CLIMATE CHANGE AND CHOICE OF ADAPTATION STRATEGIES AMONG SMALLHOLDER FARMERS IN SINANA DISTRICT OF BALE ZONE, SOUTH EASTERN ETHIOPIA

MSC

BY

BAISA KEBEDE



BALE ROBE, ETHIOPIA

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CLIMATE CHANGE AND CHOICE OF ADAPTATION STRATEGIES AMONG SMALLHOLDER FARMERS IN SINANA DISTRICT OF BALE ZONE, SOUTH EASTERN ETHIOPIA

A Thesis Submitted to the School of Graduate Studies Madda Walabu University in Partial Fulfillment of the Requirements for the Degree of Master of Science in Developmental Economics

Baisa Kebede

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APPROVAL SHEET
Maddawalabu University, School of Graduate Studies

This is to certify that the thesis entitled **"Climate Change and Choice of Adaptation Strategies among Smallholder Farmers in Sinana District of Bale Zone, South Eastern Ethiopia"** submitted to Department of Economics in partial fulfillment of the requirements for the degree of Master of Science in Developmental Economics, College of Business and Economics, Madda Walabu University, and is a record of original research carried out by Baisa Kebede under my supervision, and no part of the thesis has been submitted for any other degree or diploma. Therefore, I recommend that the student has fulfilled the requirements and hence hereby can submit the thesis to the department.

Sisay Debebe (PhD)	_____	_____
Name of Advisor	Signature	Date

We, the undersigned, members of the Board of Examiners of the final open defense by Baisa Kebede have read, evaluated his thesis entitled **"Climate Change and Choice of Adaptation Strategies among Smallholder Farmers in Sinana District of Bale Zone, South Eastern Ethiopia"**. This is, therefore, to certify that the thesis has been accepted in partial fulfillment of the requirements for the degree of Master of Science in Developmental Economics.

_____	_____	_____
Name of Chairperson	Signature	Date
_____	_____	_____
Name of Internal Examiner	Signature	Date
_____	_____	_____
Name of External Examiner	Signature	Date

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ACRONYMS AND ABBREVIATIONS

ACCCA	Advancing Capacity to support Climate Change Adaptations
CEEPA	Centre for Environmental Economics and Policy in Africa
CSA	Central Statistical Agency
FGD	Focus Group Discussion
IPCC	Intergovernmental Panel on Climate Change
MoFED	Ministry of Finance and Economic Development
NAPA	National Adaptation Program of Action
NMSA	National Meteorological Services Agency
PANE	Poverty Action Network Ethiopia
PCGCC	Pew Center on Global Climate Change
SDBoARD	Sinana District Bureau of Agriculture and Rural Development
SML	Simulated Maximum Likelihood
TLU	Tropical Livestock Unit
UKCIP	United Kingdom Climate Impact Program
UNFCCC	United Nations Framework Convention on Climate Change
WRI	World Resources Institute

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ABSTRACT

CLIMATE CHANGE AND CHOICE OF ADAPTATION STRATEGIES AMONG SMALLHOLDER FARMERS IN SINANA DISTRICT OF BALE ZONE, SOUTH EASTERN ETHIOPIA

The impact of climate change on agricultural activities in developing countries has been worsening overtime. The impact is mainly manifested by increasing temperature and decreasing precipitation levels that hurts severely overall agricultural production and productivity. This is particularly true in developing countries like Ethiopia where adaptive capacities are perceived to be low due to various factors. This study aims to identify farmers' adaptation strategies to climate change in Sinana district of Bale zone Oromia Regional State, south eastern Ethiopia. Both primary and secondary data sources were used for the study. Primary data were collected from a randomly selected 200 sample households through interview and focus group discussion. Relevant secondary data were also obtained from other secondary sources. To analyze the data, both descriptive statistics and Multivariate Probit Model were applied. The result of the model shows that the likelihood of households to adopt irrigation, improved varieties of crops, crop diversification and soil conservation practices were 45.8%, 52.4%, 64.9%,and 41.2%, respectively. The result also shows that the joint probability of using all adaptation strategies was only 1.7% and the joint probability of failure to adopt all of the adaptation strategies was 3.3%. The model result also shows that that level of education, family size, land holding, use of credit, and access to media, extension contact, farm income, non-farm income, age, and market distance have a statistically significant impact on climate change adaptation strategies. Therefore, future policy should focus on awareness creation on climate change through different sources such as media and extension, facilitating the availability of credit especially to adaptation technologies, enhancing research on use of new crop varieties that are more suited to drier conditions, improving farmers farm and non-farm income earning opportunities, improving their educational level, and improving their access to markets. Moreover, providing necessary inputs and giving fair professional service can help to build adaptive capacity of smallholder farmers.

Key words: Climate change; Multivariate Probit Model; Sinana district of Bale zone, South Eastern Ethiopia

1. INTRODUCTION

1.1. Background of the Study

Climate change has become increasingly apparent that it is already happening, and will continue to happen, bringing with its local impacts on people's livelihoods in last decades (Parry *et al.,* 2010). The threat of global climate change has caused concern among scientists as livelihoods, agricultural production and food security of the smallholders could be highly affected by changes in main climate variables (rainfall and temperature). Climate change could have negative effect on various economic activities and biophysical like human health, water resource, agriculture, forestry, biodiversity and wildlife. The consequences of climate change are hurt in third World smallholding peasant agriculture because it is rain-fed and relies on the source of nature (World Bank, 2010).

Agriculture affect climate and Climate change also affects agriculture. Its impact on agriculture in developing countries has been increasing. Higher temperature and changing precipitation levels caused by climate change decreases crop yields. This is particularly true in low-income countries, where adaptive capacities are perceived to be low. Many African countries which have economies largely based on weather condition agriculture are vulnerable to climate change. However, the rapid frequency of climate change, along with increasing socioeconomic pressures, threatens to overwhelm their ability to cope. Ethiopia is especially vulnerable to climate variability and change because large segments of the population are poor and depend on agricultural income, which is highly depends on rainfall variability and change in temperature. Most of the farmers have low access to education, information, technology, and basic social and support services, and, as a result, have low adaptive capacity to deal with the consequences of climate variability and change (Oxfam, 2013).

Ethiopia is challenged by both social and natural problems. The main social problem is poverty. It is estimated that 30% of the total population live under the international poverty line (MoFED, 2012). Poverty in the country is associated with high human population growth, low level of institutional setup and infrastructural setup, low technological level employed especially in the agricultural sector which dominates the economy of the country (Assefa and Berihanu, 2010). Frequent drought is the main environmental problem of the country. As the

agriculture of the country more depends on rainfall, drought highly affects agricultural production and livelihood of the smallholder farmers. Droughts in Ethiopia can shrink household farm production by up to 90% of a normal year output and could lead to the death of livestock and human beings (World Bank, 2009).

Flood and hailstorms are the other natural extreme events that affect Ethiopian farmers although not pronounced like the case of drought. Ethiopia was identified among the countries with the major flood events around the world in 2009 (World Bank, 2009). Ethiopia experienced drought early in 2006, but it also suffered severe floods in early August of that year killed more than 200 people in the eastern part of the country. In response to the frequent droughts and related environmental calamities, farmers in Ethiopia have developed different coping strategies (Devereux and Guenther, 2010).

There was a very high variability of rainfall over the past 50 years in Ethiopia. Rainfall trend during the last half century significantly reduced in the north, west, south and south-east parts of the country while an increasing trend has been observed in the central parts of Ethiopia during the dry season (NMSA, 2010). This has already led to a decline in agricultural production, and cereal production is expected to decline still further under moderate global warming (Ringer, 2011). Moreover, it has led to shortage of food, a decline in biodiversity, and increases in human health problems, rural-urban migration and dependency on external support. Rainfall in Ethiopia is projected to continue the trend that has been observed. Likewise, both mean maximum and minimum temperature have shown positive trend and on average a 1.3°C increase has observed between 1960 and 2009(NMSA, 2007). According to McSweeney *et al*. (2012) temperature projection on the coming decades shows an average increase of 1.1 to 3.1°C by the 2060s, and 1.5 to 5.1°C by the 2090s.This will increase the vulnerability of smallholder farmers to the harmful effects of climate change in the future.

Oromia National Regional State is the most affected region in Ethiopia due to climate change and variability. The overall natural resources base of the region is highly degraded. This initial potential together with the current global warming aggravates the vulnerability of the people to climate change impacts. Various reports agree that the region has been facing droughts that have occurred in the country indicating susceptibility of the region to climate change.

Adaptation can be viewed as reducing the severity of many impacts if adverse conditions prevail. That is, adaptation reduces the level of damages that might have otherwise occurred. The fact that climate has been changing in the past and continues to change in the future implies the need to understand how farmers perceive climate change and adapt in order to guide strategies for adaptation in the future. Studies indicate that farmers do perceive that climate is changing and that they adapt to reduce the negative impacts of climate change (David *et al*., 2010; Mertz *et al.,* 2012). Studies further show that the perception or awareness of climate change (Semenza *et al*., 2011; Akter and Bennett, 2012) and selection of adaptive measures (Maddison, 2009; Hassan and Nhemachena, 2011) is influenced by different socio-economic and environmental factors.

However, adaptation is a risk-management strategy that is not free of cost. The success of adaptation strategy depends critically on the availability of necessary resources, not only financial and natural resources, but also knowledge, technical capability, and institutional resources (PCGCC, 2007).

1.2. Statement of the Problem

Agricultural sector is the sector which is the back bone of Ethiopian economic growth. It comprises about 45% of GDP, generates 90% of foreign exchange earnings and employs more than 80% of the population (MoFED, 2012).Despite its high contribution to the overall economy, the sector is affected by a lot of factors that related by climate problems like flood and drought. It has been indicated that agriculture is the most vulnerable sector for climate change (Temesgen *et al.,*2012). This could be attributed to the fact that climate change affects the most important agricultural inputs, precipitation and temperature (Gebreegziabher *et al*., 2012)

Understanding farmers' responses to climatic impact and climate changes are crucial in choosing appropriate adaptation strategies (Mohmud *et al*., 2011). The vulnerability of developing countries is due to weak institutional capacity, limited engagement in environmental and adaptation issues, and a lack of substantiation of local knowledge (Adams *et al*., 2011). Farmers of Sinnana district, like farmers in any other part of Ethiopia, are suffering from Climate change which has become common natural disasters in the country. First, the crop and livestock production has been frequently hit by droughts, and floods.

Second, Annual River runoff and water availability has been reported to decrease dramatically. Third, Food insecurity in the area is a major challenge and all these climate shocks have worse negative impacts on the livelihood of poorer farm households as they have the lowest capacity to adapt to changes in climatic conditions. Fourth, there has been more erratic and un reliable rainfall in the rainy seasons, bringing drought and reduction in crop yields and plant varieties; the rainfall especially in the later rains towards the end of the year has been reported as coming in more intense and destructive downpours, bringing floods, landslides and soil erosion. (SDBoARD, 2012).Generally, this diverse climate in the study area influences the livelihood activities of the farming community. However, farmers in the study area have been responding to climate change through various adaptation strategies. The information obtained in various literatures was insufficient and general, but adaptation strategies vary contextually and spatially (among communities and even among individuals).

Furthermore, the literature on climate change has paid little attention to the analysis of factors influencing adaptation strategies chosen by smallholder households to adapt the impact of climate change. Thus, these are the gaps of knowledge that this study intends to bridge. Generally, in the study area research with regard to identification of farmers' adaptation strategies, factors affecting farmers' choices of adaptation strategies is either scanty or it is not in a way policy makers and practitioners can use them. Therefore, an assessment of adaptation strategies and factors influencing farm-level adaptation strategies brings more insights and recommend policies and investment strategies that help moderate potential unfavorable consequences of long-term climate change stresses. Because smallholder farmers tend to have a low capacity to adapt the changes in climatic conditions, policies that help these farmers adapt to climate change and associated climatic extremes are particularly important.

1.3. Research Questions

This study will try to answer the following research questions:

1. What are the major strategies used by the farmers in order to adapt climate change impacts?

2. What are the demographic, economic, institutional and social factors that affect the use of adaptation practices against climate change in the study area?

1.3. Objectives of the Study

1.3.1. General objective

The general objective of this study is to analyze climate change and choice of adaptation strategies among smallholder farmers.

1.3.2. Specific objectives

- To identify the implementation of adaptation strategies by farmers in response to climate change; and
- To identify the determinants of choice of adaptation strategies among smallholder farmers.

1.4. Significance of the Study

There is a sense of urgency in the country to improve the livelihoods of the destitute mass. The priorities of the national policies, sector strategies and programmer of the government are primarily targeted promoting rural and agricultural development and poverty reduction. Sustainable livelihood improvement, however, cannot be achieved without effective and efficient response to adverse impacts of climate change because climate change directly affects income, food security and nutrition. However, there is lack of sufficient information on the process of climate change adaptation options that are essential for policy makers, development practitioners and farmers.

The outcome of this study is expected to be useful for governmental and non-governmental institutions who are involved in process of reducing vulnerability of the rural poor to the adverse effect of climate change and also maintain household 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, 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.

1.5. Scope and Limitations of the Study

This study aims at identifying farmers' adaptation options against climate change impacts and their determinants in Sinnana district. The research is confined to only Sinnana district, which

can somehow represent other districts with similar agro-ecological conditions in the region and Bale zone. 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 due to, varying agro-ecological and socioeconomic diversity in the country. The other limitation of the study is use of cross-sectional data to assess smallholder farmers' adaptation strategies in the study area.

1.6. Organization of the Study

The study is structured in five main chapters. The first chapter has described the introduction of the study that includes the background, problem statement and objectives of the study. Chapter 2 presents theoretical perspectives and empirical evidences related to the main themes of the study. Chapter 3 discusses the methodological approach of the study that includes the method of data collection, analysis and hypothesis of the study. Results obtained from the study are presented and discussed in detail in chapter 4. Finally, conclusions and recommendations of the study are presented in chapter 5.

2. LITRATURE REVIEW

2.1. Definition of Concepts and Terms of Climate change:

The UNFCCC (2010) defines climate change as "a change of climate that is attributed directly or indirectly to human activity that alters the composition of the global atmosphere, and that is in addition to natural climate variability over comparable time periods". The UNFCCC makes a distinction between 'climate change' that is attributable to human activities altering the atmospheric composition of the globe and 'climate variability' attributable to natural causes. By contrast, the IPCC takes a broader view on 'climate change' and states that climate change can occur as a result of natural variability and human activity.

Climate variability: Variations in the mean state and other statistics (such as standard deviations, the occurrence of extremes, etc.) of the climate on all temporal and spatial scales beyond that of individual weather events. Variability may result from natural internal processes within the climate system (internal variability) or from variations in natural or anthropogenic external forcing (external variability) IPCC (2004). IPCC (2007) describes vulnerability as the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including increased variability and downside risk. According to the NMSA (2004), long-term climate change in Ethiopia is associated with changes in precipitation patterns, rainfall variability, and temperature, which could increase the country's frequency of both droughts and floods. The stakeholder forums and NAPA's technical working groups sought participants' perceptions of the impacts of changing climatic conditions. According to participants, although both developed and developing countries are affected by climate change, developing countries face greater challenges in overcoming its adverse consequences. Low economic development, inadequate infrastructure, and lack of institutional capacity all contribute to the country's vulnerability to the adverse impacts of climate change. In addition, Ethiopia's economy is heavily dependent on agriculture and faces increasing population growth.

Negative climatic impacts on crop production could result in a nationwide food shortage and greatly hinder the economy. If appropriate steps are not taken, workshop participants felt that food insecurity, deepened poverty, and increased incidence of disease, such as malaria and yellow fever, would be likely consequences. The farming community was identified as the

most vulnerable because of its dependence on agricultural production for its livelihood. Within the farming community, small-scale, rain fed subsistence farmers as well as pastoralists were identified as more vulnerable to changing climatic conditions than others. In addition, farm households without assets and financial resources were identified as especially vulnerable, as their limited resources restrict them from easily adapting to the changing climate (NMSA, 2004).Adaptation to climate change: Adger *et al*. (2006) defines adaptation to climate change as an adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. Adaptation can be planned or autonomous.

Planned adaptation is implemented before the impacts of climate change are observed. This type of adaptation can respond to specific projected impacts of climate change. Autonomous adaptation does not constitute a deliberate response to climatic stimuli but is triggered by ecological changes in natural systems and by market or welfare changes in human systems. This type of adaptation often occurs at the community and local level. Action and policies by governments, international organizations and other stakeholders can often influence the autonomous adaptation action undertaken directly, for example by increasing the resources available on the ground, or indirectly through measures that shape the incentives, knowledge sharing and capacity available for autonomous adaptation. Adaptation is a process by which strategies to moderate, cope with and take advantage of the Consequences of climatic events is enhanced, developed, and implemented (UNDP, 2010). UKCIP (2006) also defined adaptation as the process or outcome of a process that leads to a reduction in harm or risk of harm, or realization of benefits associated with climate variability and climate change.

Resilience: Turner *et al.* (2006) defined resilience as the degree to which an impacted system rebounds or recovers from a perturbation. Climate change impacts necessitate responses and adjustments to the biophysical and social conditions which together determine exposure to climate hazards. These responses may occur in form of autonomous action or through public as well as private planned, individual and institutional mechanisms.

Mitigation: IPCC (2004) defined mitigation as a process of curbing greenhouse gas emissions from human activities, for example emissions from fossil fuels as well as deforestation, with a view to stabilizing greenhouse gas concentration at a safe level.

Adaptive capacity: Smit and Pilifosova (2004) defined adaptive capacity as the potential or capability of a system to adjust to climate change, including climate variability and extremes, to moderate potential damages, to take advantage of opportunities, or to cope with consequences.

2.2. Impact of Climate Change on Agriculture

Recent reports concluded that the increased concentration of greenhouse gases in the atmosphere will have a significant impact on the earth's climate in the coming decades (IPCC, 2010). Global warming would alter natural climate and environmental systems in many ways, leading to an increased frequency of weather events, rising sea levels and changes in precipitation patterns. These changes could impact socio-economic activities, with series implications for the well-being of humans long into the future. Temperature, radiation, rainfall, soil moisture and carbon dioxide (CO2) concentration are all important variables to determine agricultural productivity (Zhai and Zhuang, 2012).

Pant (2012) described that climate change is the largest threat ever faced the world as it affects the earth surface widely from tropical to arctic regions and from sea to land and atmosphere. Agriculture is one of the most vulnerable sectors to climate change. Determining the effect of climate change on agriculture is complex as it affects varieties of factors such as change in temperature, change in rainfall pattern and change in carbon dioxide levels (Aydinalp and Cresser, 2011).

Climate change affects agricultural production and productivity both directly and indirectly. It directly affects agriculture by affecting the weather variables such as temperature, solar radiation, rainfall, wind speed and humidity (Deschenes and Greenstone,2009;Sowunmi and Kintola,2012) and indirectly through disease and pest outbreak as well as favoring the development of climate related diseases like malaria that affect the work force(Ngigi,2012).Newton *et al*. (2013) also indicated that climate change affects the complex interactions between crop and pathogens leading to increased outbreak of pests and diseases. The impact of climate change on agricultural production is not uniform across regions of the world; low latitude and developing countries are expected to suffer more from global warming, reflecting their disadvantaged geographic location, greater agricultural share in their economies, and limited ability to adapt to climate change (Zhai and Zhuang, 2012). The

concern of food security and climate change in the developing world would be threatened due to anticipated to experience significant change in temperature and rainfall patterns, their developing economy heavily relay on climate sensitive business and they totally depend on agriculture as source of food, which seriously affects by climate change(Newton *et al*., 2013).

The impact of climate change on agricultural production is not uniform across regions of the world; low latitude and developing countries are expected to be affected more from global warming, such emissions are expected to rise in the coming decades due to population and income growth, amongst other factors. Within the agricultural sector, fertilizer application, livestock and manure management, rice cultivation, and patterns of land use are the major sources of emissions (WRI, 2011).

2.3. Farmers Perception of Climate Change

Sometimes farmers' perception about climate change not evidenced from weather monitoring stations (Maddison, 2009). In most parts of Ethiopia, people perceive declining in rainfall and increased in frequency of drought but it did not confirmed from weather station. Research report from Oxfam (2013) indicated that observations on metrological stations lack congruence with local farmers' perception. This lack of congruence could be due to the fact that farmers' assess rainfall in relation to the needs of particular crops at particular times; small changes in quality, onset, and cessation of rain over days or even hours can make a big difference, whereas meteorological data is more likely to measure totals and larger events. Maddison (2009) also argued that this lack of congruence between farmers' perception and meteorological records could emanate from the analysis of short term climate data and/or due to averaging of record from wider areas.

The degree of farmers' perception on climate change also depends on its impact on farmers' livelihood, their social, institutional and economic background. Mongi *et al.* (2013) indicated that farmers in Tanzania were able to note the climate change using different indicators like delay of onset and early retreat of rainfall resulted in shortening of growing period and frequent drought, increased temperature and frequency of flood. However, the degree of perception is different and depends mainly on level of education, livelihood activity, location and age. Moreover, this Perception is strongly related with level of education and sensitivity of the livelihood that the respondent depends on. Maddison (2009) also concluded that most

farmers in Africa perceive increased temperature and declined precipitation. Lema and Majule (2012) confirms similar situation in Tanzania.

2.4. Climate Change and Farmers' Adaptation Options

2.4.1. The need for climate change adaptation Consideration of actions

At the very beginning, the international climate effort has focused predominantly on mitigation strategies (reducing greenhouse gas (GHG) emissions) to prevent adverse effects of climate change (PROLINNOVA, 2012). However, mitigating efforts may reduce the emission process but never prevent completely. PCGCC (2009) noted that while steep reductions in emissions could stabilize atmospheric GHG concentrations at lower levels than under "business as usual," they likely would be well above current, let alone pre-industrial, levels.

e.g., mitigation policy-that can reduce the livelihood of adverse climate effect is reasonable and prudent, and has generally been the primary focus of public attention and policy efforts on climate change. However, recognition is increasing that the combination of continued increases in emissions and the inertia of the climate system means that some degree of climate change is inevitable. Even if extreme measures could be instantly taken to curtail global emissions, the momentum of the earth's climate is such that warming cannot be completely avoided (PCGCC, 2007).

Since climate is inherently variable for quite natural reasons, human societies have always and everywhere had to develop coping strategies in the face of unwelcome variations in climate or weather extremes (Adger *et al*., 2007; PCGCC, 2009).While mitigation can be viewed as reducing likelihood of adverse conditions, adaptation can be viewed as reducing the severity of many impacts if adverse conditions prevail. That is, adaptation reduces the level of damages that might have otherwise occurred (PCGCC, 2007).

Most developing countries are struggling to climate change impact, which already faced through introduction and/or modification of different adaptation mechanisms. Regardless of whatever mitigation policies and strategies designed and implemented, climate change will be the greatest challenge for developing countries that require planning for adaptation strategies to minimize the livelihood impact and resilience from the shock. Currently, much attention

has given to climate change adaptation and it becomes as integral component of major policies and strategies in Ethiopia.

The priorities of the national policies, sector strategies and Programs of the government are primarily targeted at promoting rural and agricultural development and poverty reduction. As a result, climate change and adaptation issues are often treated indirectly in sector specific policies and programs since climate impacts are considered as a subcomponent of the overall development goal particularly in relation to natural resources and environmental protection (PANE, 2012).

2.4.2. Farmers' adaptation options

Adaptation is widely recognized as a vital component of any policy response to climate change. Below *et al*.(2013) identified about 104 climate change related adaptation options in Africa, which they organized them in to five categories such as farm management and technology; farm financial management; diversification on and beyond the farm; government interventions in infrastructure, health, and risk reduction; and knowledge management, networks, and governance.

Adaptation measures for climate change depend on the level of understanding of the issue and consequences, the degree of impact and technological capacity of farmers. Changing of planting dates, changing of crop type, soil moisture conservation practices, expanding of farm lands, crop diversification and farm income diversification (causal labor) are repeatedly reported adaptation options under small scale and subsistence farmers (Mutekwa,2012).In this regard, Mongi *et al*.(2013) reported that farmers' in Tanzania used splitting of their farm land to different time of transplanting, expanding of farm lands, switched to more drought tolerant crop species and changing of crop types as adaptation option of reduced rainfall, which is resulted due to climate change. Hassan and Nhemachena (2011) generalized the farmers' adaptation options in Africa in two aspects: increased diversification, and protecting sensitive stage of crops through managing the crop to ensure not to overlap the critical stage with harsh conditions. In addition to changing crop varieties, farmers in Nigeria use 'fadama farming' (Ishaya and Adaje, 2011). Moreover, the report included that fertilizer application, increasing farm land and mulching also used as adaptation options against climate change. According to Oxfam (2013), in addition to adopting of improved varieties, farmers in western Tigray used

diversification to high-value crops such as spices and cosmetic plants, which are tolerant to moisture deficit. These commodities fetch higher prices and used the money to buy food crops.

2.5. Empirical Studies

Different studies regarding farmers' choice of adaptation options and their determinants were carried out in different countries including Ethiopia. In the following section review of the most important empirical studies are presented.

Adaptation is an essential strategy for reducing the severity and cost of climate change impacts. Adaptation measures help farmers guard against losses due to increasing temperatures and decreasing precipitation (IPCC, 2010). The analyses presented in this study identify the important determinants of use of various adaptation measures to provide policy information on which factors to target and how, so as to encourage farmers to increase their use of different adaptation measures.

The empirical adaptation literature shows that larger family size enable farmers to take up labor intensive adaptation measures and they will be more willing to choose the adaptations options such as soil conservation techniques, chemical treatments that are labor intensive (Aymone,2012) . Temesgen *et al*. (2011) also found that increasing household sizes insignificantly increase the probability of adaptation, though the coefficient on the adaptation options has a positive sign. Educated farmers are expected to have more knowledge and information about climate change and the agronomic practices that they can use in response (Maddison, 2009). He found that farmers' awareness of changes in climate attributes (temperature and precipitation) is important for adaptation decision making.

Temesgen *et al.* (2011) also found that education is important for soil conservation as adaptation strategies. Moreover, almost all of the marginal values of education are positive across all adaptation options. Various studies have shown that sex is significant variable affecting perception and adaptation decision at the farm level.

Temesgen *et al.* (2012) also found that male-headed households adapt more readily to climate change. Other study found that female headed households adapt more readily to climate change.

Large-scale farmers are more likely to adapt because they have more capital and resources (Hassan and Nhemachena, 2011; Aymone, 2012). Productive resources such as capital, land and labor serve as important factors for coping with and adapting to climate change. The choice of the suitable adaptation measure depends on factor endowments (i.e. family size, land area and capital resources) at the disposal of farming households (Hassan and Nhemachena, 2011).

Temesgen *et al.* (2011) found that farm income of the households has a positive and significant impact on conserving soil, using different crop varieties, and changing planting dates. In addition to farm income, nonfarm income also significantly increases the likelihood of planting trees, changing planting dates, and using irrigation as adaptation options.

Different studies have shown that access to credit increases the likelihood of adaptation (O'Brien *et al*., 2000; Temesgen *et al*., 2011; Aymone, 2012). A study in Tanzania, by O'Brien *et al*. (2003) reported that despite numerous adaptation options that farmers are aware of and willing to apply, the lack of sufficient financial resources to purchase the necessary inputs and other associated equipment (e.g., purchasing seeds, acquiring transportation, hiring temporary workers) is one of the significant constraints to adaptation. In addition, Aymone (2012) found majority of the farmers who did not adapt cited lack of financial resources as the main constraint to adaptation.

Better access to extension services was found to have a strong positive influence on the probability of choosing different adaptation measures (Aymone, 2012; Temesgen *et al*., 2012). Aymone (2012)argue that farmers who have access to extension services are more likely to be aware of changing climatic conditions and to have knowledge of the various management practices that they can use to adapt to changes in climatic conditions. Aemro *et al*. (2012) analyzed determinants of farm level climate change adaptation in Babile district of east Hararghe zone using multinomial logit. The result of their analysis showed that sex of the household head, age of the household head, education of the household head, family size, livestock ownership, household farm income, non/off-farm income, access to credit, distance to the market center, access to farmer-to-farmer extension, agro ecological zones, access to climate information, and extension contact have a significant impact on choices of climate change. Belaineh *et al.* (2013) identified determinants of climate change and variability

adaptation in Doba district of west Hararghe zone using multinomial logit model. The finding of their study shows that sex, land size and frequency of extension contacts have a significant and positive impact on crop based diversification coupled with soil and water conservation practices while family size, non-farm income and training have significant negative impacts. On the other hand, land size, and frequency of extension contacts are significantly and positively associated with integrated crop-livestock based diversification while family size, non/off-farm income and training are significantly and negatively associated. Similarly, plot size and frequency of extension contacts are significantly and positively associated with rainwater harvesting whereas off-farm income have a significant and positive relation.

The empirical literature review indicates that the factors that affect adaptation options differ from place to place and from time to time. This implies that there is a need for location specific study (knowledge) about the determinants of climate change adaptation options, so that appropriate policies are taken to reduce its negative effects.

2.6. Conceptual Framework of the Study

The success of climate change adaptation depends critically on the availability of necessary resources, not only financial and natural resources, but also knowledge, technical capability, and institutional resources. In addition, many social, economic, technological and environmental trends will critically shape the future ability to adapt to climate change. While such factors as increased population and wealth will likely increase the potential level of material assets that are exposed to the risks of climate change, greater wealth and improved technology also extend the resources and perhaps the capabilities to adapt climate change (PCGCC, 2007).

Farmers' choice decisions of adaptation strategies to climate change are determined by many factors. Many of these factors influence farmers' choice of adaptation strategies directly. These factors includes the household socio-economic (assets, on and off-farm income), demographic characteristics (sex, farming experience, literacy status), and institutional factors (extension service, market distance, credit). These are the most important variables identified by much literature in determining whether or not a household take adaptation strategies used to cope with the impact of climate change.

Generally, we can understand that different empirical studies have been carried out to see the direction and magnitude of the effect of different factors on farmers' decision behavior regarding choice of adaptation methods to climate change. A factor, which is found to enhance choice of a particular climate change adaptation option in one locality at one time, may hinder it or an irrelevant factor in another locality. In the same way, Ehui *et al*. (2007) pointed out that, although some known determinants tend to have general applicability; it is difficult to develop a universal model of the process of adaptation strategies with defined determinants and hypotheses that hold everywhere. This is difficult because the socio economic and ecological distinctiveness of the different sites and the dynamic nature of the determinants, since there is repeated need for analyses under different conditions.

It is very important to clearly understand what is happening at community level, because farmers are the most climate-vulnerable group. Hence, the following analytical framework depicted the most important variables expected to influence the farmers' choice of adaptation methods to climate change taking into account the specificity of Sinana District.

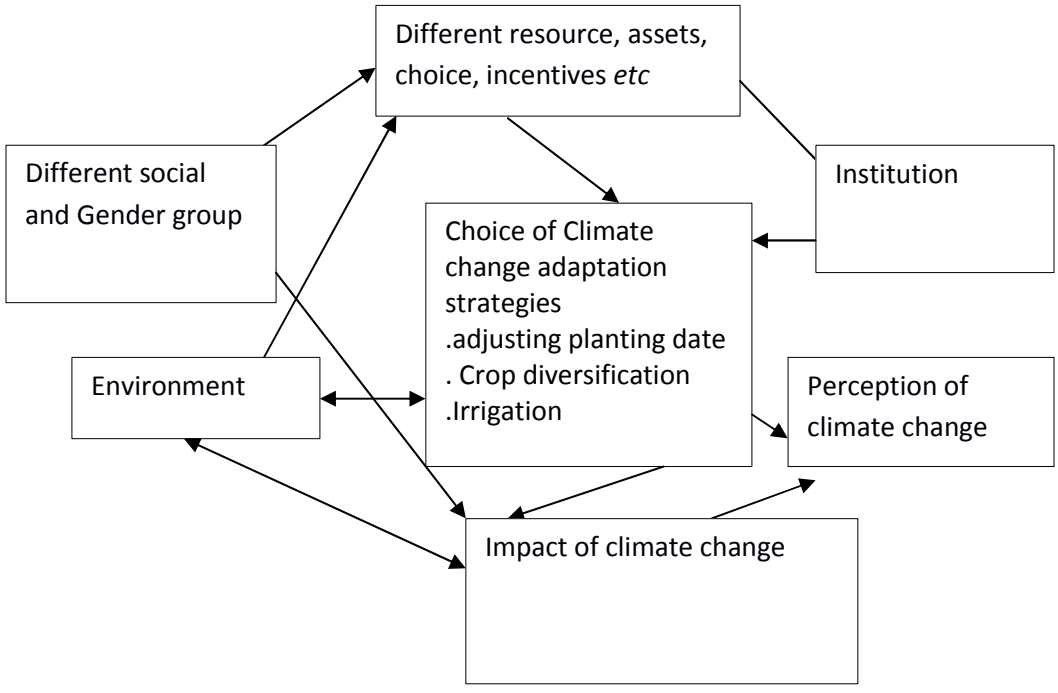


Figure 1: Conceptual framework of the study

3. RESEARCH METHODOLOGY

In this chapter, description of the study area, data sources and types, methods of data collection, sampling techniques and methods of data analysis are presented.

3.1. Description of the Study Area Location:

Bale zone is located on the boundary of South and West part of Genale River, east and north part of Wabe Shabele River. It is also bordered on the Eastern part with Somali National Regional State, in the North part with West Hararghe, in the North Eastern part with East Hararghe, in North Western part with Arsi, in Western part with East Arsi and on south and south western part with Guji zones.

Sinnana district, the study area, is one of the 18 districts of Bale zone. The district is bordered by Goba in south, Dinsho in west, Agarfa in Northwest, Goro and Ginnir in east, and Gasera in North

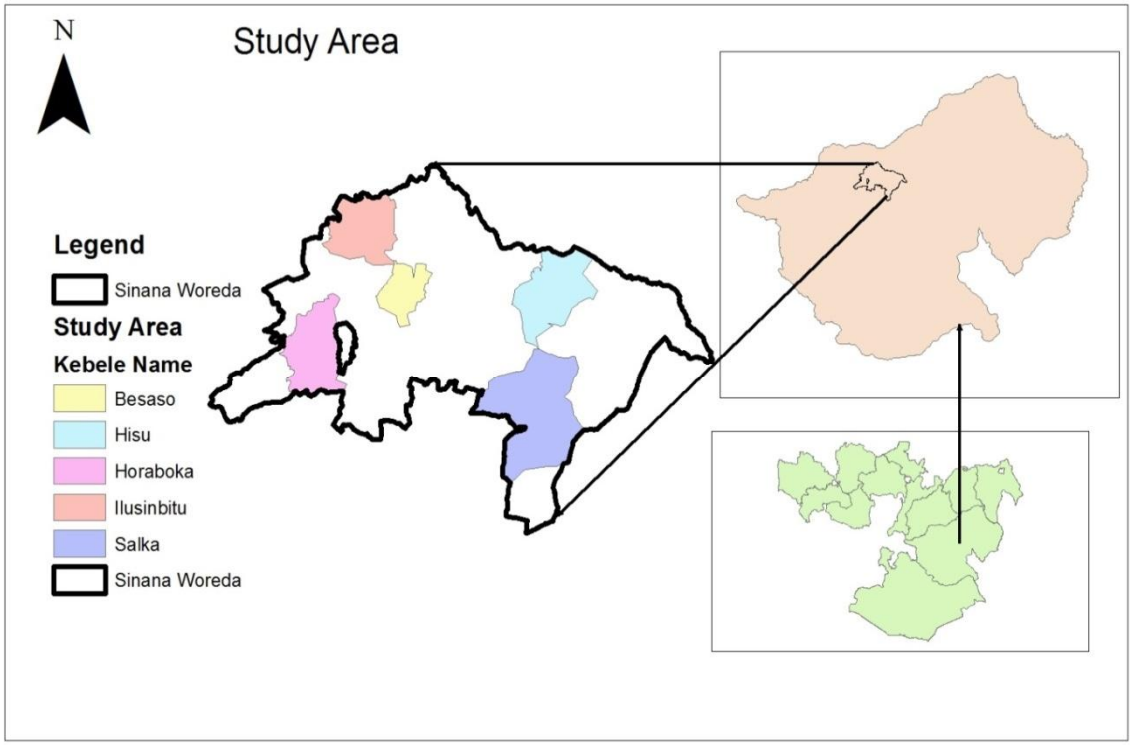


Figure 2: Map of study area

Demography: According to district data (2016) report a total household for this district 16260. From this estimated total household of the district, about 89.6% live in rural set-ups while the remaining 10.4% were urban dwellers. The two largest ethnic groups in Sinnana were the Oromo about 86.3%, Amhara (10.8%), and (2.9%) of the population are other. Afan Oromo is the language spoken with all. The majority of the inhabitants were Muslims followed by Ethiopian Orthodox Christianity and Protestants (CSA, 2010).

The climatic conditions of the Sinnana are categorized under tropical agro-climatic zone with Luvisol (dark brown or reddish & suitable soil for agriculture).The mean annual rain fall is 1200mm. In addition to this there are three rivers in it which flow throughout the year and can be used for different purposes. The rain is characterized by bimodal rain fall (Bona is stayed from July-late December and Gana is stayed from mid-March –August).

The crop production is dominated by rain fed agriculture while irrigation is practiced on small scale level using traditional stream diversion methods, underground water, and storing rain fall to produce horticultural crops. The major crops produced in Sinnana district are: wheat, barley, Beans, peens and oat. Farmers are plowing with a pair of an ox and sometimes tractor.

3.2. Data Types, Source and method of collections

The types of data that the researcher used were cross-sectional data and time series data from both primary source and secondary sources. Cross-sectional data was collected from farmers as primary data while time series data was collected from meteorological agency as secondary data.

The data collection was taken place in February and March 2018. The researcher also talk with people working in government agricultural offices concerned about climate change adaptation, and the study found data about the climate from National Meteorological Agency in Robe town.

3.2.1 Semi-Structured Interviews During the data collection

The researcher used some qualitative in-depth interviews in the beginning of the periods in each farmer's village or kebele .Ritchie and Lewis (2008: 148) write that "the aim of the in-depth interview is to achieve both breadth of coverage across key issues and depth of

coverage within each". Further, Ritchie and Lewis (2008: 141) state that "in an in-depth interview it is intended to combine structure with flexibility".

3.2.2 Questionnaire

The researcher used questionnaire for gathering additional information from both Farmers and agricultural office of Sinana district. Such data collection method is used to save time and energy.

3.2.3 Participant Observation

An important part of the research was also observation. The researcher will try to observe what the farmers doing during my visits to the villages for making interviews. Observation is not really data collection, but anyway, important parts of the field work because it gives the researcher a better understanding of the respondent's situation. It may be positive to try to see the situation through the local people's eyes.

3.2.4 Document Analysis

A lot of information and theory have been found through secondary data. Articles, books, and statistics are important parts of the thesis, not least in the former literature review in chapter 2.Data about the weather in Bale as a general and in Sinana as particular from Bale zone and Sinana agricultural office.

3.3. Sampling Size determination and Techniques

A two-stage random sampling technique was applied to select sample households. In the first stage, 5 Kebeles were randomly selected out of the total 20 rural Kebeles in the district. In the second stage, a total of 200 household heads were selected randomly using simple random sampling method proportion to their total population size. The reason for using simple random sampling is that the kebeles are located in the same agro-ecological zone. This method of sample selection gave each kebele and every household head in each kebele a chance of being included in the sample. Therefore, the sample selection was free of bias.

The study used a simplified formula provided by Yamane (1967) to determine the required sample size at 95% confidence level and margin of error 0.05

$\frac{Z^2PQ}{ME^2}$= n =143 ---------- (1)

Where Z is confidence interval (1.96); P is percentage of household live in rural area (89.6%), Q is percentage of household live in urban (10.4%), and ME is margin of error (0.05).

Since impact analysis needs relatively large samples (Holmes,2013), the researcher added 57 respondents as a reserve for possible errors and omissions and thus 200 sample smallholder farmers were included in sample size of the study.

Table 1: Sample size distribution

Keble	Population size	Proportion	Sample size
Hora Boka	1161	(1161 x200) / 7258	32
Bassaso	1343	(1343x200)/7258	37
Sanbitu	1706	(1706x200) 7258	47
Salka	1560	(1560x200) / 7258	43
Hisu	1488	(1488x200) / 7258	41
Total	7258	(1758x200) / 7258	200

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3.4. Methods of Data Analysis

Qualitative data obtained from focus group discussion and the review of documents were compiled, organized, summarized and interpreted. The quantitative data that were collected from survey was analyzed by employing descriptive statistical tools and multivariate probit model.

3.4.1. Descriptive analysis

Descriptive statistics such as mean, percentage and frequency were used to characterize farmers' perceptions on changes in long-term temperature and precipitation, to assess farmers' adaptation options and to explain the different socio-economic characteristics of the sample respondent.

3.4.2. Econometric analysis

Farmers are more likely to adopt a mix of adaptation strategies to deal with a multitude of climate induced risks and constrains than adopting a single strategy. Different studies in Africa used different empirical methods to analyze the determinants of adaptations to climate change and choice of adaptation strategies. Most commonly used analytical approaches include discrete choice regression models like the binary probit or logit (Fosu-Mensah *et al*., 2013; Acquah de, 2011), multinomial probit or logit and multivariate probit (ACCCA, 2013; Aemro *et al*., 2012). Other empirical studies used principal component analysis (Mandleni and Anim, 2011) and the Ricardian model (Kurukulasuriya and Mendelson, 2009).The short comings of most of the previous studies on adoption of climate change adaptation strategies are that they do not consider the possible inter-relationships between the various adaptation strategies (Yu *et al.,* 2011). These studies mask the reality faced by decision makers who are often faced with the alternatives that they may be adopted simultaneously and/or sequentially as complements, substitutes or supplements. Some recent empirical studies of technology adoption and climate change adaptation decisions assume that farmers consider a set (or

bundle) of possible technologies (strategies) that maximizes their expected utility (Kassie *et al*., 2012). Thus, the adoption decision is inherently multivariate and attempting univariate modeling excludes useful economic information contained in interdependent and simultaneous adoption decisions. Based on this argument, the study adopted multivariate probit (MVP) econometric technique to simultaneously model the influence of the set of explanatory variables on each of the different strategies, while allowing the unobserved and/or unmeasured factors (error terms) to be freely correlated (Lin *et al.,* 2008). The correlation may be positive correlation and negative correlation between different strategies (Belderbos *et al.,* 2007).

The dependent variable in the empirical estimation for this study is the choice of an adaptation option(s) from the set of adaptation measures (crop diversification, using improved crop varieties, use of irrigation and soil conservation practices). Following Lin *et al.* (2008), the multivariate probit econometric approach for this study is characterized by a set of m binary dependent variables Y_{hpj} such that:

$$Y'_{hpj}=X`_{hpj}\beta_j+U_{hpj} \qquad j=1, 2, ...m \text{ and} \qquad (2)$$

$$Y_{hpj}=\begin{cases}1 if Y'hpj>0\\ 0 otherwise\end{cases} \qquad (3)$$

Where j=1, 2 ...m denotes the climate change adaptation strategies available; $X`_{hpj}$ is a vector of explanatory variables, β_j denotes the vector of parameter to be estimated, and U_{hpj} are random error terms distributed as multivariate normal distribution with zero mean and unitary variance. It is assumed that a rational h^{th} farmer has a latent variable, Y'_{hpj} which captures the unobserved preferences or demand associated with the j^{th} choice of adaptation strategy. This latent variable is assumed to be a linear combination of observed household and other characteristics that affect the adoption of adaptation strategy, as well as unobserved characteristics captured by the stochastic error term. Given the latent nature of the variable $Y'_{hpj,}$ the estimation is based on the observable variable Y_{hpj} which indicates whether or not a household adopt a specific climate change adaptation strategy. Since adoption of several adaptation strategies is possible, the error terms in equation (2) are assumed to jointly follow a multivariate normal distribution, with zero conditional mean and variance normalized to unity. The off-diagonal elements in the covariance matrix represent the unobserved correlation between the stochastic component of the j^{th} and m^{th} type of adaptation strategies. This assumption means that equation (3) gives a multivariate probit model that jointly

represents decision to adopt a particular adaptation strategy. This specification with non-zero off-diagonal elements allows for correlation across error terms of several latent equations, which represent unobserved characteristics that affect choice of alternative adaptation strategies.

3.5. Definition of Variables and Hypotheses

3.5.1. Dependent variable of the model

The dependent variable (Y_i) in the empirical estimation model is the choice of an adaptation options from the set of adaptation measures. Changing crop varieties, changing crop types (crop diversification) , use of irrigation and soil conservation practices are some of the adaptation options for climate change in rain-fed agriculture of many African countries (Nhemachena and Hassan, 2010). The adaptation choices for this study are based on asking sample households the actions they take to counteract the negative impact of climate change and these include adjusting planting dates, use of improved crop varieties, crop diversification, using irrigation, and using soil conservation practices.

3.5.2. Independent variables of the model

Based on the findings of past studies on climate change adaptation strategies, the following variables are hypothesized to affect climate change adaptation strategies of smallholder farmers.

Sex of household head (SEX): It is dummy variable taking the value 1 if the sex of household is male and 0, otherwise. Male-headed households were more likely to get information about new technologies and undertake risky businesses than female-headed households (Abay and Assefa, 2007). Moreover, Tenge and Hella (2007) argued that having a female head of household may have negative effects on the adoption of soil and water conservation measures, because women may have limited access to information, land, and other resources due to traditional social barriers. The result of Nhemachena and Hassan (2010) study, however, indicated a contrary result to the above argument by showing that female headed households are more likely to use crop diversification, irrigation and water conservation practices as adaptation strategies. This study hypothesized that sex of the household head may have positive or negative relation to the using irrigation, improved crop

varieties, crop diversification, adjusting planting dates and soil conservation practices as adaptation strategies to climate change.

Age of household: Studies in Ethiopia have shown a positive relationship between numbers of years of experience in agriculture and the implementation of improved agricultural technologies (Kebede *et al.*1993).Experience in farming increases the likelihood of uptake of adaptations to climate changes (Maddison 2009, Nhemachena and Hassan 2010, Deressa *et al*. 2012).Age of the head of household can be used to capture farming experience (Deressa *et al*. 2012). On the other hand, a negative relationship between age and implementation of improved soil conservation practices can be identified (Shiferaw and Holden 1998). So age might often mean better experience, access to information, and knowledge, but also other things like a weaker health, and consequently age and experience might give both positive and negative outcomes.

Family size (FAS): It is a continuous variable which refers to the number of family members of the household head. This explanatory variable is included because it affects the labor supply at household level. The influence of family size on use of adaptation methods can be seen from two angles. The first assumption is that households with large families may be forced to divert part of the labor force to off-farm activities in an attempt to earn income in order to ease the consumption pressure imposed by a large family (Chilot, 2010). The other assumption is that large family size is normally associated with a higher labor endowment, which would enable a household to accomplish various agricultural tasks. For instance, Croppenstedt *et al.* (2006) argue that households with a larger pool of labor are more likely to adopt agricultural technology and use it more intensively because they have fewer labor shortages at peak times. This study hypothesized that households with large families may have either negative or positive effect on use of adjusting planting dates, crop diversification, irrigation, improved crop varieties and soil conservation practices to adapt to climate change.

Distance to market (DISOUT): This is a continuous variable to be measured in kilometers from home of the household. The closer the farmer is to the market the more likely the farmer receives valuable information and purchase agricultural inputs. Proximity to market is an important determinant of adaptation, presumably because the market serves as a means of

exchanging information with other farmers(Maddison, 2009).This study hypothesized that market distance influence the use of different adaptation strategies (adjusting planting dates, improved crop varieties and crop diversification) to climate change negatively.

Literacy status (LITER): It is dummy variable taking the value 1 if household head is literate and 0 if the household head is illiterate. Literacy status is believed to be associated with access to information on improved technologies and higher productivity (Norris and Batie, 1990). According to Maddison (2009) there is a positive relationship between education and adaptation to climate change. Literacy status was hypothesized to have positive influence on the use of different climate change adaptation strategies (adjusting planting dates, crop diversification, irrigation, improved varieties of crops and soil conservation practices).

Access to media (MEDIA): It is a dummy variable which takes a value of 1 if the household head has access to media (especially radio) and 0 otherwise. Access to media increases the chance of adapting to climate change, and plays a significant role in creating awareness about new technologies in fastest possible time. Thus, this study also hypothesized that access to media increases the chance of using different adaptation strategies(adjusting planting dates, crop diversification, irrigation, improved varieties of crops and soil conservation practices) to reduce the negative impact of climate change.

Contact with extension agents (EXTENSION): This is a continuous variable which takes a visiting time by extension agent per year. Extension on crop and livestock production and information on climate represent access to the information required to make the decision to adapt to climate change. Various studies in developing countries, including Ethiopia, report a strong positive relationship between access to information and the adoption behavior of farmers (Chilot, 2010), and that access to information through extension increases the likelihood of adapting to climate change (Maddison, 2009; Nhemachena and Hassan, 2010). Thus, this study also hypothesized that access to extension visit increases using irrigation, improved crop varieties, crop diversification, adjusting planting dates and soil conservation practices to adapt to climate change.

Access to credit (CREDIT): It is a dummy variable taking the value 1 if the farmers get credit access and 0, otherwise. Availability of credit eases the cash constraints and allows farmers to buy purchased inputs such as fertilizer, improved crop varieties, and irrigation facilities. Research on adoption of agricultural technologies indicates that there is a positive relationship between the level of adoption and the availability of credit (Chilot, 2010). Likewise, this study also hypothesized that there is a positive relationship between availability of credit and using irrigation, improved crop varieties, crop diversification and soil conservation practices to adapt to climate change.

Land holding (LAND): This is a continuous variable measured in hectares. Hassan and Nhemachena (2011) reported that larger farm sizes were found to encourage the use of multiple cropping and integration of a livestock component, especially under dry-land conditions. Large size allows farmers to diversify their crop and livestock options and help spread the risks of loss associated with changes in climate. This study therefore hypothesized that land holding has positive relation with using irrigation, improved crop varieties, crop diversification and soil conservation practices to adapt to climate change.

Non-farm income: This refers to annual income obtained from an employment of the household in non-farm (hand craft, selling of fire wood, weaving, petty trading, brewing and remittance) activities measured in Birr. As these activities share most of farmers' time, farmers pay little attention to their farming activity and focus on off/non-farm activities. On the other hand, access to such activities may enable the farmer to get additional income which enables the farmer to acquire purchased inputs. Aymone (2012) suggested that expanding smallholder farmers' access to off/non-farm sources of income increases the probability that they will invest in farming activities. Thus, for this study, non/off-farm income was hypothesized to affect using irrigation, improved crop varieties, crop diversification and soil conservation practices as climate change adaptation strategies negatively or positively.

Farm income (INCOME): This is a continuous variable which measures the amount of annual farm income obtained from sale of crop and livestock or livestock products measured in Birr. Farm income of the household has a positive and significant impact on conserving soil and using improved crop varieties adaptation options (Temesgen *et al*., 2011). This could be apparent because adaptation to climate change is capital intensive and hence increased income

will encourage the investment capacity on adaptation options. It is regularly hypothesized that the adoption of agricultural technologies requires sufficient financial wellbeing (Knowler and Bradshaw, 2010). Thus, for this study farm income was hypothesized to affect positively the use of irrigation, improved crop varieties and crop diversification to adapt to climate change.

Table 2: Summary of the explanatory variables hypothesized to affect adaptation to climate change

Variables	Types of Measurement variables	Hypothesis effect
Dependent variable		
Adaptation strategy to climate change (Y_{hpj})	Normal	
Independent variables		
Age	Continuous	+
Sex of household head (Male/Female)	Dummy	-
Family size (Male/Female)	Continuous	-
Level of education	Continuous	+
Distance to market (km)	Continuous	-
Access to media (Yes/no)	Dummy	+
Contact with extension agents (Yes/no)	Continuous	+
credit received (Yes/no)	Dummy	+
Land holding (hectare)	Continuous	+
Households' non-farm income (Birr/year)	Continuous	+
Households' farm income (Birr/year)	Continuous	+

4. RESULTS AND DISCUSSION

This chapter contains the results obtained from quantitative and qualitative data obtained from a household survey and desk review. Section one is sample households characteristics, farmers' perception of climate change and climate change adaptation strategies used by the farmers. Section two is results of the maximum-likelihood estimates for determinants of farmers' choice of adaptation strategies to climate change in the study area.

4.1. Socioeconomic Characteristics

For this study, primary data were collected from a total of 200 sampled households. Out of the total sample households surveyed, 97% were male headed and 3% were female headed. The survey results also show that 80.5% of the household heads were literate and 19.5% was illiterate. This implies that there is high level of literacy in the study area. Farmers in the study area are engaged in mixed farming activities, including cereal crops production (such as wheat, barley and peens), and roots (potato and onion).

Major sources of income in the study area are on-farm activities mainly from sale of crops. Trading (weekly), daily labor and hand craft are also other sources of income for some of the sample households. Farm income of the surveyed households ranges from 20507 to196000 with an average of 63157 birr per annum. The survey data indicated that the family size of the sampled households varies from 2 to 12 with an average household size of 5.39944, which is higher than the national average family size of 3.7493(CSA, 2010).The land holding of sampled households ranges from 0.5 to 7 hectares with an average size of 2.4438 hectares. The survey results show that 27.5% of the respondents reported that they were trained on issues related to climate change and its impact, whereas 72.5% reported that they were not during 2018 production year. Out of the total sample households surveyed, 6.5% reported that they received credit, whereas 93.5% reported the opposite during 2018production year.

The mean distance from the nearest market of the sample households at the time of survey was about 19.461 kilometers with the minimum and maximum distance of 4.5 and 32 kilometers, respectively. The survey result also shows that the respondents were visited by extension experts (DA) in maximum four wise per year. The survey results show that 62.5% of the respondents had access to media (radio) on the issue of climate change and its impact, whereas 37.5% reported the opposite.

Table 3: Socioeconomic characteristics of the sample households (continuous variables)

Variable	Min	Max	Mean	Std. dev.
Age	24	77	48.37	24
Family size	2	12	5.39944	2.08898
Education	0	12	4.3653	3.3297
Distance	4.5	32	19.461	10.799
Extension contact	0	4	1.482948	1.623704
Non-farm	0	18179	9955.833	6525.3458
Land	0.5	7	2.4438	0.8203
Farm income	20507	196000	63157	20507

Table 4: Socioeconomic characteristics of the sample households (categorical variables)

Variable	Frequency	Percentage
Sex	194	97
Access to Media	125	62.5
Access to Credit	13	6.5

Source: Own survey result, 2018, N= 200

4.2 Farmers' Perception of Climate Change

In order to get essential information and insight in to farmers' adaptation to climate change, looking at their perception on each indicators are quite important. Hence, knowledge about farmers' perception on climate change attributes in the study area is an appropriate issue to be discussed. For this purpose, two known climate attributes: temperature and precipitation have been used. Parameters such as annual average temperature, annual maximum temperature, annual minimum temperature and annual rainfall were used to describe farmers' perception on climate change.

To describe farmers' perceptions of climate change, it is important first to look at how climate data recorded at meteorological stations evolved (trends) and how farmers perceived these changes. Tests were undertaken for fluctuation trend in average annual temperature, average annual maximum temperature, average annual minimum temperature and annual rainfall using data obtained from Bale Robe National Meteorological agency of south Oromia

meteorological service center against time. Descriptive statistics are used to provide insights into farmers' perceptions of climate change.

4.2.1. Perception on precipitation changes

All of the respondents observed changes in rainfall patterns over the past10 years, and 88% observed a decrease in the amount of rainfall (Table 5). About 12% of the respondents noticed an increase in the total amount of rainfall and 0% of the respondents noticed no change in the amount of rainfall.

Table 5: Perception of climate change and rainfall during the last 10 years

Variable		Freq.	Percent
Perceived change of rainfall patter	Increasing	24	12
	Decreasing	176	88
	No change	0	0
Perceived change of temperature change	Increased	113	56.5
	Decreased	81	40.5
	I don't know	6	3
	No change	0	0

Source: Own survey result, 2018, N= 200

The analysis between annual rainfall and time using data obtained from meteorology agency indicated that annual rainfall in the study area decreased and again increases between different years as shown in figure 3. Such fluctuation deprives farmers to estimate (guess) weather condition in future. This makes difficult for preparation of farm land. This is the same with findings of NMSA (2004). According to NMSA long term climate change in Ethiopia is associated with change in precipitation patterns, rainfall variability, and temperature, which could increases the country's frequency of drought and flood. This outcome has resulted in many farmers lacking reliable climate adaptation information, particularly about the onset and cessation of rainfall (Antwi-Agyei *et al*. 2012).

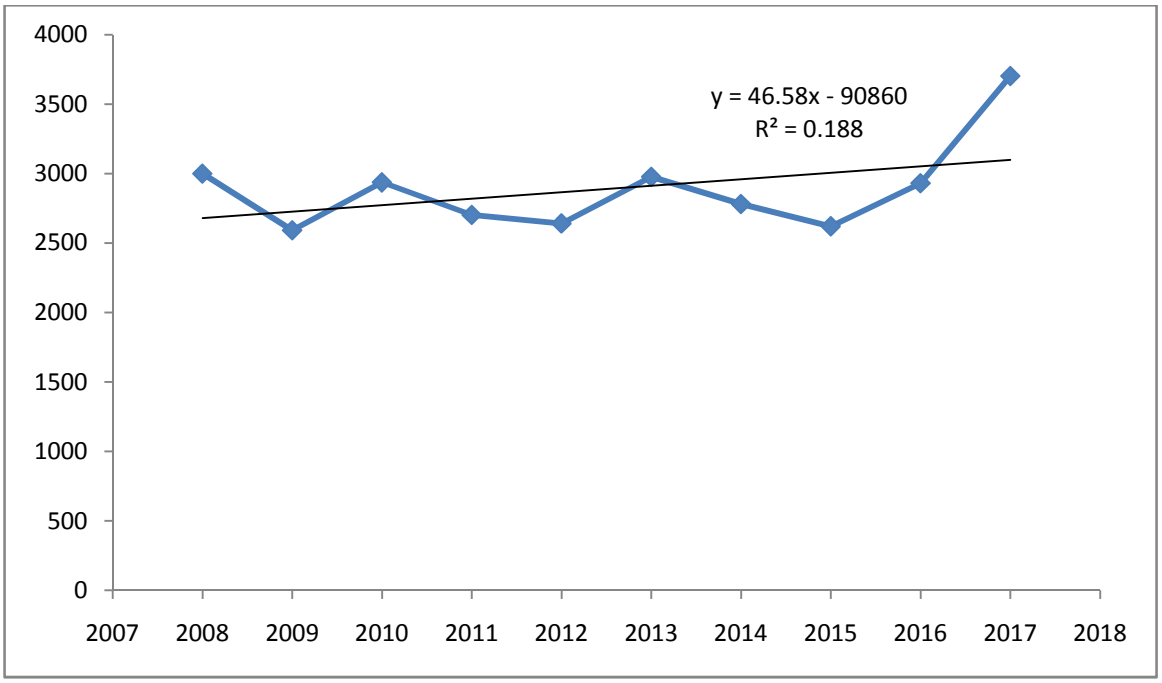


Figure 3: Trend of annual rainfall in Sinana area from 2008-2017

Source: Computed based on data obtained from National Meteorological Agency South Oromia Meteorological Service center, Bale Robe branch

4.2.2. Perception on temperature changes

Most of the farmers interviewed perceived occurrence of long-term changes in temperature. About 56.5 percent perceived that the temperature in the area is increasing. While 40.5 percent of the farmers noticed a decrease in temperature, and 3% of the farmers don't know whether there is a change in the temperature or not (Table 5). The statistical record of temperature data from the area between 2010 and 2017 (meteorological data) also shows an increasing trend except 2008 to 2010. The trend analysis between average annual temperature and time indicated that average temperature in the study area increases by about $0.097C^0$ each year (Figure 2). The trend analysis between mean minimum annual temperature and time also shows an increase in one year time results in an increase in the minimum temperature of the area by $0.058C^0$(Figure 3)

Moreover, the trend analysis between mean maximum annual temperature and time also indicated that maximum annual temperature in the study area increases by about0.12 C^0 each year (Figure 4). Thus, farmers' perceptions appear to be in accordance with the statistical record of the area. Almaz (2009) did trend analysis of temperature records for the northern

part of Ethiopia at Bahir Dar using meteorological data covering the period 1961-2000. Her results showed almost similar Pattern of increasing trends.

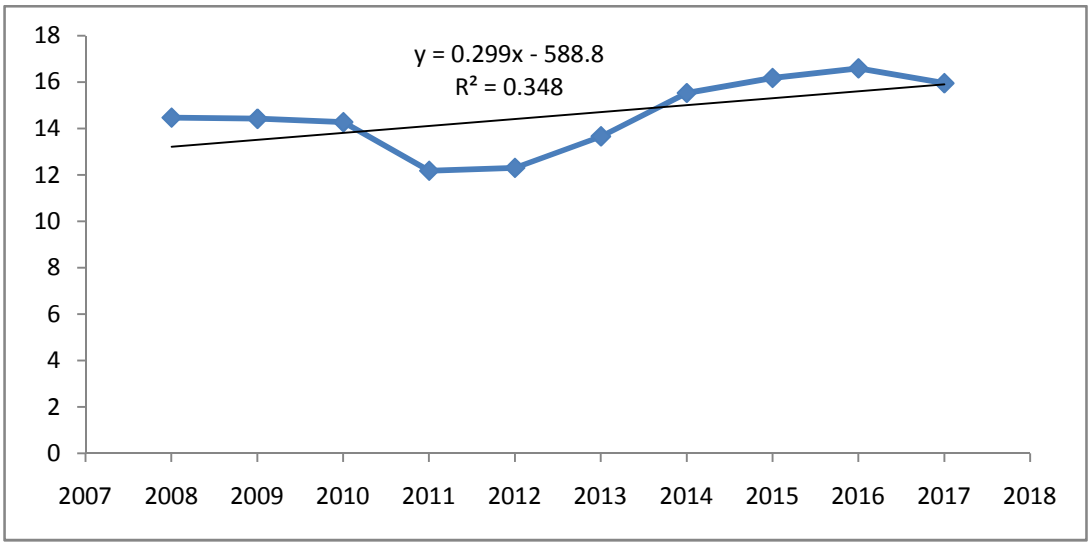


Figure 4: Trend of average annual temperature in Sinana area from 2008-2017

Source: Computed based on data obtained from National Meteorological Agency of South Oromia

Meteorological Service Center, Bale Robe branch

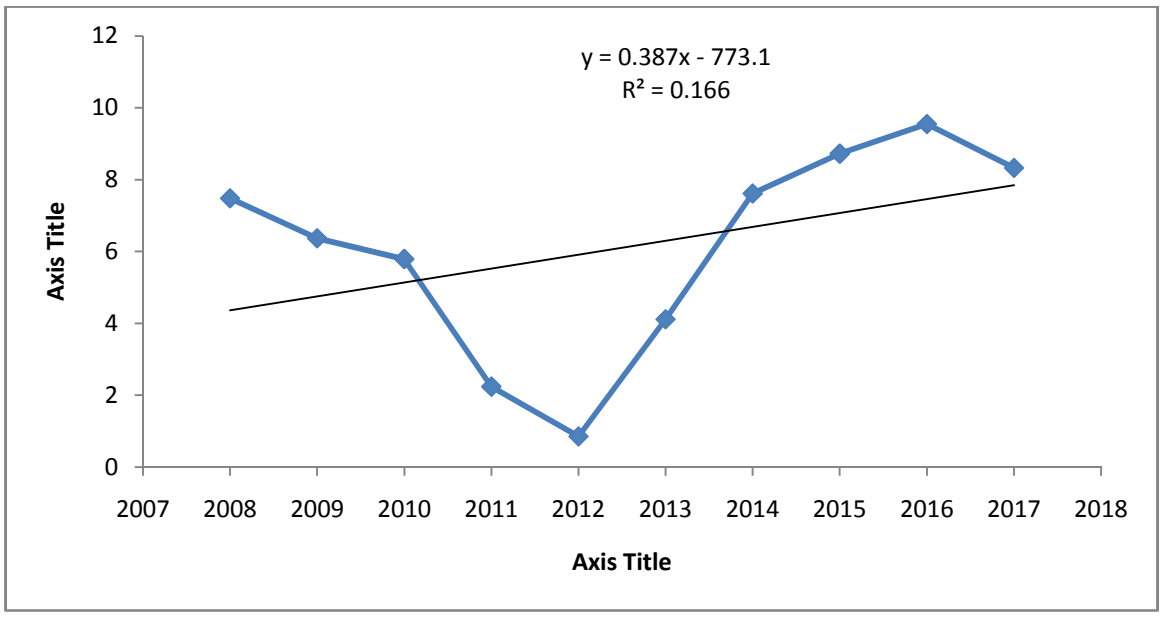


Figure 5: Trend of mean annual minimum temperature in Sinana area from 2008-2017

Source: Computed based on data obtained from National Meteorological Agency of South Oromia Meteorological Service Center, Bale Robe branch.

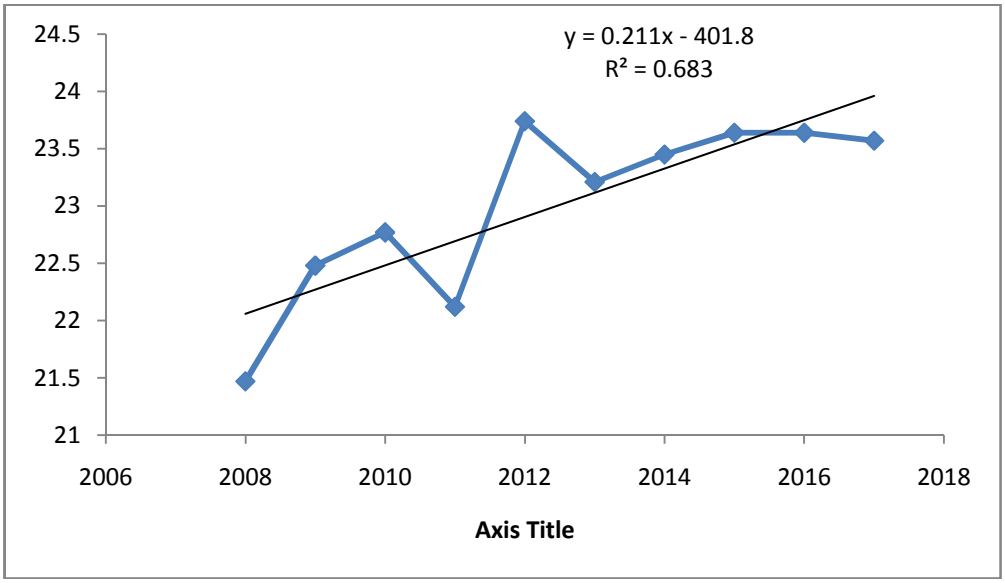


Figure 6: Trend of mean annual maximum temperature in Sinana area from 2008-2017

Source: Computed based on data obtained from National Meteorological Agency of South Oromia Meteorological Service Center, Bale Robe branch.

4.3. Climate Change Adaptation Strategies

In the study district, farmers have adopted different strategies to minimize the consequences of climate change and to manage future condition of climate change. Farming is the primary task (duty) for all of the sample households. However, there is little number of farmers who combine some level of non-farming income sources. Based on the household survey data collected from 200 households, significant proportion of farmers have observed changes in climate over the past 10 years. The sampled households were subsequently asked if they have responded through adaptation to minimize the impact of climate change. Accordingly, they reported that they are using different adaptation strategies to decreases the negative impact of climate change. These include use of: irrigation, improved crop varieties, crop diversification, and soil conservation techniques. These strategies, however, are mostly used in combination with other strategies.

Irrigation agriculture has used in few areas to supplements the inadequate or unreliable precipitation in the district since recent years. It is providing a large comparative advantage to farmers of the district. However, availability, accessibility, and scarcity of irrigation were a

great problem as reported by farmers during the survey. In the study area, about 15% of sample respondents have experience in using irrigation as adaptation strategy to minimize the problem.

In the study area 49% of farmers used improved crop varieties as adaptation strategy to reduce the adverse effect of climate change. Using drought resistant verities of crops was one of the important adaptation practices in the study area (Table 6). Farmers reported to recover, multiply and use a different improved varieties of crops (like wheat, potato and linseed varieties), which are supposed to have short life cycle. Crop diversification (dividing farm lands into varying crops) is a common practice in the study area. The system is commonly practiced in the district where cereals (wheat, barley, and oat), legumes (beans and peens), oil seed (linseed) and vegetable (onion, chili and potato) are grown together. This is one of the top four predominant adaptation practices in the study area. From group discussions made with farmers, it was noted that they have wide field knowledge on the advantages of crop diversification with varying attributes in terms of maturity period, drought tolerance, input requirements and end users of the product. From the total sampled households, about 87.5% use crop diversification as adaptation strategy to reduce the adverse effect of climate change on farm productivity (Table 6). The study also revealed that farmers diversify crop types as a way of spreading risks on the farm and this is in line with the finding of Orinda and Eriksen (2008). Crop diversification can also serve as insurance against rainfall variability (Lema and Majule, 2012).

One of the major challenges that farmers are facing in the study area in striving for development is environmental degradation, manifested in the degradation of land resources. Considering the magnitude of the moisture stress in the district, soil conservation techniques are widely adopted by farmers. Out of the total sampled households, 19.5% used soil conservation as adaptation strategy to reduce the adverse effect of climate change on farm productivity. Soil bunds, ridging, and mulching and manure application are among soil conservation techniques which are commonly used by farmers in the study area.

Table 6: Summary of main adaptation strategies used by farmers

Adaptation strategies	Number of respondents	Percent
Using irrigation	30	15
Using improved crop varieties	98	49
Crop diversification	175	87.5
Soil conservation	39	19.5

Source: Own survey result, 2018

4.4. Determinants of Farmers' Choice of Adaptation Strategies

Multivariate probit model was used to identify the determinants of farmers' choice of adaptation strategies related to climate change. The model was selected based on the justification illustrated earlier in the methodology part.

The key hypothesis that the correlation of the residuals between four equations is strongly rejected at one percent level of significance, implying that decision to adopt climate adaptation strategy is not strictly independent. This implies that irrigation, improved varieties of crops, crop diversification, and soil conservation practices are used by farmers in the study area as a major climate change adaptation strategies. These adaptation strategies help farmers to survive losses due to changes in temperature and precipitation. However, there are a number of factors which influence households' decision to choose a particular adaptation option(s). The analyses in this study identified the important determinants of adoption of various adaptation options using a multivariate probit model to provide policy information on which factors to target and how, so as to encourage farmers to increase their use of different forms of adaptation. Socio-economic and institutional characteristics are modeled to assess whether they have influence on households' choices of the previously mentioned adaptation strategies.

Results from the multivariate probit model of determinants of choice adaptation strategies are presented in Table 7. The results of the correlation coefficients of the error terms are significant based on the t-test statistics for any pairs of equations indicating that they are correlated. The results on correlation coefficients of the error terms indicate that there are complementarities (positive correlation) between different adaptation options being used by

farmers. The results supports the assumption of interdependence between the different adaptation options which may be due to complementarities in the different adaptation options and also from omitted household-specific and other factors that affect uptake of all the adaptation options.

The SML (simulated maximum likelihood) estimation results suggested that there was positive and significant interdependence between household decisions to adapt using irrigation and using improved varieties of crops; using irrigation and crop diversification; using improved varieties of crops and crop diversification; and using crop diversification and soil conservation practices. This implies that farmers use all adaptation strategies simultaneously have better advantage than who adopts a single adaptation strategy. This is supported by Fosu-Mensah *et al*.(2012) suggestion of choice of adaptation strategies that adopted by farmers.

The result of multivariate probit model shows that the likelihood of households to adopt irrigation, improved varieties of crops, using crop diversification and using soil conservation practices were 45.8%, 52.4%, 64.9%,and 41.2%, respectively. The result also shows that the joint probability of using all adaptation strategies was only 1.7% and the joint probability of failure to adopt all of the adaptation strategies was 3.3%. This implies that some farmers not adopt all adaptation strategies at the same time. This outcome has resulted in many farmers lacking consistence training (Antwi-Agyei *et al*. 2012).

Regarding to the determinants of climate change adaptation strategies, the results suggest that different household, socioeconomic and farm characteristics are significant in determining the households' decisions to choose adaptation strategy (Table 7)

Table 7: Multivariate probit simulation results for households' climate change adaptation decisions

Variables	Coefficients (Equations)			
	Irrigation	**Improved crop**	**Crop diversification**	**Soil conservation**
	Coef. (St.Err)	Coef. (St.Err)	Coef. (St.Err)	Coef. (St.Err)
Sex	0.046 (0.82)	1.16 (2.411)	-3.946(.274)	.383(.830)
Age	-0. 014(.018)	.179*(.063)	.004(.013)	-.020(.015)
Family size	.089(.082)	.284 (.204)	.041(.063)	.176*(.067)
Literacy	.097(.082)	1.017*(.373)	.059(.058)	.152**(.067)
Distance	-.038**(.019)	.005(.045)	.003(.012)	.006(.014)
Media	.171(.376)	1.642***(.872)	-0.173(.249)	-0.229(.264)
Extension	.218(.165)	1.465**(.452)	-.293**(.117)	.229***(.131)
Credit	.431***(.255)	.198(.634)	.384**(.174)	.365***(.194)
Non-farm income	.014*(.026)	.057(.062)	-.002(.002)	.003(.002)
Land size	- .465*** (.25)	.133(.999)	-.523**(.23)	.282(248)
Farm income	.60(2.87)	.011(.033)	.021**(9.16)	-.001(9.176)
Cons	.557(1.467)	1.343**(.998)	.401(6.278)	-2.72**(1.23)

Predicted probability	0.458	0.524	0.649	0.412
Joint probability (success)			0.017	
Joint probability (failure)			0.033	

Likelihood ratio test of $\rho_{21} = \rho_{31} = \rho_{41} = \rho_{32} = \rho_{42} = \rho_{43} = 0$

Multivariate probit (SML, # draws = 5)

Number of observations 200

Log likelihood -193.56379

$chi^2(6) = 14.0375$

Prob > chi^2 = 0.000***

, **, ** are significant at 1%, 5% and 10% probability level respectively

Source: Model output

Sex of household head: Sex of the household head is an important variable that affect the way of adaptation at farm level. The negative coefficients for sex variable shows that female headed households are more likely to take up crop diversification practices as climate change adaptation options. Women participate on many activities to improve the living standard of their family members, which simultaneously can be regarded as well-designed adaptation practices. They intensify their efforts in homestead production and use non-farm production options to get food when there is shortage of food, especially during natural disasters for the well-being of the family.

Moreover, women participate on some infrastructural development to conserve the soil and water and also to avoid floods by building embankments which presumably make a large contribution to the efforts required to confront climate risks. This result is consistent with findings of Khan and Bewket (2010).

Age of household head: Age of the household head is an important variable that affect the way of adaptation at farm level. The negative coefficients for age variable shows that old headed households use more crop diversification to resist climate change problem that may affect their agricultural product. The significant on the likelihood of using improved crop varieties as adaptation strategy is shows that all age groups implement it to resist the negative impact of climate change. This result is consistent with findings of Nhemachena and Hassan (2007).

Family size: Family size of the households has positive and significant impact on the adaptation choice to climate change. The model result shows that family size has positive and significant impact on the likelihood of using soil conservation as adaptation strategy to resist the negative impact of climate change. The possible reason is that large family size is normally associated with a higher labor endowment, which would enable a household to accomplish various agricultural tasks which are labour intensive like soil conservation which require large number and powerful labor force. Tagel.(2013) argue that households with a larger pool of labor are more likely to adopt agricultural technology and use it more intensively because they have fewer labor shortages.

Educational level of the household head: This variable significantly affected use of improved crop variety and soil conservation practices as an adaptation strategies. It had a

positive relationship with the dependent variables showing that being literate household head increases the use of improved crop variety and soil conservation practices as adaptation strategies to climate change. In this regard, the use of improved crop variety and soil conservation practices by farmers who were literate is likely to be greater than farmers who were illiterate. This suggests that being literate would improve access to information, capable to interpret the information, easily understand and analyze the situation better than illiterate farmers. Hence, farmers who are literate were more likely to use improved crop varieties and soil conservation practices than those illiterate farmers. This result showed that educational status increase the awareness of farmer about the consequence of climate change on productivity and benefit of crop diversification and soil conservation practices to reduce the impact of climate change. This finding is in line with the investigation of Temesgen *et al.* (2011).

Distance from the market center: Distance from the market center is negatively related to use of irrigation as adaptation strategy. Proximity to market is an important determinant of irrigation as adaptation strategy, presumably because the market serves as a means of selling their product must be near to place of production. Because most probably the product that can be produced using irrigation is easily perishable.(Maddison, 2009).Moreover, access to transportation will be high for households closer to a given market (Temesgen, 2010).Hence being more far from market center decreases the use of irrigation as an adaptation strategy. When farmers are far from the market, the transportation cost for their output will be high and this will, in turn, reduce the relative advantage of adopting irrigation system.

Access to media: Access to media (radio) has significant impact on the use of improved crop varieties to adapt to the negative effects of climate change. Media is used to access information and knowledge to strengthen local agriculture system. Farmers who are aware of changes in climatic conditions have higher chances of taking adaptive measures in response to observed changes. Because information is an important precondition for farmers to uptake adaptation measures (Madison 2009). Raising awareness of changes in climatic conditions and on new seeds and crops variety, irrigation applications, pest and disease control through radio and television would have greater impact in increasing adaptation to changes in climatic conditions.

Extension contact: The result indicates frequency of extension visit to the households has positive and significant and positive impact on use of improved crop varieties and soil conservation to reduce the negative impact of climate change. But it has negative and significant impact on using crop diversification. The reason for negative coefficient is that farmers who have large farm land not use crop diversification. Because they have enough farm land. Extension services are an important source of information on agronomic practices as well as on climate. This implies that farmers with more access to information and technical assistance on agricultural activities have more awareness about the consequence of climate change. Therefore, this study suggests that the availability of better climate and agricultural information helps farmers make comparative decisions among alternative crop management practices and enable them to adapt better with changes in climate. Tesema *et al.* (2012) and Aymone (2009) have found similar results.

Access to credit: The result indicates that access to credit has a positive and significant impact on likelihood of using irrigation and soil conservation practices. Access to affordable credit increases financial resources of farmers and their ability to meet transaction costs associated with various adaptation options they might want to take (Hassan and Nhemachena, 20011). With more financial and other resources at their disposal farmers are able to change their management practices in response to changing climatic and other factors and are better able to make use of all the available information they might have on changing conditions both climatic and other socioeconomic factors. For instance, with financial resources and access to markets farmers are able to buy necessary material needed for irrigation soil conservation, crop diversification and other important inputs they may need to change their practices to suit the forecasted and prevailing climatic conditions. This result is consistent with the finding of Tesso *et al*. (2012) as well as Aemro *et al*. (2012).

Non-farm income: The result of the model indicates that non-farm income increases uptake of irrigation as adaptation strategies to climate change. This indicates that when farmers have non farm incomes, they can afford the cost by using less of agronomic practices such as soil conservation techniques and can buy materials needed for irrigation and drought resistant (early maturing) improved crop varieties which increase productivity. The result confirms the hypothesis which states that non-farm income has a positive influence on the adaptation of climate change. The implication of the result was that availability of non-farm income improves farmers' financial position, which, in turn, enables them to purchase farm inputs such as, seed and fertilizer. Aymone (2012) and Aemro *et al.* (2012) reported similar results.

Land holding: This variable took the unexpected sign and it significantly affected use of irrigation and crop diversification as climate change adaptation strategies. The land holding of the households has a negative impact on use of crop diversification and irrigation as adaptation strategies. The possible reason could be if the farmers have more land holding they can benefit from the economic scale of it as compared with those who have small land holding. This result is also in line with the outcome of Tessema *et al*. (2013).

Farm income: The farm income of the households surveyed has a positive and significant impact on use of crop diversification as an adaptation strategy. This could be apparent because use of crop diversification enables farmers to escape out of damaging all crop varieties at the same time with the problem of climate change. The other possible explanation is that it enables farmers to have better alternative source of income in farming would increase; farmers tend to invest on purchase of improved seed varieties which increases productivity. This result is consistent with Temesgen *et al.* (2011).

5. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1. Summary and Conclusions

Climate change affects agriculture and agriculture also affects it. The impact of negative climate change is considered to be particularly strong in countries located in tropical Africa that depend on agriculture as their main source of livelihood. The fact that climate has been changing in the past and continues to change in the future implies the need to understand how farmers perceive climate change and adapt in order to guide strategies for adaptation in the future. Identifying factors influencing farm-level adaptation can facilitate the formation of policies and investment strategies that help moderate potential negative consequences of long-term climate change. Because smallholder farmers tend to have a low capacity to adapt changes of climatic conditions, policies that help these farmers adapt to global warming and associated climatic extremes are particularly important. A better understanding of the local dimensions of adaptation is therefore essential to develop appropriate adaptation measures that will mitigate these negative consequences. The knowledge of the adaptation methods to climate change enhance policy towards blocking the challenges that climate change imposing on smallholder farmers. In relation to this, the study attempted to identify factors affecting the choice of climate change adaptation strategies by smallholder farmers in Sinana district of Bale Zone in Oromia regional state, south eastern Ethiopia.

For this study, data collected from a total of 200 sampled household heads were used. Descriptive statistics were used to provide insights into farmers' perception of climate change, types of adaptation strategies to climate change and to explain factors affecting farm level climate change adaptation strategies. To assess farmers' perceptions of climate change, it is important first to look at how climate data recorded at meteorological stations evolved (trends and variability) and how farmers perceived these changes. Descriptive statistics result shows that about 97% of the farmers in the study area perceived change in temperature and also all of the farmers' perceived change in the amount of rainfall over the past 10 years. Using the data obtained from meteorology agency tests were undertaken for linear trend in average annual temperature, and annual rainfall against time of the study area. The trend analysis of average annual temperature indicated that average annual temperature in the study area

increases by about $0.097C^0$ each year. The trend analysis of annual rainfall indicated that annual rainfall in the study area is fluctuating from year to year.

Adaptation strategies used by farmers in the study area include use of irrigation, use of improved crop varieties (like short duration varieties and drought resistance varieties), crop diversification (mixed cropping and dividing farm lands in to varying crops) and use of soil conservation techniques.

This study explored the determinants of household use of different adaptation strategies using a multivariate probit model. The model allows for the simultaneous identification of the determinants of all adaptation options, thus limiting potential problems of correlation between the error terms. Correlation results between error terms of different equations were significant indicating that various adaptation strategies tend to be used by households in a complementary or supplementary fashion. For instance use of irrigation technologies need to be accompanied by other crop management practices. Supporting farmers in increasing these adaptation measures through providing the necessary resources like credit can significantly help farmers increase and sustain high productivity levels even under changing climatic conditions.

The result of multivariate probit model shows that the likelihood of households to adopt irrigation, improved varieties of crops, use crop diversification and soil conservation practices were 45.8%, 52.4%, 64.9% and 41.2%, respectively. The result also shows that the joint probability of using all adaptation strategies was only 1.7% and the joint probability of failure to adopt all of the adaptation strategies was 3.3%.Multivariate probit model results also confirm that distance, land holding, non-farm income, and access to credit have a significant impact on the use of irrigation as climate change adaptation strategy.

The result also shows that access to media, literacy, and age and extension service are significantly affect the use of improved crop varieties to adapt the climate change. In addition, farm income, land size, access to credit and extension service significantly affects using crop diversification.

Moreover, literacy status, family size, extension service and access to credit significantly affects farmers' use of soil conservation to adapt climate change impacts. Thus, the results of this study gives information to policy makers and extension workers on how to improve farm level adaptation strategies and identify the determinants for adaptation strategies. This could

contribute to reduce the negative effects of climate change and generally help agricultural as well as economic development. These findings stresses the need for appropriate policy formulation and implementation which enables farmers to decrease the impact of climate change as this is expected to have multiplier effects ranging from farm productivity growth to economic growth and poverty reduction at macro level.

5.2. Recommendations

Based on the evidences obtained from this finding and given the adverse trends in local climate and low adaptive capacity of climate change, there is a need for urgent action aimed at addressing the causes of climate change adaptation strategies in this study. These may include the following:

- Male headed households' knowledge about climate change impacts should be improved in the study area because majority of household heads were male. Therefore, policy intervention on improving their knowledge about climate change and different adaptation strategies enhance their adaptive capacity to reduce climate change impacts.
- In terms of policy implications it appears that improving educational level would do most to hasten adaptation and increase households' decision making regarding the key adaptation techniques.
- Policies aimed at promoting farm-level adaptation need to emphasize on the crucial role of providing information on better production techniques and enhancing farmers' awareness on climate change (through extension) and creating the financial means through affordable credit schemes to enable farmers to use different adaptation measures to climate change.
- Policy interventions should focus on encouraging fair training chance for all farmers so that they can use different adaptation strategies to reduce the negative impact of climate change. Because as respondents' information there is partiality on giving the chance for training among farmers. Better access to markets reduces transport and other market related transaction costs and enhances the uptake of farm-level adaptation measures. For instance, better access to markets enforce farmers to participate on irrigation, buy new crop varieties, and other important inputs they may need if they are to change their practices to cope with predicted changes in future climate. Hence it is necessary to improve farmers' relatively poor access to markets.

- Improving farmer's farm and non-farm income-earning opportunities is of great need for smallholder farmers. Thus, sufficient input supply which increases farm income and creation of non-farm employment opportunities in the rural areas can be underlined as a policy option in the minimization of the negative impacts of climate change.
- Generally, future policy should focus on awareness creation on climate change through different sources such as media and extension, facilitating the availability of credit especially to adaptation technologies, enhancing research on use of new crop varieties that are more suited to drier conditions, improving farmers farm and non-farm income earning opportunities, improving their literacy status, and improving their access to markets. Moreover, providing necessary inputs and giving fair professional service can help to build adaptive capacity of smallholder farmers.

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Appendix 1

Appendix Table 1:Long-term climate data of Bale zone area from 2008-2017

Year	Annual mean max temperature (C^0)	Annual mean max temperature (C^0)	Annual rainfall (mm)	Average annual temperature (C^0)
2008	21.46472	7.477802	2999.7	14.47126
2009	22.47488	6.367003	2592.8	14.42094
2010	22.76865	5.790645	2937.1	14.27965
2011	22.11778	2.239588	2702.8	12.17868
2012	23.73528	0.858145	2641.4	12.29671
2013	23.20797	4.112778	2977.5	13.66037
2014	23.44819	7.612285	2781.7	15.53024
2015	23.63994	8.721057	2621.3	16.1805
2016	23.63648	9.542858	2931.3	16.58967
2017	23.56857	8.32552	3702.25	15.94705

Appendix 2

Interview schedule

Questionnaire

1) Household Survey

Date of Interview_____

Name of enumerator_____

A. Household Information

1. Name of Kebele _____

2. Name of the village_____

B. Household Composition

1. Sex of household head? Female ____ Male ____

2. Age of the household head? ____ Years

3. Educational grade level of household head? Read &write_____, Grade 5 to 8 _____, grade 9 to10 _____, grade11to12_____, Collage_____, University _____

4. Farming experience of the household head? ____ Years

5. Total landholding of household head? _____ Hectare

6. Family size? _____, of these how many falls:

I . below 15 years of age (children)?_____.

ii. Between 15 and below 31 years age (Young)? _____.

iii. between 31 and 65 years of age (adult)? _____.

iv. above 65 years of age (old)?_____.

7. Ethnicity _____

8. Religion _____

9. Marital status single _____ married _____ divorce _____ widowed____

C. The main source of household income:

1. Crop production____ Livestock production____

If other specify_____

2. Would you please tell me the type and yield of the crop you grown last season?

Crop grown	Area (ha)	Yield (q/t)	Total estimated income in Birr

3. Estimated total income from byproducts of crop? _____birr

4. Do you have livestock? And how many you sold during the last one-year?

5. Did you sell livestock products last year? Yes ___No____

6. If your response is yes, answer the following for the last 12 months:
   Milk sold per litter _____ birr; Butter sold per cup ___birr
   Hides and skin sold in number_____; Eggs____ birr; Honey in birr_____
   Other specify_____

7. Total estimated income from animal products? _____birr

8. Total estimated farm income? _____birr

9. Are there any members of your family working on non-farm activities?

Yes ___ No____

10. If your response is yes, in the last 12 months approximately for how many weeks per month did members of your family engage in each of the following activities?

Activity	Total No of months	Total No of days	Daily earning	Total estimated income in Birr
nonfarm Petty				
Trading				
Hand craft				
Remittance(payment to remote recipient)				

D. Institutional Issues

1. How far (in km and in hr) is your residence from the nearest market_____District town_____

2. Have you ever been advised by development agent about the impact of climate change and means of adaptation strategies? Yes____ No____

3. If your response is yes, how many times did you get extension visit in 2016/2017 production?

Season? _____

4. Do you own land? Yes _____ No _____

5. Can you rent out your land? Yes_____ No_____ (if yes, explain to your answer)

_____ _____

8. Have you ever got information about forecasted weather condition? Yes ____ No ____

9. If your answer is yes, what are your sources of information? _____

10. Did you get any training on weather related issues from any organization? Yes ___ No ___

If yes, specify the kind of training you received_____

11. Did you get credit services? Yes ____ No ____

.If your response is yes, indicate the source of credit

12. Amount of credit received in the year 2017/18 _____birr

If no, why? _____

E. Issues of Climate Change

1. Have you observed any climate change in the last 10 years? Yes ____ No_____.

2. If your response is yes, how do you characterize the weather of this area in the last 10 years?

In terms of temperatures

Increased ____ Decreased ____ No change ____ I don't know ____

In terms of precipitation (water particles that fall from atmosphere) Increased ____ Decreased ____ No change ___I don't know___

In terms of frequency of drought Increased ____ Decreased ____ No change____

I don't know_____

In terms of frequency of flood. Increased___ Decreased___ No change ___ I don't know__

In terms of frequency of frost. Increased___ Decreased___ No change___ I don't know___

In terms of other (specify) Increased ___Decreased____ no change_____ I don't know___

3. Have you observed any long period of drought in your life time? Yes ____ no____.

4. If your answer is yes, how long does it?
Below one year ____, for one year____, for two years, ____, above two years_____
5. Have you observed any change in the amount of rainfall? Yes ___, no___
6. If your response is yes, how do you see it? increased____, decreased___, remaining the same ___, erratic nature_____
7. Have you observed any change in the onset (start) of rainfall in your life time?
Yes___ No___
8. If your response is yes, how do you see it? It becomes before the perceived period _____ it comes late than the perceived period _____ both_____
9. Have you observed any change in the duration of cessation (end) of rainfall in your life time?
Yes_____ No_____
10. If your answer is yes, how do you see it? It becomes before the perceived period _____
It ends at the perceived period _____ No change_____
11. Is the amount of rainfall enough to support your crop production? Yes ____No____
12. What steps/options have you taken to response the high variability in rainfall?
_____
13. Have you observed any change in the cropping calendar in your locality? Yes___ No____
14. If your response is yes, please fill the following tables
Historical cropping calendar

S/N	Types of crops	Yield Kg/ha	Crop calendar			Remarks
			Land preparation period	Planting period	Maturity Period	
1						
2						
3						

Current cropping calendar

S/N	Types of crop	Yield Kg/ha	Crop calendar			Remarks
			Land preparation period	Planting period	Maturity Period	
1						
2						
3						

F. Climate Change Adaptation Strategies and Choice
1. Have you made any adjustments (adaptations) in your farming practices in response to climate change? Yes ____ No____ If no adaptation method used why? _____
2. If your response is yes, which one of the following is the major adaptation mechanism and frequently used?
2.1. Replacement of local varieties by improved varieties or early maturing varieties.
2.2. Soil conservation practice

2.3. Improved crop varieties
2.4. Irrigation
2.5. Crop diversification
2.6. Other specify _____
3. If you used improved crop varieties, which one of the following?
3. 1. Complete exclusion of some crops from production due to climate change
3. 2. Change from local late maturing to early maturing crop species.
3.3. Other specify _____
4. If you used crop diversification system to adapt climate change, when and which option have you used?
Type and reason for used the options

Option	Year	Type X	Reason
Shifting			
Intercropping			
Dividing land in to varying crops			

6. If you used any moisture conservation practices in your farm, which Practices and when did you start to use? _____

Reason for adaptation
Soil fertility improvement ___ Minimize evaporation ___ Increase soil water holding____
Minimize crop failure during long dry spell ____ Protecting fungus _____ Cold (frost) resistance ____
7. How did you judge the trend of crop productivity in your life time? Increased ____ Decreased _____ No change_____.
8. Have you made adjustment in livestock management? Yes _____ No_____
9. If your answer is yes, the kind of adjustments: destocking _____ Changing type of livestock _____Other specify_____
10. Which adaptation option you used is the most effective and efficient to cope with the climate change? Changing planting date ____ planting improved varieties of crops ____
Cultivating different crops ____ Use of irrigation ___ Soil and water conservation practices___
Other (specify) _____
11. What are the hindrances for use of adaptation options of combating climate change?
Lack of money to finance____ Lack of technical knowledge ___Lack of irrigation____
Lack of weather information____ Lack of improved seed variety____
If any other specify_____
Leading Questions for Focus Group Discussion (Comment Freely)
1. Explain environmental condition in your locality.
2. What is your observation on the climatic (temperature and rainfall) condition in your area?
3. Explain years of extreme climate condition your locality (drought and flood).
4. Explain the adverse impact of climate change in the livelihoods of the community?
5. What are the major and the best adaptation strategies people use to minimize the adverse impact climate change?

6. Identify any indigenous crop cultivar, which is now out of production due to climatic change?
7. Identify any newly appeared crop infestation and diseases in your locality
8. What are the main hindrances for use of adaptation options of combating climate change?
9. What do you recommend to be done that will enhance the fight towards climate change.