that motivate farmers' decisions to undertake such changes in farming practices. Other aspects included socioeconomic implications of the changes at both household and community levels; and long-term policy and strategic interventions for enhanced resilience, which farmers believe they could be able to support them to not only adapt but also enhance their resilience to climate change and variability in future.

Focus Group Discussions

Focus group discussion (FGD) provides an opportunity to discuss thoroughly on the desired topics. The participants of focus group discussions for this study are elders, youth and women. FGDs were held in 4 study kebeles comprising 8 (5 male and 3 women) individuals per group (a total of 32 individuals from all study kebeles) .The FGD is mainly focused on collecting data in relation to farmers' perception on the local climate, climate change effect on farming systems (crop, livestock production and on other non agricultural based livelihood activities) and adaptation measures they had practiced. Besides FGDs were used as a method for cross checking information collected through other methods including individual household interviews.

Key informant interview

Key informant interviews were conducted with knowledgeable people in the community who have more awareness and understanding about the locality and issues intended to carry out study. The key informant members that were participated while undertaking the study are: four agricultural, livestock resource and environment protection office experts, eight development agents (DA) and four kebeles administrative leaders, a total of 16 key informant members were took part in all study kebeles. The major topics that were discussed include information about the general trends of climate change (rainfall, temperature, drought and floods), the effects of climate change on crop production, livestock husbandry, livelihood options and various coping and adaptation strategies measures that would be undertaken at local level and the issue of their sustainability.

3.5 Methods of Data Analysis

Descriptive statistical techniques such as mean, standard deviation, coefficient of variation, percentages, frequency, figure, table, and likert scale measurements were used to analyze effects of climate change and variability on agricultural based livelihood systems and to assess the existing responses and adaptation measures being practiced to climate change and variability. Multi nominal logit model was used to identify determinants of climate change adaptation strategies. SPSS version 20 was used to analyze descriptive results, Excel sheet was used to present patterns and trends of rainfall and temperature data, where as STATA version 14.2 was used to analyze result of multi nominal logit model.

Adaptation Strategy Index

To identify those adaptive strategies which held relative importance over others an adaptation index procedure was implemented, as measured by the formula presented below (5). Farmers were asked to assess different adaptation strategies by using the same four-point rating scale described in Section 2 to rate the importance of each strategy to their agricultural enterprises. The relative importance of adaptation strategies to climate change was calculated based on the following index formula (Uddin, and Takeya, 2005)

$$ASI = AS_n \times 0 + AS_l \times 1 + AS_m \times 2 + AS_h \times 3 \quad (5)$$

where,

ASI = Adaptation Strategy Index

AS_n = Frequency of farmers rating adaptation strategy as having no importance

AS_l = Frequency of farmers rating adaptation strategy as having low importance

AS_m = Frequency of farmers rating adaptation strategy as having moderate importance

AS_h = Frequency of farmers rating adaptation strategy as having high importance

Econometric model specification

In this study, the determinants of farmers' adaptation decisions to climate change were analyzed using a multinomial logit (MNL) model, (Kurukulasuriya and Mendelsohn, 2008). The MNL model was used based on the previous literature on determinants of farmers' adaptation to climate change (Abdi *et al.,* 2015; Deressa *et al.,* 2009). This model suits such type of analysis as it permits the analysis of decisions across more than two categories, allowing the determination of choice probabilities for different categories. However, the model requires that households are associated with only their most preferred option from a given set of adaptation strategies. Unbiased and consistent parameter estimates using this model need to assume independence of irrelevant alternatives that requires the probability of using a certain adaptation method by a given household is independent from the probability of choosing another adaptation method. We are aware that collecting and using only the most preferred adaptation option for each household risks underemphasizing the known importance to smallholder farmers of using multiple adaptation strategies, but the approach has allowed a high level of specification of the relations between adaptation strategies and underlying socioeconomic variables. The model is specified as follows.

Let Y denote a random variable with values {1, 2…J} for a positive integer J and X set of variables. In this study, Y is a dependent variable and represents the adaptation alternatives (strategies) from the set of adaptation measures, whereas the X represents the factors that influence choice of the adaptation strategies which contains household attributes, and P1, P2…Pj as associated probabilities, such that $P_1 + P_2 + \ldots + P_j = 1$. This tells as how a certain change in X affects the response probabilities P(y = j/x), j = 1, 2…J. Since the probabilities must sum to unity, P(y = j/x) is determined once the probabilities for j = 2…J are known.

$$P(y = 1/x) = 1 - (P2 + P3 + \cdots Pj) \ldots \ldots (3)$$

In the MNL model, it is usual to designate one as the reference category. The probability of membership in other categories is then compared to the probability of membership in the reference category. Consequently, for a dependent variable with j categories, this requires the calculation of j − 1 equations, one for each category relative to the reference category, to describe the relationship between the dependent variable and the independent variables. The choice of the reference category is arbitrary but should be theoretically motivated. The estimation of MNL model for this study will be carried out by normalizing one category which is named as “base category” or “reference state.” The theoretical explanation of the model is that in all cases, the estimated coefficient should be compared with the base group or reference category (Gujarati, 2004). Therefore, the choice of the reference category is based on empirical literature and theoretically motivated. The generalized form of probabilities for an outcome variable with j categories is:

$$\mathbf{P_r} = \left(y_i = {}^{j}\!/_{x}\right) = pr_{ij} = \frac{\exp\,(x'\beta j)}{1+\sum_{j=2}^{j}\exp(x'\beta j)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(4)}$$

j = 1, 2 . . . J for j > 1.

The parameter estimates of the MNL model only provide the direction of the effect of the independent variables on the dependent (response) variable; estimates represent neither the actual magnitude of change nor the probabilities. Differentiating Eq. (2) with respect to the explanatory variable provides the marginal effect of the Independent variables which give as

$$\frac{\partial pi}{\partial xk} = pj(\beta jk - \textstyle\sum_{i=1}^{j=1} pj\beta jk) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(5)}$$

Marginal effect of marginal probabilities is the function of probabilities and measures the expected change in Probabilities where particular adaptation choice is being made by a unit change of the independent variable from the mean (Greene, 2000).

Before running the model, it is useful to look into account the problem of multi-co linearity among the independent variables. The existence of multi-co linearity problem between explanatory variables of the study was be tested by using Variance Inflation factor (VI) for continuous explanatory variables and Contingency Coefficient (CC) for discrete explanatory variables. Thus it can be defined as: -

VIF or CC (X_i) $=(1-R_i{}^2)^{-1}$…………………………………………........................... (6)

Where R^2 is the multiple correlation coefficients between explanatory variables.The larger the value of R^2, the higher the value of VIF or VCC (Xi), causing multi co linearity in the variable (Xi). Therefore, in current study, only those variables, whose coefficients are statistically significant at less than or equal to 10% probability levels was discussed.

Definition and justification of model variables

Dependent variable

The dependent variable for this study is the choice of adaptation strategies from the set of adaptation options in the multi nominal logit model. The choice of adaptation to climate change is assumed to be done among the most prevalent adaptation strategies used by farmers in the study area. The adaptation choices for this study are based on asking sample households the actions they take to counterbalance the negative impact of climate change and these include adjusting planting dates, use of improved crop varieties, crop diversification, using irrigation and using soil, and water conservation, reducing livestock numbers, improving livestock breeds, selling livestock and livestock products, practicing agro forestry and income diversification. These are are some of the adaptation options for climate change in rain-fed agriculture of many African countries (Nhemachena and Hassan, 2007).

Independent variables

The explanatory variables for this study are those factors which are expected to affect smallholder farmers' choices of adaptation strategies against climate change effect on agricultural and non-livelihood. Based on the findings of past studies on climate change adaptation strategies, the following variables are hypothesized to explain smallholder farmers' choice of adaptation strategies to climate change.

Education level of household head (EDU): Education level is a continuous variable, which can be measured in years of schooling. Adaptation to climate change is a response for understanding the issue and its long-term consequences. Positive and significant effect of education on up taking adaptation methods to the changing climate is observed in Ethiopia (Temesgen *et al.,* 2008; Hassan and Nhemachena, 2008). Higher educational credentials of the household head and any other member of the household with the highest education increase the knowledge base about climate variability and related adaptation (Komba and Muchapondwa, 2012). Education significantly increases use of improved crop varieties and irrigation as adaptation strategy (Temesgen *et al.,* 2009; Gebre *et al.,* 2014). In this study, level of education was expected to influence the use of adaptation strategies positively.

Sex of household head (SEX): It is a dummy variable that takes a value of 1 if male and 0 otherwise. Different literatures provide mixed influence of sex on choosing adaptation strategies to climate variability. Some study stated that male headed household has appositive effect (Temesgen *et al,* 2008; Aemro *et al.,* 2012; Belaineh *et al.,* 2013) and negative influence (Nhemachena and Hassan, 2007; Baten and Khan, 2010; Bewket, 2013; Seid, 2014) on climate change adaptation strategies. Therefore, this study hypothesized that sex of the household head; being female-headed and male-headed, differ significantly in their choices of adaptation strategies to climate change due to major differences in terms of access to assets, education, and other critical services such as credit. Therefore, the study hypothesized the relationship between sex of the household head and adaptation options to climate change might be indeterminate.

Age of household head (AGE): It is a continuous variable measured in the number of years of the household head that indicate the experience in the livelihood. Various literatures provide mixed influence of age on the decision of choosing adaptation strategies to climate change and variability. Some study shows age has negative influence (Belaineh *et al.,* 2013) and positive influences (Temesgen *et al.*, 2008; Aemro *et al.*, 2012; Seid, 2014) on the adaptation strategies to climate change. Therefore, the study hypothesizes the relationship between age and adaptation mechanism to climate change may be indeterminate.

Family size of household (FSIZE): It is a discrete variable, which refers to the number of family members of household. A large family might be forced to divert part of its labor force into nonfarm activities to generate more income and adopt a numbers of coping strategies (Bewket *et al.,* 2013). Hassan and Nhemachena (2007) and Belaineh *et al.* (2013) also reported that large worker sizes are able to practice crop diversification, improved crop varieties, and soil and water conservation. It is, therefore, expected that large family size was positively related to the probability of using crop diversification, improved crop varieties, and soil and water conservation as adaptation of strategy.

Non-farm income (NFARM): It is a dummy variable measured in 1 for having non-farm income otherwise 0. Non/off farm income increases the likelihood of using improved crop variety, adjusting planting date, and soil and water conservation practices (Temsgen *et al.*, 2008; Aemro *et al.,* 2012). But non-farm income decreases the probability of adoption of soil and water conservation techniques and crop diversification (Belaineh *et al.,* 2013).

Therefore, this study hypothesized that the relationship between household non-farm income adaptation strategies to climate change may be indeterminate.

Land holding (LANDHD): It is a continuous variable measured in hectares. Hassan and Nhemachena (2008) reported that larger farm size was found to encourage the use of multiple cropping and integration of a livestock component, especially under dry land conditions. Large land holdings allow farmers to diversify their crop and livestock options and help spread the risks of loss associated with changes in climate. Since land holding is associated with greater wealth, the study hypothesized land holding had positive relation crop diversification with adaptation option to the climate change.

Livestock ownership (TLU): It is a continuous variable, which refers to the size or numbers of livestock owned by household measured in terms of Tropical Livestock Unit (TLU). As reported by different authors (Belachew, and Zuberti, 2015; Belaineh *et al.*, 2013) ownership of livestock has positive and significant impact on the probability of using improved crop variety, soil and water conservation techniques, planting trees, and changing planting dates as adaptation strategies. It is, therefore, hypothesized that farmers with large number of livestock were expected to use adaptation strategy because it serves as proxy for wealth status.

Extension contact (EXTCONT): It is a discrete variable measured by the number of contacts made in the year. It creates access to information and technical assistance on agricultural activities and adaptation methods through extension services. Access to extension services has a positive impact on the probability of adopting adaptation strategies to climate change and variability (Maddison, 2006; Temesgen *et al.*, 2008;

Aemro *et al.,* 2012; Belaineh *et al*., 2013). Therefore, this study hypothesized that extension contact increases the likelihood of using adaptation strategies to climate change positively.

Credit used (CREDITR): It is dummy variable that takes a value of 1 if received credit, 0 otherwise. Availability of credit eases the cash constraints of the households and allows purchasing inputs such as fertilizer, improved crop varieties, and irrigation facilities. Credit received has a positive and significant impact on likelihood of using adjusting planting date and combination of improved crop variety and crop diversification as adaptation strategies to climate change and variability on livelihood agricultural production (Weldegebriel, and Prowse (2013)). This study hypothesized that there would be a positive relationship between using of credit and using adaptation strategy.

Distance to market (MKTDIS): It is a continuous variable and measured in kilometers from home of the households to the nearest market. The closer the farmer is to the market the more likely the farmer receives valuable information and purchase agricultural inputs. Proximity to market is an important determinant of adaptation. A long distance to markets decreases the probability of farm adaptation in Africa due to market provides an important platform for farmers to gather and share information (Maddison, 2006). Hassan and Nhemachena, (2008) showed that in Kenya distance to markets negatively and significantly affected the use of soil and water conservation technologies. This study hypothesized that the greater distance from market would influence negatively due to lack of information.

Access to climate information (CLIMINFO): It is a dummy variable and takes a value of 1 if there is access to modem information about climate change and weather forecasting and 0 otherwise. Access to temperature and rainfall information from different sources has significant impact on the likelihood of using different adaptation measures like improved crop variety and crop diversification (Maddison, 2006; Temesgen *et al.*, 2009; Aemro *et al.,* 2012). This study, therefore, hypothesized that access to climate information increases adaptation strategy positively.

Table 2. The summary of independent variable, their measurement and expected sign to affect adaptation strategies to climate change

Variable name	Measurements	Expected sign
Sex	Dummy variable :1 for male and 0 for the female	It would affect adaptation strategies to climate change +/-
Age	Continuous variable measured in years	+/-
Family size	Continuous variable measured in numbers	+
Education	Continuous variable measured in schooling years	+
Farm size	Continuous variable measured in Ha	+
Non-farm income	Dummy variable :1 for those who had non-farm income and 0 otherwise	+
Livestock ownership	Continuous variable measured in numbers	+
Extension contact	Dummy variable :1 who were visited by extension service providers and 0 otherwise	+
Access to credit	Dummy variable: 1 for access to credit servi and otherwise 0	+
Information on climate change	Dummy variable: 1 for those who had climate change awareness and otherwise 0	+
Distance from market	Continuous variable measured in Km	_

4. RESULTS AND DISCUSSION

4.1. Socio-economic Characteristics of Sample Households

Frequency distribution of households by their socio-economic characteristics (Table 3), displays the descriptive statistics of the socio-economic characteristics used in the regression analysis. In terms of independent variables, we have included several household characteristics, such as sex, age (which captures the effects of experience in dealing with rainfall shocks), household size, educational attainment, land holding, livestock ownership, non-farm income sttatus of households, access to information on climate change, access to extension, access to credit service and distance from market (Table 3). About 78.2% and 21.8 of studied household were male and female, respectively. The average age of the household head in our study area is 42 years. Out of studied household the minimum age record was 22 and maximum age of household was 78. The average educational attainment level of the household head is four years; this was probably helping them to make sensible decision and adaptation of new changes regarding their farming activities. The average household size is five members. It was found that members of the HH were much involved in farming activities as main source of labour. HHs with many members reported to somehow manage all farming operations without hiring external labours, while HH with fewer members had to depend on help from other or hiring casual labour. To capture the wealth (income), total livestock endowments included using the Tropical Livestock Units (TLU) as a proxy for the capacity to cope with shocks and invest in other nonfarm diversification options.

Table 3 Frequency distribution of respondents by their demographic and socio-economic characteristics

Continous Variables		**Mean**	**Std dev**	**Min**	**Max**
Age of household head(in years)		42.0	10.76	22	78
Household size (family members)		5	1.8	2	11
Education (head)		4.45	2.82	0	13
Land holding in hectare		0.86	0.59	0.27	2.25
Livestock ownership in Tropical Livestock Unit (TLU)		3.92	1.8	1	10.32
Distance from market in km		3.57	1.94	0.12	7.9
Discrete variables		Frequency		Percentage	
Sex household	Male	155		77.8	
	Female	33		22.2	
Non-farm income in (1=if have income,0=otherwise)	Yes	98		52.12	
	No	90		47.9	
Access to information on climate change	Yes	179		95.2	
	No	9		4.8	
Access to extension	Yes	147		78.19	
	No	41		21.81	
Access to credit service	Yes	66		35.1	
	No	122		64.9	

Source: Author's computation based on field survey, 2020

4.2 Climatic Shocks Perceived by Sample Respondents in Study area

The majority (95.2%) of the farmers at the survey claimed that total annual rainfall is decreasing in the district, the rest of studied households explained that the climate has not changed (Table 4). Results from the study showed that farmers had various, mostly negative shocks, perceptions on the state of their local climate within that time frame and seemed to perceive many changes to have taken place in their local climate when they compared the current state of the local climate against the past 30 years as indicated in Table 4. The data indicated that 90.4 percent of the respondents perceived rainfall to have been decreasing for the past 30 years. In addition, 89 percent perceived to have experienced late onset of rainfall, while 64 percent perceived that end of rainfall is earlier than it used to be 30 years ago or more. Similarly, households in study area indicated increased floods (68%) due to heavy rainfall. As for temperature, 93.9 percent perceived that it has been increasing, while 6.1 percent felt that it has been no change. About 60.25, 81 and 73% of households replied that extreme heat, drought, and change in wind intensity have been increasing. 84% and 79.3% of studied households indicated that length of dry season and dry spells during cropping period, while 82.8% informed length of growing period has been decreasing (Table 4).

Apart from household interviews, the findings from FGDs also support farmers' perceptions on the changes in the local climate and the main reference to these changes is made on rainfall. This is because rainfall supports smallholder farmers because their production in the farm is mainly rain-fed. Some quotes provide justification to what farmers said during group discussions.

"*When you talk about changes in the local climate, you remind us those good years of 1960s-early 1980s. In those years, it was very predictable that in early February, belg seasonal rainfall started and we cultivated our crops timely. Again, in June we expected and got rainfall for the main season early. Rainfall was not a problem. But now thisis not the case. No one can predict the onset of rainfall anymore and even how long it will last. Rainfall is totally unpredictable and the amount is not normally sufficient at all. Nowadays, it is difficult!" (*FGDs done with elders at Bartu kebele in study area).

As to what is the state of climate this time compared to the past 30 years, it was found that the local climate has not remained static but has been changing. The changes identified from the interviews, however, were negative to both farmers and all other stakeholders including the experts. On this one, the official from Loka Abaya woreda expert was very explicit that there are changes in terms of rainfall amount, onset and the distribution. In addition, he also put it clear that for the farmers, they are nowadays facing hard time because predictability of rainfall is very difficult and sometimes impossible because unlike in the past, currently, it has no clear and predictable pattern. Currently, farmers are unable to predict rainfall patterns as they used to in the past because there are many changes that make it difficult for them to do so.

Regarding the state of temperature, various views and perceptions expressed worries that there has been an increasing trend for the past 30 years. Many of the interviewees and the participants in the FGDs had the view that the temperature is increasing. The model farmers during discusions at Argada kebele in Loka Abaya woreda said that "It has been warmer in recent years than ever, and we do not any longer have enough rainfall. Because of that, crops failed due to increased dry spells during critical growing period, this affected crop yields and resulted in bankruptcy". Examples of quotes form the basis for this argument include the following: "*As for the temperature, in my view and according to my experience, it is increasing. Because ten or twenty years ago, during this month of March it was not very hot as it is now. For instance, nowadays, it is difficult to stay at outside during day time. It's very hot during the day."* (Rude Kebele leader in study area).

''*People's perceptions on climatic shocks are very much useful to establish the fact that the particular region is facing direct or indirect problems in agriculture and other* *activities due to climate change. Consequently, understanding the perception of climate change by farmers is important as perception can shape the preparedness of these actors to adapt and change their practices. The adoption and successful implementation of new technology by farmers in their ecosystems depend on their tendency to perceive and react favorably towards changes in climate and environment. This study also tries to quantify the people's perception on various seasonal climatic variability*,'' (Stated at KIIs session in all (4) studied kebeles).

Some other studies conducted in the country and across the African continent have documented this fact (for example, Kangalawe and Lyimo, 2013; Legesse, *et al*., 2013; Teka, *et al*., 2012; Acquah and Frempong, 2011; Acquah , 2011; Mongi *et al*., 2010; Gbetibouo 2009; Agrawal *et al*., 2003).

Table 4 Perception of change in different climate indicators by farmers in Loka Abaya woreda.

Climate change indicator	**Farmers response by percentage (NHH=188)**		
	Yes		**No**
Perceived there is change in climate	95.2		4.8
	Later	**No change**	**Earlier**
Start of rainy season	89	0	11
End of rain season	25	11	64
Length of dry season	84	0	16
	Increase	**No change**	**Decrease**
Annual rainfall	9.6	0	90.4
Dry spells during cropping period	79.3	6.5	14.2
Length of growing period	13.2	4	82.8
Temperature	93.9	6.1	0
Extreme Heat	60.25	0	39.7
Drought	81	2.5	16.5
Change in wind intensity	73	6	21
Floods	68	32	0

Source: Survey result (2020)

4.3 Impact of Climate Change on Crop and livestock production by Sample Respondents

4.3.1 Impact of Climate Change on Crop Production by Sample Households

Crop production activities are one of the most economic activities in the study area in terms of food security and income generation. The impact of climate change on Crop production in study area is shown below (Table 5).

Sample rural households revealed that climate change impacts like droughts and floods are main concerns in their study area and these impacts causes vulnerable to crop production. According to responses of studied rural farm households, the major impacts of climate change on crop production in study area farmers agreed and face were: reduced productivity/yield (82.92%), increases pests/insects/diseases (71.67%) , use of traditional crop varieties decreased (66.32%), cropping pattern has changed (68.75%), traditional irrigation sources like `pond has reduced(60.42%), and reduced cultivated land (51.66%).The perceived changes in the local climate expressed by farmers seemed to have played a key role in influencing changes in the agricultural practices in the study area.

The Focus Group Discussions (FGDs) on performance of crop production cited that there is declining trend in the production. According to their views, ‘‘*they reported that there was better crop productivity before the 20 years, but now the situation is contrary to what we have experienced. One farmer from Bartu kebele my own confidence in agriculture is decreased because I keep getting confused about the seasons". The crop yield and the weather vary of course from year to year, and no season is exactly similar. Declining rainfall and irregular rainfall can be problematic. If it rains in harvesting periods it can affect the amount and the quality of the crop negatively. One woman said that if the belg* *rain comes too late in Loka abaya, the potatoes grown in the belg season will not ripen before the kiremti rainy season starts when they want to sow other cereals on the same plot of land. Furthermore farmers indicated unhealthy attributes of climatic conditions such as unpredictable patterns of rainfall, floods, dry winds, drought and unusual prevalence crop pests and diseases were the major reasons for the reduction of our crop yield while we were better striving to manage and/or protect our crops in all manners.*''

Regarding climate change impacts on crops: *crop protection experts from agricultural offices in in study area indicated in their interviews that sensitivity of crops to heat, destruction by flooding and heat waves, pests and diseases spreading leads to increased crop water requirement, reduction of arable(cultivatable) surfaces and reduction of crop yields. Natural disasters such as flood, hailstorms, or drought, will often result in severe impacts on the farmer community. The impacts might for example be that their crop field becomes almost useless. For affected farmers in study area, the impacts of hailstorms for example mean disruption of the planting seasons, crop damage, or sometimes completely yield loss. Hailstorms across the Ethiopian highlands are often battering the enset, a banana-like plant also called false banana that in parts of the Loka abaya highlands is a staple crop, traditionally and still often seen as a stable pillar of food security. Hail results often in damage to the enset and coffee more than ever.*

The results of the impact of long term climate change observed in the present study are similar to the earlier studies of (Nater, 2010 and Hagos *et al.*, 2014; Admassu *et al.* (2013)).

Table 5 Impact of long term climate change on crop production in study area

Impact	**Response of studied households (NHH=188)**		
	Agree (%)	**Can't Say (%)**	**Disagree (%)**
Use of traditional crop varieties decreased	60.42	38.33	1.25
Cropping pattern has changed	68.75	12.92	18.33
Traditional irrigation sources like `pond has Reduced	66.32	0.00	33.68
Reduced productivity	82.92	7.5	9.58
Increases Pests/insects/diseases	71.67	22.4	6.29
Reduced cultivated land	51.66	47.92	0.42

Source: (Household survey, 2020)

4.3.2 Impact of Climate Change on Livestock Production by Sample Households

Respondents who kept livestock in study area experienced various climate change impacts. About 80.2, 77.43, 70.3, 66.32, and 60.21 % (Table 6) agreed that climate change increased scarcity of forages, grass species composition decreased, decreased productivity (mainly milk and its products), decreased livestock number, and drinking water availability decreased.

Table 6 Impact of long term climate change on livestock production in study area

Impact	**Response of studied households (NHH=188)**		
	Agree (%)	**Can't Say (%)**	**Disagree (%)**
Increased scarcity of forages in the area	80.2	11.8	8
Grass species composition decreased	77.43	6.31	16.3
Drinking water availability decreased	60.21	3.25	36.54
Decreased livestock number	66.32	19.26	14.42
Decreased productivity (mainly milk and its products)	70.3	4.5	25.2
Increased livestock disease outbreak	53.8	47.2	-
Death of livestock due to heat stress (e.g. poultry)	36.4	59.1	4.5

Source: Survey result (2020)

Table 6 presents the summary of the respondents' perceptions on the impact of climate change on livestock production. Climate change increased scarcity of forages**:** The majority of livestock owners in Loka Abaya woreda use natural pastures to feed their animals with only a few having other means such as buying hay for the animals. The observation of the sample respondents is that the quality of the pastures is deteriorating in the sense that the quantity of available grass and grass species has gone down. This is because of rainfall shortage and unusual variation. Available water sources include streams, earth dams and wetlands. Thus the livestock owners rely on these water sources for their animals. Due to high temperatures and shortage of rainfall, the streams, wetlands and earth dams dry up sometimes and resulting to decrease in drinking water for humans and animals. Livestock owners have been troubled by outbreaks of diseases, with the most recent one being lump skin disease. Parasitic populations especially ticks, have increased.

Livestock owners have experienced death of their poultry due to excessive heat and poultry disease like new castle disease.

Concerning climate change impacts on livestock production the results of Focus Group discussion indicates that changes in precipitation reduce forages: *They indicated the leaf of our enset plant decreased. Similarly changes in temperature reduce water availability for drinking and livestock.*

Due to climate changes there will be, and have already been, reduced productivity and fertility of animals. This is mostly a result of heat stress and increased water requirements. Moreover, drier conditions, drought, or flood, might mean decreased grassland and communal land for animals in lowland areas of Loka abaya. The productivity of grasses in study area depends almost wholly on the amount and timing of rainfall. This means that many animals produce less amounts of milk and the fertility of the animals can also decrease (Key Informant interivews from Livestock Resource Office).

Findings from similar studies showed that climate change has an impact on livestock production. The impact of climate change on livestock production is measured through the effects of climate change on natural pastures (grazing grass and shrubs), water resources, livestock diseases and biodiversity (Yirgu *et al.*, 2013; Admassu *et al.*, 2013 and Megersa *et al*., 2014).

Besides to these, Abate (2009) found that drought and delay in the onset of rain led to poor regeneration of grass, water shortage and heat stress on livestock. It further reports that the drought and delay of rainfall led to increased mortality of livestock, vulnerability to diseases and physical deterioration due to long distance travel for water and pastures. Digambar (2011) reported that as a result of severe drought, there was direct impact on the growth of palatable grass species and that regeneration of fodder species in pasture and forest fodder is decreasing because of less rainfall leading to a shortage in diversity and quality of livestock fodder. According to Thornton *et al.,* (2015), this has led to a decrease in livestock population which has further affected production of milk, milk products and meat. The drought also affected livestock by drying wetlands, pasture land, water resources, streams and decreasing availability of drinking water for livestock. Temperature increase led to outbreak of new borne diseases and scarcity of fodder led to change in livestock pattern (Digambar, 2011).

4.3.3 Impact of Climate Change on Livelihood Conditions by Sample Households

The result of analysis in Table 7 indicated that climate change affected livelihood in different ways. The results revealed that majority of sample respondents (74.58%) agreed that climate change reduced income, while 69.17% believed it affected business (e-g increased price of food) items, and 26.34% reported climate change increased dependency on relief programs. Moreover 22.32% and 12.25 percent of them said loss of assets and increased rural migration due to respectively.

The farmers in FGD boldly reported that, *our vulnerable livelihood systems to climate change make us unprivileged. The flexibility of deficit rainfall, seldom heavy rainfall and unprecedented dry spells while engaging in farming activity unfortunately resulted in bankruptcy through: deteriorating our environment caused by floods, decreased crop/livestock yield, and increase some of us who are seeking food assistance. Our ''son'' whatever…. let we say ,with local production decline income opportunities and* *purchasing power of small-scale producers, as well as seasonal workers dependent on harvesting and crop processing, has been decreasing. At the same time, prices for the most important crops exponentially increased*.

Throughout time being after 17 years we had been observing dramatically strange scenes. Climate change has been resulting both crop/livestock yield instability, increases crop prices affecting off-farm, and non-farm income and livelihood sources, and reduce farmers' ability to access food due to yield and income instability, (KIIs with Disaster Prevention Preparedness and Food Security expert, 2020).

The results of the impact of long term climate change on livelihood observed in the present study are similar to the earlier studies of (FAO (2016); Abebe, 2017; Buit *et al.*, 2015 and Melissa *et al.*, 2017), they indicated that climate change is profoundly impacting the condition in which agricultural activities are conducted. The effects of climate change on production are translated into social and economic consequences through a range of different pathways that can result in changes in agricultural incomes, food markets, prices and trade patterns, and investment pattern.

Moreover, (WFP, 2016, Zewdie, 2014 and Giller *et al.*, 2016) also indicated climate change affected social condition through affecting livelihood systems: destruction of farms, lost income, unemployment resulted in high youth migration, increase remittances, lack of compensation and low food stock.

Table 7 Impact of long term climate change on livelihood conditions in study area

Impact	Response of studied househol (NHH=188)		
	Agree (%)	Can't Say (%)	Disagree (%)
Reduced income	74.58	13.34	12.08
Affected business (e-g increased price (food) ítems	69.17	23.33	7.50
Increased dependency on relief programs	26.34	0.00	73.66
Loss of assets	22.32	18.41	50.27
Increased rural migration	13.89	42.4	43.71

Source: Survey result (2020)

4.4. Rainfall and Temperature Data Analysis

4.4.1. Annual Rainfall Variability

The annual rainfall shows inter-annual variability of over the last 29 years (Figure 3). Annual rainfall of the study area ranged between 301.5mm in 2016 and 1252.4mm in 2007.The annual average areal rainfall in the Local Abaya districts is 888.65mm, with a standard deviation of 216.8mm and coefficient of variability of 24.39%. Of the 29 years of observation, 16 years (65.5%) recorded below the long-term average annual rainfall amount while 12 years (34.48%) recorded above average. Between 1990-1993, 1993, 1998-2000, 2002-2004,2008-2009 and 2015-2017 the annual rainfall has been below the long-term mean, whereas 1988 and 1989 ,1994, 1996-1997, 2001, 2005-2007 and 2010-

2014 the annual rainfall for these years was above the mean. The 2016 rainfall amount emerges as the lowest on record in the district. The agricultural population of the study area is totally dependent on this rainfall for agricultural activities including livestock production. A slight fluctuation in the rainfall amount, intensity, and onset and cessation time directly influences the agricultural productivity (MOA, 2014; NMA, 2007). These results are in line with findings conducted in Ethiopia and other nations of Africa. For example, a study in Ethiopia indicates that the rainfall has shown a decreasing trend (Legesse, *et al.*, 2013 and Teka *et al.*, 2012). The study conducted in other African countries also supported this finding through confirming decreasing trends of rainfall for the long period of time (Admassu *et al.*, 2013; Kangalawe and Lyimo, 2013; Gebre *et al.*, 2014; Gizachew, and Shimelis, 2014).

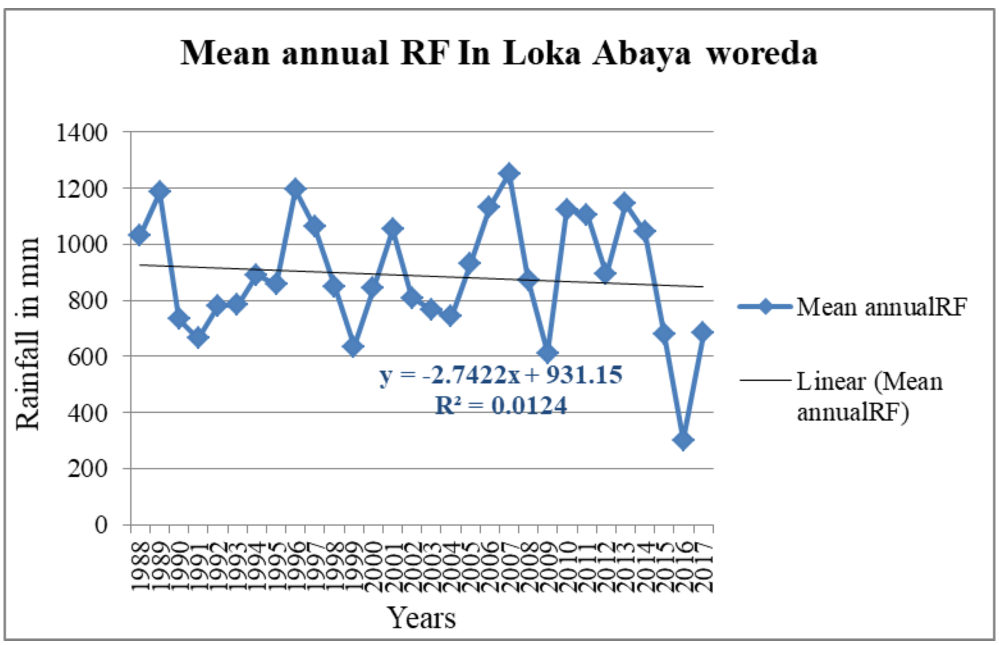

Figure 3. Inter annual rainfall variation in Loka Abaya

Source: NMA (2020)

4.4.2 Inter Seasonal Variation of Rainfall in Loka Abaya Woreda

There was higher inter-seasonal variability in the amount of belg and kiremt rainfall. Rainfall of belg season has shown (Figure 4) decline trend from 1988-2017. It has decreased by 1.46 mm per year over the past three decades. On the other hand kirem train has shown (Figure 4) an increasing trend, its amount increased by 1.13 mm per year in the period as noted above.The main rainy season (kiremt rainfall) contributes largely to the Loka Abaya district. Belg is the short rainy season and lasts between Feb and May. The Kiremt season, which is the longest rainy season, lasts between June and September. More than 65% of the total rain falls during this season and the highest rainfall occurs in July and August as can be noted in study area. Rain that occurs during the Kiremt season is very intensive and, hence, the severity of soil erosion is high during these two months. "There are big changes in Loka Abaya rural district; rainfall distribution is not good like in the previous years for example 'Meher' the long rain season was used to start around 9thofJuly, but things have changed, nowadays there are rains which have no specific season like the ones that rain in January and they are not good for farmers to start growing their crops except to supplement irrigation (DAO, 2019).The increase of rainfall variability observed is likely to further restrict access to water resources; shorten growth season; impact soil fertility; and alter quantity and quality of available grass for livestock feed. These factors would lead to reductions of animal and crop productivity (World Bank, 2013). Since the early 1980s seven major and several localized droughts as well as failure of seasonal rains have negatively affected agricultural production (CARE-Ethiopia 2014). Declining Belg rains (Feb-May), as projected by one study (although contradicted by others), could have significant effects on both crop production and livestock rearing due to their important role in Ethiopian food production (Yirgu *et al.,* 2013). Seldom torrent kiremt rainfall which cause flood resulted in soil erosion and affects crop production (Gizachew and Shimelis, 2014).

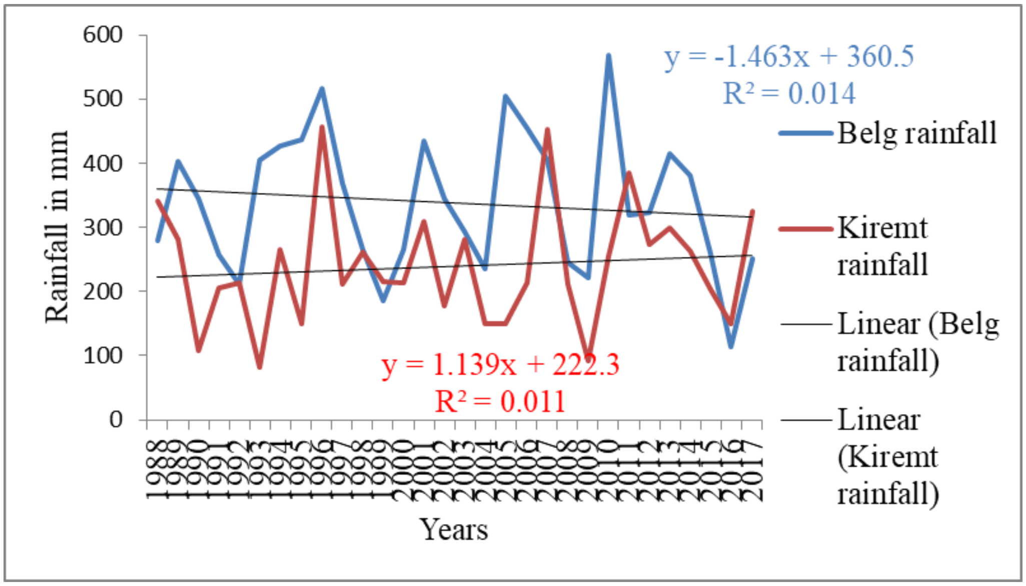

Figure.4 Belg and Kiremt rainfall trend and variability at Loka Abaya

Source: Sketched from NMA, 2020.

As it is shown in Table 8, coefficients of variations were 24.39%, 31.75% and 38.98% for annual, belg and kiremt rainfall, respectively; which indicate that there was moderate inter-annual and high inter seasonal variability of rainfall between 1988 and 2017. Degree of variation in amount of rainfall was higher for belg and kiremt season.

Table 8. Coefficient of variation total annual, belg, kiremt rainfall and SD at Loka Abaya (1988-2017)

Rainfall(mm	Mean RF (mm)	SD(mm)	CV (%)
Annual	888.65	216.81	24.39
Belg	337.89	107.28	31.75
Kiremt	239.9733	93.56	38.98

Source: Computed from the data obtained from NMA, 2020

4.4.3 Temperature Changes in Loka Abaya Woreda

A maximum, minimum and average temperature trend of the woreda over the same period presented in Figure 5. The results show that annual temperature was in an increasing trend for the last 29 years (1988–2017). The estimated trend line for average annual temperature is y = 0.108x + 22.33. The trend line has a positive slope implying the average temperature is going up by $0.108^{O}C$ in the past 29 years. The maximum and minimum temperature trends were showed increasing trends in the study area in the observation period. Maximum temperature increased faster while the minimum temperature increased gradually. For example, the former increased by $0.126^{O}C$ while the later increased by $0.04^{O}C$ in the past 29 years. The analysis of households' observations of their surrounding environment shows that farmers' perceptions appear to be in accordance with the statistical record in the district. About 93.3% of the surveyed households observed increasing temperature trend over the past 29 years. Only 6.3 % of them have not noticed any temperature change. In line with this study several other studies at various spatial and temporal scales have recognized warming trends in minimum and maximum temperature (Amsalu *et al*., 2014; Garbrecht *et al.,* 2014; Gedefaw *et al.,* 2018). Even though the magnitude in the average min and max differs, the general warming trend matches with studies reported both at national level and local level (Tesso *et al.,* 2012).

Farmers explained temperature has become so high than before, during the past three decades belg season was the cold season. According to District Agricultural Officer some pest out breaks observed such as stock borers, Caterpillars, whiteflies, Aphids and Thrips observed since. Thus, the decrease in rainfall and increase in temperature created a favorable environment to these and other more pests. Intermediate rainfall favours the growth of most pests. Farmers expressed that the most significant impacts of temperature rise on crop agriculture were largely concerned with impacts on water availability, possible expansion of pest and disease ranges and significant impacts on soil moisture, and fertility due to increasing evaporative losses. In line with this under all assessed emission scenarios the surface temperature is projected to rise over the 21st century, whereby, changes in precipitation will not be uniform in sub-Saharan African countries (IPCC 2014a).In addition, global warming further weakens agricultural production in developing countries including Ethiopia. It contributes to soil degradation and loss of arable land; crop yield and animal productivity reduction; alteration of vegetative covers; and pests and diseases spreading.

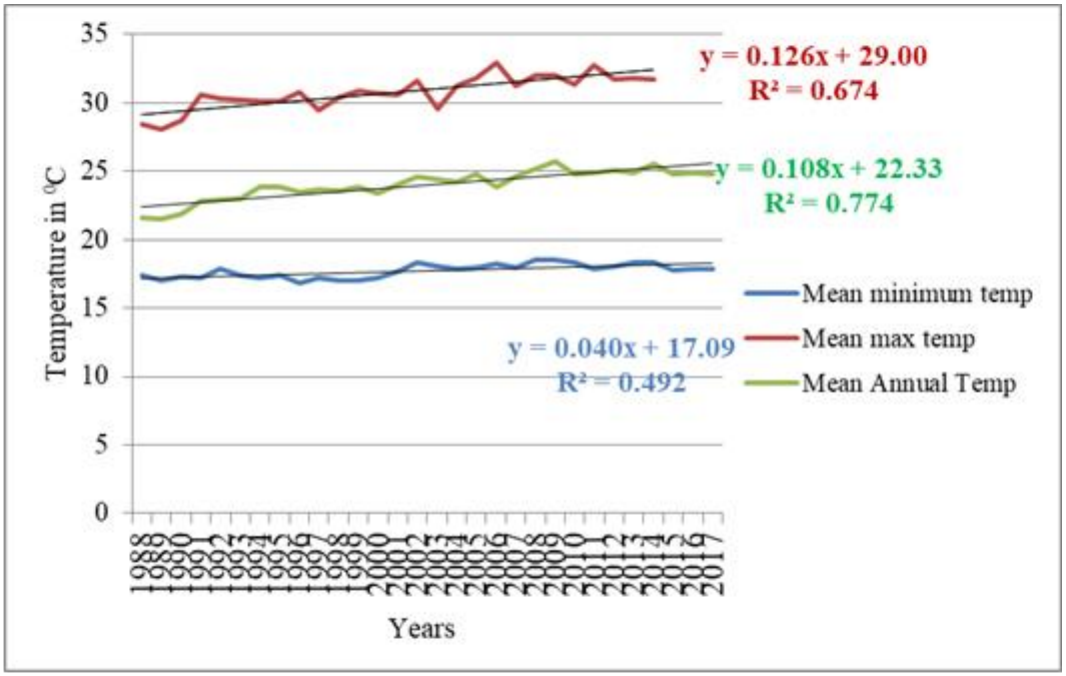

Figure 5.Mean annual, min and max temperture of Loka Abaya woreda

Source: Sketched from NMA data (2020)

4.5 Adaptation Strategies in Response to Climate Change Impacts Used by Farmers

Households reported that they have used more than one type of adaptation strategies. This implies that a single strategy is not adequate in adapting to the impact of climate change as combination of several strategies is likely to be more effective than a single strategy. The adaptation strategies to climate change that the studied households has been using while engaging in various livelihood strategies in study area is presented below based on rank (Table 9). Out of 12 adaptation strategies, increased use of crop diversification was ranked first and thus most important, among farmers' adaptive strategies to climate change. Farmers in their experience indicated that crop diversification in their farm increases the yield of production, and improving nutrient availability to the plants.

To cope with decreasing rainfalls, farmers juggle with mixing long cycle crops and short cycle crops on their farms in all study kebeles reflected in the following narrative: *We plant maize, beans and potatoes, we mix both long and short season crops, because of the rains, it rains sometimes and sometimes it doesn't, when we have long rains, we harvest the long season crops and short season crops with little rains* (male participant in FGD).

Both crop protection experts and development agents cited that continuous mono-cropping (for example maize/teff cultivation) has different adverse effects which include pest resurgence, and soil quality deterioration, in addition to the issues of loss risk associated with monocultures. In response to these effects, farmers adopt diversified cropping practices, reducing overall farm risk and expanding opportunities for farm profit, which generally act to boost the farmers' average incomes.

Using improved crop varieties was identified as the second-ranked adaptation strategy. It involves switching from one crop variety to another in response to climatic stresses and changes, on the most commonly grown crops, maize, teff, wheat, potato, sweet potato and haricot bean a major cash crop. Farmers found using drought and disease tolerant crop varieties in response to negative impact of climate change in study area. The third most important adaptation strategy was the "reducing livestock number" (farmers benefitted from managing their livestock by reducing their numbers). Tree plantation and changed land-use practices such as crop rotation and intercropping, as an adaptation ranked 4^{th} and 5^{th} choice by farmers was shown to be important across the study kebeles.

Tree plantation as an adaptation strategy provides a suitable micro climate for farmers under agricultural operation and farmers witnessed tree planting provided them food *sources. In a system with reduced mechanical tillage based on mulch cover and biological tillage, alternatives have to be developed to control pests and weeds. Practicing crop rotation and intercropping has many advantages, which include reduced risk of pest and weed infestations; better distribution of water and nutrients through the soil profile; exploration for nutrients and water of diverse strata of the soil profile by roots of many different plant species, resulting in a greater use of the available nutrients and water; increased nitrogen fixation through certain plant-soil biota; improved balance of nitrogen, phosphorus and potassium (N-P-K) from both organic and mineral sources; and increased formation of organic matter*,(KIIs, done with Environment Protection and Agricultural Officess).

Sample respondents faced with recurring and severe episodes of drought and floods in the Loka Abaya woreda, farmers have been undertaking vast projects of land restoration, via local techniques of sustainable management of soil and water, especially related to water conservation, and small scale irrigation.

Climate Smart Agriculture (CSA) with the help of projects under Hawassa University was put in practice the soil and water conservation measures. For instance, manure, mulching, and stone lines are the major water and soil management practices that the respondents use to combat drought, while stone lines are more used to combat erosion. The techniques include a diverse range of integrated measures for improving water management, restoring fertility, and increasing soil humidity, (Key informant interview with Environment Protection experts). Farmers ranked crop diversification, improved crop varieties, reducing livestock number, tree plantation, crop rotation and intercropping, soil and conservations practices and non-farm incomes. Other strategies including small-scale irrigation, selling livestock and its products, income from remittance, and migration. However, the little number of sample respondents ranked in twelve position explained that they have no any remedies in response to climate change, due to the fact that they had no enough farm land, livestock number, and technical supports from lacal governments.

In line with this result, Melissa *et al.* (2017) and Bryan *et al.* (2013) reported in a similar ways that farmers adopted various strategies ranging from changes in livelihood to new farming strategies. These changes in agricultural management practices and livelihoods by the farmers in response to changes in climate often result into positive effects to the land and ecosystems.

Table 9 Ranked order of the adaptation strategies to climate change in study area (n = 188).

Adaptation measures	**Importance on your farm**				**ASI**	**Rank**
	High	**Medium**	**Low**	**No**		
Crop rotation and intercropping	54	30	61	33	283	5
Crop diversification	98	72	18	-	456	1
Improved crop varieties	80	101	7	-	449	2
Selling livestock and its products	19	15	46	108	130	9
Reducing livestock number	74	86	20	8	414	3
Small-scale irrigation	15	49	60	64	203	8
Soil and conservations practices	38	63	24	53	264	6
Tree plantation	71	62	55	-	382	4
Income from remittance	14	19	25	130	105	10
Income diversification	33	48	29	78	224	7
Migration	10	17	22	49	86	11
Not have any remedies	-	-	6	182	6	12

Source: Computed based on Survey result (2020)

4.6 Factors Affecting Adaptation Strategies to Climate change

To quantify the impact of various explanatory factors affecting farmers' choice of adaptation methods, multinomial logistic regression model was employed for all adaptation measures. For the sake of computation of this part the mostly used adaptation strategies by farmers (Table 9), was considered in MNL model (Table 10 and 11). There was cheched no problem of multi-co linearity between explanatory variables of the study. Both Variance Inflation factor (VIF) for continuous explanatory variables and Contingency Coefficient (CC) for discrete explanatory variables were free from multi-colinearity. The model was run and tested for its appropriateness over the standard multinomial logistic model. Moreover, the likelihood function of the multinomial logistic regression model was significant (LR chi2 (66) =472.42 and Prob >χ2 0.0000) showing strong explanatory power of the model. Additionally, results show that most of the explanatory variables and their marginal values are statistically significant at 10% or lower and the signs on most variables are as expected, except for a few (Table 11). The coefficients of logistic regression that tell us about the direction of effect of independent variables are presented in Table 10 and the marginal effects that explain the effect of a unit change in explanatory variables on the dependent variable are shown in Table 11.

Table 10. Parameter estimates of the multinomial logistic regression (MNL) model of adaptation measures

Explanatory Variable	CRDV	RLNO	ICRV	SWC	INDV	UIRG
	Coef	Coef	Coef	Coef	Coef	Coef
SEX	-4.94**	-3.76**	-4.33**	-5.15***	-3.66	-6.51***
AGE	0.03	0.05	-0.02	0.7*	0.04	-0.01
FAMSZ	0.79*	0.45	0.82**	0.59	0.24	0.37
EDCN	0.72*	0.62**	0.68*	0.31	1.37***	0.92**
FARSZ	-3.06	-4.50	-4.87*	-4.34	-4.56	-5.09*
LOWN	0.62	1.58***	1.28***	1.41***	1.33**	1.58***
EXSRV	46.1	25.4	28.9	23.4	26.1	28.5
CCINF	3.81*	3.05	7.12***	5.14***	2.67	5.64**
ACRE	18.6	16.4	20.5	15.7	19.7	24.1
Market	0.11	-0.87	46.9	-0.45	0.44	0.51
Nfinc	-1.53	-0.16	-1.01	-0.39	0.16	-0.32

Bases category : No adaptation
No of observation = 188
Prob >χ2 0.0000,
LR chi2(66)=472.42
Log likelihood=-124.83819
Pseudo *R* square =0.6542

Note: *CRDV stands for (Crop Diversification): RLNO (Reducing Livestock Number) : ICRV (Improved Crop Varieties): SWC (Soil and Water Conservation): INDV (Income Diversification): UIRG (Using Irrigation Practices) ***, ** and * significant at 1, 5 and 10 % respectively.*

Table 11 Marginal effects from the multinomial logistic regression (MNL) models of farm-level adaptation measures

Explanatory Variable	CRDV	RLNO	ICRV	SWC	INDV	UIRG	No adaptation
	Marginal Coef	Marginal Coef	Marginal Coef	Marginal Coef	Marginal Coef	Marginal Coef	Marginal Coef
SEX	-0.01.	0.02	0.11	-0.12	-0.02	0.13	0.10
AGE	0.001	0.001	-0.003	0.30***	0.001	-0.003	-0.002
FAMSZ	0.001	-0.003	0.02	0.01	-0.005	-0.02	-0.01*
EDCN	-0.001	0.012	-0.008	0.016	0.014	0.011**	-0.17*
FARSZ	0.069***	-0.067	-0.029	-0.041	-0.005	-0. 036	-0.108*
LOWN	-0.032	0.431***	-0.092	0.513*	-0.01	-0.023	-0.036***
EXSRV	0.751	0.181	-0.223	0.05***	-0.035	-0.122	-0.602
CCINF	0.072*	-0.071	0.1694*	0.128***	-0.035	-0.019	0.099
ACRE	-0.057	0.140	-0.052	0.074	0.020*	0.275***	-0.399
Market	-0.001	-0.053	0.018	-0.002	0.012	0.011	0.014
Nfinc	-0.038	0.019	-0.031	-0.005	0.013**	0.036	0.007

*Note that Asterisks *, ** and *** stands for statistically significant at 10,5 and 1% level*
Source: - Survey result computed from MNL Model by Stata version 14.2 software.

According to marginal effects of MNL result age, family size, education status of household, farm size, livestock ownership, extension service, access to credit service, climate change information and non-farm income of household were among the explanatory variables that affect farmer's adaptation to climate change significantly, whereas sex households and market condition aren't affect adaptation measures of farmers significantly.

Elaborations of significant variables were presented below:

Age: _ Age of farmers affect the propensity of using soil and water conservation (adaptation to climate change) positively and significantly. If the age of farmers increased by one year the probability of farmers to implement soil and water conservation increased by 30.2% at 1% significant level. The head of the household's age represents experience in farming. In line with this studies (Maddison 2006; Ishaya and Abaje 2008 ; Behrman *et al.*,2014) indicated that experienced farmers have a higher probability of perceiving climate change as they are exposed to past and present climatic conditions over the longer horizon of their life span.

Family size (FAMSZ): A negative coefficient of family size indicates a negative relationship between family size and probability of adaptation at 10 significant levels (Table 11). For instance, an increase by one individual in the average family would lead to a 1.2 % decrease in the likelihood of not adapting (using) any adaptation measure to climate change (Table 11). Findings of the studies of Bewket *et al.* (2013) and Deressa *et al.* (2009) also support our findings of a positive relationship between household size and adoption of agricultural technology or adaptation to climate change.

Education (EDCN):- Education is known to be an important factor in accessing advanced information on new improved agricultural technologies and increased agricultural productivity (Elahi *et al.,* 2015). In this study, the highly significant coefficient of education of the household head shows that the probability of adapting to changes in climate decreases and increases with an increase in the years of schooling (Table 11). The marginal coefficients in Table 11 show that 1 % increase in the years of schooling of household head would lead to the decrease in the probability of no adaptation by (1.7 %) at 10% significant level, and increase income diversification (1.4 %) at 5% significant level, as adaptation measures to climate variability and change. Various studies (Bryan *et al.,* 2013; Deressa *et al.,* 2009; Maddison, 2007) also found a significant positive relationship between education of household head and adaptation to climate change that supports the finding of this study. Hence, it can be concluded that farmers with more years of schooling are more likely to adapt to changes in climate compared to the farmers with little or no education.

Farm size (FARSZ):- Farm size represents the total land area held by a farm household and may be taken as a proxy for farm household wealth. The results in Table 11 Indicate that the land area has negative and positive, and significant impacts on no adaptation and crop diversification. A 1 plot increase in the land area decreases and increases these probabilities of abandoning adaptation and crop diversification by 10.8 and 6.9 %, at 10 and 1% significant level respectively (Table 11). Land is an important resource for agricultural production and other economic activities in terms of its contribution to employment generation, livelihood and poverty alleviation (*ibid*). Adoption of an innovation will tend to take place earlier on larger farms than on smaller farms (Gbetibouo, 2009 and Antwi-Agyei *et al.,* 2014).

Livestock ownership (LOWN):- Owning the large number of animals affects the probability of leaving no adaptation, reducing livestock numbers and using soil and water conservation. This means having more number of livestock made farmers to abandon no adaptation, reduce livestock numbers and promotes soil and water conservation by 3.7, 43.1 and 51.3% respectively at 1, 1 and 10 % significant levels respectively. In this regard studied farmers informed that the livestock plays a very important role by serving as a store of value to reduce and cope up drought and provides traction (especially oxen) and manure required for soil fertility maintenance. Several studies (Anane *et al.,* 2016;Giller *et al.,* 2016 ;Roobroeck *et al.,* 2016) confirmed similar results.

Extension service (EXSRV):- The results in Table 11 indicate that provision of extension services is significantly and positively related to soil and water conservation. The results of the marginal effect in Table 11 show that access to extension services leads to 5.07 % increase in the likelihood of soil and water conservations as an adaptation method, at 1% significant level. For all other adaptation measures, no significant relationship is found between extension and adaptation measures. These results support the farmers' complaints about the lack of updated information on adaptation to climate change from the agricultural extension department. The provision of agricultural extension services is an ongoing process and can be defined as a systematic tool of dissemination of useful and practical information related to agriculture and and/or livelihood, including improved farm inputs, farming techniques and skills to farmers or rural communities with the objective of improving their farm production and income (Belaineh *et al.*, 2013 and Syngenta, 2014).

Climate change information (CCINF):- Information on seasonal and daily weather forecasting (i.e., temperature and rainfall) has a positive and significant effect on the probability of using crop diversification, improved crop varieties, and implementing soil and water conservation, as adaptation methods (Table 11). The results show that access to information on seasonal and daily weather increases the probability of crop diversification (7.2 %), increased using improved crop varieties (16.9%), and implementing soil and water conservation (12.8 %) at 10 and 1% significant level respectively. This indicates, the information on weather/climate forecasting increases the likelihood of adaptation to climate change.Various studies in developing countries, including Ethiopia, report a strong positive relationship between access to information on climate/weather and the adoption behaviour of farmers (Gebrehiwot, & Veen, (2013) and Shackleton *et al.*, 2015).

Access to credit service (ACRE):_

Access to farm credit also has a significant effect on the adaptation to climate change. Access to farm credit is positively and significantly related to income diversification and small scale irrigation (Table 11).The farmers who have access to credit have increased the probability of diversifying incomes from different sources and engaged in small scale irrigation by 2.1 and 27.5 % at 10 and 1% significant level respectively. Those farmers who had access to credit through Sidama microfinance explained that getting loan from this institution supported them by providing and fulfilling essential inputs for example improved seeds and , heps them to diversify to non farm activities to improve their livelihood under harsh climatic condition. In line with this, Nabikolo *et al.*, 2012 and Weldegebriel and Prowse, 2013) indicated that farmers with well-developed social institutions are considered to have a greater adaptive capacity than those with less-effective institutional arrangements. According to Hassan, R. and Nhemachena, 2008 farmers with better credit access are expected to have a higher capacity to adapt to climate change.

Non-farm income (NFINC):- It affects the propensity of income diversification positively and significantly. The farmers who have non-farm income increase the probability of income diversification by 1.3% at 5% significant level. The interviewed farmers who had non farm income realized that it encouraged them to diversify to different jobs to better lead ther life besides to subsistent livelihood. Farmers with a higher income may be less averse to risk and have more access to information, a lower discount rate and a longer-term planning horizon (Malik & Smith, 2012).

5. CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

Climate change has currently been recognized across disciplines and groups of people as a serious challenge facing societies today. The study was conducted to identify the effects of Climate Change and Variability on rural households livelihood and their adaptation Strategies in Loka Abaya woreda, Sidama Region. The study was motivated by the fact that changes in the distribution and amount of rainfall which have resulted in low precipitation and frequent drought has been affecting agriculture and livelihood of farmers in the district feeding all people, providing employment to households while supporting economic growth. The objectives of study were: to explore effects of climate change and variability on agricultural based livelihood systems, to assess the existing responses and adaptation measures being practiced to climate change and variability and to identify determinants of climate change adaptation measure by farmers. Multi-stage sampling technique was employed to select 188 study sample respondents. Both primary and secondary data was collected and utilized to meet the objective of the study. Primary data were collected from the sample households, KIIs and FGDs. Secondary data reviewed from offices and published sources.

Descriptive and relevant inferential statistics such as frequency, percentages, mean, standard deviation, likert-type rating technique, and multinomial logit (MNL) model, factor analysis were used for data analysis taking the research objectives into account. SPSS version 20 used to analyze descriptive parts of result for objective 1 and 2, and STATA 14.2 version software was used to analyze multinomial logit model (MNL) result of objective 3.

Results from the study indicated that the state of climate of the area has been changing when a comparison is made with over 30 years based on farmers' FGDs,' and KIIs experts' perceptions.

Results from the study revealed that the state of climate (95.2%) in the area is changing; rainfall was decreasing while temperature was increasing. The other states of climate *i.e* extreme heat, drought, and change in wind intensity have been increasing. The climate change impacts experienced by respondents in study area were: reduced productivity/yield, increases pests/insects/diseases, use of traditional crop varieties decreased, cropping pattern has changed, traditional irrigation sources like pond has reduced, and reduced cultivated land. The finding of study indicated sample households agreed that climate change increased scarcity of forages, grass species composition decreased, decreased productivity (mainly milk and its products), decreased livestock number, and drinking water availability decreased. Moreover results revealed, out of studied households (74.58%) agreed that climate change reduced income, while 69.17% believed it affected business items (e-g increased price of food), and 26.34% reported climate change increased dependency on relief programs. Identifying the impacts of climate change on agricultural production and various livelihood activities will help in order to adapt to possible changes in climate conditions, by incorporating the climate change in economic plan and building farmers and concerned intersectorial capacity through training.

The finding of study indicated that farmers used a diverse adaptation strategies to climate change in Loka Abaya woreda. Majority of studied farmers ranked crop diversification, improved crop varieties, reducing livestock number, tree plantation, crop rotation and intercropping, soil and conservations practices and non-farm incomes ranked 1 up to 7 as an adaptation strategy to climate change. Other strategies including small-scale irrigation, selling livestock and its products, income from remittance, and migration ranked as 8, 9, 10, 11 and 12^{th} respectively. The farmers' use of earlier listed adaptation strategies while engaging in agricultural and non-agricultural livelihood activities in Loka Abaya woreda is crucial to reduce the effects of climate change, to increase productivity from climate resilient farming, protect environment, sustainable development, and thus, realize food security.

According to marginal effects of MNL result age, family size, education status of household, farm size, livestock ownership, extension service, access to credit service, climate change information and non-farm income of household were among the explanatory variables that affect farmer's adaptation to climate change significantly, whereas sex of households and market condition aren't affect adaptation measures of farmers significantly. Focusing on factors that influence farmers use of adaptation strategies to climate change might help to fight against challenges in adapting to climate change.

5.2 Recommendation

Based on finding of this study, there is need for putting in place policies and programmes that will make the farmers to be proactive in the use of resources and at the same time adapting to climate change.

Particularly the following recommendations are proffered:

- Small-scale farmers by themselves in Loka Abaya woreda are using various adaptation strategies to climate change that are not fully guided by any policy. They should also jointly participate with woreda government, non governmental organizations like productive safety net program, and people in need in addressing climate change impacts could help them in the provision of input-based adaptation strategies (e.g. multiple crop varieties) so that their production and productivity can be enhanced in the face of changing climate.

- The researcher suggest that there is a need for resilient farmers who are able to deal with not only the predictable and unpredictable climate change events but also other interconnected socioeconomic and institutional factors.

- Considering the importance of rain-fed agriculture for majority of households as a means of livelihood in Loka Abaya woreda and the fact that ambitious mitigation efforts can only lessen but not prevent future climate change, the researcher recommends that the ministry of agriculture introduce new technology specifically focused on small-scale farmers‘adaptation to climate change so as to improve food security.

- Factors influencing households' decisions to adopt climate change strategies point the need for woreda and local government support households and ensure sustainability of livelihood activities and enhance food security. Agriculture extension services should be strengthened by increasing the interaction between households and extension officers by providing enough transport to ensure they conduct adequate field visits to farmers. Local government ought to adjust access to credit services in corporateing with OMO micro finance to narrow the farmers financial déficits, to get essential farm inputs and diversify a non farming job activity besides to onfarm job activity which is vulnerable to climate change.

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Biogragphical Sketch

The author was born in 1990 in Boricha woreda, Sidama Region. He attended his primary school at Fulassa Aldada Kidus yosef, and high school at Hawassa Addis Ketema. He completed BSc by Natural Resource and Manangement in Dilla University on Dec 2015 academic year and Soon after his graduation, he was employed in Environment, Forest and Climate change Authority, in Sidama Region. And then he joined the School of Post Graduate Studies at Hawassa University in 2018/19 academic year to pursue his MSc program in Climate change and sustainable agriculture.

Appendices

Appendix table1 time series rainfall and temperature data

Inter annual rainfall data

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	TOTRF
1988	6.1	26.2	43.6	151.3	85.3	48.6	153.1	139.2	126.6	169.6	67.6	15.4	1032.6
1989	34.1	44.2	94	178.7	130.2	102	121.5	57.2	77.3	126.4	83.4	136.6	1185.6
1990	4.7	126.7	122.7	81	141	35.1	23.3	48.7	52.4	44.8	26.7	25	732.1
1991	23.5	40	109.1	28.1	119.3	63.8	65.5	76.6	103.1	24.7	5.4	6	665.1
1992	8.4	0	20.8	133.6	57.1	44.1	84.5	84.4	121.6	166	25.4	35.5	781.4
1993	82	138.7	15.3	165.6	224.4	57.5	0	24.1	0	56.3	18.7	0	782.6
1994	0	5.3	58.6	162.2	205.4	76.1	85.5	103.6	48.5	61.6	73.3	10.9	891
1995	0	28.6	79.1	217.4	140.5	52.5	62.7	35.2	84.4	94.9	43.2	19	857.5
1996	17.4	5.3	112.7	247.9	155.6	161	102.5	193.6	107.3	54.6	31.7	6	1195.6
1997	3.4	0	20	217.7	131.1	60	86.2	65.4	34	216.9	166.6	61.1	1062.4
1998	58.2	41.7	48.9	117.6	99.5	69.4	79	112.1	29.8	169.3	22.6	0.4	848.5
1999	10.2	0	85	62.2	39.2	52.8	95.9	67.3	46.7	144.6	15.1	16.1	635.1
2000	0	0	10.1	93.9	161.5	56.6	82.3	74.6	38.6	212.1	86.5	27.8	844
2001	27.5	15.1	130.5	150.5	152.9	80.6	130.5	98.8	70.1	139	49.6	8.6	1053.7
2002	32.5	16.9	179.4	133.4	32.1	69.4	45	63.9	45.9	66.9	19.9	104.1	809.4
2003	10.5	6.7	33.6	163.2	96.7	56.1	79.5	145.6	22.4	44.6	52.3	55.1	766.3
2004	43.9	27.1	13.1	164.2	57.7	41.7	29.9	78.8	81.9	53.2	102	47.7	741.2
2005	16.4	8	107.3	150.1	247.7	45.1	84.4	20.6	88.5	132	31.1	0	931.2
2006	13.8	45.8	155.3	174.5	125.1	60.1	40.6	111.9	5.2	170	103.5	126.6	1132.4
2007	67.9	22.9	72.9	132.4	200.5	163.1	105.1	185.1	155.4	98.6	48.5	0	1252.4
2008	7.8	5.6	35.8	114.6	94.9	34.7	97.2	79	85.7	202.6	112.4	0	870.3
2009	0	11.9	15.3	90.8	114.6	44.4	18.4	28.6	53.5	153.3	35.1	45.6	611.5

2010	34.9	70.8	191	183.2	194.1	108.9	55.1	92.3	75.8	91.9	8.7	18	1124.7
2011	0	11.9	31.8	49.2	238.3	145.6	115.5	124.7	112.4	66.6	210.3	0	1106.3
2012	0	0	10.6	211.1	101.1	48.8	112.1	112.5	107.6	90.8	68.1	30.2	892.9
2013	17.7	12.6	75.6	181.3	157.9	71.3	98.8	129.1	161	157.5	77.8	3.9	1144.5
2014	6.2	45.9	104.8	72.2	203.2	61.8	64.7	136.6	85.5	176.2	86.8	0	1043.9
2015	14.3	6.7	70.9	87.8	101.2	40.8	97.1	65.7	72.5	92.4	31.7	0	681.1
2016	0	0	13.8	48.5	52.4	32.6	16.4	101.4	5.1	22.8	7.7	0.8	301.5
2017	0	0	24.4	123	103	48.8	150	127	34.2	42	17.8	12.5	682.7
Mean of inter-annual rainfall													888.65

Source: National Meteorological Agency (2019)

Mean minimum and maximum temperature

Years	Max.tem	Min.tem	Mean ANNT
1988	25.87	17.4	21.635
1989	26.01	17	21.505
1990	26.5	17.3	21.9
1991	28.4	17.2	22.8
1992	28.02	17.9	22.96
1993	28.7	17.4	23.05
1994	30.6	17.2	23.9
1995	30.3	17.4	23.85
1996	30.24	16.8	23.52
1997	30.08	17.2	23.64
1998	30.1	17	23.55
1999	30.8	17	23.9
2000	29.5	17.2	23.35
2001	30.42	17.7	24.06
2002	30.9	18.3	24.6
2003	30.73	18.1	24.415
2004	30.63	17.9	24.265
2005	31.6	18	24.8
2006	29.53	18.2	23.865
2007	31.28	18	24.64
2008	31.78	18.5	25.14
2009	32.89	18.5	25.695
2010	31.28	18.3	24.79
2011	31.96	17.9	24.93

2012	31.98	18.1	25.04
2013	31.38	18.3	24.84
2014	32.76	18.3	25.53
2015	31.7	17.8	24.75
2016	31.8	17.9	24.85
2017	31.75	17.85	24.8
Source: National Meteorological Agency(2019)			

Appendix table2 Parameter estimates of MNL model of adaptation

```
. mlogit FAMS SEX AGE  FAMSZ EDCN FARSZ LOWN      EXSRV CCINF ACRE      Market Nfinc, baseoutcome(1)

Iteration 0:   log likelihood = -361.04578

Iteration 1:   log likelihood = -167.20288

Iteration 2:   log likelihood = -144.64858

Iteration 3:   log likelihood = -129.79842

Iteration 4:   log likelihood = -126.07377

Iteration 5:   log likelihood = -125.05735

Iteration 6:   log likelihood =   -124.883

Iteration 7:   log likelihood = -124.84697

Iteration 8:   log likelihood = -124.84014

Iteration 9:   log likelihood = -124.83864

Iteration 10:  log likelihood = -124.83829

Iteration 11:  log likelihood = -124.83821

Iteration 12:  log likelihood = -124.83819

Iteration 13:  log likelihood = -124.83819
```

Multinomial logistic regression Number of obs = 188

LR chi2(66) = 472.42

Prob > chi2 = 0.0000

Log likelihood = -124.83819 Pseudo R2 = 0.6542

FAMS	Coef. Std. Err.	z	P>z	[95% Conf.	Interval]
No_adaptation	(base outcome)				
Crop_diversification					
SEX	-4.94912 2.177835	-2.27	0.023	-9.217599	-.6806411
AGE	.0306599 .0509674	0.60	0.547	-.0692345	.1305542
FAMSZ	.7976922 .416994	1.91	0.056	-.0196009	1.614985
EDCN	.7210432 .4353285	1.66	0.098	-.132185	1.574271
FARSZ	-3.064292 2.851102	-1.07	0.282	-8.652349	2.523764
LOWN	.6212226 .5821426	1.07	0.286	-.519756	1.762201
EXSRV	46.02047 4455.973	0.01	0.992	-8687.527	8779.568
CCINF	3.810755 2.286942	1.67	0.096	-.6715695	8.29308
ACRE	18.62434 4024.482	0.00	0.996	-7869.215	7906.463
Market	.1076596 .7606648	0.14	0.887	-1.383216	1.598535
Nfinc	-1.5361 1.508574	-1.02	0.309	-4.492852	1.420651
_cons	-23.85021 3965.725	-0.01	0.995	-7796.528	7748.828
REducing_livestock_no					
SEX	-3.764868 1.874204	-2.01	0.045	-7.43824	-.0914964
AGE	.0539093 .0382542	1.41	0.159	-.0210676	.1288862
FAMSZ	.4556719 .3333149	1.37	0.172	-.1976133	1.108957
EDCN	.6255291 .319578	1.96	0.050	-.0008322	1.25189
FARSZ	-4.504538 2.805801	-1.61	0.108	-10.00381	.9947304
LOWN	1.588728 .4281985	3.71	0.000	.7494742	2.427981
EXSRV	25.43811 2031.93	0.01	0.990	-3957.071	4007.947
CCINF	3.054518 1.991746	1.53	0.125	-.849233	6.958269
ACRE	16.43229 4024.482	0.00	0.997	-7871.407	7904.271
Market	-.8729328 .598762	-1.46	0.145	-2.046485	.3006192
Nfinc	-.1689727 1.086702	-0.16	0.876	-2.29887	1.960924
_cons	-4.330542 2.862928	-1.51	0.130	-9.941778	1.280695
Improved_crop_varieties					
SEX	-4.331919 2.096638	-2.07	0.039	-8.441254	-.2225827
AGE	-.0277686 .048713	-0.57	0.569	-.1232443	.0677071
FAMSZ	.8279174 .4065041	2.04	0.042	.031184	1.624651

EDCN	.6863924	.4071894	1.69	0.092	-.1116841	1.484469
FARSZ	-4.84282	2.83198	-1.71	0.087	-10.3934	.7077583
LOWN	1.289944	.4941292	2.61	0.009	.3214685	2.258419
EXSRV	28.92424	2031.93	0.01	0.989	-3953.586	4011.434
CCINF	7.128124	2.388335	2.98	0.003	2.447073	11.80917
ACRE	20.56135	4024.481	0.01	0.996	-7867.277	7908.4
Market	.4696368	.7353509	0.64	0.523	-.9716245	1.910898
Nfinc	-1.013118	1.438839	-0.70	0.481	-3.833192	1.806955
_cons	-9.143679	4.190559	-2.18	0.029	-17.35702	-.9303336
Soil_and_water_conservation						
SEX	-5.15382	1.794334	-2.87	0.004	-8.67065	-1.636989
AGE	.0744429	.0381326	1.95	0.051	-.0002956	.1491815
FAMSZ	.597482	.3261073	1.83	0.067	-.0416767	1.236641
EDCN	.3113305	.3349695	0.93	0.353	-.3451976	.9678587
FARSZ	-4.342832	2.752696	-1.58	0.115	-9.738017	1.052354
LOWN	1.419122	.4298907	3.30	0.001	.5765515	2.261692
EXSRV	23.42081	2031.93	0.01	0.991	-3959.089	4005.93
CCINF	5.141108	1.902909	2.70	0.007	1.411475	8.87074
ACRE	15.74004	4024.481	0.00	0.997	-7872.099	7903.579
Market	-.450473	.6032637	-0.75	0.455	-1.632848	.7319023
Nfinc	-.3922744	1.111268	-0.35	0.724	-2.570319	1.78577
_cons	-4.908397	2.804093	-1.75	0.080	-10.40432	.5875237
Income_diversification						
SEX	-3.663821	2.519369	-1.45	0.146	-8.601694	1.274052
AGE	.0449343	.052676	0.85	0.394	-.0583086	.1481773
FAMSZ	.2416909	.5343145	0.45	0.651	-.8055462	1.288928
EDCN	1.371738	.4468465	3.07	0.002	.4959354	2.247542
FARSZ	-4.560324	3.229804	-1.41	0.158	-10.89062	1.769975
LOWN	1.330516	.5232962	2.54	0.011	.3048746	2.356158
EXSRV	26.08771	2031.93	0.01	0.990	-3956.423	4008.598
CCINF	2.672335	2.553925	1.05	0.295	-2.333267	7.677937
ACRE	19.73757	4024.482	0.00	0.996	-7868.102	7907.577
Market	.4457518	.9060337	0.49	0.623	-1.330042	2.221545
Nfinc	.1610602	1.651474	0.10	0.922	-3.075769	3.397889
_cons	-11.07493	5.146532	-2.15	0.031	-21.16194	-.9879085
small_scale_irrigation						
SEX	-6.508913	2.208161	-2.95	0.003	-10.83683	-2.180997
AGE	-.0107194	.0498524	-0.22	0.830	-.1084283	.0869894

FAMSZ	.3773113	.4232122	0.89	0.373	-.4521695	1.206792
EDCN	.925445	.4072921	2.27	0.023	.1271672	1.723723
FARSZ	-5.096681	2.991987	-1.70	0.088	-10.96087	.7675049
LOWN	1.58777	.5152033	3.08	0.002	.57799	2.59755
EXSRV	28.54081	2031.93	0.01	0.989	-3953.969	4011.051
CCINF	5.648001	2.405892	2.35	0.019	.9325394	10.36346
ACRE	24.11131	4024.482	0.01	0.995	-7863.728	7911.95
Market	.5066408	.7523327	0.67	0.501	-.9679043	1.981186
Nfinc	-.3289244	1.467603	-0.22	0.823	-3.205374	2.547525
_cons	-9.59297	4.464824	-2.15	0.032	-18.34386	-.8420752

Appendix table3 Marginal effect of explanatory variables

. margins,dydx(*)

Average marginal effects Number of obs = 188

Model VCE : OIM

dy/dx w.r.t. : SEX AGE FAMSZ EDCN FARSZ LOWN EXSRV CCINF ACRE Market Nfinc

1._predict : Pr(FAMS==No_adaptation), predict(pr outcome(1))

2._predict : Pr(FAMS==Crop_diversification), predict(pr outcome(2))

3._predict : Pr(FAMS==REducing_livestock_no), predict(pr outcome(3))

4._predict : Pr(FAMS==Improved_crop_varieties), predict(pr outcome(4))

5._predict : Pr(FAMS==Soil_and_water_conservation), predict(pr outcome(5))

6._predict : Pr(FAMS==Income_diversification), predict(pr outcome(6))

7._predict : Pr(FAMS==small_scale_irrigation), predict(pr outcome(7))

	Delta-method dy/dx	Std. Err.	Z	P>z	[95% Conf.	Interval]
SEX						
_predict						
1	.1082857	.0337225	3.21	0.101	.0421907	.1743806
2	-.0103128	.0426662	-0.24	0.809	-.093937	.0733114
3	.0267995	.0647429	0.41	0.679	-.1000944	.1536933
4	.1084065	.0580217	2.87	0.362	-.005314	.222127
5	-.1179754	.0514913	-2.29	0.422	-.2188965	-.0170542
6	.0244642	.0403243	0.61	0.544	-.05457	.1034984
7	-.1396676	.0568481	-2.46	0.214	-.2510879	-.0282473
AGE						
_predict						
1	-.001514	.0008346	-1.81	0.270	-.0031498	.0001217
2	.0010577	.0009838	1.08	0.282	-.0008706	.0029859
3	.0006131	.0011691	0.52	0.600	-.0016784	.0029045
4	-.0031542	.0011567	-2.73	0.106	-.0054213	-.000887
5	.3029023	.0010345	2.81	0.005	.0008746	.00493
6	.0004881	.0008077	0.60	0.546	-.0010949	.0020711
7	-.0003929	.0011572	-0.34	0.734	-.002661	.0018752
FAMSZ						
_predict						
1	-.0126757	.0073346	-1.73	0.084	-.0270512	.0016998
2	.0077494	.0077193	1.00	0.315	-.0073802	.022879
3	-.0027034	.0108045	-0.25	0.802	-.0238798	.018473
4	.0249578	.0090785	0.83	0.106	.0071642	.0427513
5	.0107668	.009562	1.13	0.260	-.0079743	.0295079
6	-.00514	.0083802	-0.61	0.540	-.021565	.011285
7	-.0229549	.0088015	-2.61	0.469	-.0402054	-.0057043
EDCN						
_predict						
1	-.0175462	.0064612	-1.94	0.052	-.0252099	.0001175
2	-.0005444	.0103691	-0.05	0.958	-.0208675	.0197787
3	.0120663	.0095851	1.26	0.208	-.00672	.0308527
4	-.0084908	.0131324	-0.65	0.518	-.0342298	.0172483
5	-.0162386	.0108264	-1.50	0.134	-.0374579	.0049807
6	.0144816	.0056964	2.54	0.011	.0033169	.0256463

7	.011272	.0107085	1.05	0.293	-.0097163	.0322603
FARSZ						
_predict						
1	-.1086987	.0611849	-1.78	0.076	-.0112215	.2286189
2	.0693772	.0262813	2.64	0.008	.0178667	.1208876
3	-.0670855	.0675234	-0.99	0.320	-.1994289	.065258
4	-.0294333	.0564728	-0.52	0.602	-.1401178	.0812513
5	-.0410265	.0646878	-0.63	0.526	-.1678124	.0857593
6	-.0047291	.0354209	-0.13	0.894	-.0741528	.0646945
7	-.0358014	.0684548	-0.52	0.601	-.1699704	.0983675
LOWN						
_predict						
1	-.0366197	.0048097	-7.61	0.000	-.0460465	-.027193
2	-.0326217	.014276	-2.29	0.022	-.0606022	-.0046412
3	.0360223	.0090609	3.98	0.000	.0182633	.0537814
4	-.0926878	.0151633	-0.18	0.859	-.0324073	.0270318
5	.5131204	.0081144	1.68	0.093	.0027836	.0290244
6	-.0007591	.0060627	-0.13	0.900	-.0126417	.0111235
7	-.0235457	.0139985	-1.34	0.516	-.0038909	.0509823
EXSRV						
_predict						
1	-.6021231	49.77012	-0.01	0.990	-98.14976	96.94552
2	.7517799	161.2735	0.00	0.996	-315.3385	316.842
3	.1814921	39.73879	0.00	0.996	-77.70511	78.06809
4	-.2236862	73.20359	-0.00	0.904	-143.7001	143.2527
5	.0507578	26.64119	2.74	0.008	-52.16501	52.26653
6	-.0357403	9.983653	-0.00	0.997	-19.60334	19.53186
7	-.1224802	33.24528	-0.00	0.997	-65.28204	65.03708
CCINF						
_predict						
1	.0996962	.0368093	-2.71	0.107	-.171841	-.0275514
2	.0721871	.038796	1.86	0.063	.1482257	.2038516
3	-.0712313	.0458426	-1.55	0.120	-.161081	.0186185
4	.1694477	.0946125	1.79	0.073	-.0159893	.3548847
5	.1285243	.0394033	3.26	0.001	.0512952	.2057534
6	-.0354197	.0298126	-1.19	0.235	-.0938514	.023012
7	-.0194378	.0835207	-0.23	0.816	-.1831353	.1442598
ACRE						

_predict						
1	-.3998337	98.5759	-0.00	0.997	-193.605	192.8054
2	-.0572786	.0380581	-1.51	0.132	-.1318712	.0173139
3	.1401133	47.05003	0.00	0.998	-92.07625	92.35647
4	-.0528585	1.33636	-0.04	0.968	-2.672077	2.56636
5	.0744739	45.82628	0.00	0.999	-89.74339	89.89234
6	.0200873	4.118407	1.87	0.067	.051841	0.1092016
7	.2752962	.25937	1.26	0.009	.2330597	.7836521
Market						
_predict						
1	.0146919	.013406	1.10	0.273	-.0115834	.0409672
2	-.0011228	.0153742	-0.07	0.942	-.0312556	.02901
3	-.0530709	.0233739	-2.27	0.123	-.098883	-.0072588
4	.0188303	.0183064	1.03	0.304	-.0170496	.0547102
5	-.0025115	.0205812	-0.12	0.903	-.04285	.0378269
6	.0119004	.0151766	0.78	0.433	-.0178452	.041646
7	.0112827	.0172689	0.65	0.514	-.0225637	.0451291
Nfinc						
_predict						
1	.0066336	.025509	0.26	0.795	-.0433632	.0566304
2	-.0387434	.0338164	-1.15	0.252	-.1050223	.0275355
3	.0191879	.042644	0.45	0.653	-.0643927	.1027686
4	-.0312301	.0436446	-0.72	0.474	-.116772	.0543118
5	-.005033	.0428405	-0.12	0.906	-.0889988	.0789328
6	.0130236	.0253128	0.51	0.017	.0365885	.0626357
7	.0361614	.0382088	0.95	0.344	-.0387264	.1110492

Appendix table 4 Correlation coefficient of discretevariables

```
. correlate sex extension credit CCIN Nfinc
(obs=188)
```

	sex	extens~n	credit	CCIN	Nfinc
sex	1.0000				
extension	-0.0372	1.0000			
credit	0.0560	0.4421	1.0000		
CCIN	-0.1222	0.3788	0.4033	1.0000	
Nfinc	-0.0221	-0.1068	-0.0005	-0.0581	1.0000

Appendix table5 Variance of inflation factors for continuos variables

```
. estat vif
```

Variable	VIF	1/VIF
familysize	1.09	0.917571
farmsize	1.08	0.928466
age	1.05	0.950909
education	1.05	0.952452
livestock	1.05	0.952530
market	1.03	0.967414
Mean VIF	1.06	

Appendix table 6 Livestock Category &Tropical Livestock Unit

Livestock category	**TLU-equivalent**
Calf	0.25
Weaned calf	0.34
Heifer or Bull	0.75
Cows or Oxen	1.00
Donkey (young)	0.35
Donkey (adult)	0.70
Sheep or Goat (adult)	0.13
Sheep or Goat (young)	0.06
Horse or Mule	1.10
Chicken	0.013

Source: Storck *et al*. (1991).

HAWASSA UNIVERSITY

SCHOOL OF GRADUATE STUDIES COLLEGE OF AGRIICULTURE

PROGRAM OF CLIMATE CHANGE AND SUSTAINABLE AGRICULTURE

QUESTIONNAIRE FOR HOUSEHOLD HEADS

My name is Adisu Petros MSc student at Hawassa University, College of Agriculture. I am conducting a research concerning **Effect of Climate Change and Variablity on Rural livelihood and Its Adaptation Strategies** in your woreda (Loka Abaya Woreda). Hence, your opinion and perception will help me in this regard. Dear Respondents: The questionnaire is designed to generate data that will be used for academic purpose only. Therefore, please feel free and share us your rational views.

Part I: Demographic and socio-economic characteristics of the respondent household

1. Age of household head :________________2. Sex of households head: 1. Male 2. Female

3. Marital status: 1). Married 2) Unmarried 3) Divorced 4) Widowed

4. Language: ______________________________

5. Religion: 1) Christian 2) Muslim 3) Others (specify) ____

6. How long have you lived in the Kebele? ------------- Years

7. Total family size ? Female:……_Male ……. Total……….

8. Age group of family members: a. < 10 years of age: Male …………. Female …….. b. 10-14 years of age: Male ……….. Female ……… c. 15-50 Years of age: Male ………… Female …… d. > 51 years of age : Male …. ……...Female……..

9. Literacy level of the respondent 1. Illiterate 2. Only read and write 3. Formal education (grade ---)

10. Family members able to read and write: 1 Female……. 2. Male… 3. Total: ………

11. What are your occupation (list them in order of importance)

Type of occupation	Rank (1st, 2nd, 3rd, etc)
Agriculture	
Trader	
trader and agricultura	
Wage labor	
Wage labor and Agriculture	
Other (specify)	

12. What are the major challenges/problems that you face in your crop production? Please indicate them in order of importance

Challenge	Rank (1st, 2nd, 3rd etc.)
Moisture stress	
Lack of oxen	
Lack of labor	
Soil fertility	
Insect pest	
Pest	
Other (specify)	

13. Do any member of your family practice seasonal migration 1. Yes 2. No

14. If yes who is migrating from the family members 1. Father 2. Children 200

15. If yes for how long they migrate? 1. Less than three months 2. Up to six months 3. More than six months

16. What other skill do you have other than farming? 1. Weaving 2. Blacksmithing 3.Pottery 4. Wood work 5 .Other …………………………………………………….

17. How many local holidays do you observe in a month... days .

PART II. Livestock Husbandry

1. How many heads of the following livestock do you have?

Livestock	Numbers	Livestock	Number
Cows		Sheep and goats	
Oxen and Bulls		Equines	
Heifers		Honey Bees	

Calf		Poultry	

2. What is the dominant grazing system you practice in your village? 1. Free grazing 2. Stall (cut and carry)

3. Do you have private grazing land? 1. Yes 2. No

4. If yes what is the area of the private grazing land? ……….. ha.

5. Do you use common wood land for grazing? 1.Yes 2. No

6. If yes what is the potential of these common woodlands as source of grazing? 1. Very high 2. Not so important

7. Serves only as resting place

8. Do you face grazing land shortage? 1. Yes 2. No

9. If yes during which season? 1. Dry season 2. Rainy season 3. Both

10. Do you want to keep more livestock in the future? 1. Yes 2. No

11. If yes reason/ If No reason: …………………………………………………………………

Part III: Land Holding and Crop Production

1. What is the size of your land holding? ……….. ha.

2. Do you cultivate all of your land holding 1. Yes 2. No ……….

3. If no how do you benefit from your land? 1. Share cropping 2. Rent it for money 3. Other ………………………………………………………………………………………………..

4. Do you feel that your land holding is adequate to produce enough for your subsistence? 1. Yes 2. No

5. If no how do you satisfy your land requirement? 1. Rent in land 2. Engage in off farm activities 3. Other ……………………………………………………………………………….

6. Do you have land holding certificate? 1.Yes 2.No

7. Can you rent out your land for 10 or 20 years? 1 Yes 2. No (explain to your answer)

8. Do you feel that the land belongs to you and your family indefinitely? 1. Yes 2. No

9. If no who control ownership of land? ……………………………………………………..

10. How sloppy is your farm land? 1. Plain 2. Medium 3.Very steep slope?

11. Have you constructed water harvesting structure on your land holding? 1. Yes 2. No 12. Have you constructed soil and water conservation structure on your land holdings? 1. Yes 2. No 13. Do you have a pair of oxen to plough you land? 1. Yes 2. No

14. If no how do you satisfy you need for plowing oxen? 1 Hire 2. Oxen for labour exchange 3. Oxen sharing

15. In which category do you classify your soil on basis of its fertility? 1. Low fertility 2. Medium fertile 3. Highly fertile

16. How productive is your land without fertilizer? 1. High 2. Medium 3.Low 17. 16. What type of agriculture do you practice? 1. Rain-fed 2. Irrigated 3.Mixed 18. Does your annual production cover the annual food need of your family? 1. Yes 2. No

17. What type of agriculture do you practice? 1. Rain-fed 2. Irrigated 3. Mixed

18. Does your annual production cover the annual food need of your family? 1. Yes 2. No

19. How many quintals do you produce by crop type during good rainy season on average?

Crop type	Yield /ha in qt	Crop type	Yield /ha in qt
Teff		Maize	
Barleyy		Faba bean beans	
Wheat		Field Peas	
Sorghum		Millet	

20. If no how do you satisfy your food needs? a. Purchase by selling livestock or other products b. Sell labour to generate income c. Practice petty trade

21. What are the major challenges/problems that you face in your crop production? Please indicate them in order of importance

Challenge	Rank (1st, 2nd, 3rd etc.)
Drought	
Erratic rainfall/uneven distribution rainfall	
Lack of oxen	
Lack of labor	
Soil fertility	
Insect pest	
Pest	
Land shortage/small land size	
Lack of improved seed	

Other (specify)	

PART IV: Land Use Land Cover Change Issues

1. Is there any change on the forest land/wood land area in your locality after the resettlement? 1. Yes 2. No 3. Have no idea.

2. If there is change in the area of woodland is it decreasing or increasing in size? 1. Increasing 2. Decreasing 3. No change

3. Is the grazing land area cover in your locality changing in size? 1. Yes 2. No

4. If there is change in the area of grazing land is it decreasing or increasing in size? 1. Increasing 2. Decreasing

5. If you answer that the woodland is decreasing what are the major reasons behind deforestation, please give the rank (1st, 2nd, 3rd, etc.) in its severity.

Reasons	Rank in order of severity (1st, 2nd, 3dr, etc)
-Expansion of farm land by illegal farmers	
- Cutting of trees for the purpose of contracting the house	
-Grazing encroachment	
Other (specify)	

6. Is there a land use plan in the Kebele? 1. Yes 2. No 3. No information.

7. If there is a land use plan, please give the details and how it was done? …………
………………………………………………………………………………………………….

8. What type of tree species are grown in your farm land or around the homestead or elsewhere in your locality list the major trees you are planted? (list them) ……………..

9. Do you grow trees? 1. Yes 2. No

10. If yes, how many trees have you grown? ………………………………………………….

11. List the major trees/shrub found in your locality………………………………………….

12. In your locality is there any indigenous tree that are extinct or becoming extinct because of deforestation a) Yes b) no

13. If yes list out the name of indigenous trees that are already extinct or being extinct in your locality: ……………………………………………………………………………………..

PART V. Institutional Factors

1. Do you get agricultural extension services in your area? 1. Yes 2. No

2. Do you have access to information media? 1.Yes 2. No.

3. If your answer is yes, which medium do you possess? 1. Radio 2. TV 3. Newspaper 4. Extension agents e).Other …………………….

4. Do you have access to credit? 1. Yes 2. No.

5. Do you have market access nearby? 1.Yes 2. No

6. If your answer is yes, how far is it? ……….. km (approximately)

7. Are there roads that connect the Kebele you with nearby towns or cities? 1. Yes 2. No

8. Do you have health centers in your village? 1. Yes 2. No

9. Do you have education centers at your village? 1. Yes 2. No

10. Is there electric services in your village? 1. Yes 2. No

11. Do you have access and use improved production inputs and technologies? 1. Yes 2. No

PART VI. Climate Change and its effect Assessment

1. Is today's weather the same as the weather conditions that were 30 years from now? 1. Yes 2. No 2. If No, what are the major indicators?

2. If No, what are the major indicators in your local area?

Climatic variable	Yes	No
Rainfall amount has increased		
Rainfall amount has decreased		
Rainfall amount is the same		
Early onset of rainfall		
Late onset of rainfall		
Poor distribution of rainfall		
Frequent high volume flood		
High temperature		
Strong wind		

Other (specify)		

3. How do you evaluate the trend of the climatic variables change over the last ten years? 1. The change has become severe 2. . Slow change 3. No visible difference has been observed 4. No change at all

4. What problems have you faced on your livelihood due to climatic variability and change?

Impact of long term climate change on agriculture in study area

Impact	**Response of studied households**		
	Agree	**Can't say**	**Disagree**
Use of traditional crop varieties decreased			
Cropping pattern has changed			
Traditional irrigation sources like `pond has Reduced			
Reduced productivity			
Increases Pests/insects/diseases			
Reduced cultivated land			

Impact of long term climate change on livestock production in study area

Impact	**Response of studied households**		
	Agree	**Can't say**	**Disagree**
Increased scarcity of forages in the area			
Grass species composition decreased			
Drinking water availability decreased			
Decreased livestock number			
Decreased productivity (mainly milk and its products)			
Increased livestock disease outbreak			
Death of livestock due to heat stress (e.g. poultry)			

Impact of long term climate change on livelihood conditions in study area

Impact	**Response of studied households (mark on your choice)**		
	Agree	**Can't say**	**Disagree**
Reduced income			
Affected business (e-g increased price of food) items			
Increased dependency on relief programs			
Loss of assets			
Increased rural migration			

5. Which local indicators do you use to evaluate the temperature trend in the area? (Please support your choice with example).

1. Prevalence of human and animal diseases that are not familiar to the area (malaria etc).
2. Introduction of plant and animal species that were not popular in the area (goat in highland not common).

3. Observation of physical structures and societal clothing styles (disappearance of ice cover in mountain peaks, frost damage become uncommon, drying up of rivers, streams, swampy areas ,lakes, dressing light cloths etc.

4. Other specify …………………………………………………………….

6. What do you say about the trend of rainfall over the last 20 years? 1. Increased 2. Not changed 3. Decreased 4. Change in times of raining 5. Increase in frequency of drought 6. I don't know 7. Other (specify)………..

7. Which local indicator do you use to evaluate today's rain fall pattern?

a. Loss of some plant and animal species:...YES/NO

b. Increased drought frequency: YES/NO c. Rainfall comes early or lately…YES/NO

d. Decline of soil productivity/fertility:….YES/NO

e. Decline of agriculture yields: YES/NO

f. Decrease available water:,……………...YES/NO

g. Other (specify) __..

8. Have you heard of the world “climate change” before? 1. Yes 2. No

9. If yes when………………………………………………………………………………

10. From which source you heard about climate change? (Multiple answers is possible) 1.Television 2. Newspaper 3.Friends/families 4.Radio 5. School/college 6. Government agencies/information

11. What do you think is the cause of climate change? 1. Human actions 2. Natural process 3.Both human action and natural process 4.Wrath of God 5. Don’t know/I have no idea

12. Have you encountered any climate related disasters after 1989? 1. Yes 2. No

13. If your answer to question No. 11 is yes, please fill the cells of the table below.

A. Year the incident happened: ………………………………………..………….

B. Loss encountered in terms of crop, livestock, human lives: ……………………..

C. Coping mechanisms applied: ……………………………………………………..

(**Key**: 1. Climatic shock(s): a) flood b) drought c) erratic rainfall d) frost e) pest &disease prevalence f) soil erosion g) heavy ice h) crop logging (by wind or water), i) other (specify)

2. Coping mechanism: a): inter household transfers and loans, b) sell of household assets, c). insurance):begging, e): government assistance, f): reduced socialization for saving, g). Wage labor h) making local drink i) selling forest products j) Handicraft work, k). Petty trading, l) renting tools/animals, m) giving community service (food for work), n) redaction of consumption level, 0) migration in search of employment, p) mortgaging of land, q)food appeal/aid), r). Credit form merchants or money lenders, s). Other (specify)

14. How far did you travel in search of water for your livestock?

Period	Distance travelled		
	< 2 kilometers	2-5 kilometers	Greater than kilometers
1989-1999			
2000-2009			
2010-2019			

15. Which of the following options do you used to minimize the risk of feed security?

a. Created good amount of animal feed during needed times: Yes/NO

b. Increased water availability:…..….Yes/NO

c. Increased fish production: ……….Yes/NO

d. Enhanced food crops growth…Yes/NO

e. Open up new lands for farming:…...Yes/NO f. Introduction of good technology: …..Yes/NO g. Enhanced self-help arrangements:....Yes/NO

h. Other (specify) ………………………………………………………………….

16. Has climate change and variability created any good opportunities for you? 1. Yes 2. No

17. If Yes, Please support your answer with explanation………………………………………….

18. Do you practice soil and water conservation on your farm land? 1. Yes 2. No 3. Don't know 19. Do you feel that such practices help you to reduce the negative impacts of climate change? 1. Yes 2. No 3. Do not know

PART VII Assessment of Adaptation option to climate change and barriers faced

1. What adjustments in your farming/livelihood have you made to the long-term shifts in the rainfall?

a. Enhance traditional irrigation schemes: ……………….YES/NO

b. used drought resistant crop varieties: ………………... YES? NO

c. used improved crop varieties: ……………………...YES/NO

d. shifting from crop producing to planting vegetation:…YES/NO

e. adopt crop rotation and mixed cropping:……….……. YES/NO

f. enhancing animal rearing practice : ………...……….YES/NO

g. If there are others list them them………………………………………

2. Do you think the adaptive mechanism(s) you employed for the temperature problem is the best and viable one in current and future climate change and variability? 1. Yes 2. No 3. Do you think the adaptation options listed in the Table are helpful to adapt to climate change bad effects?

3. Do you think the adaptation options listed in the Table are helpful to adapt to climate change bad effects while engaged in livelihood?

Adaptation Option	Rank the most usable one
1.Change crop variety	
2.Plant a different crop	
3. Diversify crops	
4. Shift planting dates	
5. Move to different sites (Migrate to urban area)	
7. Build a water harvesting scheme	
8. Implement soil conservation	
9.Plant trees for shading	
10.Change from crop to livestock Management	
11. Reduce number of livestock	
12. Change from livestock to crop	
13.Diversity from farming to non-farmin Activities	
14. Lease your land	
15.Pray more or increase your ritual offering to traditional rain makers	
16. Increase use of irrigation/groundwater/watering	
17. Look for daily work	
18. Collect fuel wood for sale	
19. Sell assets: livestock, etc	
20. Other	

Appendix 3.2 Guiding questions for Focus Group Discussion (FGD) (with selected farmers representing cross section of the community, women group, youth group, Kebele leaders)

Address (location) of the village…………………………………….

Focus group size………….

Focus group composition: Male headed households/Women headed households/Youth Group, Kebele Leaders Checklist of questions

1. What visible changes have you observed as related to rain fall, temperature, soil fertility, forest vegetation, wildlife, crop productivity, livestock productivity, flow of streams, occurrence of big floods, incidence of drought, forest vegetation cover, river/stream flow etc during your life time in the village?

2. How often is the occurrence of drought in the locality? And what are the probable causes?

3. Have you heard of “climate change”? If yes from which sources?

4. What are your traditional or local indicators to realize that there is e climate change?

5. How is the trend of the rainfall and the temperature during the past 20 to 30 years? Is it increasing, decreasing, coming on time and stopping at the right time?

6. What coping and adaptation strategies have community members crafted to alleviate problems arising as a result of climatic variability/drought?

7. Do farmers have sufficient knowledge about Adaptation options to climate change?

8. Are the crops you cultivate now the same as h the crops your father or forefather was growing? If no, reasons for changing the crops?

9. Are the animals you are raring no the same as the animals your father or forefather used to rare? If no, reasons for changing the animals?

10. What customary self-help arrangements are there to support each other in your villages during the times of climatic extremes?

11. What effect has climate change inflicted on the livelihood of the local people?

12. Do you believe that it is possible to reduce or totally stop the negative impacts of climate change? if yes how?

13. What effect has climate change inflicted on the livelihood of the local people?

14. Can you tell us the sowing time of common grown crops some twenty-thirty years back and what time of the year do you practice seed sowing in recent years?

15. What development interventions are carried out in the village to avert the impact of climate change? (afforetation, water harvesting, irrigation, soil and water conservation, off farm employment, etc.

16. Do you agree that development interventions in the village are well planned, well discussed and undertaken after consensus or lack these attributes?

17. Do you feel that farmers are happy to participate in development activities such as soil and water conservation, forestry development without payment?

18. How do you evaluate the sustainability of development interventions promoted by government and nongovernment?

19. How do you evaluate the agricultural extension agents’ role in motivating and mobilizing the community to strengthen their adaptive strategies to climatic changes?

20. How do you evaluate the value of tree planting to individual households' livelihood improvement and improving climate change?

21. What trainings are given to the community to reverse climatic shocks?

22. What agricultural technology and meteorological information/early warning are provided to farmers to avert climate shocks? If yes by whom?

23. Do farmers have strong organizational arrangement that could enhance local development and social cohesion? Please give your opinion.

24. What are the successes stories you observed in relation to coping and adaptation strategies adopted by farmers to withstand climatic shocks?

25. What should the government and the community do to avert the impact of climate change in the Kebele?

Appendix 3.3 Guiding question for Key Informants in the Study Kebeles

1. What visible changes have you observed as related to rain fall, temperature, soil fertility, forest vegetation, wildlife, crop productivity, livestock productivity, flow of streams, occurrence of big floods, incidence of drought, forest vegetation cover, river/stream flow etc during your life time in the village?

2. How often is the occurrence of drought in the locality? And what are the probable causes?/How is the trend of the rainfall during the past 20 to 30 years? Is it increasing, decreasing, coming on time and stopping at the right time?

3. What coping and adaptation strategies have community members crafted to alleviate problems arising as a result of climatic variability/drought?.

4. Can you tell us the sowing time of common grown crops some twenty-thirty years back and what time of the year do you practice seed sowing in recent years?

5. What effect has climate change inflicted on the livelihood of the local people?

6. What development interventions are carried out in the village to avert the impact of climate change? (afforetation, water harvesting, irrigation, soil and water conservation, off farm employment, etc.

7. Do you agree that development interventions in the village are well planned, well discussed and undertaken after consensus or lack these attributes?

8. How do you evaluate the sustainability of development interventions promoted by government and nongovernment?

9. Do you feel that farmers are happy to participate in development activities such as soil and water conservation, forestry development without payment?

10. How do you evaluate the agricultural extension agents’ role in motivating and mobilizing the community to strengthen their adaptive strategies to climatic changes?

11. How do you evaluate the value of tree planting to individual households’ livelihood improvement?

12. What agricultural technology and meteorology information system do you access regularly and during climatic extremes?

13. Do you receive early warning information on short term variations and/or long term climate change from any sources?

14. Do you believe that it is possible to reduce or totally stop the negative impacts of climate change? if yes how?

15. What are the successes stories you observed in relation to coping and adaptation strategies adopted by farmers to withstand climatic shocks?

16. What should the government and the community do to avert the impact of climate change in the Kebele?

Thank you for your cooperation!