SMALLHOLDER FARMERS PERCEPTION OF CLIMATE CHANGE AND FACTORS AFFECTING CHOICES OF THEIR ADAPTATION PRACTICES: THE CASE OF LOKA ABAYA WOREDA, SIDAMA REGION, ETHIOPIA

MSc THESIS

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HAWASSA UNIVERSITY COLLEGE OF AGRICULTURE

HAWASSA, ETHIOPIA

MAY, 2021

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(Submission Sheet-1)

This is to certify that the proposal entitled "**Smallholder Farmers Perception of Climate Change and Factors Affecting Choices of Their Adaptation Practices: the case of Loka Abaya Woreda, Sidama National Regional State of Ethiopia",** submitted in partial fulfillment of the requirements for the degree of masters of Science in climate change and sustainable agriculture, and has been carried out by Nigatu Tunsisa, under our supervision.

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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 Master of Science of Climate change and sustainable agriculture at Hawassa University 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 thesis 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 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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ACRONYMS AND ABBREVIATIONS

CSA	Central Statistical Agency
FAO	Food and Agriculture Organization
FGDs	Focus Group Discussions
GDP	Gross Domestic Product
IPCC	Intergovernmental Panel on Climate Change IPCC
KII	Key Informant Interview
OECD	Organization for Economic Cooperation and Development
SSA	Sub Saharan Africa
m.a.s.l	Meter Above Sea Level
MNL	Multinomial Logit
CC	Climate Change
FDRE	Federal Democratic Republic of Ethiopia
UNFCCC	United Nations Framework Convention on Climate Change
UNDP	United Nations Development Programme
WWL	World Wild Life
NASA	National Aeronautics and Space Administration
GHG	Green House Gas
HHs	Households
ITCZ	Inter-Tropical Convergent Zone
UNEPA	United Nations Environmental Protection Agency
VI	Variance Inflation
CC	Contingency Coefficient

DEDICATION

I dedicate this Thesis manuscript to my mother Arfaso Gragn and father Tunsisa Tumicha.

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Smallholder Farmers Perception of Climate Change and Factors Affecting Choices of Their Adaptation Practices: The case of Loka Abaya Woreda, Sidama, Region.

By Nigatu Tunsisa Tumicha
Advisor: Tesfaye Woltamo(PhD)
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Abstract

Climate change has currently been recognized across disciplines and groups of people as a serious challenge facing societies today. This study was motivated by the fact that smallholder farming as part of the broader agricultural sector locally affected by climate change while contributing to food security, economic growth and employment provision particularly in study area. This study sought to analyze Smallholder Farmers Perception of Climate Change and Factors Affecting Choices of Their Adaptation Practices: The case of Loka Abaya Woreda, Sidama Region. It further aimed to identify small holder farmers' perception on climate change, adaptation practices to CC at farm level and to analyze factors affecting adoption of different adaptation strategies by small holder farmers. The study used cross sectional survey design to accomplish the study. A multi-stage sampling procedure was used to select 148 sample respondents. Both primary and secondary data sources were used to while collecting study data. To collect the required data household survey, FGDs, and KIIs were used from primary data sources. Furthermore the study collected secondary data sources from published and unpublished materials. Descriptive statistics and econometric model was used to analyze the objectives of the study. The finding of study indicated that the state of climate of the area has been changing when a comparison is made with over 30 years based on perceptions of smallholder farmers, local elders, local leaders and experts. Most of the interviewed small holder farmers had experienced the change in climate; fully aware that temperature is getting warmer, rainfall has decreased, occurrence of drought, rainfall starting latter, unpredictable rainfall, and risk of crop and livestock diseases have increased due to climate change. This had impacted crop production through crop failure and reduced yield. Furthermore, other major losses incurred due to climate change could be ordered sequentially as livestock productivity decreased, crop area reduced, income reduced, high food costs, and river run off decreased, crop/ animal disease outbreaks, plant species decreased/loss , dependency on relief increased (food insecurity) as the other impacts of climate change, respectively. The main farming's adaptation strategies to CC used by smallholder farmers in Loka abaya woreda were found to be: crop diversification, diversifying sources of livelihood, planting/keeping drought tolerant crops/livestock, use of agro-forestry and reforestation/ afforestation as the main climate change adaptation strategy in the study area. Other important climate change adaptation strategies used by the farmers in the study areas include: Soil and water conservation techniques, use of irrigation system/water storage, changing planting dates, incomes from remittances, and out migration from climate risk areas. The findings of multinomial logistic regression model (MNL) explained that out of eleven selected variables, six of them (age, family size, farm size, education, contact with extension personnel, access to credit service ,attaining information on climate change and distance from market) were statistically significant factors that affect small holder farmers use of adaptation strategies to climate change in study area. The study, therefore, recommends, local governments, research institutions and farmers needed to be mainstreamed and institutional networks strengthened in order for effective and stable small holder farmers based adaptation practice to inevitable climate change.

Key words: Adaptation, Climate Change Effect, MNL model; Small holder farmer, Loka Abaya

CHAPTER ONE: INTRODUCTION

1.1Background of the Study

Climate change is rapidly emerging as a global critical development issue affecting many sectors in the world and is considered to be one of the most serious threats to sustainable development. Globally, an unprecedented increase in greenhouse emissions has led to increased climate change impacts. Climate change and agriculture are interrelated processes, both of which take place on a global scale (OECD, 2015). Global warming is projected to have significant impacts on conditions affecting agriculture, including temperature, precipitation and other extreme events of climate change (FAO, 2017).

The phenomenon of climate change and its impact on humanity has received wide attention worldwide over, at least in the last few decades (Eshetu *et al.*, 2014; Bayrau *et al.,* 2015). This is against a backdrop that climate change impacts are perceived, acknowledged and significantly felt by people, especially so in developing countries where many vulnerable groups and rural households have limited resources to cope with and adapt to climate change and its variability (Simpson, and Burpee, 2014).

Agriculture is the economic mainstay in most African countries, except in oil-exporting countries, contributing 20-30% of Africa's gross domestic product (GDP) and 55% of the total value of African exports, with 70% of the continent's population depending on the sector for their livelihood (Organization for Economic Cooperation and Development (OECD), 2009). In most African countries, crop production is mainly subsistence and rain-fed, but due to climate change frequent and untimely raining affects harvest of produce and thus, food production. This makes Africa particularly vulnerable to the impacts of climate change. The vulnerability of the region is further worsened by the fact that the climate is already too hot as it is tropical in nature.(IPCC, 2014;Mwakalila, 2014, and Keyyu, 2012,)

Ethiopian agriculture contributes more than 50% of the country's GDP, 85% to labor force and 90% to foreign exchange earnings. The sector also contributes to more than 90 percent of national export and serves as the main source of input to the industrial sector (Emerta, 2013). Ethiopia is no exception when it comes to climate change vulnerability. In Ethiopia, climate change is manifesting through recurrent drought, flooding, increase of mean annual temperature and changes in precipitation pattern (Lema *et al.,* 2014). Being dependent on rainfed agriculture, these conditions threaten the country's economy and food security. More than 95% of crop and/or livestock production which is rainfall dependent has been produced by small holders and subsistent farmers who have less capacity to adapt to climate change (FDRE, 2015). According to Emerta, 2013, Ethiopia has lost a cumulative level of over 13 percent of its agricultural output between 1991 and 2008 in relation to climate change.

Smallholder farmers in Ethiopia have vast adaptive capacities to the impacts of climate change and climate variability consequently influencing the social status among farming communities differently, FAO (2016). Most regions in Ethiopia have been seriously impacted by climate change and variability including Loka abaya woreda in Sidama Region, whereby there have been increased frequency of drought and floods, changes in the timing of rainfall, rain comes late than expected followed by terrible drought and famine (Abebe, 2017).

The study area is partly located in semi-arid region of Great Rift Valley which is prone to recurrent drought, erratic rainfall and flood disaster(Lokka Abaya Woreda Agriculture and Natural Resource Development Office, 2012).Any adverse impacts on crops, livestock and other livelihood activities was resulted repercussion on the local households 'livelihood security and economy and widen the gap between the rich and the poor. In this recent time smallholder farmers of the woreda have been adjusting their actions to climate variability and change as adapting strategies through diversifying livelihoods even though they may not describe their actions enough as public adaptation strategy. Different studies have been conducted in different regions of Ethiopia to assess climate change impact, perceptions, adaptations and adaptation strategies and adaptation barriers. However, the studies have concluded that different countries, and/area have different exposures to the risks of climate change.

Although there are many studies on the impacts of climate change in Ethiopia (e.g.,Deressa *et al.*, 2010;Hadgu *et al.*, 2015; Eshetu *et al.*, 2014), these studies overlooked the role of adaptation on agriculture, livelihood, and food security. It is also argued that adaptation and copying strategies by farmers varies in time and space and therefore local-level studies are important for implementing effective adaptation plans and policies (IPPC, 2014). Moreover, current research on social networks in Ethiopia focuses mainly on the effects of network size on technology adoption (Di Falco *et al.*, 2013; Wossen *et al.*, 2013) and there is no empirical study on which types of community inclusive matter the most, and how such types of rural community do networks matter for climate change adaptation. Similarly, the various studies on agricultural extension reforms in Ethiopia (legesse *et al.*, 2013), are subject to a range of problems including, methodological, scope and identification of indicators.

1.2. Statement of the Problem

The study area, Lokka Abaya woreda, is considered to be one of the areas most vulnerable to climate change and its effects on environmental degradation because of its geographic location and lowland agro ecology (Bewket *et al.*, 2015). These impacts on average temperature and precipitation have a baseline impact on the productive capacity of agricultural activity, altering the underlying yield expectations and risk regimes faced by farmers. Additionally, the study area faces recurrent, climate-related natural disasters; events such as floods, droughts, and dry winds have affected abundantly for the past two decades more than ever. These natural disasters have damaged agriculture and its production in ways that severely affected the farming activities, food security and areas economy as well (Woredas Agriculture and Natural Resource Development office, 2012).

This study tried to examine the climate change effect and smallholder farmers adaptation practices at the area, since climate and its bearing effects, best practices to the perceived impacts are affected by geo spatially and agroecolgy. There was a little study that highlights climate change with farming /livelihood activities (Abayneh, 2018; and Markos, 2017),they studied the climate change effects on crops and contribution of livelihood diversification to climate adaptation, at a shallow level, they did not comprehensively enquired the issues.

This study, therefore, identified stallholder farmers perception of climate change and factors affecting the choice of their adaptation practices, in Loka abaya woreda, Sidama, National Regional state.

1.3. Specific Objectives

1. To assess smallholder farmers perception on climate change in the study area;

2. To identify the climate change adaptation practices at farm plot level

3. To analyze factors affecting adoption of different adaptation strategies by small scale farmers.

1.4 Research Questions

1. How do you perceive the existence of climate change in your farming practices?

2. What were farm plot level climate change adaptation strategies practiced by the farmers?

3. What were the factors affecting different adaptation strategies of the farmers to climate change in the study area?

1.5 Significance of the Study

The outcome of this study is expected to be useful for local governmental and non-governmental institutions that are involved in process of supporting and protecting community under changing climatic condition and also will help flow of relevant information about the level of vulnerability of the community to climate change, and thus maintain/sustain household livelihood and/or food security. To bring more insights on adaptation strategies that are crucial to cope with climate change, this study also investigates key factors that govern farmers' decision to climate change adaptations, and thus policy makers will be better informed of the impacts of climate change as they are felt on the ground, the challenges and opportunities that people face in adjusting their livelihoods, and what further assistance should be provided. Furthermore, researchers may also benefit from the method employed and results obtained as a departing tool for further study. The outcome of the study is expected to be relevant to many areas of Sidama Region and other parts of the county with similar agro-ecology and socio-economic structures. Therefore, the study would have significant contribution for the local and national government, in an effort to minimize the impact of climate change and variability at local level through providing the necessary policy input. Based on qualitative and quantitative approaches, this study is expected to contribute to the current debate on the dynamic links between climate change adaptation practice, and rural household socio-economic relationships through detail analysis.

1.6 Scope and Limitation of the Study:

The study concentrates on identifying farmers'perception of climate change and factors affecting their choice of adaptation practices in Loka abaya woreda. The research is confined to only Loka abaya woreda, in Sidama Region. Thus the study can't represent other districts in the region. The study has certain limitations that emanate from limited financial resource, facilities and time. Limited area coverage in terms of locations selected for the study, because of time and budget constraint to conduct further research in other districts, hinder drawing conclusions at macro level in the area.

1.7 Organization of the Study

In this study chapter one comprise introduction, statement of the problem, significance of the study, specific objectives, scope and limitation, chapter two include literature review, under chapter three lists research methodology, chapter four elaborates results and discussion, and chapter five presents summary and conclusion .

CHAPTER TWO: LITERATURE REVIEW

2.1 Overview of Climate Change

Climate includes patterns of temperature, precipitation, humidity, wind and seasons. The term climate change affects more than just a change in weather; it refers to seasonal changes over a long period of time (www.ecy.wa.gov/climatechange/whatis.html). The United Nations Development Programme (UNDP) (2013) defines climate change as a scientifically proven phenomenon that includes any change in the climate, whether due to its natural variability or as a result of human activity. United Nations Framework Convention on Climate Change, (UNFCCC) (1992) defines climate change as change which is attributed directly or indirectly to human activities that alter the composition of the global atmosphere and which are in addition to natural climate variability observed over comparable time periods. Climate change is a normal part of earth's natural variability, which is related to interactions among the atmosphere, ocean, arid land, as well as changes in the amount of solar radiations reaching the earth (IPCC, 2007b).

The global climate is changing and this is a result of increased global warming mainly resulting from human activities. The last decade of the 20th century and the beginning of the 21st have been the warmest period in the entire global temperature record, starting from the mid–19th century (IPCC, 2007b). Scientists have done lots of research on the energy from the sun and have ruled that out as a main cause for climate change. Also, lots of natural cycles have been identified in the climate such as El Nino, but none can be attributed to cause the relative big, long – term changes being observed. There is overwhelming and growing evidence that the warming is due to increasing amounts of greenhouse gases

(GHGs) in the atmosphere, resulting from human activities – burning fossil fuels, changing land use pattern (www.metoffice.gov.uk/climate-climate/guide/what-is-it/why).

Climate change is a global concern because the changes associated with it have the potential to alter ways in which people live their lives globally. These global changes not only threaten to deprive humans of their lands but also to end lives of living beings that cannot adapt to the chaotic weather the world is experiencing (Anonymous, 2010). Though climate change is a natural phenomenon that has always been dynamic and that varies globally in space and time (Ribot 1996), current concerns have arisen because of recorded human industrial and development activities of the past centuries that have caused changes over and above natural variations (IPCC, 2013). The implications and characteristics of climate change show that it is a multi-dimensional problem whose causes and effects are challenges to recent development initiatives. These challenges being posed possess the capacity to increase the already existing poverty situations across many countries of the world, affect more people generally thereby increasing the vulnerability of the poorer countries, and groups.

Trend analysis of annual rainfall in Ethiopia shows that rainfall remained more or less constant when averaged over the whole country while a declining trend has been observed over the Northern and Southwestern Ethiopia (IPCC, 2007).

Awareness and a partial understanding of most of the interactive processes in the Earth system that govern climate and climate change predate the IPCC, often by many decades. . A deeper understanding and quantification of these processes and their incorporation in climate models have progressed rapidly since the IPCC First Assessment Report in 1990. As climate science and the Earth's climate have continued to evolve over recent decades, increasing evidence of anthropogenic influences on climate change has been found. Correspondingly, the IPCC has made increasingly more definitive statements about human impacts on climate. Debate has stimulated a wide variety of climate change research. The results of this research have refined but not significantly redirected the main scientific conclusions from the sequence of IPCC assessments.

The climate system is a complex, interactive system consisting of the atmosphere, land surface, snow and ice, oceans and other bodies of water, and living things. The atmospheric component of the climate system most obviously characterizes climate; climate is often defined as 'average weather'. Climate is usually described in terms of the mean and variability of temperature, precipitation and wind over a period of time, ranging from months to millions of years (the classical period is 30 years). The climate system evolves in time under the influence of its own internal dynamics and due to changes in external factors that affect climate (called 'forcings'). External forcings include natural phenomena such as volcanic eruptions and solar variations, as well as human-induced changes in atmospheric composition. Solar radiation powers the climate system. There are three fundamental ways to change the radiation balance of the Earth: 1) by changing the incoming solar radiation (e.g., by changes in Earth's orbit or in the Sun itself); 2) by changing the fraction of solar radiation that is reflected (called 'albedo'; e.g., by changes in cloud cover, atmospheric particles or vegetation); and 3) by altering the longwave radiation from Earth back towards space (e.g., by changing greenhouse gas concentrations). Climate, in turn, responds directly to such changes, as well as indirectly, through a variety of feedback mechanisms.

2.2 Causes and Impacts/Effects of Climate Change

Climate change could be referred to as increase in average global temperature Natural and human activities are believed to be responsible in contributing to an increase in average temperature. The cause of climate change is believed to be the unlimited burning of fossil fuels – coals, oil and natural gas – releasing CO2 in the atmosphere at an ever increasing rate (World Wild Life Global (WWF), 2013).

2.2.1 Natural Causes of Climate Change

In the natural causes of climate change, the earth's climate is influenced and changed through natural causes like volcanic eruptions, ocean current, earth's orbital changes and solar variations.

Volcanic eruption: when a volcano erupts, it throws out large volume of SO2, H2O vapour, dust and ash into the atmosphere (edugreen.teri.res.in/explore/climate/causes.htm.) Large volumes of gases and ashes possess the capacity to influence climatic patterns for years by increasing planetary reflectivity thereby causing atmospheric cooling.

The GHGs and CO2, are also produced, however, the CO2 in the cause of volcanic eruption is in significant when compared to emissions created by humans.

***Ocean current*:** the oceans are a major component of the climate system. They cover about 71% of the earth and absorb twice as much of the sun's radiations as the atmosphere or land surface (edugreen.teri.res.in/explore/climate/causes.htm). Ocean move vast amounts of heat across the planets: - deep ocean circulations of cold water from the poles towards the equator and movement of warm water from the equator towards the poles. Without this movement, the poles will be colder and the equator will be warmer; thereby resulting in imbalance in the earth's cooling system. The oceans play important role in determining the atmospheric concentration of CO_2. Changes in ocean circulation may affect the climate through the movement of CO_2 in and out of the atmosphere.

***Solar variations*:** the sun is the source of energy for the earth's climate system. Although the sun's energy output appears constant from an everyday point of view, small changes over an extended period can lead to climate change. However, current global warming cannot be explained by solar variations because if the global warming was being caused by a more active sun, then there would have been warmer temperature in all layers of the atmosphere. But observations reveal a cooling in the upper atmosphere, a warming at the surface and in the lower parts of the atmosphere,

2.2.2 Human Causes of Climate Change

On earth, human activities are changing the natural greenhouse effect. Human activities contribute to climate change by causing changes in earth's atmosphere in the amounts of GHGs and aerosols (small particles and cloudiness). The largest known contribution comes from the burning of fossil fuels which releases carbon (IV) oxide gas to the atmosphere (Solomon et al, 2007). Over the last century, the burning of fossil fuels like coal and oil has increased the concentration of CO_2; this happens because the coal and oil burning process combines carbon with oxygen in the air to make CO_2 (National Aeronautics and Space Administration (NASA), 2012). The industrial revolution of the 19th century saw the large-scale use of fossil fuels for industrial activities. Natural resources are being used extensively for construction, industries, transport and consumption. Also population has increased and still increasing to incredible extents.All these have contributed to a rise in GHG in the atmosphere (edugreen.teri.res.in/explore/climate/causes.htm.).

Other human activities that contribute to climate change include bush burning, cutting down of trees, use of generator, gas flaring from oil companies and burning of fossil fuels from vehicles, gases released from industries; excess use of chemicals and crude oil spillage (Egbule, 2010; Okoroh, 2011). Umunakwe (2011) found out that, respondents in Imo state perceived causes of climate change to included gas flaring, and natural phenomenon.

2.3 Influence of Climate Change in Ethiopia

The climate influences on Ethiopia have been described by different authors where they show that it is affected by global and regional synoptic systems, which prevail in different seasons of the year. Moreover they converge that during the main rainy season which provides enough amount of rain (more than 85 % of annual rainfall) for crop growing. It covers the period from June to September. The major rain producing components during this season are mainly seasonal migration of the Inter-Tropical Convergence Zone (ITCZ) and a complex local topography. It is dictated primarily by El Nino-Southern Oscillation (ENSO), and secondarily reinforced by more local climate indicators near Africa and the Atlantic and Indian Oceans. On the other hand, development and persistence of the Arabian and Sudan thermal lows along 20˚N latitude; development of the deepening and persistence of the Indian subcontinent's depressions and the associated monsoon trough, and development of tropical easterly jet (TEJ) and its persistence are weather producing system that influence the main rainy season (NMA, 2007; Boko *et al.,* 2007, Dawit, 2010 and Gebremichael *et al.*, 2014).

Impacts of Climate Change on Agriculture

Climate change continues to impact on agriculture, fisheries and the natural environment but agriculture itself also contributes to climate change. Farming systems, whether mixed crop-livestock systems or crop and pastoral farming systems are characterized by the way resources are used, land, crops and livestock managed and their interaction with the local and international economy, Egziabher *et al.*(2013). It brings with it changes in weather pattern that can have serious repercussions on all living things, upsetting seasonal cycles, harming ecosystems and affecting agriculture and food production.

Agriculture is highly sensitive to climate variability and weather extremes, such as droughts, floods and severe storms. While food production may benefit from a warmer climate, the increased potential for droughts, floods and heat waves will pose challenges for farmers, thereby affecting their farming activities. These perceived negative effects on farming activities are already obvious and have been reported in some parts of south east Nigeria (Umunakwe, 2011). Okoroh (2011) also reported that the impacts/effects of climate change on agriculture are observed as decrease in crop yield. Additionally, the enduring changes in climate, water supply and soil moisture could make it less feasible to continue crop production in certain regions (United Nations Environmental Protection Agency (UNEPA), 2012). According to IPCC (2007b) recent studies indicate that increased frequency of heat stress, droughts and floods negatively affect crop yields and livestock beyond the impacts of mean climate change, creating the possibility for surprises, with impacts that are larger, and occurring earlier, than predicted using changes in mean variables alone. This is especially the case for subsistence sectors at low latitudes.

According to CTA (2008) the principal impacts of climate change on cropping systems which has direct effect on food production include:

a .reduced production due to changing rainfall pattern;

b. Emerging diseases, pests and vectors;

c. Spatial redistribution of pests; and

d. Erratic rainfall patterns etc.

Analysis of the impacts of climate change suggests that agro-ecological systems are the most vulnerable sectors (www.gcrio.org). Agriculture in low latitude developing countries is expected to be especially vulnerable because climates of many of these countries are already too hot. Further warming is consequently expected to reduce crop productivity adversely. These effects are exacerbated by the fact that agriculture and agro-ecological systems are especially prominent in the economies of African countries and the systems tend to be less capital and technology intensive (Boko *et al.*, 2007). Apart from the effects on cropping pattern, climate change brings with it proliferation of pests and diseases; these can hinder storage when the need arises because of temperature increases. Diseases tend to spread to areas where they were previously unable to thrive. A good example is the spread of tsetse fly to the drier regions of northern Nigeria from the southern part. This assertion is also corroborated by Egbule (2010) and Okoroh (2011) that the impacts of climate change lead to preponderance of pests and disease outbreaks in animals, as well as, on stored farm produce. This change also affect the agro-pastoral system as animals have to trek very long distances in search of green grass (Otitoju, 2013). These movements of the animals also contribute to spread of disease causing organisms and leads to conflict on available resources. The impacts of climate change is not limited to cropping and agro-pastoralism, it is being felt on fisheries and aquaculture. There is need to focus on the impact on fisheries ecosystems and the food and nutritional security and livelihoods of fish dependent communities. In African, Caribbean and Pacific (ACP) countries, fishing communities are impoverished and ill-prepared to adapt to the negative impacts of climate change.

According to CTA (2008) the main impacts of climate change on fisheries and aquaculture include:

i. Disturbances in fish fertility;

ii. Increased mortality among young fish due to rising water temperatures, particularly in lagoons and rivers;

iii. Effects of strong salinity in these surroundings exacerbated by the penetration of sea water that seriously affects fishery resources and already fragile ecologies; and

IV. Frequent fish migration into deep water (CTA, 2008).

Ethiopian agriculture is heavily dependent on natural rainfall, with irrigation agriculture accounting for less than 1% of the country's total cultivated land. Thus, the amount and temporal distribution of rainfall and other climatic factors during the growing season are critical to crop yields and can induce food shortages and famine (CSA, 2008). Like many other developing countries, agriculture (with the largest number of livestock in Africa) is the single largest livelihood of an overwhelming majority in Ethiopia, 85% of the population (ibid). During drought and delay in the onset of rain land becomes dry and difficult to plough, forage deficit leads to weakness and oxen mortality (engine of subsistent cultivation), and lack of precipitation hinders seed cultivation and germination of cultivated seeds. Evenweeks delay in the onset of rain was found to have significant difference on the harvest and has deprivation of households' livelihood (Abate, 2009).

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

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

2.4 Adaptation Measures

Agricultural adaptation options can be classified into four main categories: (1) technological developments, (2) government programs and insurance, (3) smallholder farming system and (4) farm financial management (Bassett, and Fogelman, 2013). While the first two categories are principally the responsibility of public agencies as they require changes at macro-scale, the third and fourth category mainly involve farm-level decision-making by smallholder farmers. However, there are interdependencies between all of the groups that have to be considered if the adaptation context is to be understood.

This study focuses on farming system, since it is mainly smallholder farmers' decision-making that shapes this dimension. Measures include changes in farm operational practices and can be grouped into the classes farm production, land use, land topography, irrigation, and timing of operations (Agrawal, 2010). Changes of farm production reduce sensitivity to climate-related risks and increase the flexibility of the farm to climate variability (Bryan *et al.*, 2013). It includes the diversification of crop and livestock types and varieties, as well as intensification through application of fertilizer and agro-chemicals (Boko *et al.*, 2007). Changes of land use practices include changes in the location of crop and livestock production, as well as croprotation, mixed-cropping and alternative fallow and tillage practices (e.g. conservation tillage) (Cifdaloz *et al.*,2010). Land topography changes include land contouring and terracing, as well as the construction of water storage facilities (dams, reservoirs, ponds). Changes of water management practices include the introduction or the enhancement of irrigation systems, such as piped irrigation, sprinkler irrigation or drip irrigation and of water harvesting systems (run-off catchment facilities on the roof, pipes, tanks). Changing the timing of farm operations includes changes of planting, spraying or harvesting dates to take advantage of the changing duration of the growing season (Di-Falco *et al.*,2011a). In adaptation literature, early and late planting are the most mentioned strategies in this group. Most of the adaptation measures aim at improving soil moisture and nutrient retention by reducing water run-off, evaporation rates and increasing water up-take (Braatz, 2012). In more general terms these adaptation measures include manly responses, that reduce vulnerability to climatic stresses, such as drought events and climate variability

(Adger, 2006). In the following paragraphs adaptation measures are discussed in more detail:

Change crop variety: Using stress-tolerant varieties can improve yields and agricultural productivity in light of drought (Smith, 2009). In particular in the maize seed sector farmers have the choice between different drought-resistant or early-maturing varieties (Monica, 2013). Regarding vegetables fewer stress-tolerant varieties are available, making water availability and access to agro-chemicals a precondition for the cultivation. Although the production of certified seed has increased in study area over the past decade the use has remained low due to poor distribution systems and high prices. Furthermore, the lack of control mechanisms promotes misuse in the seed market and furt\her exacerbates access to good quality seeds.

Fertilizer usage and application of animal manure: Appropriate application of mineral fertilizer and animal manure can increase yields and improve soil fertility (Gornall *et al.*, 2010). High input costs and unclear labeling lead to fewer application of artificial fertilizer among smallholder farmers. Moreover, decisions on purchasing fertilizers are made before planting, that is at a time of year when farmers have already sold their harvest from the previous season and risky investments are avoided (CTA, 2008).

Livestock adaptation practices: Switching to animals that are more tolerant to drought or diseases can improve productivity and drought resilience of livestock production (Thornton *et al.*, 2015). Especially local breeds are already adapted to harsh climate conditions (Megersa *et al.*, 2014). Furthermore, small species such as chicken with less water requirement can increase adaptive capacity. Livestock feed management can be improved by storing animal feeds, e.g. as desho grass, which has positive side effects on soil erosion (Thornton *et al.,* 2015). Rotating production between crops and livestock can reduce soil erosion and improve soil moisture and nutrient content (Smit and Skinner, 2002).

Mixed cropping, inter-cropping and crop rotation: Planting of two or more crops simultaneously in the same field can increase soil biodiversity and fertility, help to conserve water and increases returns per hectare (Niang *et al.,* 2014). Spreading the risk on different crops on one plot is a typical trait of smallholder farming systems and has been practiced for a long time (Otitoju, 2013)). Inter-cropping describes the same as mixed-cropping, the only difference being that crops are planted in a geometric pattern, e.g. in rows (Egziabher *et al.*, 2013). Maize planted in interchanging rows with other crops can serve as a windshield. Not only spatial but also temporal distribution of crops can be applied to improve soil fertility and adapt the cropping pattern optimally to different conditions during the year. Crop rotation describes planting crops sequentially in the course of the year, thereby enhancing soil fertility and reducing sensitivity to pests and diseases (Thierfelder and Wall 2015).

Agroforestry: Interplanting of woody species among or in proximity to the main crops delivers multiple benefits to farmers including food provision, supplementary income and environmental services (Imbach *et al.,* 2017). Fruit, fodder and fuel wood production can be increased, while runoff or erosion are decreased and soil fertility is enhanced. Trees provide shade, shelter and protection from wind (Nadi, 2014). Furthermore, carbon dioxide is deprived from the atmosphere, making this measure particularly interesting for mitigation purposes. However, benefits differ strongly depending on planted species.

Conservation tillage: Conservation farming practices lead to improved on-farm water productivity and increased yields (Nater, 2010). Most important methods in this group are minimum-, zero-tillage and mulch-tillage. The soil is only opened where the seeds are placed, with as little disturbance as possible to avoid transpiration losses through soil cracks (Singh, 2017).

In-field water conservation: Building terraces and bunds or changing the slope of the field can slow the speed of water and increase thus infiltration close to the crops' roots to improve soil water holding capacity (Thomas *et al.,* 2007; Shackleton *et al.,* 2015).

Water harvesting and storage: Water harvesting structures includes a number of topographical measures that are used for collecting rainwater from a surface area (Bernier et al., 2015). With structures like ridges, bunds and dams rainwater is diverted, stored and used for irrigation at a later point in time (Lema *et al.,* 2014).Harvested water can be used for supplemental irrigation during dryspells to increase yield stability or for planting off-season cash crops to increase household income (Boko *et al.,* 2007). However, high investment costs and knowledge requirements restrict widespread up-take by smallholder farmers in SSA.

Irrigation: This type of adaptation improves farm productivity, enables diversification of production (e.g. to horticultural products) by increasing moisture retention in the soil and increasing water availability (Giller *et al.,* 2016). Limited access to water, low rain-fall efficiency and limited access to technologies and institutional support prevent widespread application of irrigation (Deressa *et al.,* 2009).

Changing planting dates: This measure has the potential to maximize farm productivity during the growing season and reduce heat stress and moisture deficiencies (Asrat and Simane (2017a). Late planting minimizes the risk of being surprised by a late onset of the rains. Early planting is practiced in order to enable replanting in case the crops do not germinate. The decision to change planting dates is based on the farmers' observations of the rainy season during the past few years and is particularly relevant for rain fed agriculture.

2.5 Empirical Studies on Climate Change

Previous studies on climate change in Ethiopia have focused on measuring the impact of climate change on agriculture (see Hailemariam, 1999; Deressa, 2007). These studies have analysed the monetary impacts of climate change using Ricardian and agronomic models and suggested some adaptation measures mainly water harvesting and irrigation. However, the studies are limited in terms of offering insights into adaptation strategies at micro or farm household level due to their aggregate nature (Falco *et al.*, 2011). The number of studies that investigated perceptions and local adaptation strategies are limited (Gebrehiwot & Veen, 2013; Kassie *et al.*, 2013; Legesse, Ayele, & Bewket, 2013).

Another study by Deressa *et al.* (2011) looked into the perceptions of adaptation to climate change using the Heckman selection model on a sample of 1,000 households in five regions in Ethiopia. They find that farmers" perceptions are related to age, wealth, and information on climate change, social capital and agro ecological settings.

Gebrehiwot and Venn (2013) studied farm level adaptations to climate change in Tigray region, northern Ethiopia. Using a multinomial logit model and data from 400 smallholder farmers, they find similar factors influencing farmers‟ perceptions as reported in Deressa *et al* (2011).

Legesse *et al.* (2013) using a survey of 160 households from Doba district in Eastern Ethiopia, examined farmers‟ perceptions and applied a multinomial logit model (MNL) to identify factors influencing adaptation strategies of farmers to climate variability and change. They find crop diversification, soil and water conservation practices, integrated crop and livestock diversification, off-farm income activities and rainwater harvesting as the dominant adaptation strategies.

2.6 Conceptual Framework

This study is aimed at exploring adaptation practices to climate change of smallholder rural households. Communities and households face climate related stresses such as increased surface temperature, changes in the timing and amount of rainfall, hail storms, floods, droughts, wind instability etc (IPCC, 2007). Thus, the lives and livelihood assets of the rural community are under such threats and their associated consequences. The institutions and processes operating from the household to national level determine an individuals' household' s or communities' access to assets, livelihood options, and thereby affect the vulnerability to climate change impacts. As reported by different researchers, Deresa *et al*. (2008), Yesuf *et al*. (2008), there are many climate change adaptation livelihood strategies, including changes in crop variety and planting dates, crop diversification, irrigation development, water harvesting, tree planting, herd splitting, herd mobility, cattle breeding, migration, etc.

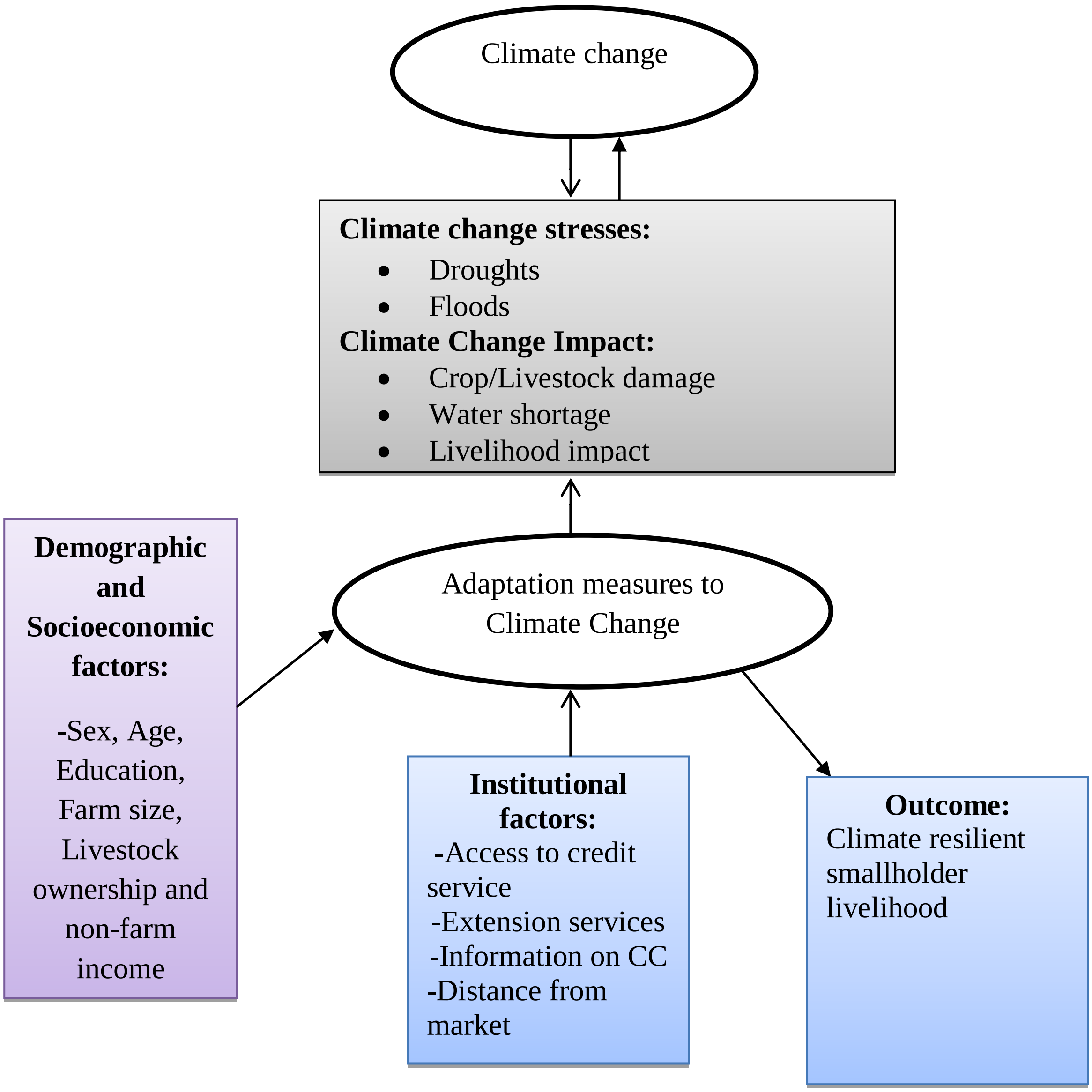

Figure 1 Conceptual frame work of the study

Source: Sketched by author (2020)

CHAPTER THREE: RESEARCH METHODOLOGY

3.1 Description of the Study Area

The study was conducted in the semi-arid area in Lokka Abaya Woreda,Sidama National Regional State, Ethiopia. The area is located East of Lake Abaya at 6^{o} 40′05”-- 6 ^{o} 54′06”N and 38 ^{o}00′13”--38^{o} 15′00”E and the total area of the District is about 1,190 km^{2} and its altitude ranges from 1500-1768 meter above sea level (m.a.s.l) (Bewket et al., 2015). The major part of the District is characterized by semi-arid which constitutes fifteen kebeles along with a few sub-humid areas which includes about ten kebeles. Based on the Censesus conducted by the CSA (2007) this District has a total population of 124,771 of which 63,050 are men and 61,661 women; 1.07% of its population are urban dwellers.

3.1.1 Climate

The agro-ecology of Lokka Abaya District can be considered as low lands and sub-humid. It is characterized by a warmer climate following the traditional classification of agro-ecological zones in Ethiopia. The region is characterized by hot and warm condition and experienced recurrent drought in recent years (Bewket*et al.*,2015). The rainfall pattern of the area is bi-modal type in which the short rainy season is from March to April, while the main rainy season is from June to September. However, the rainfall season could extended from March to September. The annual minimum and maximum temperature of the area is 17 and 20 ^{0}C, respectively and the annual rain fall is about 900- 1400mm (Bewket*et al.,* 2015). High temperature during dry seasons and erratic rainfall and moisture stress are the common climatic problems in the study area.

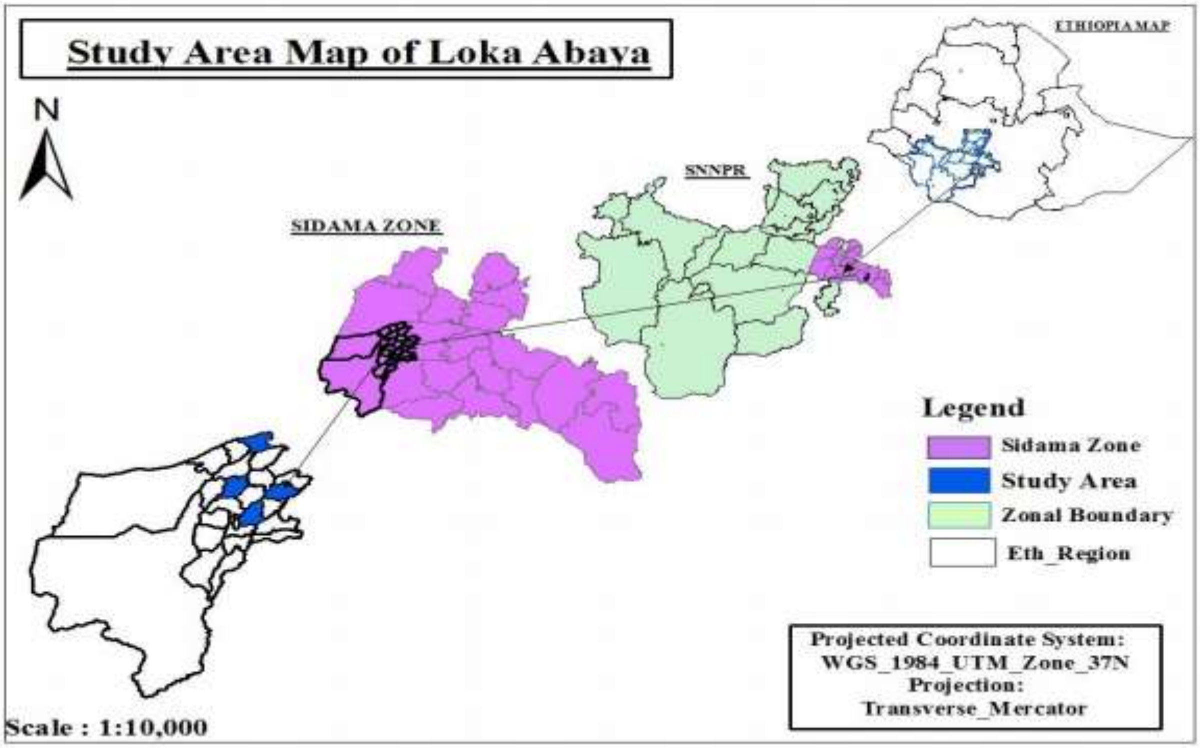

Figure: 2 map of the study area

Source: **CSA, 2019**

3.1.2 Topography

The topography of the district is rugged surface cross-cut by various gorges that flow west wards. Due to its physiographic setting, it has steep slopes, rivers like Bilate, valley and protected area like Lokka Abaya National Park with its diverse fauna and flora and Fluvial deposits soils are dominant features of the study area Lokka Abaya woreda Agriculture and Natural Resource Development Office (2012)

3.1.3 Agriculture

From the total area of the district cultivated land is 20.2% while 42.6% is under forest (Bewket *et al.*, 2015). Agriculture is the main source of livelihood and major crops grown in the district includes: perennial crops (mainly coffee and enset), cereals (maize,) legumes (haricot bean) and root crops (sweet potato). The farmers in this woreda also practice mixed farming system which includes growing of different cash crops and raring livestock. The major agriculture and food security related challenges of the district includes degradation of natural resources, frequent droughts, severe flooding and increasing population (Bewket *et al.*, 2015).

3.1.4 Livelihoods

The livelihood system of the local communities in the study area is mainly mixed farming. The farmers in this district practice mixed farming which is found to the east (towards Dale District) growing cash crops like coffee, inset, root crops like sweat potatoes and other crops with livestock. Other livelihood practices of the communities include harvesting of natural resources such as, firewood collection, charcoal production, honey collection and harvesting building materials.

3.2 Research Design

The study employed a cross-sectional survey research design as its framework to guide the process of data collection. Cross-sectional survey research design was used to collect the data mainly using questionnaires or structured interviews to capture quantitative or qualitative data at a single point in time.

3.3 Data type and Source

The study used both qualitative and quantitative data for this study. A quantitative data type was obtained from sample household interviews that can be measured and quantified. Qualitative data focused on the expressions and feelings of smallholder farmers, key informants, and focus group discussion participants. The study used both primary and secondary data sources. The primary data was generated from sample household survey, focus group discussions members and from key informants. Whereas, secondary data was obtained from environmental and agricultural office, published and unpublished sources.

3.4 Sampling Procedure and Sample Size Determination

The study followed a multi-stage sampling procedure where combinations of purposive and simple random sampling (probability and non-probability method) were employed. Firstly, Lokka Abaya woreda was selected purposively because the area frequently susceptible to climate related problems. In the second stage, out of 25 kebeles in the woreda from these, 4 kebeles were selected by simple random technique. These were Bartu, Danshe-Gambela, Argeda and Harodimtu. In the sample kebeles, there were a total of 2,664 households then, a simplified formula provided by Yamane (1967) was used to determine the required sample size (148 sample households) at 95% confidence level, with 0.08 level of precision. In order to select the required individual sample household systematic random sampling technique was used based on list of households obtained from kebele adminstrations.

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

Where; n is sample size of population

N is total households of selected kebeles

e is precision level

$$n = \frac{N}{1+N(e)^2} = \quad n = \frac{2664}{1+2664(0.08)^2} = 148$$

Table: 1 Sample size distribution in the sample Kebeles

Study Kebeles	Total Households (Population)	Sample Households.*
Bartu	669	31
Danshe-Gambela	695	37
Argeda	703	52
Harodimtu.	597	28
Total	**2,664**	**148**

NB:* Individual sample unit sampled by systematic random sampling technique.

Source: Computed before main survey(2020)

3.5 Methods of Data Collection

To obtain the information from sample households, semi-structured questionnaires (interview schedule) was employed and the farmers were interviewed on related issues about the contribution of smallholder farming systems in building climate change resilience through adaptation based on their farming practices over two decades. The method of data collection includes Household Surveys, Focus Group Discussions (FGDs), and Key Informant Interview (KII) and, checklists for FGDs and KII were developed and used. Likewise, a semi-structured questionnaire was pre-tested on non-sample kebeles before main interview.

3.5.1. Household Survey

A 148 household survey was the main source to collect the information required of the study. Interviews was employed to generate household level data on socio-economic characteristics of household (like age, sex, land size, extension contact, education level of household heads, non-farm income, households use of credit, and other relevant information) households‟ farming activities, strategies and incomes, effects of climate change over the past three decades and farmers adoption of improved farming technology to tackle climate change. The interview schedule waspre-tested from 20 non-sampled kebeles having similar/matched characteristics to the sampled household.

3.5.2. Key Informant Interviews (KII)

These were those who have the knowledge about the issues regarding the objectives of study. A total of eleven key informants, interviews were conducted in all study kebeles which includes DAs, kebele administers, district agricultural and environment office expert. They were interviewed to generate information about the, climate change effects, and adaptation practices. Accordingly, 4 development agents, 4 kebeles administer and 3 woreda Agriculture and environment protection office experts were involved during the interview process.

3.5.3. Focus group discussions (FGDs)

A total of nine FGDs were conducted; one focus group discussion in each kebele having different sex, age groups and farming experiences in each group. Only five household heads were selected mainly because of time management and expectation of lack of interest from the participants to spend more times on discussion. The discussion was aimed to dig out information on climate change, effect of climate change on crop, livestock, water resources, adaptation practices.

3.6 Methods of Data Analysis

In this study, descriptive statistics and Econometric model like multinomial logit model was used. For the descriptive part of the result such as, tables, percentages, frequency, were used to analyze farmer's perception to climate change, and adaptation practices to climate change. To analyze the factors affecting adaptation measures used in response to climate change multinomial logit model was used. Excel sheets, Statistical Packages for Social Scientists (SPSS) version 20.0 and STATA version 14.2 were used for raw data entry and analysis of the data.

3.6.1. Likert-Type Rating Scale Technique

This technique was used to compliment and further explain objective (ii). To actually know that an adaptation practices is used by the farmers to adapt with climate change, this 3- point likert-type rating technique was developed to know the level of intensification of each strategy. The 3-point likert-type rating scale was graded as Very High Intensification (VHI) = 3, High Intensification (HI) = 2, and Low Intensification (LI) = 1. The mean score of respondents based on the 3-point likert-type rating scale was computed;

$\frac{3+2+1}{3} = \frac{6}{3}$=**2.00** cut off point

3.6.2 Econometric Model Specification

In this study, to analyze factors affecting adoption of different adaptation practices by small holder farmers, a multinomial logit (MNL) model was used. The MNL model was used based on the previous literature on determinants of farmers' adaptation measures to climate change (Abdi*et al,* 2015; Deressa*et al.*, 2009;Kurukulasuriya and Mendelsohn, 2008). 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 (Dasgupta, 2014), 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 (Deressa *et al.*, 2011). 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.

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

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 was conducted 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

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

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 $\frac{\partial pi}{\partial xk} = pj(\beta jk - \sum_{i=1}^{j=1} pj\beta jk)$ ………… (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-colinearity problem between explanatory variables of the study will be tested by using Variance Inflation factor (VIF) 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.

3.7 Definition and Justification of Model variables

Dependent variable

The dependent variable of this study is farmers' choice of adaptation measure in response to climate change.

Independent variables

Independent variables are variables that determine whether a household recognizes climate change and take some mechanism used to adapt the impact of climate change. Based on the clue of findings of past studies on climate change adaptation strategies, the following variables were hypothesized to determine farmers' choice of adaptation practices to climate change.

Age of the household head (Age): Age of household is continuous variable and it was categorized as age group from 25-40, 41-55 and above 56 years. This indicates the age of the household head in years and can be used to capture farming experience. Adaptation to climate change is developed from experience accumulated over time (Gbetibouo, 2009). Moreover, Deressa *et al*. (2009) and Tesso*et al*. (2012) also indicated that age of the household has a positive and significant effect on adopting climate change adaptation options. Experienced farmers are more likely to use one or more climate change adaptation strategies (Maddison, 2006). Thus, in this study, age was expected to affect climate change adaptation options positively.

Sex of the household head (SEX): It is a dummy variable which indicate 1 if male household head and 0 otherwise. It has been argued that male-headed households in Ethiopia have access to information, agricultural inputs, institutions and other attributes. Accordingly, they have a significant and positive influence on adoption of climate change adaptation strategies (Deressa*et al*., 2009; Legesse *et al*., 2013). In contrast, Nhemachena and Hassan (2007) noted that female-headed households are more likely to adopt climate change adaptation methods. The authors argued that most agricultural operation in Africa is performed by female farmers that might give the opportunity to perceive the impact of climate change. This study followed the former argument which indicated that male headed households were more likely to use adaptation methods as they have more access to resources and information. The expected sign for this variable would be indeterminate.

Level of education of the household head (EDUN): Education as a continuous variable measured in years of formal schooling of the household head. Education was categorized as 1= if no formal educ, 2=primary (1-8th grade), 3=secondary (9-12 grade), and 4= tertiary (degree, diploma, certificate).The number of years of schooling achieved by the household head is used as a proxy for managerial input. Education plays an important role in the adoption of innovations/new technologies. Maddison (2006) argued that education diminishes the probability that no adaptation is taken. Therefore, in this study, education level of the household head was hypothesized to be positively influencing farmers' decisions to adapt to climate change.

Family size (FMS): Family size is measured by the number of members in a household. This variable was categorized as1if it lies in 1-4, 2=5-7, 3=8-10 and 4=>11. It is assumed to represent the labor input to the farm. Mano and Nhemachena (2006) contended that large household size is mostly inclined to divert part of its labor force into non farming activities, Hassan and Nhemachena (2008) challenged this view arguing that the opportunity cost might be too low in most small holder farming systems as off farm opportunities are difficult to find in most cases. On the other hand Gbetibouo (2009) reported that household size enhances the farmers' adaptive capacity to respond to climate change. In this study therefore, family size was assumed to affect adaptation practices positively or negatively.

Access to credit service (credit): The availability of credit is vital for the farmers' to adopt new agricultural technology and to diversify income sources. Credit can be used to narrow financial constraints for the farmers to introduce improved farm technology, to buy fertilizers and fulfill necessary inputs. It is a dummy variable which indicates 1 for farmers who have access to credit 0 otherwise. Therefore, it will be hypothesized to influence farmers' adaptation measure to climate changes positively.

Extension service (EXSR): The provision of agricultural extension service and agriculturally relevant climate information enhances farmers' awareness of climate change and knowledge on adaptation measures. Research findings in Ethiopia also showed that access to extension have a positive and significant effect on adaptation to climate change (Deressa *et al*., 2009; Tesso *et al*., 2012; Legesse *et al*., 2013; Tessema *et al*., 2013). This variable is a dummy variable which represent 1 for farmers' get agricultural extension service and 0 otherwise. Therefore, extension contact was hypothesized to influence farmers' adaptation to climate changes negatively/positively.

Farm size (FRMSZ): - Farm size is the total landholding of the farm household that uses for the farming activities and it is measured in terms of hectare. The variable was categorized 1 if the households had <0.5 ha: 2, 3 and 4 for, 0.6-1 ha, 1-2ha and >2ha, respectively. The farm household with holding big farm land has more opportunity to use farm technology. Therefore, it is continuous variable and was expected a positive sign for the farmers' who owned sufficient land and thus would use adaptation choice to climate change in comparison with farmers who have less farm size.

Livestock ownership (TLU): - It is the total number of livestock holding of the farmer and it is continuous variable measured in tropical livestock unit (TLU). Livestock plays a very important role by serving as a store of value, source of traction (especially oxen) and provision of manure required for soil fertility, maintenance and for transporting products. Livestock is generally considered to be an asset that could be used either in the production process or be exchanged for cash or other productive assets. Deressa*et al*. (2009) and Taddesse (2011) also showed positive influence of livestock ownership on adoption of climate change adaptation options. Therefore, it was hypothesized that the livestock holdings of the household to affect climate change adaptation options positively.

Access to climate information (ACCINF): Availing accurate information on climate change is vital to determine use of adaptation practices. The presence of well-functioning weather stations and proper processing of weather data and dissemination of weather forecasts as well as acceptance of the information by users is assumed to influence adaptation efforts to climate change (Kassie *et al.*, 2013). This is dummy variable indicating 1 if the household head had access to climate change 0 other wise. This variable was also expected it would affect farmers' use of adaptation strategies to climate change positively.

Non-farm income: This is income derived from activities that are not associated with farming and it is a dummy variable that indicates whether the farmer earns income from non-farm activities or not. This variable takes a value of 1 if the woman household involves in non-farm activities or 0, otherwise. Expected sign is positive. Responses to climate change through adaptation require sufficient financial well-being (Deressa *et al.,* 2009), he notes that the higher income for the farmers the less risk-averse. The effect is to boost the farmers' financial resources and hence their ability to adapt climate change options.

Distance to nearest market: This is a continuous variable and the closer the market, the lesser would be the transportation charges, reduced walking time, and reduced other marketing costs, better access to market information and facilities. In this study distance to the nearest market is hypothesized to affect farmers' decision on climate change adaptation options negatively. Also, those households who are close to the market were assumed to have more probability to choose better market outlets and diversify their farming system. As farm households are nearer to market places, it is expected to be more likely participating in intensive farming activities that demands to adapt climate change and climatic information (Deressa *et al.,* 2011). Therefore in this study, it was expected that as a given farm household gets far away from such centers the livelihood of adapting climate change adaptation options is decrease.

Table 2:- Hypothesis of explanatory variables

Name of Variables	Variable definition	Measurement	Nature	Expected sign
HHAGE	Age of a household head, continuous variable	Year	Continuous	+ve
HHSEX	Sex of household head(1=male, and 0=female)	Year	Dummy	±ve
EDHH	Education of the household head(1=read ,and write,0=Does not read and write)	Year	Continuous	+ve
FASZ	Family size	Number	Categorical	±ve
CRED	Access to credit(1=use of credit ,and 0=No use of credit)	Number	Dummy	+ve
EXSVS	Extension service (1= get extension, and 0=do not get extension)	Number	Dummy	+ve
FASZE	Farm size	Hectare	Continuous	+ve
LIVOWN	Livestock ownership	Tropical Livestock Unit(TLU)	Continuous	+ve
NNFI	Non-farm income	Number	Continuous	+ve
DIS NMKT	Distance to nearest market	Kilometer	Continuous	- ve
ICC	Information on climate change (1= if households had climate change information , and otherwise 0)	Dummy	Dummy	+ve

CHAPTER FOURE: RESULT AND DISCUSSION

4.1 Socio-Demographic Characteristics of Sample Households

Socio-economic characteristics of the respondents are very important to determine the impact of climate change on agriculture, thus, important variables those may influence the perceptions of the respondents and are directly associated with impact of climate change are considered in this section. Selected variables are sequentially arranged and presented under following subheads:

Age, sex, education and family size: The maximum age of respondents was 78 years while the minimum was 25 years with an average age of 54 years. There were more male (91.8%) respondents than female (8.2%), majority of 44.5% of respondents had the education level of primary school. Also, the maximum HH size was 12 members, while the minimum size was 2 members, but majority of HH have the average size of 7 members (Table3).

Land holding: The number of standard acres/hectares of land owned and cultivated by each respondent family was considered in determination of their size of land holding. The economic and social position of respondents in the society depends upon the size and fertility of the land in his/her possession. The data in Table 1clearly indicates that 47.9 percent of the respondents were possessing less than 0.6 to 1ha of land and belonged to large farmers category, while, 23.9 and 22.9 percent of the respondents belonged to medium farmers (less than 0.5 ha, and 1-2ha). Only 5.4 percent of the respondents were having more than 2 ha (small farmers) of land.

Access to Credit

Acquisition of credit is main practice of the respondents to recuperate from adverse circumstances due to uneven climatic conditions. Access to affordable credit increases their ability and flexibility to change production strategies in response to the forecasted climate conditions. Availability of credit eases the cash constraints and allows them to buy inputs such as fertilizer, improved crop varieties, and irrigation facilities. Easily access to credit helps the farmers to purchase the required inputs that may influence the extent of adoption of the farmers and adaptation towards adverse effect of climate change.

The credit acquisition patterns of the respondents (Table 3) reveal that majority of the respondents (57.4%) had acquired credit, the rest had not. Access to credit is an important pre-condition to take up adaptation measures to perceived effects of climate change.

Contact with extension personnel

With regards to contact of respondents with extension personnel, compiled results are given in Table 3. Majority (73.6%) of the sample respondents had a contact with extension personnel, whereas, 26.4% of sample respondents had no contact with extension personnel. Through dealing with extension personnel farmers can get information regarding improved agriculture technologies and weather forecast. Weather related information may help them in changing their farm operations according to climatic conditions.

Distance to market

Market is the place where buying of agriculture inputs and selling of agriculture produces are taken place among large number of buyers and sellers. Distance to market is taken as variable in accordance with availability of agriculture inputs. Distance to market is directly correlated with availability of agriculture inputs, lesser the distance means easier they get.

Table 3 shows the distribution of respondents according to their distance to market for seasonal farm inputs. It can be observed that 78.3 percent of the respondents were getting farm inputs from the market within near distance whereas 21.7 per cent of them were getting inputs within the far away.

Table3. Frequency distribution of sample respondents by their socio-economic characteristics in Loka Abaya woreda

Variable	**Full sample (N=148)**	
Age (years)	**Frequency**	**Percentage**
25-40	58	39.1
41-55	74	50
>56	16	4.05
Total	**148(Mean=54 years)**	**100**
Sex		
Male	136	91.8
Female	12	8.2
Total	148	100
Level of Education		
No formal education	9	6.08
Primary	66	44.5
Secondary	59	39.8
Tertiary	15	12.7
Total	**148 (Mean=8)**	100
Household size	**Mean=7**	
1-4	39	26.3
5-7	70	47.2
8-10	36	24.3
>11	3	2.02
Total	148	100
Farm size	**Mean=0.93**	
<0.5 ha	35	23.6
0.6-1 ha	71	47.9
1-2ha	34	22.9
>2ha	8	5.40
Total	148	100

Table3. Frequency distribution of sample respondents by their socio-economic characteristics in Loka Abaya woreda

Variable	**Full sample (N=148)**	
Livestock ownership by TLU	**Mean=5.64**	
<3	44	29.7
3-5	52	35.1
5-10	40	27.02
>10	12	8.1
Total	148	100
Non- farm income		
Yes	60	40.5
No	88	59.5
Total	148	100
Access to credit		
Yes	88	59.4
No	60	40.6
Total	**148**	**100**
Extension contact		
Yes	109	73.6
No	39	26.4
Total	148	100
Climate change information		
Yes	126	85.1
No	22	14.9
Total	148	100
Distance from market		
Near(below 1km)	116	78.3
Far(above 1km)	32	21.7
Total	148	100

Source: Household survey result (2021)

4.2 Trends of Rainfall and Temperature

4. 2. 1 Farmers Perceptions to Climate Change and Variabilities

As the understanding on global climate and its change is prerequisite to take appropriate initiatives to combat climate Change. It can be observed (Table 4) that majority of the farmers (97.5%) were fully aware that temperature is getting warmer due to climate change, whereas, 85.7, 77.25, 70.4, 66.2 and 63.42 percent of the farmers were fully aware about rainfall has decreased, occurrence of drought, rainfall starting latter, unpredictable rainfall, and risk of crop and livestock disease has increased, respectively. While, somewhat awareness belonged to about 48.3, 45.3, 31.5, 26.8, and 18.2 per cent of the respondents for the phenomena viz. duration of seasons is changing, rainfall starting earlier, planting date change, unpredictable rainfall and increase in recurrence of floods, respectively. With regards to overall awareness for each phenomena, respondents were more aware about temperature is getting warmer (98.75%), rainfall has decreased (90.2%) and occurrence of drought (88.125%) with the rank of I, II and III, respectively.

In the FGDs, selected farmers were asked to reflect on what indicators they have been using to perceive change in climate. Their responses revealed loss of livestock and plant species, increased temperature and respondents says decreasing in rain fall and spread of crop and animal disease, shortening of growing period, early cessation and late onset of rain, heavy and unseasoned rain and pests have caused massive crop failure/loss and yield decline.

Farmers perceived the variability and decrease in amount of rainfall, which had consequences on crops. As the rains were more variable, farmers were unable to predict the planting dates. The study by Monica (2013) suggested that changes in the onset or end of rainy season and any changes in monthly rainfall are predominantly important for farming activities, as some crops like maize need a particular volume of rainfall in a given time to grow. She added that, such changes might also affect farmers' ability to plan and choose appropriate planting times.

Farmers had admitted an increase in pests and diseases invasion to crops, which mostly triggered by increased temperatures in the area. This was also highlighted by IPCC (2015) which suggested that the distribution, reproduction, maturation, and survival rate of pests and diseases on their vectors, and their intermediate hosts are influenced by the effects of CC and CV.

Table 4 Farmers perception on local climate change in Loka Abaya woreda

Indicators	**Response of sample farmers about climate change (N=148)**				
Did you experience the change in climate?	**Yes**		**No**		
	94.33%		5.77%		
	Fully aware(%)	**Somewhat aware (%)**	**Not aware at all (%)**	**Over all awareness (%)**	**Rank**
Rainfall has decreased	85.7	9.2	5.9	90.2	II
Unpredictable rainfall	66.2	26.8	10	79.6	V
Rainfall starting earlier	39.5	45.3	15.2	62.15	IX
Rainfall starting latter	70.4	16.2	13.4	78.5	IV
Increase in recurrence of floods	61.1	18.2	10.7	70.2	VI
Temperature is getting warmer	97.5	2.5	0	98.75	I
Occurrence of drought	77.25	21.75	1.25	88.125	III
Duration of seasons is changing	42.6	48.3	9.1	66.75	VIII
Planting date change	46.2	31.5	22.3	61.95	X
Risk of crop and livestock disease has increased	63.42	11.4	15.18	69.12	VII

Source: Computed from questionnaire survey (2021)

The level of awareness of the respondents about climate change is presented in Table 6. It reveal that about 56.08 per cent of them were moderately aware, whereas, 24.32 and 14.2 per cent farmers belonged to highly aware and somewhat awareness category. Very few farmers (5.4%) were not aware about phenomena due to climate change. Similar findings were also reported by Legesse *et al.*, 2013; Alemayehu, and Bewket, 2017; Mudzonga, 2011 pointed out that small holder farmers experienced with climate change in different levels, and suggested that it is important for households to realize and appreciate that there is climate change or variability in the area before adjusting to the perceived changes.

Table 6 Distribution of respondents according to their level of awareness about climate change

Level of awareness about climate change	**Frequency(N=148)**	**Percentage (100)**
Nil	08	5.4
Low	21	14.2
Medium	83	56.08
High	36	24.32

Source: - Survey result (2021)

4.2.2. Trends of rain fall variability in the study area (1991-2020)

Climate change is expected to create a serious risk on environment, agricultural production and food security of most developing countries including Ethiopia. The Ethiopian climate is characterized by great variation in different parts the country and a history of climate extremes such as drought and flood, and increasing and decreasing trends in temperature and precipitation is common in the country. The data obtained from Ethiopia metrological Agency revealed that the coefficient of variation of study area were 40, 32.5 and 23.3% for kiremt, belg and annual rainfall, respectively which indicate that there was high inter annual variability of rainfall between 1991-2020. Degree of variation in amount of rainfall was higher for kiremt season than belg (Table 5).Various studies indicated that the trends in inter-annual and inter-seasonal rainfall variability like declining in amount, increasing in intensity and with increasing temperature are aggravating the rate of erosion, and consequently negative implication on crop and livestock productivity (Kassie et al.,2013).

Table 5 Coefficient of variance for annual, Kiremt and Belg rainfall (1991-2020)

Rain fall	Mean rain fall(mm)	CV (%)
Annual	889.5	23.8
Kiremt	305.9	40
Belg	348.5	32.5

Source: National Metrology Agency of Ethiopia (2020)

4.6.3 Trends of temperature in the study area (1991-2020)

The average yearly maximum temperature of the woreda was 30.7oC , while the average minimum temperature of 17.66 oC. As indicated in Figure 13, the maximum temperature of Loka Abaya District over the past 30 years increased by about 0.032 oC annually, while average minimum temperature is increased by 0.043 oC (Figure 13 and 14).This result obtained from the Ethiopia Metrology Agency is in line with the survey result of respondents regarding the increment of temperature over the past thirty years in the study area.

4.2.1 Climate Change Impacts Faced by Farmers

Sample household indicated that they had experienced noteworthy changes or events in the natural environments over the last three decades which they thought were due to climate change. Climate change impacts faced by sample respondents during last 30 years, as shown in Table7, is an example. The results indicated by sample farmers that, majority about (85.1%) crop yield reduced and risk of crop failure has increased (66.8%) due to change in rainfall pattern. Further, other major losses incurred due to climate change could be ordered sequentially as livestock productivity decreased, crop area reduced, income reduced, high food costs, and river run off decreased, although farmers also showed the crop/ animal disease outbreaks, plant species decreased/loss , dependency on relief increased (food insecurity) as the other impacts of climate change, respectively.

In this study, FGDs explained that farmers also complained that rainfall sometimes becoming so heavy causing floods which damage their crops resulting to fewer harvest or complete loss of crops. Moreover, in all studied kebeles, farmers concurred that they had experienced severe droughts in several years, although, most farmers recalled year 2016 (2008 E.C) as a year of most severe droughts that culminated in losses of livestock and crops. The late rain and droughts lead to Crop loss, decreased productivity or loss of livestock, water shortage, soil erosion, and reduced income from agricultural production, food insecurity/famines, and decreased ability to meet other basic needs. These results provide evidence for increasing risk of droughts over Loka abaya. Increase in frequency of droughts will add further pressure on smallholder agriculture and lead to greater losses (WB, 2009).

KIIs also showed that a decrease in and/or increased variability of rainfall, are of particular concern, as even small variations in the onset of rains might have a substantial impact on crop productivity and supply of feed resource for livestock in Loka abaya woreda.

A perception of high incidence of animal/crop diseases was indicated in different ways at Loka abaya. Examples of diseases associated with climate change reported in farmers, FGDs, and key informant interviews and questionnaires included heart water, east coast fever, anaplasmosis and pneumonia are diseases and or pests names in Loka abaya. Other diseases and pests mentioned included blindness, babesiosis, worms and lumpy disease. Similarly, smallholders perceive increased incidences of crop diseases. Crop diseases mentioned include blight, and leaf rust that affects maize and wheat in Loka abaya woreda. Crop pests mentioned include spider mite, stock borer, aphids, and millipedes (tiny black ants). The respondents reported that disease prevalence had increased in comparison to the time they settled as a result of increasing temperatures and droughts. In addition, the farmers' sentiments can be supported by the IPCC reports, citing the increase and burden of some livestock and crops diseases due to increasing temperatures and decreasing water availability caused by climate change (IPCC, 2007 and 2013).

Across the developing world, the majority of the poor and most of the hungry live in rural areas, where family farming and smallholder agriculture is a prevailing, major constraining factors that compromise agricultural productivity gains and the generation of stable incomes for family farmers include weather-related shocks (FAO, IFAD and WFP, 2015). It has been well-documented that the main drivers of food insecurity are climate-related disasters, and negative impact on nutrition due to food insecurity being mostly driven by drought, while tropical floods are stated to also affect food security by destroying livelihood assets (Porter *et al.,* 2014). This corresponded what was reported by majority of farmers during interviews under this study.Also, the study by (Patrick, 2014) in selected cities across Tanzania revealed that, temperature trends have been dramatically increasing, and is responsible for increased evapo-transpiration in the soil hereafter making crops fail to reach mature due to lack of enough moisture in the soil hence shortage of food.

Table 7 impacts related to climate change perceived by households in Loka Abaya woreda

Types of damage/Impact	**Percentage**
Risk of crop failure has increased	66.8
Crop yield reduced	85.1
Crop area reduced	56.08
Crop and animal disease outbreaks	34.4
Plant species decreased/loss	26.3
Livestock productivity decreased	62.1
River run off decreased	40.5
Income reduced	47.9
Dependency on relief increased (Food insecurity)	33.7
High food costs	43.2

Source: Household survey (2021)

4.3 Climate Change Adaptation Strategies Used by Smallholder Farmers

Adaptation measures to climate change are reported by sample farmers in Loka abaya (Table8). The full adaptation potential of Loka abaya smallholder farmers is not yet known, although from a technical standpoint, there is likely to be considerable scope for modifying these agricultural/non-agricultural systems to improve the livelihoods of smallholder farmers, even in the face of climate change. Small holder farmers in study area used different practices which will reduce variability to economic livelihoods and food security. Majority (89.8, 80, 71.6, 68.9, and 62.16%) of the respondents chose or were using crop diversification, diversifying sources of livelihood, planting/keeping drought tolerant crops/livestock, use of agro-forestry and reforestation/ afforestation as the main climate change adaptation strategy in the study area. Other important climate change adaptation strategies used by the farmers in the study areas include: Soil and water conservation techniques, use of irrigation system/water storage, changing planting dates, incomes from remittances, and out migration from climate risk areas. However, about 3.4% of sample respondents were not withstand climate change shocks in study area due to lack of adequate farm land, financial resources, education on improved farm technology, and lack of appropriate weather forecast information.

Table 8 Frequency distribution of climate change adaptation strategies used by smallholder farmers in Loka Abaya woreda

Type of strategies	Farmers(N=148) responding "Yes" in using different adaptation measures to climate change	
	Frequency	**Percentage**
Planting/keeping drought tolerant crops/livestock	106	71.60
Use of agro-forestry	102	68.90
Changing planting dates	64	43.20
Crop diversification	133	89.80
Use of minimum tillage system (zero or minimum)	65	43.90
Use of irrigation system/water storage	71	48.00
Soil and water conservation techniques	90	60.80
Reforestation/ Afforestation	92	62.16
Diversifying sources of livelihood	118	80.00
Out migration from climate risk areas	26	17.50
Incomes from remittances	43	29.05
Using nothing	5	3.40

Analysis of response of FGDs and KIIs revealed that smallholder farmers on adaptation options practiced to withstand climatic change showed that many have used adaptation measures schemes including diversifying sources of livelihood (they used to express that it is impressive that some farmers were pursuing non-farm and off-farm activities as the extra livelihood sources rather than agriculture), some used drought resistant crop varieties, and improved crop varieties and many farmers diversified crop production to planting trees while not undermining the importance of other practices and enhanced livestock rearing in response to climate change. On adaptation strategies discussions with focus groups, experts and key informants revealed that there are efforts to cope with adverse climate change, however; lack of sufficient capital, shortage of land, low level of infrastructure and use of improved technologies, remain as barriers to adapt the adverse effects of climate change.

Regarding this study, the most common climate variability and climate change adaptation strategies in rural Africa including Ethiopia are identified by a number of scholars (Deressa *et al.*,2010; Gbetibouo, 2009;Hadgu*et al.,* 2015Laestadius*et al.,*2014;FAO, IFAD, & WFP(2015) Hassan and Nhemachena (2008). These include growing of drought and heat resistant and early maturing crop varieties, crop and livestock diversification, use of small-scale irrigation, water harvesting and storage, improved water exploitation methods, labor migration, strengthening agro-forestry practices, food storage, controlled grazing, changing planting dates, engaging in off-farm activities etc. These adoption options are thought to be developed out of necessity by the farmers themselves.

Table 9: Distribution of the respondents by level of Intensity of use of climate change adaptation strategies

Type of strategies	Response of full sample (N=148)			
	Maximum	Minimum	Mean	SD
Planting/keeping drought tolerant crops/livestock	3	2	2.15***	0.41
Use of agro-forestry	3	1	2.01**	0.49
Changing planting dates	3	1	1.53*	0.37
Crop Diversification(Planting different crop varieties)	3	2	2.67***	0.53
Use of minimum tillage system (zero or minimum)	2	1	1.13*	0.32
Use of irrigation system/water storage	2	1	1.40*	0.44
Soil and water conservation techniques	2	1	1.98**	0.57
Reforestation/ Afforestation	3	2	2.26***	0.61
Diversifying sources of livelihood	3	1	2.19***	0.55
Out migration from climate risk areas	2	1	1.09*	0.36
Incomes from remittances	2	1	1.04*	0.44

Note that: **** stands for very high intensification (VHI)*
*** stands for high intensification (HI)*
** stands for low intensification (LI)*
S. D. means standard deviation.
The 3-point likert-type rating scale was graded as Very High Intensification (VHI) = 3, High Intensification (HI) = 2, and Low Intensification (LI) = 1. The mean score of respondents based on the 3-point likert-type rating scale was computed as
$\frac{3+2+1}{3} = \frac{6}{3}$=**2.00** cut off point

Source: Computed from household survey, 2021.

Furthermore the study also revealed that at how much intensity the earlier adaptation practices was used by farmers. In Loka abaya woreda, crop diversification(planting different crop varieties) (2.67), reforestation/afforestation (2.26), diversifying sources of livelihood (2.19) and, planting/keeping drought tolerant crops/livestock (2.15) as adaptation practices were very highly intensified as a result of change in climate by the respondents; use of agro-forestry (2.01),soil and water conservation techniques (1.98) were highly intensified ; while incomes from remittances (1.04), out migration from climate risk areas (1.09), use of minimum tillage system (zero or minimum) (1.13), use of irrigation system/water storage (1.40) ,and changing planting dates (1.53) were lowly intensified (Table 9). Concerning the level of intensity of use of climate change adaptation strategies, various scholars (Abid *et al.*, 2015, Nadi, 2014; Otitoju, 2013 and Seid (2016)) explained in their studies that the extent to which a system is affected by climate change largely depends on its adaptive capacity.

4.4 Factors Affecting Small holder Farmers Choice of Adaptation to Climate Change

Factors affecting households' choice of adaptation strategies to climate change was explained by MNL regression model. The results of the multinomial logistic regression for the different adaptation strategies categories are presented in (Table 10 and 11). The dependent variable was the adaptation strategies and predictor variables were socioeconomic factors. From the results, households indicated to be either adapting to climate change by employing one or more adaptation strategies.

Table 10: Parameter estimates of the multinomial logistic regression (MNL) models of adaptation practices.

Explanatory Variable (Independent variable)	Dependent variables				
	Crop diverfn	Planting /keeping drought tolerant crops/livestock	Agro forestry farming	Diversifying livelihood sources	Soil and water conservation practices
	Estimated Coef	Estimated Coef	Estimated Coef	Estimated Coef	Estimated Coef
Sex	2.21**	1.48	-.48	1.29	0.25
Age	0.24***	0.018	0.11***	0.03	-0.07
FAMSZ	0.11	0.87***	0.22	0.06	-0.72**
EDUCN	0.38**	0.07	0.36**	0.07***	-0.02
FARMSZ	-0.95	-1.64**	-0.52	-3.81**	-0.01
LVOW	-0.001	0.37**	0.12	-0.08	0.03
EXCT	0.06	-1.22*	-1.81**	-0.99	0.45
CRSR	-3.52***	-2.11***	-4.09***	-0.67	-0.29
INCC	-0.41	0.69***	0.43	0.56	-0.72
NNFIC	-0.21	0.06	0.91	0.31	-0.22
MARKA	-0.36*	-0.26*	-0.45**	-0.39*	-0.35
Bases category	Changing planting date				
No of observation	148				
Prob> chi^2	0.0000				
LR chi2(55)	=193.34				
Log likelihood	=-153.30942				
Pseudo *R* square	=0.3867				

Where:

FAMSZ--- Family size; LOW--- Livestock ownership

EDUCN--- Education; EXCT--- Extension contact

FARMSZ--- Farm size; CRSR--- Credit service

Table 11 Marginal effects from the multinomial logistic regression (MNL) models of adaptation practices.

Explanatory Variable (Independent variables)	Dependent variables				
	Crop diverfn	P/keeping drought tolerant crops/livestock	Agro forestry farming	Diversifying livelihood sources	Soil and water conservation practices
	Marginal Coef	Marginal Coef	Marginal Coef	Marginal Coef	Marginal Coef
Sex	-.24	.18	-.03	.10	.001
Age	.0066***	-0.003	.0063***	-.001	-.003
FAMSZ	-.011	.912***	-.006	-.018	-.028**
EDUCN	.010	-.026	.012	.035***	-.005
FARMSZ	.01	-.062	.101*	-.22**	0.03*
LVOW	-.011	.039***	0.003	-.017	-.001
EXCT	.123*	-.056	.161***	-0.16	.031
CRSR	-.12	-.02	-.23	.121**	.03
INCC	-.133	.425***	-.07	-.04	-.43
NNFIC	.015	.04	-.11	.041	-.001
MARKA	-0.003	.001	-.02	-.001	-.004

Asterisk:, ** and *** stands for significant at 10, 5 and 1% level, respectively*.

Source: Computed from household survey (2021)

Before running the model the contingency coefficient for discrete variable and variance of inflation factor for continous variable was cheched and it was proved that there is no problem of multi-colinearity between explanatory variables. The estimation of the multinomial logit (MNL) model for this study was undertaken by normalizing one category, which is referred to as the "reference state," or the "base category." In this analysis, the base category is changing planting date. The result of the multinomial logit (MNL) model indicate that different socio economic factors (family size, age of the household head, years of education of household head, and sex of the household head,) economic variables (farm size, livestock ownership and non-farm income) and institutional variables (extension contact, access to credit and climate change information) affect the farmers' choice of the main farm-level climate change adaptation strategies in Loka abaya. Results of the parameter estimates (the estimated coefficients from the multinomial logit (MNL) models are presented in Tables 11.

Age of the household head Age is significantly, and positively affected crop diversification and using agro forestry as adaptation strategies to climate change in Loka abaya (Table 10).This implies that if the age of farmers increased by one year the probability of choosing crop diversification, and using agroforestry increases by 0.0066(0.66%) and 0.0063(0.63%) at 5 and 1% significant level, respectively. This result agrees with the findings of (Belayneh *et al.,* 2013) which found that adaptation to climate change increased with age for younger farmers as they gain experience and increase their stock of human capital but declines with age for those farmers closer to retirement and also the work of Hassan and Nhemachena (2008) which found that age is inversely related to the probability of choosing and using mono crop-livestock under irrigation. As indicated by Hassan & Nhemachena (2008) the influence of age on adaptation choices has been mixed in the literature. Some studies found that age had no influence on a farmer's decision to participate in forest and soil and water management activities while others found that age is significantly and negatively related to farmers' decisions to adopt. However, Bayard *et al.* (2007) found that age is positively related to the adoption of conservation measures.

Education: Education of the household head has an inverse relationship with the probability of a farm household choosing nothing, and has a positive relationship with the probability of a farm household choosing diversifying livelihood sources as climate change adaptation strategies in Loka abaya (Table 10). This implies that a one-unit increase in education would lead to 0.026 (2.6%) and 0.035 (3.5%) decrease and increase the probability of not choosing anything and using diversifying livelihood sources respectively in the study area (Table10).It was expected that farmers with higher levels of education are more likely to adapt better to climate change using various methods because a farmer who has more years of education is more likely to adopt improved methods and expected to be more efficient to understand and obtain new technologies than less-educated people. The similar outcome have found and explained in the articles written by Maddison (2006) finding that, educated farmers are expected to have more knowledge and information about climate change and the agronomic practices that they can use in response.

Farm size: It affects the probability using agroforestry, and soil and water conservation positively and significantly as adaptation strategy to climate change in study area. The farmers with more farm land encouraged them to use agroforestry and soil and water conservation by 0.101(10.1%) and 0.030 (3%) at 10% significant level.In general, an increase in farm size increases the likelihood of adapting to climate change using agroforestry and soil conservation. This result is expected in the sense that the more households have larger farms, the more they tend to work more intensively on their land instead of going for another alternative to adapt to climate change. They can do this by keeping agroforestry and by applying soil conservation measures.Households with larger farm sizes, therefore, are more probably to diversify their crops/livestock and planting tree under agroforestry system especially under dry land conditions and help spread the negative impacts of changes in climatic conditions. Several studies found that farm size also positively and significantly affects the adoption of climate change adaptation technology

(Hadgu*et al.,* 2015, and Belayneh*et al.,* 2013) they identified that owning adequate farm land have a significant and positive impact on adoption of improved farm technology to reciprocate climate change impacts .

Livestock ownership: The result shows that there is a positive relationship between livestock ownership and the probability of choosing planting/keeping drought tolerant crop/livestock as adaptation strategy. The farmers who own the more number of animals could use planting/keeping drought tolerant crops /livestock by 0.039(3.9%) at 1% significant level (Melissa *et al.,* 2017, and seid *et al.,* 2016) pointed out that livestock ownership have a statistically significant impact on climate adaptation strategies *i.e.* those farmers who have large number of livestock could recover from climatic shocks.

Access to extension services (EXCT) significantly ($p < 0.05$) influence the choice of adapting to climate change using crop diversification, and using agroforestry. The farmers who got extension services increases the probability of using crop diversification, and using agroforestry by 12.3 and 16.08% at 10 and 1% significant level. The result indicates the importance of increasing institutional support so as to encourage the use of strategies such as crop diversification, and agroforestry to acclimatize to the impacts of climate change. This is because farmers who have better access to extension services have better opportunities to get information on changing climatic conditions and the various farming practices that they can use to adapt to changes in climatic conditions. This is also in line with the result of Egziabher *et al.,* 2013, and Di Falco *et al.,* 2011, asserted that contact with extension influenced the choice of households when adapting using the alternative strategies compared with those who did not contact with.

Access to credit (CRSR), significantly ($p < 0.05$) influence the choice of adapting to climate change: diversifying livelihood sources as adaptation strategies. This indicates that having credit services increases the probability of diversifying livelihood sources as adaptation strategies by 12.1% at 5% significant level than compared to those who don't get credit services. Nhemachena & Hassan, (2008) indicated that affordable credit increases financial resources of farmers and their ability to meet transaction costs associated with various adaptation options they might want to take. Credit by its nature is expected to relax the financial constraint of farmers and makes the farmers to have a positive influence on climate change risk in order to adapt the existing condition. However, this is applied only as far as it is profitable and accepted by farmers.

Attaining information about climate change (INCC) affects the probability of not using anything, crop diversification and planting/keeping drought tolerant crops livestock. This indicates that being aware of climate change reduces the probability of not using anything by (13.02%), increases crop diversification (13.3%), and planting/keeping drought tolerant crops/livestock (42.5%) at 10%, 5% and 1% significant level, respectively. This assumption was in line with the results of similar work on climate change adaptation strategies done by (Hadgu *et al.*, 2014).

Distance from market (MARKA). This shows that if the distance from market increased by 1 km the probability of not using anything in response to climate change increased by 3.4% at 1% significant level. Regarding to this, a study conducted by (Aemro *et al.*, 2012), verified that distance (nearness/farness) from market influences farmers adaptation practices to climate change, and faring from market center decreases the livelihood of farmer's adaptation practices.

CHAPTER FIVE: CONCLUSION AND RECOMMENDATION

5.1 Conclusion

This study examined the smallholder farmers' perception of climate change and factors affecting their choice of adaptation practices in Loka Abaya woreda, Sidama national regional state of Ethiopia.

In the finding showed that majority (94.33%) of sample farmers in Loka abaya woreda they have experienced climate change effects over the two decades preceding the implementation of the study. The finding has concluded that most of small holder farmers of Loka Abaya woreda had known climate change and fully aware that temperature is getting warmer, rainfall has decreased, occurrence of drought, late onset , unpredictable rainfall, and risk of crop and livestock disease has increased due to climate change, ,respectively. The evidence showed the climate change had impacted crop production causing crop failure and reduced yield. Further, other major losses incurred due to climate change could be ordered sequentially as livestock productivity decreased, crop area reduced, income reduced, high food costs, and river run off decreased, farmers also showed the crop/ animal disease outbreaks, plant species decreased/loss, dependency on relief increased (food insecurity) as the other impacts of climate change, respectively.

The main farming's adaptation strategies to climate change used by smallholder farmers in Loka abaya woreda were found to be: crop diversification, diversifying sources of livelihood, planting/keeping drought tolerant crops/livestock, use of agro-forestry and reforestation/ afforestation as the main climate change adaptation strategy in the study area. Other important climate change adaptation strategies used by the farmers in the study areas include: Soil and water conservation techniques, use of irrigation system/water storage, changing planting dates, incomes from remittances, and out migration from climate risk areas. From the evidence it could be concluded that with the use of different climate change adaptation strategies, the small holder farmers are still underutilizing their present choices and this make them to be both technically and profit inefficient. Right combination of different adaptation rather than using one of these strategies through their wealth of experience and making judicious use of their resources at the present technology level will make them to be more efficient.

The marginal prediction of multinomial logistic regression model (MNL) analyzed reveals that age of household, family size, farm size, education, contact with extension personnel, access to credit service ,attaining information on climate change and distance from market were found statistically significant factors that affect farmers use of adaptation strategies to climate change in study area.

5.2 Recommendation

Based on the findings from this study, the following recommendations are put forward to local government (i.e. public sector), private sectors and farmers as important decision makers;

1. It has been reported that temperatures are still going to increase and rainfall intensity, frequency and distribution would be unpredictable and unreliable and change in other states of climate. For rural households, whose livelihood is dependent on rainfed agriculture; crop diversification, diversifying sources of livelihood, planting/keeping drought tolerant crops/livestock, use of agro-forestry and reforestation/ afforestation would increase their resilience to climate impacts and improve their livelihoods and food security.
2. To enhance use of adaptation strategies, households should overcome the negative factors that hinder them from adapting to climate change. They should seek information on climate change to avoid maladaptation, form unions and cooperatives, change cropping systems to mixed farming or intercropping. These adjustments can be possible even without external intervention from local government.
3. Various adaptation practices were used by sample small holder farmers in Loka abaya, thus adaptation practices to climate change needs to be seen as an integral part of a country's development planning, rather than as a separate issue, and adaptation measures that lead to better overall development outcomes are preferable to ones that focus exclusively on adapting to climate change impacts while ignoring other stresses.
4. The strong correlation between the socio-institutional variables and the choice of adaptation strategies suggests the need for local government to establish and strengthening of local institutions, such as micro-finance and extension institutions to support households and to

ensure sustainability of agricultural activities and enhance food security under climate change.

5. The studies solely dig out the finding of climate change in relation to small holder farming and confounding adaptation practices in study area. The local research institutes should carry out the detail studies on non-climatic factors that drawback small holder farmer from being resielent under the campaign of poverty reduction.

References

Abate Feyissa Senbeta, (2009); Climate Change Impact on Livelihood, Vulnerability and Coping Mechanisms; a Case Study of West-Arsi Zone. Thesis Submitted to Lund University Masters Program in Environmental Studies and Sustainability Science (LUMES), Lund University, Sweden

Abayneh Shuite(2018). Impact of Climate Change on Crop Production in Loka Abaya Woreda of Sidama Region. Thesis Submitted to Hawassa University Masters Program in Climate Change and Sustainable Agriculture (CCSA), Hawassa University, Ethiopia.

AbebeEngida, (2013); Impact of climate Variability and change on food security and local adaptation strategies in Arsi-Negel Woreda central rift valley, Ethiopia. Unpublished master's Thesis, Addis Ababa University, Ethiopia.

Abid, J. Scheffran1, U. A. Schneider, and M. Ashfaq.(2014)Farmers' Perceptions of and Adaptation Strategies to Climate Change and their Determinants: the case of Punjab province, Pakistan

Adesina F.A. 1988. Developing stable agroforestry systems in the tropics: An example of local agroforestry techniques from south western Nigeria. Discussion papers in Geography 37, Department of Geography, University of Salford,United Kingdom, Pp. 27.

Adesina F.O, W.O. Siyambola, F.O Oketola, D.A Pelemo, L.O Ojo, A.O. Adegbugbe. 1999. Potentials of agroforestry for climate change mitigation in Nigeria: Some preliminary estimates. Glob. Ecol. Biogeogr. vol. 8, Pp. 163–173.

Adger, W.N. 2006.Vulnerability. Global Environmental Change, 16: 268–281.

Adger, W.N., S. Huq, K. Brown, D. Conway and M. Hulme. 2003. Adaptation to climate change in the developing world. Progress Dev. Stud. 3: 179-195.

Aemro, T., Jemma, H. and Mengistu, K. (2012). Climate change adaptation strategies of smallholder farmers: The case of Babilie district, East Harerghe Zone of Oromia Regional State of Ethiopia. Journal o f Economics and Sustainable Development, 3(14):1-12.

Agrawal, A. 2010. "Local Institutions and Adaptation to Climate Change." In *Social Dimensions of Climate Change: Equity and Vulnerability in a Warming World. New Frontiers of Social Policy*, edited by R. Mearns and A. Norton, 173–197. Washington, D.C.: World Bank.

Alemayehu and W. Bewket, 2017."Determinants of smallholder farmers' choice of coping and adaptation strategies to climate change and variability in the central highlands of Ethiopia," *Environmental Development*, vol. 24, pp. 77–85, 2017. View at: Publisher Site | Google Scholar

Asrat P, Simane S (2017a). Adaptation benefits of climate-smart agricultural practices in the Blue Nile Basin: empirical evidence from North-West Ethiopia. In: Filho WL, Belay S, Kalangu J, Menas W, Munishi P, Musiyiwa K (eds) Climate change adaptation in Africa: fostering African resilience and capacity to adapt. Vol. 1. Springer International Publishing AG, Cham, Switzerland

Bayrau A, Assefa B, Hagos A (2015). Productivity and welfare impact of climate change in sugarcane and cotton producing regions of Ethiopia. EDRI Research Report 23. Addis Ababa: Ethiopian Development Research Institute.

Belaineh Legesse, Yared Ayele and WoldeamlakBewket, 2013.Smallholder farmers' perceptions and adaptation to climate variability and climate change in Doba district, west Hararghe, Ethiopia. Asian Journal of Empirical Research 3(3):251-265.

B.H., Anderies, J.M. & Abel, N. 2001. From metaphor to measurement: resilience of what to what? Ecosystems, 4: 765–781.

Bassett, T., and C. Fogelman. 2013. "Déjà Vu or Something New. The Adaptation Concept in the Climate Change Literature." *Geoforum* 48: 42-53. http://dx.doi.org/10.1016/j. geoforum.2013.04.010

Batima, P. 2006. Climate change vulnerability and adaptation in the livestock sector of Mongolia. Assessments of impacts and adaptations to climate change. International START Secretariat, Washington DC, US.

Boko, M., Niang, I., Nyong, A., Vogel, C., Githeko, A., Medany, M., Osman-Elasha, B., Tabo, R. and Yanda, P. 2007. Africa climate change 2007. Impacts, adaptation and vulnerability. Contribution of working group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge UK. p200.

Braatz, S. 2012. Building resilience to climate change through sustainable forest management.This publication. Carpenter, S.R., Walker,

Bryan, E., C. Ringler, B. Okoba, C. Roncoli, S. Silvestri, and M. Herrero. 2013. "Adapting Agriculture to Climate Change in Kenya: Household Strategies and Determinants.' Journal of Environmental Management 114: 26-35. http://dx.doi.org/10.1016/j.jenvman.2012.10.036 .

Cifdaloz, O., Regmi, A., Anderies, J.M. & Rodriguez, A.A. 2010. Robustness, vulnerability, and adaptive capacity in small-scale social–ecological systems: the Pumpa Irrigation system in Nepal. Ecology and Society, 15(3): 39 (available at http://www.ecologyandsociety.org/vol15/iss3/art39/).

CSA, (2008); Central statistics Authority: Population and Housing Census Report.2008.

Dawit, A. 2010.Future climate of Ethiopia from PRECIS Regional Climate Model.Experimental Design. Ethiopia. p16. 9

De Young, C. 2012. Building resilience for adaptation to climate change in the fisheries and aquaculture sector.This publication.

Department for Food and International Development (DFID). 2004. Adaptation to climate change: The right information can help the poor to cope. Global and local environment team, policy division.

Devereux, S., S. Maxwell. 2001. Food Security in Sub-Saharan Africa. ITDG Publishing, London.

Di Falco, S., Veronesi, M., &Yesuf, M. (2011a). Does adaptation to climate change provide food security? A micro-perspective from Ethiopia.*American Journal of Agricultural Economics*, *93*(3), 825–842.

Di Falco, S., & Bulte, E. (2013).The Impact of Kinship Networks on the Adoption of Risk Mitigating Strategies in Ethiopia.*World Development*, *43*, 100–110. Edugreen.teri.res.in/explore/climate/causes.htm.

Egbule, C. L. (2010). *Indigenous and emerging adaptive agricultural technologies to climate change in the Niger Delta region of Nigeria*. (Unpublished M. Sc Thesis).University of Nigeria, Nsukka, Enugu state, Nigeria.

Egziabher, K. G., Mathijs, E., Gebrehiwot, K., & Bauer, H. (2013).*The Economic Impact of a New Rural Extension Approach in Northern Ethiopia: Division of Bioeconmics, Department of Earth and Environmental Sciences*. Leuven, Belgium.

Emerta, A. (2013). Climate Change, Growth and Poverty in Ethiopia. The Robert S. Strauss Center for international security and Law: CCAPS.

Ericksen, P.J. 2008.Conceptualizing food systems for global environmental change research. Global Environmental Change, 18(1): 234–245.

Eshetu Z, Simane B, Tebeje G, Negatu W, Amsalu A, Berhanu A, Bird N, Welham B, Trujillo NC (2014) Climate finance in Ethiopia, promoting effective climate finance project report. Overseas Development Institute (ODI). http://www.a-id.org/pdf/climate-finance-in-ethiopia.pdf Accessed 1 May 2016.

FAO, IFAD, & WFP. (2015). *The State of Food Insecurity in the World. Meeting the 2015 international hunger targets: taking stock of uneven progress*. Rome, FAO.

FAO.(2016). Ethiopia Climate-Smart Agriculture Scoping study. Addis Ababa: Food and Agriculture Organization of the United Nations.

FAO.(2017). FAO'S work on climate change.United Nations Climate Change Conference. http://www.fao.org/3/a-i8037.pdf .

Federal Democratic Republic of Ethiopia (FDRE) (2015) Ethiopia's climate resilient green economy climate resilience strategy agriculture and forestry.Ministry of Agriculture and Rural Development, Addis Ababa.

Fellmann, T. 2012. The assessment of climate change related vulnerability in the agricultural sector: Reviewing conceptual frameworks. This publication.

Folke, C., Carpenter, S.R., Walker, B., Scheffer, M., Chapin, T. &Rockström, J. 2010. Resilience thinking: integrating resilience, adaptability and transformability. Ecology and Society, 15(4): 20 (available at http:// www.ecologyandsociety.org/vol15/iss4/art20/).

Food and Agriculture Organization (FAO). 2008. Climate change for fisheries and aquaculture: Technical background document from the expert consultation held on 7-9 April 2008, Rome. Hoffmann, I. 2008. Livestock genetic diversity and climate change adaptation. Livestock and Global Change Conference proceeding. May 2008, Tunisia.

Füssel, H.-M.& Klein, R.T.J. 2006. Climate change vulnerability assessments: an evolution of conceptual thinking. Climatic Change, 75 (3): 301–329.

Gbetibouo, A (2009). Understanding farmers' perceptions and adaptations to climate change and variability: The Case of the Limpopo Basin, South Africa (trans: Division EaPT). IFPRI–wide Discussion Paper. International Food Policy.

Gebremichael1, A., Quraishi, Shoeb. andMamo, G. 2014. Analysis of seasonal rainfall variability for agricultural water resource management in Southern Region, Ethiopia. *Journal of Natural Sciences Research,* Vol.4 (11).pp: 15-25.

Giller, K.E., Karanja, S., Mark T., Wijk, V., Rufino, M.C. 2016. Adaptation of agriculture to climate change in semi-arid Borena, Ethiopia. *Regional Environmental Change,* 16, 2317–2330

Gornall, J., Betts, R., Burke, E., Clark, R., Camp, J., Willett, K. & Wiltshire, A. 2010. Implications of climate change for agricultural productivity in the early twenty-first century. Philos. Trans. R. Soc. Lond. B Biol. Sci., 365: 2973–2989.

Greene WH. Econometric analysis. 4th ed. New York: Prentice Hall International Inc; 2000

Gujarati D. Basic econometrics. 4th ed. New York: Mc Graw Hill; 2004.

Gunderson, L. &Holling, C.S., eds. 2001.Panarchy: understanding transformations in human and natural systems. Washington, DC, Island Press.

Hadgu, G., Tesfaye, K., Mamo, G., &Kassa, B. (2014).Analysis of farmers‟ perception and 129 adaptation methods to climate variability/change in Tigray region, northern Ethiopia. *Agricultural and Environmental Sciences*, 15–25.

Hadgu, G., Tesfaye, K., Mamo, G., &Kassa, B. (2015). Farmers ‟ climate change adaptation options and their determinants in TigrayRegion , Northern Ethiopia. *African Journal of Agricultural Research*, *10*(9), 956–964.

Holling, C.S. 2001.Understanding the complexity of economic, ecological, and social systems. Ecosystems, 4: 390–405.

IFRC. 2016. Emergency appeal Ethiopia: Drought. International Federation of Red Cross and Red Crescent Societies.

Imbach P, Beardsley M, Bouroncle C, Medellín C, Läderach P, Hidalgo H, Alfaro E, Van Etten J, Allan R, Hemming D, Stone R, Hannah L, Donatti CI. 2017. Climate change, ecosystems and smallholder agriculture: an introduction to the special issue. Climate Change. https://doi.org/10.1007/s10584-017-1920-5 .

Intergovernmental Panel on Climate Change, Cambridge Univer.Press, Cambridge, United Kingdom and New York, NY, USA P. 517.Intergovernmental Panel on Climate Change (IPCC). 2007. Climate Change 2007: Climate change impacts, adaptation and vulnerability - Summary for policymakers. Contribution of Working Group II to the

IPCC (2007b).*Climate* change *2007: The physical science basis. Contribution of workinggroup I to the fourth assessment report of the Intergovernmental Panel on ClimateChange.* [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M.Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.Fourth Assessment Report of the IPCC.

International Fund for Agricultural Development (IFAD). 2009. Livestock and climate change. Livestock thermaticpapers.Available online at www.ifad.org/irkm/index.tm Intergovernmental Panel on Climate Change (IPCC) 1998. The regional impacts of climate change: An assessment of vulnerability. Special Report of IPCC Working Group II [Watson, R.T., M.C. Zinyowera, and R.H. Moss (eds.)].

IPCC.*Climate Change 2007: Synthesis Report, Contribution of Working Groups I, II and III to the Fourth assessment Report of the Intergovernmental Panel on Climate Change*; IPCC: Geneva, Switzerland, 2007.

IPCC. 2007a. Climate change 2007: the physical science basis. Contribution of Working Group I to the Fourth Assessment.Report of the Intergovernmental Panel on Climate Change. S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor& H.L. Miller, eds..Cambridge, UK, and New York, USA, Cambridge University Press, 996 p.

IPCC. 2007b. Climate change 2007: impacts, adaptation and vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Glossary, pp. 869–883. M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linder, & C.E. Hanson, eds. Cambridge, UK, and New York, USA, Cambridge University Press.

IPCC. 2012. Managing the risks of extreme events and disasters to advance climate change adaptation (SREX). Special Report of the Intergovernmental Panel on Climate Change

IPCC, 2013.'Summary for Policymakers. In: Climate Change 2013: The Physical Science Basis' Contribution of Working Group I to the Fifth Assessment Report of the IPCC [Stocker, TF, Qin, D, Plattner, GK, Tignor, M. Allen, SK, Boschung, J, Nauels, A, Xia, Y, Bex V, &Midgley, PM, (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Intergovernmental Panel on Climate Change (IPCC), in Climate Change (2014): Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, IPCC, Geneva, Switzerland.

IPCC, 2015, 'Meeting Report of the IPCC Expert Meeting on Climate Change, Food, and Agriculture' [Field, CB, Barros, VR, Dokken, DJ, Mach, KJ, Mastrandrea,MD, Bilir, TE, Chatterjee, M, Ebi, KL, Estrada, YO, Genova, RC, Girma, B, Kissel, ES, Levy, AN, MacCracken, S, Mastrandrea, PR, & White LL, (eds.)], World Meteorological Organization, Geneva, Switzerland, pp. 68.

Kassie, B. T., Hengsdijk, H., Rötter, R., Kahiluoto, H., Asseng, S., & Ittersum, M. V. (2013). Adapting to Climate Variability and Change: Experiences from Cereal-Based Farming in the Central Rift and Kobo Valleys, Ethiopia. *Environmental Management*, *52*(5), 1115–1131. doi:10.1007/s00267-013-0145-2.

Keyyu, J 2012, 'Impact of climate change in the Kilimanjaro region of Tanzania' Tanzania wildlife research institute (TAWIRI).

Kjøhl, M., Nielsen, A. &Stenseth, N.C. 2011.Potential effect of climate change on crop pollination. Rome, FAO (available at http://typo3.fao.org/fileadmin/templates/agphome/documents/Biodiversity pollination/Climate_Pollination_17_web__2_.pdf).

Laestadius, L.I., Neff, R.A., Barry, C.L. and Frattaroli, S. (2014). '"We don't tell people what to do'': an examination of the factors influencing NGO decisions to campaign for reduced meat consumption in light of climate change', Global Environmental Change, 29, pp.32-40.

Lema, AA, Munishi, LK &Ndakidemi, PA 2014, 'Assessing Vulnerability of Food Availability to Climate Change in Hai District, Kilimanjaro Region, Tanzania' American Journal of Climate Change, vol. 3, pp. 261-271.

Markos Keshora (2017). Contribution of Livelihood Diversification to Climate Change Adaptation in Loka Abaya Woreda of Sidama Region. Thesis Submitted to Hawassa University Masters Program in Climate Change and Sustainable Agriculture (CCSA), Hawassa University, Ethiopia.

Martin-Breen, P. &Anderies, J.M. 2011. Resilience: a literature review. New York, USA, The Rockefeller Foundation.

Melissa, M. Rojas-Downing, A., Nejadhashemi, A., Harrigan, T., and Woznicki, S. (2017). Climate change and livestock: Impact, Adaptation and mitigation. *Regional Environmental Change*, *16:* 145-163.

Monica, CB 2013, 'Using climate information to support adaptation planning and policy-making: A practical case study in Bagamoyo District, coastal Tanzania' Stockholm Environment Institute.

Mudzonga, E. (2011). Farmers' Adaptation to Climate Change in Chivu of Zimbabwe.Trade and Development Studies Centre, Belgravia, Harare, Zimbabwe.

Mwakalila, S 2014, 'Climate change impacts and adaptation strategies in Kilimanjaro transect in Tanzania' Journal of Environmental Science and Water Resources, vol. 3, no. 1, pp. 007-014.

Nadi, P.M. 2014. Climate Change Adaptation for Smallholder Farmers in Rural Communities: the Case of Mkomazi Sub-Catchment, Tanzania., Dissertation Submitted in Fulfillment of the Requirement for the Title of Doktor der Wirts chaftswissenschaften (Dr. rer.pol.) Carl von Ossietzky University of Oldenburg, FAKULTÄT II - INFORMATIK, WIRTSCHAFTS- UND RECHTSWISSENSCHAFTEN.

NAPA (National Adaptation Program of Action), 2007. Addis Ababa, Ethiopia. p85.

Nater, T, (2010). *UNCCD News, Climate Change and adaptation in Ethiopia*, URL: http://newsbox.unccd.int/2.1/ (accessed 8.3.2011).

National Aeronautic and Space Administration (NASA) (2012).*Global climate change: A blanket around the earth*. Available online: www.climate.nasa.gov/causes/; retrieved on 3rd October, 2012.

Nhemachena, C. and Hassan, R. 2007. Micro-level analysis of farmers‟ adaptation to climate change in Southern Africa. IFPRI Discussion Paper No. 00714. International Food Policy Research Institute, Washington, D.C.

Niang, I., Ruppel, O. C., Abdrabo, M. a., Essel, A., Lennard, C., Padgham, J., & Urquhart, P. (2014). Africa. In Climate Change 2014: Impacts, Adaptation and Vulnerability -

Contributions of the Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. (pp. 1199–1265).

Nigus.Gebremedhin, (2011); The impacts of climate change on rural livelihood and their adaptation methods: the case of Alamataworeda, southern Tigray, unpublished master's thesis , Addis Ababa University, Ethiopa

OECD. 2009. Managing risk in agriculture: a holistic approach. Paris.

OECD (2015 Forthcoming) Policy Approaches to Drought and Floods in Agriculture, OECD Studies on Water, OECD Publishing.

Okoroh, J. P. (2011). *Knowledge of climate change among farmers in Okigwe Senatorial zone of Imo state, Nigeria*.(Unpublished M. Sc Thesis). University of Nigeria, Nsukka, Enugu state, Nigeria

Otitoju, M. (2013).The Effects of Climate Change Adaptation Strategies on Food Crop Production Efficiency in Southwestern Nigeria

Patrick, MN 2014, 'Climate Change Adaptation for Smallholder Farmers in Rural Communities: The Case of Mkomazi Sub-Catchment, Tanzania' Oldenburg, Germany. Downloadable at http://oops.uni-oldenburg.de/1962/1/ndaki_diss_20141027_bn.pdf.Accessed on December 14, 2015.

Shackleton, S., G. Ziervogel, S. Sallu, T. Gill, and P. Tschakert. 2015. "Why is Socially-Just Climate Change Adaptation in Sub-Saharan Africa So Challenging? A Review of Barriers Identified from Empirical Cases." *Wiley Interdisciplinary Reviews: Climate Change*6(3):321-344. http://dx.doi.org./10.1002/wcc.335.

Seid S. (2016). Farmers' Perception of and Adaptation to Climate Change and Variability: The Case of Assosa District, Western Ethiopia. Journal of Natural Sciences Research: Vol.6 (17):117-122.

Simpson, B., &Burpee, G. (2014).*Adaptation Under the New Normal of Climate Change : The Future of Agricultural Extension and Advisory Services. Modernizing Extension and Advisory Services Project.USAID*. Washington, DC.

Singh, G.S. (2017). Traditional agriculture: A climate-smart approach for sustainable food production. DOI: 10.1007/s40974-017-0074-7. Banaras Hindu University, Varanasi, India.

Smit, B. &Wandel, J. 2006.Adaptation, adaptive capacity and vulnerability. Global Environmental Change, 16: 228–292.

Smith, P. (2009). Synergies Among Mitigation, Adaptation and Sustainable Development. In: Nelson, G.C. (Ed.) Agricultural and Climate Change: An Agenda for Negotiation in Copenhagen. International Food Policy Research Institute.

Solomom, S., Qin, D., Manning, M., Chen, Z., Marqius, M., Averyt, K. B., Tignor, .& Miller, H.L. (Eds.) (2007).*The physical basics. Contribution of working group one to the fourth assessment report of IPCC*. Cambrigde, UK: Cambridge University Press

Storck, H., Berihanu Adnew, Bezabih Emana, and Shimelis WoldeHawariat. 1991. Farming system and farm management practices of smallholders in Harareghe highlands.Farming systems and resource economics in the tropics, vol. 11, Wirtschafts- Verlagvauk, Kiel, Germany.

Technical Centre for Agriculture and Rural Cooperation (CTA) (2008). *Implications of climate change for sustainable agricultural production system.*Ouaguaougou, Burkina Faso.

Tessema, Y.A., C.S Aweke, G.S Endris, 2013. Understanding the process of adaptation to climate change by small-holder farmers: the case of east Hararghe Zone, Ethiopia. *Agricultural and Food Economics*, available athttp://www.agrifoodecon.com/content/1/1/13, Accessed on 10 Nov, 2013.

Tesso, G., B. Emana, M. Ketema, 2012. Econometric analysis of local level perception, adaptation and coping strategies to climate change induced shocks in North Shewa, Ethiopia. International Research Journal of Agricultural Science and Soil Science, 2(8): 347-363

Thornton, P.K, Boone, R.B. and Ramirez-Villegas, J. 2015. Climate change impacts on livestock. CCAFS Working Paper No. 120. Copenhagen, Denmark: CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS).

Umunakwe, P. C. (2011). *Strategies for climate change adaptation among rural households in Imo state, Nigeria*. (Unpublished M. Sc Thesis). University of Nigeria, Nsukka, Enugu state, Nigeria.

United Nations Framework Convention on Climate Change- UNFCCC (1992).*Full text of the convention.*Available online at http://unfccc.int/essential_background/convention/background/items/2536.php, retrieved on 12th March 2012

United Nations Environmental Protection Agency (UNEPA), (2012). Available online: http://www.epa.gov/climatechange/impacts-adaptation/health.html ; retrieved on 3rd October, 2012

UNDP (2013).*Climate change*. Available online: http://www.undp.org/climatechange/adapt/basics3.html .

World Bank.*Climate Change and Development*; World Bank: Washington, DC, USA, 2009.

Wossen, T., Berger, T., Mequaninte, T., &Alamirew, B. (2013). Social network effects on the adoption of sustainable natural resource management practices in Ethiopia. *International Journal of Sustainable Development & World Ecology*, *20*(6), 477–483.

www.climatechangechallenge.org/Resources%20centre/Climate-Change/3-what-causesclimate-change.htm .

www.ecy.wa.gov/climatechange/whatis.html .

www.worldwildlife.org/climate/publications/WWFBinaryitem4926.pdf .

Yamane, T. 1967. Statistics, an Introductory Analysis, 2nd Ed., New York: Harper and Row.

Appendices

Appendix 1 Parameter estimates of multinomial adaptation model

. mlogit SMLADST SEX Age FAMSZ EDUCN FARMSZ LVOW EXCT CRSR INCC NNFIC MARKA, baseoutcome(1)

Iteration 0: log likelihood = -249.97701

Iteration 1: log likelihood = -174.73282

Iteration 2: log likelihood = -170.00765

Iteration 3: log likelihood = -168.64628

Iteration 4: log likelihood = -162.25757

Iteration 5: log likelihood = -157.62476

Iteration 6: log likelihood = -155.29067

Iteration 7: log likelihood = -154.54371

Iteration 8: log likelihood = -153.33471

Iteration 9: log likelihood = -153.30948

Iteration 10: log likelihood = -153.30942

Iteration 11: log likelihood = -153.30942

Multinomial logistic regression Number of obs = 148

LR chi2(55) = 193.34

Prob> chi2 = 0.0000

Log likelihood = -153.30942 Pseudo R2 = 0.3867

SMLADST	Coef. Std. Err.	z	P>z	[95% Conf.	Interval]
Changing planting dates	(base outcome)				
Crop_diversification					
SEX	-2.219351 1.009641	- 2.20	0.028	-4.198211	- .2404915
Age	.1176866 .0310467	3.79	0.000	.0568362	.1785369
FAMSZ	.1074123 .2624518	0.41	0.682	-.4069838	.6218084
EDUCN	.3840818 .1854126	2.07	0.038	.0206798	.7474838
FARMSZ	-.9556033 .6300415	-	0.129	-2.190462	.2792553

		1.52			
LVOW	-.0006424 .2004063	-0.00	0.997	-.3934315	.3921467
EXCT	.0673523 .8696201	0.08	0.938	-1.637072	1.771776
CRSR	-3.523443 .9122847	-3.86	0.000	-5.311488	-1.735398
INCC	-.4159177 .8663433	-0.48	0.631	-2.113919	1.282084
NNFIC	-.217782 .8484645	-0.26	0.797	-1.880742	1.445178
MARKA	-.3623478 .1918459	-1.89	0.059	-.7383589	.0136633
_cons	-2.227111 2.439409	-0.91	0.361	-7.008265	2.554043
Planting_keeping_drought_toleran					
SEX	1.481799 1.430757	1.04	0.300	-1.322434	4.286032
Age	.0185606 .0273489	0.68	0.497	-.0350423	.0721635
FAMSZ	.8724344 .3072861	2.84	0.005	.2701647	1.474704
EDUCN	.0733975 .191606	0.38	0.702	-.3021434	.4489384
FARMSZ	-1.649291 .6398965	-2.58	0.010	-2.903465	-.3951169
LVOW	.3738294 .1856363	2.01	0.044	.009989	.7376698
EXCT	-1.225825 .7293604	-1.68	0.093	-2.655345	.2036954
CRSR	-2.118213 .7862771	-2.69	0.007	-3.659288	-.5771381
INCC	3.918254 1.329279	2.95	0.003	1.312915	6.523594
NNFIC	.0692638 .7363243	0.09	0.925	-1.373905	1.512433
MARKA	-.2607164 .1532868	-1.70	0.089	-.5611529	.0397202
_cons	-7.878279 2.999694	-2.63	0.009	-13.75757	-1.998987
Use_of_agro_forestry					
SEX	-.4807347 1.14605	-0.42	0.675	-2.726951	1.765482
Age	.1067377 .0302327	3.53	0.000	.0474828	.1659926
FAMSZ	.2256166 .2647038	0.85	0.394	-.2931933	.7444265
EDUCN	.3688602 .1868721	1.97	0.048	.0025975	.7351229
FARMSZ	-.5296014 .6265615	-0.85	0.398	-1.757639	.6984366
LVOW	.124068 .1902571	0.65	0.514	-.248829	.4969649
EXCT	-1.807843 .8056054	-2.24	0.025	-3.386801	-.2288857
CRSR	-4.097745 .9412138	-	0.000	-5.94249	-2.253

		4.35			
INCC	.4309073 .8837067	0.49	0.626	-1.301126	2.162941
NNFIC	-.9129164 .7974792	-1.14	0.252	-2.475947	.650114
MARKA	-.4574866 .1916126	-2.39	0.017	-.8330403	-.0819329
_cons	-2.591215 2.432898	-1.07	0.287	-7.359608	2.177177
Diversifying_sources_of_livelihо					
SEX	1.295389 1.488824	0.87	0.384	-1.622652	4.21343
Age	.0270313 .0309983	0.87	0.383	-.0337243	.0877868
FAMSZ	.0564412 .3092787	0.18	0.855	-.5497339	.6626162
EDUCN	.6645557 .1859176	3.57	0.000	.3001639	1.028947
FARMSZ	-3.817951 1.515128	-2.52	0.012	-6.787546	-.8483549
LVOW	-.0829211 .2402293	-0.35	0.730	-.5537619	.3879196
EXCT	-.9862291 .8453021	-1.17	0.243	-2.642991	.6705327
CRSR	-.6666081 .9452304	-0.71	0.481	-2.519226	1.18601
INCC	.564502 .9926843	0.57	0.570	-1.381123	2.510127
NNFIC	.3128346 .9071973	0.34	0.730	-1.465239	2.090909
MARKA	-.3935671 .2112082	-1.86	0.062	-.8075276	.0203935
_cons	-1.678492 2.784465	-0.60	0.547	-7.135943	3.778958
Soil_and_water_conservation_tech					
SEX	.2592862 1.585739	0.16	0.870	-2.848705	3.367277
Age	-.0716293 .0546503	-1.31	0.190	-.178742	.0354834
FAMSZ	-.7214329 .3422102	-2.11	0.035	-1.392153	-.0507132
EDUCN	.0250564 .2907042	0.09	0.931	-.5447134	.5948262
FARMSZ	-.0188606 .0953579	-0.20	0.843	-.2057586	.1680373
LVOW	.031789 .2670217	0.12	0.905	-.4915639	.5551418
EXCT	.4467295 1.410237	0.32	0.751	-2.317285	3.210744
CRSR	-.2966348 1.205412	-0.25	0.806	-2.6592	2.06593
INCC	-.7230372 1.35803	-0.53	0.594	-3.384726	1.938652
NNFIC	-.2210666 1.308899	-	0.866	-2.786462	2.344329

		0.17			
MARKA	-.357418 .332047	- 1.08	0.282	-1.008218	.2933822
_cons	6.381218 3.710495	1.72	0.085	-.8912189	13.65366

Appendix 2 marginal effect from multinominallogit adaptation model

margins,dydx(*)

Average marginal effects Number of obs = 148

Model VCE : OIM

dy/dx w.r.t. : SEX Age FAMSZ EDUCN FARMSZ LVOW EXCT CRSR INCC NNFIC MARKA

1._predict : Pr(SMLADST==Changing_ planting _date), predict(pr outcome(1))

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

3._predict : Pr(SMLADST==Planting_keeping_drought_toleran), predict(pr outcome(3))

4._predict : Pr(SMLADST==Use_of_agro_forestry), predict(pr outcome(4))

5._predict : Pr(SMLADST==Diversifying_sources_of_liveliho), predict(pr outcome(5))

6._predict : Pr(SMLADST==Soil_and_water_conservation_tech), predict(pr outcome(6))

	Delta-method					
	dy/dx	Std. Err.	Z	P>z	[95% Conf.	Interval]
SEX						
_predict						
1	-.0208949	.0851569	-0.25	0.806	-.1877994	.1460096
2	-.2495168	.0660272	-3.78	0.103	-.3789277	-.120106
3	.1895916	.1429066	1.33	0.185	-.0905001	.4696833
4	-.0271971	.1026991	-0.26	0.791	-.2284836	.1740895
5	.100193	.0974537	1.03	0.304	-.0908128	.2911987
6	.0078242	.044582	0.18	0.861	-.079555	.0952034
Age						
_predict						
1	-.0042047	.0021098	-1.99	0.046	-.0083399	-.0000694
2	.0066905	.0015563	4.30	0.000	.0036401	.0097408
3	-.0038387	.0017702	-2.17	0.134	-.0073083	-.0003691
4	.0063998	.0016708	3.83	0.000	.0031251	.0096745
5	-.0016206	.0014794	-1.10	0.273	-.00452	.0012789
6	-.0034264	.0017789	-1.93	0.254	-.006913	.0000603

FAMSZ						
_predict						
1	-.0265368	.0186625	-1.42	0.155	-.0631146	.0100411
2	-.0116424	.0183772	-0.63	0.526	-.0476611	.0243762
3	.0912155	.0248737	3.67	0.000	.0424639	.1399672
4	-.0061137	.0207652	-0.29	0.768	-.0468127	.0345853
5	-.0186228	.0176641	-1.05	0.292	-.0532439	.0159982
6	-.0282998	.0113539	-2.49	0.513	-.0505529	-.0060466
EDUCN						
_predict						
1	-.0265469	.0143995	-1.84	0.065	-.0547693	.0016756
2	.0109982	.0117622	0.94	0.350	-.0120553	.0340517
3	-.0266031	.0143841	-1.85	0.164	-.0547954	.0015893
4	.0123139	.0130688	0.94	0.346	-.0133006	.0379284
5	.0355574	.0076581	4.64	0.000	.0205477	.050567
6	-.0057195	.008088	-0.71	0.479	-.0215716	.0101326
FARMSZ						
_predict						
1	-.140392	.5420974	-3.33	0.001	-.0578825	.2229014
2	.0108809	.0544004	0.20	0.841	-.0957419	.1175037
3	-.0621447	.0667963	-0.93	0.352	-.1930631	.0687737
4	.1011071	.0599917	1.69	0.092	-.0164745	.2186887
5	-.2204055	.1048127	-2.10	0.035	-.4258346	-.0149765
6	.0301702	.0156657	1.93	0.054	-.000534	.0608744
LVOW						
_predict						
1	-.0139729	.0154159	-0.91	0.365	-.0441875	.0162416
2	-.0110215	.0139057	-0.79	0.428	-.0382761	.0162332
3	.0398741	.0146022	2.73	0.006	.0112544	.0684939
4	.0031507	.0140527	0.22	0.823	-.0243921	.0306935
5	-.0171361	.0138872	-1.23	0.217	-.0443546	.0100824
6	-.0008944	.0071689	-0.12	0.901	-.0149451	.0131564
EXCT						
_predict						
1	.0797625	.0602289	1.32	0.185	-.038284	.1978091
2	.1237727	.0640089	1.93	0.053	-.0016824	.2492277
3	-.0566562	.0577812	-0.98	0.327	-.1699053	.056593
4	.1608886	.0612267	2.63	0.009	.2808907	.7408865
5	-.0160742	.0460714	-0.37	0.711	-.1073724	.073224
6	.0310837	.0415236	0.75	0.454	-.0503011	.1124685
CRSR						
_predict						
1	.2253172	.0544882	4.14	0.2415	.1185223	.332112
2	-.123089	.0573903	-2.14	0.132	-.2355718	-.0106061

3	-.0229904	.0580356	-0.40	0.692	-.136738	.0907572
4	-.2372162	.0685471	-3.46	0.301	-.371566	-.1028663
5	.1214059	.0489858	2.48	0.013	.0253954	.2174163
6	.0365725	.0293268	1.25	0.212	-.020907	.0940521
INCC						
_predict						
1	-.1302953	.0717963	-1.81	0.070	-.2710134	.0104228
2	-.1332019	.0545985	-2.44	0.315	-.2402131	-.0261907
3	.4256429	.1159481	3.67	0.000	.1983887	.652897
4	-.0702784	.062742	-1.12	0.263	-.1932504	.0526935
5	-.0487165	.0576833	-0.84	0.398	-.1617738	.0643407
6	-.0431507	.0384376	-1.12	0.262	-.118487	.0321856
NNFIC						
_predict						
1	.016027	.0632164	0.25	0.800	-.107875	.1399289
2	.0153617	.0639948	0.24	0.810	-.1100658	.1407893
3	.0364208	.0628444	0.58	0.562	-.086752	.1595937
4	-.1046749	.0651469	-1.61	0.108	-.2323605	.0230107
5	.040691	.0556639	0.73	0.465	-.0684082	.1497903
6	-.0038257	.0385528	-0.10	0.921	-.0793877	.0717364
MARKA						
_predict						
1	.0344897	.0115763	2.98	0.003	.0118005	.0571789
2	-.0039782	.0161534	-0.25	0.805	-.0356383	.0276818
3	.0032208	.0143051	0.23	0.822	-.0248168	.0312583
4	-.0204971	.0177402	-1.16	0.248	-.0552673	.0142731
5	-.0085207	.0144413	-0.59	0.555	-.0368251	.0197838
6	-.0047145	.0099355	-0.47	0.635	-.0241877	.0147588

Appendix 3 Contingency coefficient for discrete variable.Correlate sex EXCT CRSR INCC NNFIC

(obs=148)

	sex	EXCT	CRSR	INCC	NNFIC
sex	1.0000				
EXCT	-0.0829	1.0000			
CRSR	-0.1157	0.0231	1.0000		
INCC	0.0682	-0.0009	0.0843	1.0000	
NNFIC	-0.0781	0.1133	0.0950	0.2148	1.0000

Appendix4 Variance of inflation factor factor for continuous variable

. estatvif

Variable	VIF	1/VIF
Age	1.12	0.893135
LVOW	1.10	0.910450
EDUCN	1.05	0.950192
MARKA	1.04	0.958161
FAMSZ	1.03	0.974373
FARMSZ	1.02	0.980877
Mean VIF	1.06	

Appendix 5 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 AGRICULTURE
FUCALITY OF GENDER, ENVIRONMENT AND DEVELOPMENT STUDIES
QUESTIONNAIRE FOR HOUSEHOLD HEADS

Dear Respondents: the main objective of this questionnaire is to understand Adaptation practices to climate change in Loka abaya woreda, Sidama National Regional State , Ethiopia. This type of local level study is important for planners as well as decision makers at different level. Therefore, the information that you provide is believed to help the concerned bodies in understanding effect of climate change and adaptation strategies on it. Hence, taking the above objectives into consideration, you are kindly asked to provide the appropriate answer for the following questions.

PRELIMINARY QUESTIONS

Date of interview_________________ Questionnaire number_____________________

Name ___________________________ Kebele ___________________________________

Address/Village __________________ Phone No.________________________________

Part I. General Information

1. Socio-economic characteristics of household head

1.1 Age of household head _______

1.2 Sex of household head a) Female b) Male

1.3 Family size ______

1.4 Educational qualification a. None ( ) b. FSLC ( ) O' level certificate ( ) d. ond/nce ( ) e. Bachelors Degree or its equivalent ( ) f. Others please specify. ( ) _____________________________

1.5 What farm size do you own (ha)……………

1.6 Type of farming you engaged a. Crop farming ( ) b. Livestock farming ( ) c. Both ( )

1.7 If you engaged in crop farming what are types of crops that you produce? For what purpose do you produce?

Types of Crops grown	Area coverage in Ha	Home Consumption% Quintal /ha/	Commercial % Quintal /ha/
Maize			
Sorghum			
Potato			
Sweet potato			
Teff			
Wheat			
Barely			
Bean			
Pea			
Haricot bean			

1.8 Do you rear animals? (a) Yes [ ] (b) no [ ]

1.9 If you replied yes to Q.no 1.6 what Type of livestock do you have

S/N	Livestock type	Number
1	Cows	
2	Calves	
3	Heifers	
4	Oxen	
5	Bull calves	
6	Sheep	
7	Goat	
8	Poultry	
9	Horses	
10	Donkeys	
11	Mules	

1.8 What stock size of animal do you have………………

Institutional Characteristics

2. Do extension agents visit you? (a) Yes [ ] (b) No [ ]
2.1 If yes, how many times have extension agents visited you within the past one year……..

3. Do you have access to credit? (a) Yes [ ] (b) No [ ]

3.1 If yes, what was your source(s) of credit (1) institutional sources [ ] (2) non institutional sources

4. Have you had any training on climate change? (a)Yes [ ] (b) No [ ]
4.1 If yes, how many times have you had the training within the last two decades year [ ]

B. Perception of Climate Change and Variability

5. Have you observed any changes in climate? A) Yes B) No

5.1 If yes for earlier question how do you describe the climate condition of your area through time?

Indicators	**Response of sample farmers about climate change**				
Did you experience the change in climate?	**Yes**		**No**		
	Fully aware	**Somewhat aware**	**Not aware at all**	**Over all awarenes s**	**Rank**
Rainfall has decreased					
Unpredictable rainfall					
Rainfall starting earlier					
Rainfall starting latter					
Increase in recurrence of floods					
Temperature is getting warmer					
Occurrence of drought					
Duration of seasons is changing					
Planting date change					
Risk of crop and livestock disease has increased					

5.1 How much extents do you aware climate change? A) Nil, B) Low, C) Medium, D) High

5.2 What are the main climate changes impacts that you have experienced? Explain the impacts associated with climate change:

-In terms of crop production………………………………………………………………

-In terms of crop area production…………………………………………………………………….

-how do you describe crop and animal disease outbreaks/during climate change...

-Plant species ………………………………………………………………………………….

-Livestock productivity ……………………………………………………………………….

-River run off ………………………………………………………………………………….

-Income condition of household……………………………………………………………….

-Dependency on relief (Food security status)…………………………………………………

-Cost of food crops…………………………………………………………………………….

6. Adaptation practices

6.1 Do you use any practices that smooth the impacts of climate change while engaging in agricultural/livelihood activities? A) Yes, B) No

6.2 If your response is yes for q6.1 what are the main adaptation strategies that you are used to reduce the effects of climate change?

Farming related measures during climate change

- What farming mechanisms/techniques you apply to withstand drought?
- What are the most effective ways of farming related measures to withstand drought and dry-spells? Why?
- Given to the frequency and intensity of drought, do you think engaging in farming related activities is effective? If yes, why? If no, why do you engage in then?

Mobility related measures

• Do you/your household members use mobility to manage drought related problems? If no, why? If yes, under what condition do you choose to migrate? Among household members, who will often move and why? Where is the common destination? How long the mobility will stay away?

• From your experience, do you think that mobility is effective way of managing drought in your life? Why/why not?

Diversification

• Do you engage in different activities other than farming as way of managing drought related problems in your living? If no, why? If yes, in what activities do engage in? (Probe for roles of different household members). Do you think that it is effective way of managing drought related problems? Why/why not?

6.3 State the level of intensity of the practice used by ticking the appropriate box;

S/no	Type of strategies	Very high intensification	High intensification	Low intensification
1	Planting/keeping drought tolerant crops/livestock			
2	Use of agro-forestry			
3	Changing planting dates			
4	Crop Diversification(Planting different crop varieties)			
5	Use of minimum tillage system (zero or minimum)			
6	Use of irrigation system/water storage			
7	Soil and water conservation techniques			
8	Reforestation/ Afforestation			
9	Diversifying sources of livelihood			
10	Out migration from climate risk areas			
11	Incomes from remittances			

Key Informant Interview (Agriculture and Rural Development Officials) questions

1. Are you originally from this kebele? How long have you been in the area?
2. How many times do you give advisory services?
3. In your opinion what is climate change?
4. Is there any form of climate change in your woreda or kebele? 1. Yes, 2.No
5. How do you communicate the climate change related information in your Woreda/ Kebele?
6. If you say yes to Q4; have you seen any long-term changes of temperature and rainfall for the last three decades? How do you detect, and what is the root cause to change?
7. Have you ever encountered any climate change related extremes in your local area?
8. Have you seen any incidence of disease or pest cases on animal and crop production? Over the past 36 years? (Explain)
9. Would you like to explain the extent of climate change effects on crop and livestock/ livelihood of your woreda/village/kebele?
10. What are the local coping mechanisms/adaptation choices the farmers used to reduce the climate change effects on agricultural activity/ livelihood?

13. What are the major challenges in alleviating the problem and what do you think should be done??

Points to be covered during Focus Group discussions.

General questions

1. How do you explain the agricultural trend; crop and livestock production and productivity in this area?
2. What are the major limiting factors of the crop and livestock production? What is the reason for this?
3. If you agree there is reduction in crop yield and livestock productivity what was the possible cause?
4. Is there any change in cropping/ seasonal calendars (seasons) in your farming area?
5. What methods the farmers used to withstand the existing changes of seasonal/cropping calendar?
6. What are the major activities undertaken by households to generate income other than agricultural practice?
7. Could you explain why your income source is lost or reduced?
8. Do you know what does climate change means? How do you explain the change? What would be the cause of these changes?
9. In the last three decades, how would you describe the rainfall pattern in terms of:-
    1.) Onset and Cessation/Off-set of rainfall
    2.) Rainfall amount/intensity
    3,) Seasonal rain distribution.
    4,) Temperature
10. Where did you hear climate change related information?
11. Do you think lack of access to information increase vulnerability to climatic shocks? How?
12. How do you explain frequency of Vulnerability to climate induced shocks?
13. What are the manifestations of climate change? Are flood, drought, and wurch (frost)frequently occurring? Does it impose impact on crop and livestock production?
14. What are the local adaptation strategies used by community to face climate change impact? In your opinions how the adopted strategies are productive for long-term?
15. Could you tell me why you are unable to adapt with climaztic shocks?

Thank you for your cooperation!

Biographical Sketch

The author was born in 1991 in Boricha woreda of Sidama region. He attended his primary and secondary school at Leku primary and secondary school ,and preparatory school at Hawassa in the same Region. He joined the Dilla University in 2010 academic year and graduated with B.Sc. degree in Natural Resource Management in June, 2012. Soon after his graduation, he was employed by Government Organization, as the Natural resource management at in the Boricha woreda, Sidama Region until August 2018, and then he joined the School of Graduate Studies at Hawassa University in 2018/19 academic year to pursue his MSc program in Climate change and sustainable agriculture.