FARMERS’ PERCEPTION AND ADAPTATION STRATEGIES TO CLIMATE CHANGE: THE CASE OF WOREILLU DISTRICT OF AMHARA REGION, NORTHEASTERN ETHIOPIA

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DEDICATION

I dedicated this thesis manuscript to my father ***Minwuye Zeru*** *who devoted his entire life for his children's success but unlucky to see their victory. He was an amazing farmer who was a bright minded and highly encouraged to enroll his children's even though he himself did not attend any formal education. Dad, your visionary spirit is always with us and became strength to us to realize your dreams. May God put your soul in heaven.*

STATEMENT OF THE AUTHOR

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

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BIOGRAPHICAL SKETCH

The author was born in 1988 in Hullet Ejju Enessie District, East Gojjam Zone of Amhara Region of Ethiopia. He attended his elementary education at Adasha and Motta elementary Schools. He also attended his secondary and preparatory education at Motta preparatory and Senior Secondary School. After successful completion of his preparatory school education, he joined Jimma University in 2007/2008 and graduated with BSc degree in Agricultural Economics in June 2010 with distinction. After his graduation, he joined Bench Maji Zone Marketing and Cooperatives Department as cooperatives organization and promotion expert and served from 2010 to March 2012. During this time he got the chance to work with different governmental and non-governmental organizations serving as a focal person and projects coordinator at zonal level. He then joined Wollo University as Graduate Assistant in March 2012. He also served as head department of Agricultural economics in the same University. After two year of service in Wollo University, he joined Haramaya University in 2015 to pursue his MSc degree in Agricultural and Applied Economics.

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ACRONYMS AND ABBREVIATIONS

AEO	African Economic Outlook
CRGE	Climate Resilient Green Economy
CSA	Central Statistics Agency
EPCC	Ethiopia Policy for Climate Change
FAO	Food and Agriculture Organization
GHGs	Greenhouse Gases
GTP	Growth and Transformation Plan
IIA	Independence of Irrelevant Alternatives
IPCC	Intergovernmental Panel on Climate Change
MNL	Multinomial Logit
MVP	Multivariate Probit
MoA	Ministry of Agriculture
MSL	Maximum Simulated Likelihood
NBE	National Bank of Ethiopia
NGO	Non-Governmental Organization
NMA	National Meteorological Agency
PANE	Poverty Action Network Ethiopia
SWC	Soil and Water Conservation
TLU	Tropical Livestock Unit
WDADO	Woreillu District Agriculture Development Office

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ABSTRACT

Climate change has adversely affected the livelihoods of people in developing countries where a large proportion of the population is heavily dependent on agriculture. Severe and repeated rise in temperature and rainfall failures caused loss of crops and livestock which resulted in food insecurity in Ethiopia. This study aims to investigate farmers' perception and adaptation strategies to climate change in Woreillu District. Both qualitative and quantitative data obtained using primary and secondary sources. The primary data were collected from 155 randomly selected respondents through interview while the qualitative data using five focus group discussions. Secondary data on temperature and rainfall for the period 1993-2016 were also gathered from National Meteorological Agency Kombolcha sub-office. Descriptive statistics and Likert scale measurement were used to analyze perception of farmers and identify adaptation strategies to climate change. Multivariate Probit (MVP) model was estimated to identify factors affecting farmers' choice of these strategies to climate change. The descriptive statistics result showed that 87.74% and 83.22% of the respondents perceived the existence of climate change with its attributes, temperature and rainfall, respectively. The result of MVP model revealed that the likelihood of farmers to adopt adjustment of planting date, agro-forestry, drought tolerant varieties, soil and water conservation practices, and irrigation were 54.1%, 38.9%, 47.8%, 63.4%, and 59.6%, respectively. It also showed that the joint probability of adopting and failure to adopting all adaptation strategies were 9.9% and 6.3%, respectively. Agro-ecological setting, sex, education level, landholding, farm income, non-farm income, livestock ownership, access to credit, extension visit, farmer-to-farmer extension, access to climate information and average distance from home to the farm have significant influence on the choice of climate adaptation strategies. Consequently, the future policy focus should target improving the level of perception of farmers to climate change and adaptation strategies using extension service, encouraging farmer-to farmer extension and using different sources of climate information like media. It is also necessary to focus on improving literacy status, widening the sources and amount of farm and non/off farm income and enhancing accessibility of credit to improve the adaptive capacity of farmers.

Keywords: Adaptation, climate change, Likert scale, multivariate probit, perception, Woreillu

1. INTRODUCTION

1.1. Background of the Study

The mean global temperature has been increasing since the 1850s, mainly due to the accumulation of greenhouse gases (GHGs) in the atmosphere. The main causes are the burning of fossil fuels to meet increasing energy demand, and the expansion of intensive agriculture to meet increasing food demand, which is often accompanied by deforestation. This process of global warming shows no signs of abating and is expected to bring about long-term changes in weather conditions (FAO, 2009).

Climate change has been adversely affecting the livelihoods of people in developing countries where a large proportion of the population is overwhelmingly dependent on agriculture. It has exacerbated poverty, food insecurity and vulnerability of agrarian communities in Sub-Saharan Africa (Akponikpè *et al*., 2010; Bryan *et al*., 2009).

Agriculture has a multiple roles in the economy of Ethiopia. Food security, 73% of employment, 36.7% of the GDP of the country and 70% of the raw material requirements of local industries are drawn from this sector (NBE, 2016; AEO, 2016). Since Ethiopia's agriculture is tremendously rainfall dependent, it greatly suffers from the risks associated with a decrease and a high variability in rainfall. It is a major threat to the sustainability of growth of the country due to its negative impact on agricultural output. Long-term records indicate that there have been severe and repeated rise in temperature and rainfall failures resulting in severe food insecurity, including famines in Ethiopian due to significant loss of crops and livestock. The frequency and severity of these natural shocks are also increasing (Mahoo *et al*., 2013). The 2015 El Niño is a recent history which severely hit Ethiopia (FAO, 2016).

The speed of climate change is inducing and modifying known variability patterns beyond the coping capacity of systems (FAO, 2008). The increasing frequency and magnitude of extreme weather events coupled with unprecedented changes in the climate is also imposing new and potentially overwhelming pressure on the capacity of existing adaptation strategies (Ziervogel *et al*., 2008). Therefore, deliberate and conscious adaptation that can cope with these evolving impacts is an immediate concern in agriculture. Particularly in countries like Ethiopia, where agriculture is highly tied with climate, adaptation is a priority measure.

As agricultural production remains the main source of income for most rural communities, adaptation of the agricultural sector to the adverse consequences of climate change is essential to safeguard the livelihoods of the poor and to ensure food security. It can greatly reduce vulnerability to climate change by making rural communities better able to adjust to climate change and variability, moderating potential damages, and helping them cope with adverse effects. Adaptation also require the involvement of multiple stakeholders, including policymakers, extension agents, NGOs, researchers, communities, and farmers. A better understanding of how farmers' perceive climate change, existing adaptation measures, and the factors influencing the decision to adapt farming practices is needed to craft policies and programs aimed at promoting successful adaptation of the agricultural sector (IPCC, 2001).

Despite the low adaptive capacity to climate change of Africa in general and Ethiopia in particular, farmers have developed traditional adaptation strategies to withstand the great climate inter-annual variability and extreme events. They have been trying, testing, and adopting different types of coping strategies. An unusually persistent drought may also increase farmers' vulnerability in the short term; but, it may encourage adaptation in the medium to long-term. These practical coping mechanisms are particularly true for the drought prone areas in Ethiopia and in the African Sahel region, which is susceptible to frequent climatic hazards (Elasha *et al*., 2006).

Ethiopia has developed and implemented a range of legal, policy and institutional frameworks to address climate change, environmental protection and the sustainable utilization of natural resources. The Ethiopian Growth and Transformation Plan (GTP) I and II also gave prior emphasis to the environment for sustainable development which focuses on improving watershed management, afforestation, and soil conservation. The vision of the country to becoming a middle-income and carbon-neutral economy by 2025 is also through the implementation of the Climate-Resilient Green Economy (CRGE) strategy developed in 2011. Despite these plans and policy frameworks, Ethiopia still faces serious challenges from changing climate conditions, which calls for a continuous adaptation and support to develop on a low carbon trajectory (AEO, 2016).

Perceiving climate change is the leading step in the process of adapting agriculture to climate change (Temesgen *et al*., 2011). Knowing of farmers' concerns and the manner in which they perceive climate change is crucial to offer effective policies for supporting successful adaptation of the agricultural sector. Further, it is also important to have precise knowledge about the type and extent of adaptation methods being taken up by farmers and the need for further advances in existing adaptation set ups. Hence, understanding how farmers perceive changes in climate and what factors shape their adaptive behavior is useful (Mertz *et al*., 2009; Weber, 2010).

A wide range of adaptation options that are thought to reduce agriculture's vulnerability to climate change are pursued both at macro- and micro-levels. The government of Ethiopia has also taken up the issue of climate change, and adaptation in particular, as a priority agenda in the transformation of the nation's agriculture. In line with the national food security macro-level initiatives, the government is pursuing different adaptation strategies such as operationalizing of agro-weather advisory service extension and response mechanism, safety net programs and natural resource management (EPCC, 2015). The natural resource management and SWC practices which are being undertaken in Woreillu District are indicators of the concern of government to climate change with its limitations.

1.2. Statement of the Problem

The overdependence of agriculture on rainfall and temperature makes overwhelming reliance of the economy on agriculture a serious problem which is by no means immune to climate change. This calls for the essentiality of agricultural adaptation to climate change. According to IPCC (2007), unless effective adaptation strategies are carried out timely, some African countries could lose up to 50% of yield from rain-fed agriculture by the year 2020 and access to food will be severely confronted in many African countries. Thus, Ethiopia cannot be an exception given its overdependence on climate driven economy. Climate change impacts that significantly undermine the prominent role of agriculture in food production and economic growth chiefly signify the criticality of adaptation. Although Ethiopia has made some efforts to adapt and mitigate climate change risks, the efforts are still low especially when compared with the impending calamity.

Woreillu is one of the most vulnerable districts to climate change in South Wollo Zone. Climate change posed a huge threat to farmers in the district due to their overwhelming reliance on small-scale agriculture. According to information obtained from Woreillu District

Agriculture Development Office, it is the most severely affected district by drought and agricultural production in the district is frequently affected by climate change related shocks (WDADO, 2016).

Understanding perception and adaptation strategies to climate change and identifying determinants is thus highly vital for Ethiopia in general and Woreillu district in particular as it allows policy makers to formulate a host of strategies and instruments towards reducing climate change danger. Without having sufficient information about the perception, adaptation strategies and their determinants, implementation of appropriate policy in the area for the potential increment in output, food self-sufficiency as well as sustainability of the required development could not be possible.

Earlier studies on climate change in different parts of Ethiopia cannot be implied for other specific areas. It is because adaptation strategies vary contextually and spatially within communities and even among individuals so that identified adaptation measures do not necessarily translate from one area to another area (Temesgen *et al*., 2009; Belaineh *et al*., 2013). The capacity to adapt to climate change is unequal across and within societies. Adaptation responses are also underpinned by common enabling factors. These include effective institutions and governance, innovation and investments in environmentally sound technologies and infrastructure, sustainable livelihoods and behavioral and lifestyle choices (IPCC, 2014). There are individuals and groups within all societies that have insufficient capacity to adapt to climate change. The agro-ecological setting of farmers also influences the perception of farmers to climate change (Diggs, 1991). According to Füssel (2007), addressing adaptation practices to specific societies or communities may make it possible to offset the adverse impact of climate change.

There is also a methodological gap in addressing the issue of identifying factors that affect choice of adaptation strategies. Majority of previous studies used multinomial logit (MNL) model to identify factors affecting choice of adaptation strategies to climate change. This model assumes that a farmer faces a set of discrete, mutually exclusive adaptation options from which a farmer chose exactly one adaptation strategy. However, a farmer may choose more than one adaptation strategy at a time and identified adaptation option can be interdependent.

Therefore, there was a need to undertake a research at household or farm level in different areas of Ethiopia which are very essential to know micro level farmers' perception to climate change, identifying adaptation strategies and identifying determinants using multivariate probit (MVP) model. This helps to design appropriate policies and strategies in that local context. Such information was in fact scant in Woreillu District in particular.

In this regard, no empirical study has been conducted to examine the perception of farmers to climate change, identify adaptation choices and their determinants in the study area to date to the best of the researchers' knowledge. Consequently, the primary motive to embark on this research was to investigate and fill the existing gap of knowledge on farmers' perception and adaptation strategies to changing climate and their determinants in the area.

1.3. Research Questions

The pertinent questions that guided this research were:

1. Did farmers perceive the existing climate change?
2. What are the major adaptation strategies to climate change adopted by farmers?
3. What are the factors determining choice of adaptation strategies?

1.4. Objectives of the Study

The general objective of this study was to investigate farmers' perception and adaptation strategies to climate change in Woreillu district.

The specific objectives were:

1. To analyze farmers' perception to climate change;
2. To identify farmers' adaptation strategies to climate change; and
3. To identify factors affecting choice of adaptation strategies in the study area.

1.5. Significance of the Study

Farmers' perception to climate change and adaptation strategies differs from district to district and hence it needs detail study to identify the adaptation methods that fits with specific place. This study has been conducted at micro level and thus considered particular adaptation strategies in the study area. It revealed the perception level of the smallholder farmers about climate change at local level and their reaction to the change in order to adapt the situation which could help to look at better alternatives for effectiveness in adaptation practices. Hence, it enables to understand climate change perception and identifies the most commonly used adaptation strategies among the set of options and verifies factors that significantly influence adaptation strategies.

The study provides information about household level perception and adaptation strategies with their determinants in the area. It would assist local policy makers and development practitioners in designing and formulating policies that seeks to capitalize the farmers' dominant adaptation strategies to reduce climate change danger in the study area in their development intervention and build climate change resilient economy at the national level. Finally, the study can be used as a base for further studies in the area of climate change. It will serve as source of information and reference material for studies that will be conducted on adaptation strategies against climate change impacts.

1.6. Scope and Limitations of the Study

This study was limited to Woreillu district, South Wollo Zone of Amhara Region. It also focused on analyzing smallholder farmers' perception and identifying adaptation strategies to climate change and their determinants considering time limitations. It made a comprehensive analysis of the smallholder farmers' perception and adaptation strategies to climate change and determinant of farmer's adaptation choice in Woreillu district. The study identified the major adaptation mechanisms which are most frequently used by the farmers and the determinants for the farmers' decision to take adaptation measures to climate change.

The major limitation of this study is that it identified only five major adaptation strategies in the choice set for the MVP model and aggregates some of others in each category to avoid convergence problem in running the model. However, there are a large number of adaptation measures that could be taken by farmers in the area. It is also limited to crop production and adaptation strategies related to animal production are not included. Furthermore, the impact of each adaptation strategy is not considered in this study.

1.7. Organization of the Thesis

This thesis is structured into five main chapters. Chapter two presents the theoretical and empirical review of literature to climate change, perception and adaptation strategies in response to climate change. Chapter three describes the methodology used in the study. It consists of the description of the study area, sampling technique, methods of data collection and analysis. Chapter four wholly devoted to present and thoroughly discuss the results of the study. Finally, the summary, conclusions and recommendations of the study are offered in chapter five.

2. LITERATURE REVIEW

2.1. Definitions and Basic Concepts

Weather: The behavior of the atmosphere on a day-to-day basis in a relatively local area is known as weather. A description of the weather would include daily temperatures, relative humidity, sunshine, wind and rainfall (Ramamasy *et al.*, 2007).

Climate: Climate in a narrow sense is usually defined as the average weather, or more rigorously, as the statistical description in terms of the mean and variability of relevant quantities over a period of time ranging from months to thousands or millions of years. The classical period for averaging these variables is 30 years, as defined by the World Meteorological Organization. The relevant quantities are most often surface variables such as temperature, rainfall, and wind (IPCC, 2012).

Climate change: Climate change refers to a variation in the state of the climate that can be identified by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer. It refers to any change in climate over time, whether due to natural variability or as a result of human activity (IPCC, 2007). Climate change may be due to natural internal processes or external forcing such as modulations of the solar cycles, volcanic eruptions, and persistent anthropogenic changes in the composition of the atmosphere or in land use (IPCC, 2014).

Climate change refers to ongoing changes in the global climatic system resulting primarily from anthropogenic global warming as a consequence of the increased and continuing emissions of greenhouse gases, and the loss of vegetation cover and other carbon sinks (FAO, 2008). It can also be defined as gradual changes in climate norms, notably temperature and changes in the frequency, extent and severity of climate and weather extremes, explained as a persistent change in the mean and variability of climate variables such as temperature, rainfall, humidity and soil moisture (Krishna, 2011).

Greenhouse gases: The atmospheric gases which are responsible for causing global warming and climate change. The major GHGs are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), chlorofluorocarbons (CFCs), and ozone (O_3). Less prevalent but very powerful greenhouse gases are hydroflurocarbons (HFCs), periflurocarbons (PFCs) and sulphur hexafluoride (SF_6) (Kiehl and Trenberth, 1997).

Perception: It is the process by which people receive information or stimuli from our environment and transform it into psychological awareness (Van and Hawkins, 2000). People infer about a certain situation or phenomenon differently using the same or different sets of information. The knowledge, interest, culture and many other social processes shape the behavior of an actor who uses the information and tries to influence a particular situation or phenomenon (Banjade, 2003).

Saarinen (1976) also expressed perception as an extremely complex concept and confines social perception which is concerned with the effects of social and cultural factors on cognitive structuring of our physical and structural environment. This varies with the individual‘s past experiences and present sets or attitudes acting through values, needs, memories, moods, social circumstances, and expectations.

Adaptation: Adaptation is the adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities (IPCC, 2007). In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment to expected climate and its effects (IPCC, 2014).

Adaptation is a process by which strategies to moderate, cope with and take advantages of the consequences of climatic events are enhanced, developed, and implemented (UNDP, 2007). It is an adjustment in ecological, social or economic systems in response to actual or expected stimuli and their effects or impacts. The term refers to changes in processes, practices and structures to moderate potential damages or to benefit from opportunities associated with climate change (IPCC, 2007).

Vulnerability: Vulnerability is the extent to which a natural system or human society is unable to cope with the negative impacts of climate change, variability and extremes. It depends on changes in climate as well as the sensitivity and adaptive capacity of the system or society (Pittock, 2003). Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity (IPCC, 2001).

Disaster: Disaster is a serious disruption of the functioning of a community or a society causing widespread human, material, economic or environmental losses which exceed the ability of the affected community or society to cope using its own resources (ISDR, 2004).

Exposure: The degree of climate stress upon a particular unit analysis is known as exposure. It may be represented as either long-term change in climate conditions or by changes in climate variability including the magnitude and frequency of extreme events or people, property, systems or other elements present in hazard zones that are thereby subject to potential losses or the nature and degree to which a system is exposed to significant climatic variations is known as exposure. Measures of exposure can include the number of people or types of assets in an area (IPCC, 2001).

Coping: It is the use of available skills, resources, and opportunities to address, manage, and overcome adverse conditions, with the aim of achieving basic functioning in the short to medium-term during and immediately after a climate-induced hazard (IPCC, 2012).

Mitigation: Mitigation is a human intervention to reduce the sources or enhance the sinks of greenhouse gases. Examples include using fossil fuels more efficiently for industrial processes or electricity generation, switching to solar energy or wind power, improving the insulation of buildings and expanding forests and other sinks to remove greater amount of carbon dioxide from the atmosphere. In climate change policy, mitigation is defined differently, being the term used for the reduction of greenhouse gas emissions that are the source of climate change. Tackling climate change by limiting greenhouse gas emissions is known as mitigation (IPCC, 2001).

2.2. Overview of Climate Change

Climate change is a multifaceted biological and physical process. It is impossible to precisely predict future climate conditions, but the scientific consensus is that global land and sea temperatures are warming under the influence of greenhouse gases, and will continue to warm regardless of human intervention for at least the next two decades (IPCC, 2007). According to Joel *et al*. (1998), the climate has changed, is changing, and will continue to change regardless of what investments in mitigation is made.

Africa is also highly stressed, has low adaptive capacity and easy vulnerable to climate change. The main consequences of negative impact of climate change or climatic hazards are poverty, unequal access to resources, food insecurity, social and political conflicts and incidences of diseases. This impact of climate change presents a considerable challenge to regional agricultural development. The Sub-Saharan African countries in particular have low adaptation mechanism and are vulnerable to the widespread effect of climate change. With this bid serious problem, GDP is predicted to lost in the coming 2100 in most part of the continent. For instance, 2-7% in part of Sub-Saharan Africa, 2-4.5% in West and Central Africa, and 0.4-1.3% in North and Southern Africa (FAO, 2009).

According to IPCC (2007), increase in global average temperature above the range of 1.5-2.5^{0}C will negatively influences species distribution and survival. In most developing countries where the majority of the population is dependent on natural resources based livelihoods, it has an impact on socio-economic and threat to overall sustainable development. It was predicted that during 21th century, greenhouse gases mission will increase by 25-90%. This will be continuing for future periods.

Climate change affects many sectors, including water resources, agriculture and food security, infrastructures, ecosystems and biodiversity, human health and coastal zones. Because of its innate link to natural resources, agricultural production is at the mercy of uncertainties driven by climate variation, including extreme events such as flooding and drought (Kurukulasuriya and Rosenthal, 2013).

2.2.1. Cause of climate change

Climate change is caused by the emission of greenhouse gases into the earth's atmosphere through both natural processes and human activities; though growing evidence demonstrates the largest contribution is from the latter. The burning of fossil fuels, largely as a result of transportation, is the primary contributor to the emission of carbon dioxide while processes such as deforestation and industrial agriculture are the main contributors to the emission of methane and nitrous oxide compounds into the atmosphere. Despite constituting less than 15% to total GHG emissions, methane is a very strong greenhouse gas which is 23 times stronger than CO_2 (IPCC, 2007).

2.2.2. Climate change impact

Agriculture is ranked as the most susceptible sector to climate change impacts and so do the livelihoods of subsistence farmers and pastoralists. Climate change exerts multiple stresses on the biological, physical, social and institutional environments that affect agricultural production. Its impacts disproportionately affected Sub-Saharan African countries including Ethiopia because of the higher dependency of their economies on climate-sensitive activities such as rain-fed agriculture. Some of the induced changes are expected to be immediate, while others involve gradual shifts in temperature, vegetation cover and species distributions. Climate change is expected to and in parts of Africa has already begun to alter the dynamics of drought, rainfall and heat waves, and trigger secondary stresses such as the spread of pests, increased competition for resources, and biodiversity losses (Christensen *et al.*, 2007).

It is difficult to predict the impact of climate change on complex biophysical and socio-economic systems that constitute agricultural sectors. Warmer climates and changes in rainfall seem to destabilize agricultural production in many parts of Africa. Total agricultural production significantly declines due to the unexpected change in climate. This is anticipated to challenge the systems that provide food security. As a result, it could threaten the efforts to improve food security. The projected impact of climate change on agricultural productivity differs per region and per agricultural activity. Typically, mixed farming or crop farming is practiced in the highlands while the lowlands are characterized by nomadic pastoralism (Gregory *et al*., 2005).

There is growing evidence that climate change has had negative effects on agriculture. Agriculture, mainly in developing countries, is commonly agreed to be the sector which is most negatively affected by climate change. Moreover, Africa's agriculture is hardly hit with impacts of climate change due to its low level of economic development and adaptive capacity (IPCC, 2007; Lobell *et al.*, 2011).

2.3. Climate Change in Ethiopia

Climate change is a key concern to Ethiopia and need to be tackled in a state of emergency. It has brought an escalating burden to already existing environmental concerns of the country including deforestation, serious soil erosion and loss of top soil and land degradation which in turn have adversely impacted agricultural productivity (MoA, 2011).

2.3.1. Climate change and agricultural sector in Ethiopia

The economy of Ethiopia is mainly based on rain-fed agriculture which is the source of livelihood for the majority of its population (CSA, 2007). The country exhibits different agro-ecological zones attributed to varied microclimates within which different growing seasons existed and different agricultural activities practiced. There are different ways of classifying the climatic systems of Ethiopia, including the traditional and the agro-climatic zone in classification systems (Yohannes, 2003). Among the different ways of classifying the climatic systems of the country, the traditional and agro-ecological classifications are the most common ones (Temesgen *et al.*, 2010). The agro-ecological zone classification system combining growing periods with temperature and moisture regimes has 18 major agro-ecological zones which are further sub-divided into 49 agro-ecological zones. According to MoA (2000), these agro-ecological zones can be grouped into six major categories which include Arid zone (31.5%), Semi-arid (3.5 %), Sub-moist (19.7%), Moist (25%), Sub-humid and humid (19.3%) and Per-humid which covers close to 1 % of the Country.

The traditional classification, based on altitude and temperature, shows the presence of 5 climatic zones (NMA, 2007). Based on traditional classifications, agro-climatic zones of Ethiopia could be divided as *Wurch* (upper highlands), *Dega* (highlands), *Weyna Dega* (midlands), *Kola* (low lands) and *Berha* (desert) (MoA, 2000).

Climate is the main determinant of Ethiopian economic growth due to the fact that agriculture sector is continued to be the engine of the country's economic growth. Agriculture includes crop production, livestock husbandry, forestry, fishery and others. Out of 39% of contribution of agriculture to the country's GDP, crop production is estimated to contribute to the agriculture sector on average about 70.2%, livestock sub-sector accounts around 20.3% and forestry and other subsectors around 9.5% of the total agricultural value in the country at the end of 2014/15 (FDRE, 2016).

The mean annual distribution in Ethiopia is characterized by large spatial variation which ranges from about 2000 mm over some pocket areas in the southwest to less than 250 mm over in Afar and Ogaden lowlands' (Kurukulasuriya and Mendelsohn, 2008). The problems cause by climate change on agriculture and for which MoA is responsible to take actions against are land degradation, biodiversity loss, animal diseases, crop diseases and pests, factors that reduce agricultural production, shortage of food and feed, intensified disasters and increased environmental refugees (MoA, 2011).

The heavy dependence of Ethiopia's economy on rain-fed agriculture exacerbated its vulnerability to climate change impact. In addition, its geographical location and topography in combination with low adaptive capacity entail a high vulnerability to the impacts of climate change. Historically, the country has been prone to extreme weather variability. Rainfall is highly erratic, most rainfalls with high intensity, and there is a high degree of variability in both time and space. Since the early 1980s, the country has suffered 11 major drought years (Masih *et al*., 2014).

Even in recent years, Ethiopian farmers and systems experienced one of the worst droughts in 50 years which was comparable to the 1983-5 drought in large part due to El Niño. The 2015 El Niño was the most severe drought in half a century. Significant rainfall deficits severely impacted the lives and livelihoods of farmers and herders throughout the country. Following two consecutive poor rainy seasons; *belg* and *kiremt,* harvests were well below average, with some areas experiencing between 50 and 90 percent crop loss. The livestock sector has also seen extreme mortality and morbidity rates and abnormal migration in search of pasture and water. Many families dependent on agriculture have become indebted and dependent on humanitarian assistance. At the start of 2016, more than 10.2 million people were in need of emergency food aid, 1.7 million households were seed insecure and 2.4 million households in need of livestock support (FAO, 2016).

Rainfall failure, floods, drought and other changes in the country's natural and environmental system due to climate change intimidate the performance of the economy as a whole and cause severe malnutrition and loss of livelihoods for households mainly in marginal and less productive lands in the country (PANE, 2009). This effect is attributed to the fact that those changes can seriously depress agricultural production in the country. This clearly demonstrates that, economic growth in general and households` welfare in particular are significantly influenced by changes in rainfall, temperature and other climate variables (World Bank, 2006). This shows that the impact of climate change in the country can be felt not only on agricultural output but also on other sectors of the economy.

Many studies have concluded that the agriculture sector of the country is the most affected sector by climate change. The trends in the contribution of agriculture to the country's total GDP clearly explain the relationship between the performance of agriculture, climate and the total economy.

2.3.2. Projected climate change in Ethiopia

The models predicting future climate change scenario in Ethiopia put conclusion that temperature will increase in the coming decades. However, there is conflicting results concerning the predicted level of rainfall (Tadele *et al.*, 2013). There are constant, decreasing and increasing levels of projected rainfall levels which were generated using different models. According to Mahoo *et al*. (2013), the frequency and severity of natural shocks in Ethiopia is increasing because of severe and repeated rainfall failures which strengthens the scenario that rainfall is decreasing time to time. According to NMA (2007), temperature will increase in the range of 1.7-2.1^{0}C by the year 2050 and 2.7-3.4^{0}C by the year 2080 over Ethiopia. The country will experience an increasing level of temperature and rainfall in the coming decades. However, it stated that a small increase in rainfall can be expected.

Studies also indicated that Ethiopia in the coming years will face a decrease in agricultural production due to the adverse impact of climate change and variability's (Tadele *et al*., 2013). In addition, World Bank (2007) stated that climate change is projected to reduce yields of the wheat staple crop by 33% in Ethiopia .This suggests that agricultural production as the dominant contributor of growth and development of the country is highly vulnerable to climate change and climate variability which further seriously threaten food security of citizens. While the more pronounced effects on crops and livestock are likely to materialize in later decades, efforts to enhance the resilience to climate shocks of crop yields and livestock production should be improved. This will enable to secure an increment in agricultural output and lead to achieve the overall economic performance and objective of Ethiopian growth and transformation plan for the coming periods.

2.4. Perception and Adaptation to Climate Change

2.4.1. Climate change perception

In agrarian communities, the linkage between agriculture and climate is much more complex than others, and farmers are able to identify specific and important weather patterns. Farmers usually base their crop and other production decisions using local knowledge systems which are developed from years of observations and experiences. Local knowledge forecasts provide more than just information about the forecast. They provide a set of behavioral rules that households and communities follow when certain indicators are or are not observed. Predicting climate is also an important cultural component for farmers (Burton *et al.*, 1992).

According to Maddison (2007), perceiving change and then deciding whether or not to adopt a particular measure is process in climate change adaptation. Whenever they have the opportunity, farmers tend to adopt new variety of measures or technologies in response to the perceived changes of weather conditions. The supports from extension workers, information gained and technologies available to them will highly influence their adaptation and response capacity. For instance, farmers use water conservation techniques whenever the rainfall patterns are changed and amounts of rain are reduced. They tend to plant different crop varieties and use short term crops with adjustment of planting dates. These adjustments are done when they perceive reduction in rainfall and changes in the onset and offset of rainy seasons.

For poor farmers, adaptation strategies to climate change are vital because failure to take adaptation measures could lead to social problems and displacement (Downing *et al.*, 1997). To approach the issues of climate change appropriately, the local communities' or farmers understanding and level of awareness about climate change is determinant factor. Farmers perceive climate change as having a strong spiritual, emotional, and physical dimension (Apata *et al.*, 2009).

The study by Benedicta *et al.* (2010) showed that farmers are well aware of climate change, but few seem to actively take steps toward adjusting their farming activities. According to Temesgen *et al.* (2011), majority of farmers were able to recognize that temperatures have increased and there has been a reduction in the volume of rainfall, still few farmers' lack the perception of change in climatic condition of their area to take steps to adjust their farming activities. The degree of farmers' perception on climate change also depends on its impact on farmers' livelihood, their social, institutional and economic background. It is different and depends mainly on level of education, livelihood activity, location and age.

2.4.2. The basics of adaptation and adaptation strategies to climate change

Over the coming decades, climate change impacts on agriculture are likely to increase due to greater climate variability, and increased frequency and intensity of extreme events. Policymakers have largely focused on tackling climate change through mitigation of human-induced emissions of greenhouse gases and sequestration of carbon in order to address the expected pressures on the agricultural as well as other economic sectors. However, it is becoming widely accepted that mitigation alone is implausible to be sufficient as a climate policy (Pielke, 1998).

Adaptation and mitigation are two different policy responses to the issue of climate change. They are however inherently linked. Since mitigation measures alone will not be able to immediately avoid global warming, adaptive measurements are needed to avert the negative consequences of climate change at the short-term. On the long-term, mitigation measures will be able to avoid further warming or even reduce the effect (Parry *et al.*, 2007).

A plenty of studies have consequently emphasized the need to take adaptation in addition to mitigation strategies. The goal of an adaptation measure should be to increase the capacity of a system to survive external shocks or changes. The IPCC (2001) noted that adaptation through changes in processes, practices or structures is an essential element in reducing adverse impacts or enhancing beneficial impacts of climate change. Adaptation strategies are also required to overcome the expected adverse impacts from higher temperature and changing rainfall patterns (Kurukulasuriya and Mendelsohn, 2007). The main aspect of climate change adaptation constitutes building resilience which is the capacity of a system to tolerate disturbance without collapsing into a qualitatively different state that is controlled by a different set of processes (FAO, 2003).

There are many different strategies that the farmers can implement to reduce the risk of climate change impacts. Farmers use different adaptation strategies that fit with the types of the problems caused by climate change they faced. This is due to the fact that impact of the climate change is unevenly distributed over different geographic areas and hence the adaptation mechanisms also vary with types and level of the impact of climate change (IPCC, 2007).

A number of adaptation strategies that the farmers used to reduce the impact of climate change are identified in different literatures. These include; changing planting dates, changing crop variety, mix crop and livestock production, planting short season crop, planting trees, decrease livestock, moving animals or temporary migration, change livestock feeds, soil and water management, change from livestock to crop production, change animal breeds, irrigation or water harvesting, and seek off-farm employment are among some of the several strategies available to enhance social resilience in the face of climate change (Bradshaw *et al.*, 2004; Nhemachena and Hassan, 2007).

Studies carried out independently by Temesgen *et al*. (2009), the World Bank (2010), and Mengistu (2011) also showed that diversification, using different crop varieties, changing planting dates, planting trees, adoption of drought tolerant and early maturing crop varieties, changing cropping densities, water harvesting techniques, increased use of soil and water conservation techniques or soil erosion prevention programs, increased use of irrigation and or use of irrigation techniques, changing fertilizer application, pesticide application, applying different feed techniques, the pastoral system or the herd composition, improvement or rehabilitation of terraces, home-garden agriculture are among the common adaptation strategies farmers carry out in response to climate change.

Even though there are a wide range of adaptation options, there is no assurance that a particular farmer will undertake adaptive response. The extent to which adaptation strategies are implemented varies among individual farmers depending on their capacity and willingness to adopt (Crimp *et al.,* 2010).

There are factors that are restricting adaptive capacity and willingness to adopt as a potential source of limits and barriers to adaptation. A complex mix of conditions determines the capacity of systems to adapt. The main features of communities or regions that seem to determine adaptive capacity are biophysical, economic, social, technological, information, skills, infrastructure, and institutional characteristics (Munasinghe and Swart, 2005).

2.5. Review of Empirical Literature

Different researches have been undertaken by scholars to understand farmers' perception to climate change, to explore adaptation strategies in response to these changes, and to investigate the determinants of perception and choice of adaptation methods. Results of these researches provided varied verification about farmers' perception and choice of adaptation strategies in their respective study areas.

2.5.1. Farmers' perception to climate change

Fosu-Mensah *et al.* (2012) conducted study on farmers' perception and adaptation to climate change in Sekyedumase district in Ghana. Results showed that about 92% of the respondents perceived increases in temperature, while 87% perceived decrease in rainfall over the years. Even though the communities are highly aware of climate issues, only 44.4% of farmers have adjusted their farming practices to reduce the impacts of increasing temperature and 40.6% to decreasing rainfall, and mentioned that lack of funds as the main barrier to implementing adaptation measure.

A research was undertaken by Bryan *et al*. (2009) on adaptation to climate change in Ethiopia and South Africa which examined farmers' perceptions of climate change in Ethiopia and South Africa. The result showed that even though farmers perceived changes in temperature and rainfall, a large percentage of farmers did not make any adjustments to their farming practices. Belaineh *et al.* (2013) also found that there are nearly unified perceptions of climate variability and change among gender and social groups.

Abid *et al*. (2015) studied farmers' perceptions of and adaptation strategies to climate change and their determinants in Punjab province of Pakistan. The results demonstrated that awareness of climate change is widespread throughout the area, and farm households make adjustments to adapt their agriculture in response to climatic change.

A study has been conducted by Nega *et al.* (2015) on perception of climate change and its impact by smallholders in pastoral/agro pastoral systems of Borana, South Ethiopia. The results suggested that most participants perceived climatic change and its negative impact on agriculture and considered climate change as a salient risk to their future livelihoods and economic development. Different levels of perception were expressed in terms of climate change and the impact on traditional rain-fed agriculture. Age, education level, livestock holding, access to climate information and extension services significantly affected perception levels. Solomon *et al*. (2016) also undertook a research on perception and adaptation models of climate change by the rural people of Lake Tana Sub-basin, Ethiopia by employing Heckman probit and MNL models. The farmers' perceptions to climate change found to be statistically and significantly related to factors such as marital status, farm size, climate change information access and the level of income generations.

Gadédjisso-Tossou (2015) conducted a study on understanding farmers' perceptions of and adaptations to climate change and variability the case of the Maritime, Plateau and Savannah Regions of Togo. The analysis of farmers' perception to climate change revealed high increase in temperature and decrease in rainfall. These results were in accordance with the trend analysis of climate data records in the study area particularly on the temperature.

Adeoti *et al.* (2016) examined farmers' vulnerability, perception and adaptation to climate change in Kwara State using descriptive statistics and MNL model. The study revealed that majority (84%) of the farmers believed that temperature had increased while about 65.8% noticed that rainfall had declined. Abrham *et al*. (2017) also investigated smallholder farmers' adaptation to climate change and determinants of their adaptation decisions in the Central Rift Valley of Ethiopia using a descriptive statistics and MNL model. The result showed that 90% of farmers have already perceived climate change and 85% made attempted to adapt.

Wondimagegn and Lemma (2016) conducted a study on climate change perception and choice of adaptation strategies base on empirical evidence from smallholder farmers in east Ethiopia. According to this study, majority of farmers in the study area are aware of climate change patterns and their adverse effect on income, food security, diversity, forest resources, food prices and crop and livestock diseases. Results showed that, from the sample households, more than 95% perceived the rise in average temperature and about 86% perceived the decrease in precipitation over the years.

2.5.2. Adaptation strategies to climate change and their determinants

Burton *et al.* (1992) presented that adaptation to climate change and risks takes place in a dynamic social, economic, technological, biophysical, and political context that varies over time, location, and sector and determines the capacity of systems to adapt. Adaptive capacity varies considerably among regions, countries, and socio-economic groups. The ability to adapt and cope with climate change impacts was also a function of wealth, technology, information, skills, infrastructure, institutions and equity.

A research was conducted by Nhemachena and Hassan (2007) on micro-level analysis of farmers' adaptation to climate change in Southern Africa using a multivariate discrete choice model to identify the determinants of farm-level adaptation strategies. The results confirmed that access to credit, extension, and awareness of climate change are some of the important determinants of farm-level adaptation.

Hassan and Nhemachena (2008) examined determinants of African farmers' strategies for adapting to climate change using a multinomial choice analysis. The results indicated that warming poses the highest risk and encourages irrigation, multiple cropping and integration of livestock. Increased precipitation reduces the probability of using irrigation and will benefit most African farms, especially in drier areas. Better access to markets, extension and credit services, technology and farm assets (labor, land and capital) found to be critical for helping African farmers to adapt to climate change.

Temesgen *et al.* (2009) identified the major methods used by farmers to adapt to climate change in the Nile Basin of Ethiopia, the factors that affected their choice of methods and the barriers to adaptation by employing multinomial logit (MNL) model. Based on their findings, the level of education, gender, age, and wealth of the head of household; access to extension and credit, information on climate, social capital, agro-ecological settings, and temperature found to influence farmers' choices.

A research conducted by Bryan *et al*. (2009) on adaptation to climate change in Ethiopia and South Africa which examined farmers' perceptions of climate change, the extent of adaptation, barriers to adaptation, and the factors influencing adaptation and adaptation choices in Ethiopia and South Africa by employing a probit model. The research found that the most common adaptation strategies include use of different crops or crop varieties, planting trees, soil conservation, changing planting dates, and irrigation. The results of the probit model revealed that wealth and access to extension, credit, and climate information are factors that influenced farmers' decision to adapt in Ethiopia. Food aid, extension services, and information on climate change were found to facilitate adaptation among the poorest farmers.

Gbetibouo *et al*. (2010) conducted a research on climate adaptation strategies of farmers in the Limpopo Basin of South Africa. The results showed that even though many farmers noticed long-term changes in temperature and precipitation, most could not take remedial action. The common adaptation responses reported included diversifying crops, changing varieties and planting dates, using irrigation, and supplementing livestock feed. A MNL analysis of climate adaptation responses noted that access to water, credit, extension services, off-farm income, employment opportunities, tenure security, farmers' asset base, and farming experience are the key that enhanced farmers' adaptive capacity.

A study has been conducted by Gutu *et al*. (2012) on econometric analysis of local level perception, adaptation and coping strategies to climate change induced shocks in North Shewa, Ethiopia using two steps process of Heckman model to analyze adaptation to climate change. Perception to climate change found to be the prime determinant for adaptation. Farmers found to follow different coping mechanisms where some of them negatively affected the future development of the community and immediate recovery from climate change impacts. The result concluded that awareness creation on climate change, facilitation of credit availability, investment on non-farm engagement, improve good mix of livestock holding, encourage adult education, dissemination of indigenous early warning information, diversifying crops to perennial trees, and improved frequencies of agricultural extension contact enabled farmers well perceived climate change and then adapted to the changes.

A study has conducted by Fosu-Mensah *et al.* (2012) on farmers' perception and adaptation to climate change in Sekyedumase district in Ghana. The major adaptation strategies identified included crop diversification, planting of short season varieties, change in crops species, and a shift in planting date. Results of logit regression analysis indicated that the access to extension services, credit, soil fertility, and land tenure are the four most important factors that influenced farmers' perception and adaptation. The main barriers included lack of information on adaptation strategies, poverty, and lack of information about weather.

Aemro *et al*. (2012) investigated climate change adaptation strategies of smallholder farmers in Babilie District, East Harerghe Zone of Oromia Regional State of Ethiopia. The results from the MNL analysis showed that sex, age, and 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 found to have a significant impact on climate change adaptation strategies.

Belaineh *et al.* (2013) examined smallholder farmers' perceptions and adaptation to climate variability and climate change in Doba District, West Hararghe Ethiopia. The adaptation strategies used in MNL model were crop diversification and the use of soil and water conservation practices, integrated crop and livestock diversification, engaging in off-farm income activities and rainwater harvesting. It was found that agro-ecological locations, sex, family size, plot size, off-farm income, livestock holding, frequency of extension contact and training were the determining factors influencing adaptation strategies.

Temesgen *et al.* (2014) analyzed climate change adaptations of smallholder farmers in Southeast Ethiopia using a descriptive statistics and MNL model. The model result depicted the strong and positive association between the combined measures of agronomic practices and use of agricultural inputs with education, access to weather information, access to credit and farm income. Similarly, sex of the household head and access to weather information were found to significantly affect the choice decision of inputs and agronomic practices like use of drought tolerant crop species and crop diversification measures.

A research done by Gebru *et al.* (2015) on farmers' climate change adaptation options and their determinants in Tigray Region, North Ethiopia in which descriptive statistics were employed to assess adaptation options while the MNL model was used to identify factors influencing households choices. The results revealed that farmers use change in crop type/ variety, soil and water conservation practices, crop diversification, change in planting date and irrigation practices as climate change adaptation options. Educational level, age, sex of the household head; farm income, access to extension service, access to credit, access to climate information and agro-ecological settings were the most important determinant factors that significantly affected the choice of farmers to climate change adaptations.

A research has been conducted by Abid *et al*. (2015) on farmers' perceptions of and adaptation strategies to climate change and their determinants in Punjab province of Pakistan. Changing crop varieties, changing planting dates, planting of shade trees and changing fertilizers were the main adaptation methods implemented by farm households in the study area. The results from the binary logistic model revealed that education, farm experience, household size, land area, tenancy status, ownership of a tube well, access to market information, information on weather forecasting and agricultural extension services influenced farmers' choices of adaptation measures. The results also indicated that adaptation to climate change is constrained by several factors such as lack of information, lack of money, resource constraints and shortage of irrigation water in the study area.

Gadédjisso-Tossou (2015) conducted a study on understanding farmers' perceptions of and adaptations to climate change and variability the case of the Maritime, Plateau and Savannah Regions of Togo. Descriptive statistics and MNL were used to analyze data obtained from a cross-sectional survey. The results also showed that crop diversification, change in crops, find off-farm jobs, change of the amount of land, change of the planting date and plant short season variety found to be the adaptation methods employed by the farmers. The MNL analysis showed that education level, farming experience, access extension services, access to credit and access to climate information were the factors that enhanced farmers' adaptive capacity to climate change and variability.

Solomon *et al*. (2016) undertook a research on perception and adaptation models of climate change by the rural people of Lake Tana Sub-basin, Ethiopia by employing Heckman probit and MNL models. The MNL model results revealed that age, educational level, wealth status, agricultural extension services, and distance to the nearest health center are found to be significant for determining climate change adaptation.

A study by Adeoti *et al.* (2016) examined farmers' vulnerability, perception and adaptation to climate change in Kwara State using descriptive statistics and MNL model. The econometric investigation revealed that education of household head, farming experience, land ownership, rainfall and temperature were the most relevant and significant factors that determined the farmers' choice of adaptation strategies to climate change in the study area. The major barriers to adaptation include lack of information on adaptation methods, land tenure problem and inaccessibility to credit.

Wondimagegn and Lemma (2016) conducted a study on climate change perception and choice of adaptation strategies base on empirical evidence from smallholder farmers in east Ethiopia. The study found that the major adaptation strategies used by farmers in response to adverse effects of climate change include cultivating different crops, planting different crop varieties, changing planting dates, use of soil and water conservation techniques, conservation agriculture practices and engaging in non-farm income activities. The MVP model result revealed that the choice of adaptation strategies are influenced by gender of household head, household size, farm size, distance from market and number of farm plots.

Abrham *et al*. (2017) investigated smallholder farmers' adaptation to climate change and determinants of their adaptation decisions in the Central Rift Valley of Ethiopia using a descriptive statistics and MNL model. It is found that farmers made attempted to adapt using practices like crop diversification, planting date adjustment, soil and water conservation and management, increasing the intensity of input use, integrating crop with livestock, and tree planting. The econometric model result indicated that education, family size, gender, age, livestock ownership, farming experience, frequency of contact with extension agents, farm size, access to market, access to climate information and income were the key factors determining farmers' choice of adaptation practice.

In summary, most of the studies regarding climate change in Ethiopia focused in basins, pastoral and severely drought affected areas repeatedly. Nevertheless, for farmers to perceive and adapt for the changing climate, agro-ecological setting, socio-economic conditions and way of living of the community matter at most. In connection to this, some areas which are highly productive but gradually affected by climate change have been left unconsidered. Given the need for agro-ecologically based policy measures for climate change, it is impossible to aggregate these findings as evidence for the country. Thus, studying climate change perception and adaptation at micro level in different areas with different socio-economic and institutional characteristics is worthwhile to suggest policy options conditioning on the context of a specific area. In addition, most of these studies used MNL model to identify factors affecting choice of adaptation strategies to climate change. However, adaptation strategies are interdependent by nature and employing this model is inappropriate.

2.6. Conceptual Framework of the Study

In this study, farmers' adaptation process at the farm level described as a three-step procedure. First, there is an increasing level of emission of greenhouse gasses to the environment which caused climate change. The changes in climatic conditions were manifested by an increase in temperature and decrease in rainfall availability so that emergence of unfavorable situation for agricultural practices. Climate change thus causes adverse impacts on livelihood of farmers. Farmers then have to perceive climate change and its adverse impacts on their agricultural production and their livelihood in order to respond to the change so that capable to lessen side effects. There is also an awareness creation and some other intervention from government and non-government organizations to enable farmers to perceive climate change and to take adaptation measures. Secondly, farmers then took certain measures to adapt to climate change based on their perception and intervention from governmental and non-governmental organizations. In fact, there are a number of adaptation options from which farmers made a choice. Finally, farmers' adoption of particular adaptation measures was subject to various household and institutional factors. The following analytical framework depicted the most important variables expected to influence the farmers' choice of adaptation strategies to climate change the case of Woreillu District (Figure 1).

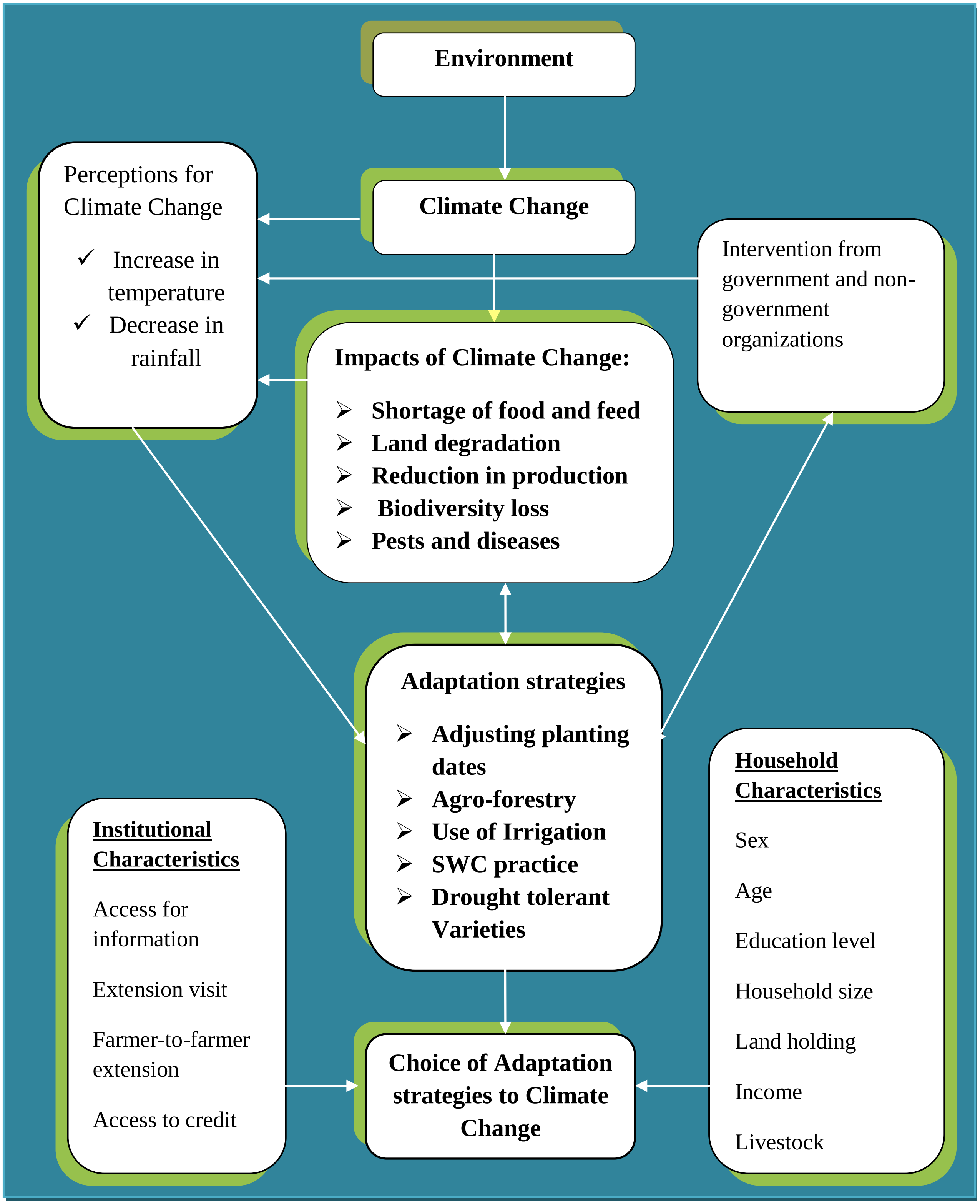

Figure 1: Conceptual framework

Source: Own synthesis based on literature reviews

3. RESEARCH METHODOLOGY

3.1. Description of the Study Area

The study was conducted in Woreillu district, South Wollo Zone of Amhara Regional State. Woreillu is found at 492 km in the North direction from Addis Ababa, 571 km from Bahir Dar and 91 km from Dessie. It is bordered by Jama in the southwest, Legahide in the west, Legambo in the northwest, Dessie zuria in north, Albuko in the east and Wanchet in the southeast. The district has 20 peasant associations (kebeles) with a total land area of 740.96 square-kilometers. It is situated between 10^{0}36'N and 39^{0}26'E latitude and longitude respectively. Its' altitude ranges from 1700 to 3200 meters above sea level (WDADO, 2016).

According to the agriculture office of the district, agro-ecologically the district is classified as *dega* (highland) accounting 82%, and *woinadega* (midland) accounting the rest 18%. Most kebeles produce crops in *meher* season while a few kebeles produce also in *belg* season. The annual rainfall ranges from 414.2 mm to 1250 mm which is usually inadequate, poorly distributed and highly variable in inter and intra seasons. The population of the district is estimated to be 128,603 out of which 63,861 are male and 64,742 are female**,** with population density of 173.6 per square. The farming system that the community practicing are mixed farming systems in which both crop cultivation and rearing livestock are practiced. Cereals like wheat, barley, and *teff* and pulses like field pea, rare lentils, and beans are some of the dominant crops grown in the area. The major livestock reared in the district are cattle, sheep and poultry. The average land holding of the household is 1.3 hectares per household. Out of the districts' total area, 48% is arable land, 5% is grazing land, 22 % vegetation and bushy, 7% settlement, and 18% waste land. According to the information from Agriculture office, the district is repeatedly and severely affected by climate change induced hazards (WDADO, 2016). The location map of the study area is depicted below (Figure 2).

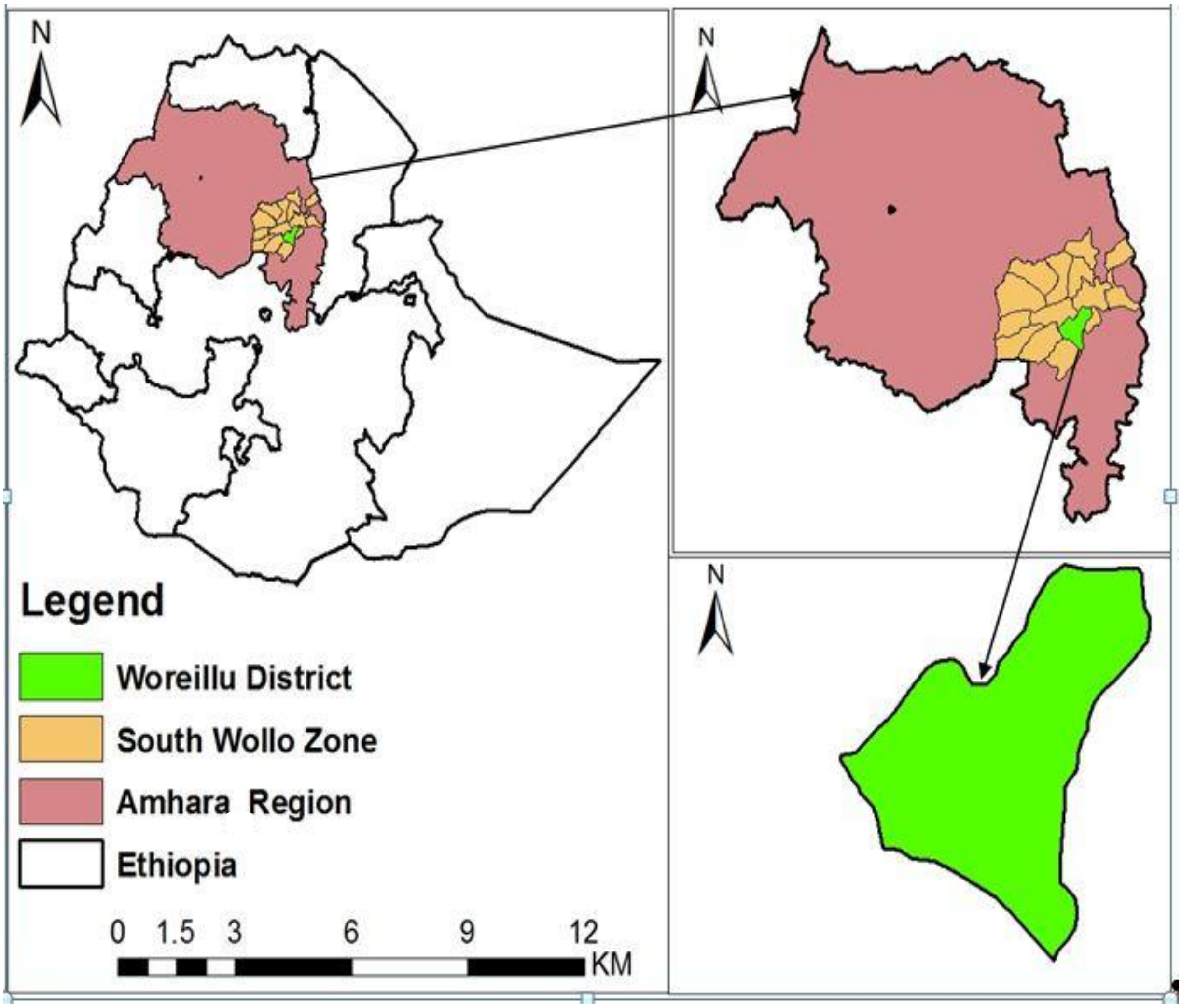

Figure 2: Map of the Woreillu District

Source: Extracted from Arc GIS software

3.2. Sampling Techniques

The study was undertaken in Woreillu district because of the severity of the effect of climate change in the area. A two-stage stratified random sampling technique was applied to select sample households. According to Kothari (2004), if the population from which a sample is to be drawn does not constitute a homogeneous group, then stratified sampling technique is applied so as to obtain a representative sample. In this technique, the population is stratified into a number of non-overlapping sub-populations or strata that are individually more homogeneous than the total population and sample items are selected from each stratum to constitute a sample. The strata are formed on the basis of common characteristic of the items to be put in each stratum so that ensure elements being most homogeneous within stratum.

In the first stage, the kebeles in the district have been stratified into two as dega and woinadega. Farmers within the same agro-ecology have homogenous characteristic in different aspects. They have similar agricultural practices, traditional knowledge and skills. There are a total of 20 kebele administrations in the district out of which 16 kebeles are *dega* (highland) and 4 kebeles are *woinadega* (midland). Then four kebele administrations from *dega* and one kebele from *woinadega* have been randomly selected proportionate to number of kebeles in each agro-ecological zone because of homogeneity of kebeles within the identified agro-ecologies. The formula provided by Yamane (1967) was used to determine the required sample size at 95% confidence level and 8% level of precision.

$$n = \frac{N}{1 + N(e)^2} = \frac{21627}{1 + 21627(0.08)^2} = 155$$

Where: $n =$ Sample size $N =$ Size of population $e =$ Level of precision

In the second stage, a total of 155 sample households have been selected randomly using probability proportional to number of household heads size sampling technique from sample kebeles.

Table 1: Distribution of sample households across sample kebeles in the district

Sample kebeles	Total number of households	Sample size	
		Number	Percent (%)
Highland	**5282**	**119**	**76.77**
Werebayasu	1433	32	20.64
Dolu	1250	28	18.06
Gatira	1327	30	19.36
Batel	1272	29	18.71
Midland	**1612**	**36**	**23. 23**
Kuyu	1612	36	23.23
Total	**6894**	**155**	**100**

Source: Own computation from secondary data, 2017

3.3. Methods of Data Collection

The study used both primary and secondary data sources to collect qualitative and quantitative data. The primary data on demographic, socio-economic and institutional factors were collected from 155 sample households of Woreillu District using semi-structured questionnaire and five focus group discussions (FGD) involving 8-10 purposively participants selected in each group. The FGDs included model farmers, development agents, district officials and elders. A pilot study was first undertaken for pre-testing the questionnaire and the questionnaire has been revised in light of the results of the pilot study. Secondary data were collected from documents of different offices in South Wollo Zone and Woreillu District. In addition, a 24 years rainfall and temperature data for the period 1993-2016 have been collected from the National Meteorological Agency (NMA) branch office in Kombolcha.

3.4. Methods of Data Analysis

Descriptive statistics, Likert scale measurement and multivariate probit (MVP) regression analysis were the main analytical techniques that are used to analyze the data.

3.4.1. Analysis of perception to climate change and adaptation options

In order to get essential information and insight into farmers' adaptation to climate change, looking at their perception on each climate attributes were quite important. Descriptive statistic and Likert scale measurement were used to characterize farmers' perception on changes in long-term temperature, rainfall and other aspects.

To analyze smallholder farmers' perception to change in climate, further comparison were made correspondence with climate data recorded in Kombolcha Meteorological Sub-station (KMS) for 24 years for the period (1993-2016 G.C) by fitting a linear trend of annual means of temperature and rainfall. Making this trend in annual average temperature and rainfall a base for comparison, the perception of farmers were analyzed whether it was in line with or opposite to the linear trend fitted from KMS data. This has been done by asking household heads questions about their opinion on the direction of climate change and using a five level Likert scale measurement on some attributes of climate change. Percentages were used to analyze the proportion of respondent in each level. Farmers who strongly agree and who simply agree were considered perceived the change while others not. Percentages were also used to identify adaptation options used by farmers.

3.4.2. Determinants of choice of adaptation strategies

The analytical approach that was commonly used by earlier studies in an adoption decision involving more than two categories is the multinomial logit (MNL) model. For example, Temesgen *et al.* (2009), Aemro *et al*. (2012), Gebru *et al.* (2015), Gadédjisso-Tossou (2015), Solomon *et al*. (2016), Adeoti *et al.* (2016), and Abrham *et al*. (2017) used MNL model to identify factors influencing households' choices of adaptation strategies to climate change. The advantage of using a MNL model is its' computational simplicity in calculating the choice probabilities that are expressible in analytical form (Tse, 1987). This model provides a convenient closed form for underlying choice probabilities, with no need of multivariate integration, making it simple to compute choice situations characterized by many alternatives.

In MNL model, it is assumed that each farmer faces a set of discrete, mutually exclusive choices of adaptation measures from which a person chooses exactly one adaptation strategy. There is an assumption of the independence of irrelevant alternatives (IIA) property, which states that the ratio of the probabilities of choosing any two alternatives is independent of the attributes of any other alternative in the choice set (Hausman and McFadden, 1984; Tse, 1987). However, in real situations, a farmer might choose more than one adaptation strategy at a time and each adaptation strategy could be interdependent to each other. Hence, MNL model could not be appropriate for such cases and another model which can resolve these limitations is required.

The multivariate probit (MVP) model is an appealing model of choice behavior because it allows a flexible correlation structure for the unobservable variables (Huguenin *et al*., 2009). It is a generalization of the probit model used to estimate several correlated binary outcomes jointly. The MVP is one form of a correlated binary response regression model that can simultaneously estimate the influence of the set of explanatory variables on each of the different practices, while allowing for the potential correlation between unobserved disturbances as well as the relationship between the adoptions of different practices (Belderbos *et al.*, 2004). The model is based on the multivariate normal distribution and is recommended in cases of interdependence among the irrelevant alternatives (Greene, 2003).

According to Belderbos *et al.* (2004), complementarities (positive correlation) and substitutabilities (negative correlation) between different options may be the source of the correlation between error terms. Another source of positive correlation is the existence of unobservable household specific factors that affect choice of several adaptation options but are not easily measurable such as indigenous knowledge. The correlations are taken into account in the MVP model. This study, therefore, used a MVP econometric technique to overcome the shortfalls of using the MNL model to assess determinants of adaptation measures.

The judgment of whether or not to use any adaptation option could fall under the general framework of its value and production improvement capacity. Consider a rational farmer who pursues to improve agricultural productions over a specific time and must choose among a set of 'j' adaptation options. Hence, the farmer 'i' decides to use 'j' adaptation options if the perceived benefit from option 'j' is greater than the utility from other options (say, 'k') stated as:

$$U_{ij}\left(\beta_j' X_i + \varepsilon_j\right) > U_{ik}\left(\beta_k' X_i + \varepsilon_k\right), k \neq j$$

Where U_{ij} and U_{ik} are the perceived values by farmer i of adaptation options j and k, respectively; X_i is a vector of explanatory variables that influence the choice of the adaptation option: β_j and β_k are parameters to be estimated and ε_j and ε_k are the error terms.

Under the revealed preference assumptions, the farmer practices an adaptation option that generates net benefits and does not practice an adaptation option otherwise; we can relate the observable discrete choice of practices to the unobservable continuous net gain variable as $Y_{ij} = 1$ if $U_{ij} > 0$ and $Y_{ij} = 0$ if $U_{ij} < 0$. In this formation, Y is a dichotomous dependent variable taking the value of 1 when the farmer chooses an adaptation option in question and 0 otherwise (Nhemachena and Hassen, 2007).

According to Lin *et al*. (2005) and Nhemachena and Hassen (2007), the MVP econometric approach that was used for this study is characterized by a set of five binary dependent variables like adjusting planting date, using agro-forestry, using drought tolerant variety, using SWC practices, and using irrigation such that:

$$y_{ij}{}^{*} = x_{ij}{}' \beta_j + \varepsilon_{ij}, \qquad j = 1, 2, 3, 4, and\ 5$$

and

$$y_{ij} = \begin{cases} 1\ if\ \ y_{ij}{}^{*} > 0 \\ 0\ otherwises. \end{cases}$$

Where y_1 = adjusting planting date, $y_2 =$ using agro-forestry, $y_3 =$using drought tolerant variety, $y_4 =$ using SWC practices, and $y_5 =$ using irrigation, x is a vector of explanatory variables, $\beta_1, \beta_2, \ldots\ldots, \beta_5$ are conformable parameter vectors, and random error terms $\varepsilon_1, \varepsilon_2, \ldots., \varepsilon_5$ are distributed as multivariate normal distribution with zero means, unitary variance and an 5×5 contemporaneous correlation matrix $R = [\rho_{ij}]$, with density $\emptyset(\varepsilon_1, \varepsilon_2, \ldots\ldots, \varepsilon_5; R)$. The likelihood contribution for an observation is the 5-variate standard normal probability:

$$Pr(y_1, y_2, \ldots, y_5|x) = \int_{-\infty}^{(2y_1-1)x'\beta_1} \int_{-\infty}^{(2y_2-1)x'\beta_2} \ldots \times \int_{-\infty}^{(2y_5-1)x'\beta_5} \emptyset(\varepsilon_1, \varepsilon_2, \ldots, \varepsilon_5; Z' RZ) d\varepsilon_5 \ldots d\varepsilon_2 d\varepsilon_1$$

Where $Z = diag[2y_1 - 1, \ldots 2y_5 - 1]$.

The maximum likelihood estimation maximizes the sample likelihood function, which is a product of probabilities across sample observations as shown above (Nhemachena and Hassan, 2007).

3.5. Definition and Measurement of Variables and Working Hypothesis

Dependent variables

The dependent variables for MVP model of this study were the adaptation options that the sample households employed in response to climate change. The choice of adaptation strategies were based on the actions the sample households take to counteract the negative impact of climate change. From previous researches, different climate change adaptation methods have been identified. The researcher asked numerous alternative adaptation strategies to the sample respondents and finally identified five major adaptation methods most commonly used in the area as dependent variable for the multivariate probit model. These included adjusting planting dates, use of agro-forestry, use of drought tolerant varieties, use of water and soil conservation (SWC) practices, and use of irrigation.

Adjusting planting dates (y_1): It involves the adjustment of planting time better suit to the shifts in growing season by delaying or undertaking early planting/sowing. Hassan and Nhemachena (2008) also identified that changing planting dates is one among farmers' perceived adaptation strategies.

Agro-forestry (y_2): Includes growing eucalyptus tree, spice trees, incense trees, coffee, rosemary, avocado, mango, papaya and other fruits and trees used for timber production and has a multi-purpose (as a sources of income and means of keeping climate balance). It also constitutes trees used for energy consumption and prevents deforestation. Temesgen *et al.* (2009) also used planting trees as a common adaptation strategy.

Use of drought tolerant variety (y_3): It involves using varieties better fitting to the new climate such as the use of stress tolerant crops or varieties that have a shorter growing period and pest and disease resistance crops. It also includes cultivating crops which are suitable to the new climate and growing conditions. Elasha *et al*. (2006) mentioned planting of drought resistant varieties of crops as one of adaptation measures. World Bank (2010) also identified that planting disease and drought-resistant short period varieties is one measure of adaptation to climate change.

Soil and water conservation practice (y_4): Includes the adoption of soil and water conservation practices such as soil/stone bending, terracing, mulching, and runoff diversion to prevent erosion, improve soil fertility, and conserve soil moisture. Hassan and Nhemachena (2008) and Solomon *et al*. (2016) also used this measure as one adaptation strategies to climate change.

Use of irrigation (y_5): It involves the adoption of farmers to build water, harvesting schemes such as traditional hand dug or shallow open wells for the abstraction of groundwater for irrigation, diversion and pumping of spring water to practice irrigation. Temesgen *et al*. (2008) and Solomon *et al*. (2016) identified use of irrigation as one strategy for climate change adaptation.

Independent variables

To identify the independent variables to be used in the study, different literatures were reviewed regarding the factors that affect farmers' choices of adaption strategies to climate change. Based on most of the previous studies, the following are commonly identified independent variables.

Agro-ecological setting (AE): It comprises the condition of climate and soil type (growing period, temperature and moisture) in the area. It is a dummy variable nominated 0 for *Woinadega* (midland) and 1 for *Dega* (highland). A study by Gebru *et al.* (2015) demonstrated that agro-ecological setting affected the use of irrigation, SWC practices, and changing variety. Temesgen *et al.* (2009) also noted that agro-ecology significantly affected the use of irrigation, planting trees, improved variety, and adjusting planting date. Besides, Solomon *et al*. (2016) found that difference in agro-ecology significantly affected use of irrigation and climate change resilient variety in response to climate change. This implied that farmers living in different agro-ecological zones have different perceptions and make use of different adaptation methods. This variable was therefore hypothesized to either positively or negatively affects choice of adaptation strategy.

Sex of the household head (SEX): It is a state of being male or female. This is a dummy variable taking a value of 1 if the household head is male and 0 otherwise. According to Temesgen *et al.* (2009), being male has a positive effect on the use of SWC practices, planting trees, and using different crop variety. This implies that male-headed households are more likely to take these adaptation strategies. However, Nhemachena and Hassan (2007) found that female-headed households are more likely to take up SWC practices, irrigation, different crop variety and adjusting planting dates than male-headed households. The authors explain that females are engaged in more farm activities than males and have better farm experience and information. In addition, Abrham *et al*. (2017) found that male-headed houses are less likely to adapt climate change using planting trees. Therefore, this variable was expected to have either a positive or negative influence on choice of adaptation strategy.

Age of the household head (AGE): Age is a continuous variable that indicates the length of time that household head has existed. This variable is measured in years. According to a research by Gebru *et al.* (2015), age has a positive effect on the use of different crop variety, irrigation, and SWC practices. Temesgen *et al.* (2009) also found that age has a positive influence on the use of irrigation, adjusting planting date, and planting trees while Aschalew (2014) found negative influence of age on the same adaptation strategies. In addition, Abrham *et al*. (2017) established that an increase in age has a negative influence on the practice of planting trees. Thus, the older the farmer, the more experienced in farming he/she will be and the more he/she will recognize the past and present climatic conditions so that able to choose the best among alternative adaptation strategies. The variable was hypothesized to have either a positive or negative effect on choice of adaptation strategy.

Education level of the household head (EDU): It is the completed education level of head of the household for formal education. It is a discrete variable and measured through completed years in school. According to Solomon *et al*. (2016), education improves the level of understanding about climate change adaptation so that increases the likelihood of using drought tolerant variety. Adeoti *et al.* (2016) found that education increases the use of drought tolerant variety and adjusting planting dates. The result of Temesgen *et al.* (2009) also found that the use of irrigation, SWC practice, drought tolerant variety, planting trees and adjusting planting date increase whenever education level increases. Abrham *et al*. (2017) and Abid *et al*. (2015) stated that education has a positive influence on the SWC and adjusting planting date because it is likely to enhance farmers' ability to receive, interpret and comprehend information relevant to make innovative decision in the farms. Generally, possession of higher level of formal education increases farmers' propinquity for new information and the probability of perceiving and adapting to climate change. Therefore, it was expected to have a positive negative influence on choice of adaptation strategy.

Family size (FAMSIZE): Family size indicates the number of individuals under a household in man-equivalent and it is a continuous variable. The research result found by Belaineh *et al.* (2013) stated that increase in family size reduces crop diversification and the use of SWC as adaptation strategy. On the other hand, Gbetibouo *et al.* (2010) and Abid *et al*. (2015) stated that family size positively affected the use of irrigation as an adaptation strategy. Abid *et al*. (2015) also added that the increase in family size increases the likelihood of using SWC practice and agro-forestry. As the size of the family increase, the farmers' ability for taking some climate change adaptation measures increases while for some others decreases. The variable was expected to either positively or negatively affect choice of adaptation strategy.

Landholding size (LHSIZE): Landholding size is the total amount of cultivated landholding of a farm household. This variable is continuous and measured in hectares. Nhemachena and

Hassan (2007) found that increase in landholding increases the likelihood of utilizing irrigation, SWC practice, adjusting planting dates, and use of drought tolerant variety. Wondimagegn and Lemma (2016) also found that large landholding increase the use of SWbC practice. On the other hand, Aschalew (2014) revealed that large landholding decrease the use of irrigation while it increases the use of agro-forestry and drought tolerant variety. Landholding size could affect the land allocation of farmers to different enterprises. The bigger the landholding, the more likely the farmer is to adopt suitable strategies and less likely to others. The variable was expected to either positively or negatively affect choice of adaptation strategy.

Farm income (FRINCM): It is a return from investment of capital, labor, land and time to the farmer**.** This is a continuous variable and measures the amount of income the farmers make per year from investment in their farm. In other words, it is the amount of annual farm income obtained from the sale of crop and livestock or livestock products measured in Ethiopian Birr. The work of Aemro *et al*. (2012) found that an increase in farm income increases the likelihood of using SWC practices and drought tolerant variety. Aschalew (2014) and Temesgen *et al.* (2009) asserted that as farm income increases the probability of adopting irrigation, adjusting planting date, and using drought tolerant variety increases. Aschalew (2014) also found that households with higher farm income are more likely adopt agro-forestry. It was hypothesized that the more farm income a farmer has the more likely to perceive and adapt to climate change using a convenient strategy by devoting higher time and money for this activity. It was expected to positively influence choice of adaptation strategy.

Off-farm/non-farm income (NFRINC): This refers to annual income obtained from an employment of the household in off-farm activities like laborer and non-farm activities like petty trading, hand craft, selling of fire wood, gifts and remittance. It is a continuous variable and measured in Ethiopian Birr. Aemro *et al*. (2012) found that off/non-farm income positively affected farmers’ use of SWC practices, adjusting planting date, and improved variety. Additionally, Temesgen *et al.* (2009) confirmed that off-farm income increases the likely of farmers to planting trees and adjusting planting dates. In contrary to this, Belaineh *et al.* (2013) revealed that an increase in off-farm income decreases the likely of crop diversification and the use of SWC practices as adaptation strategy. Farmers are assumed to get additional income source and may or may not give time to take adaptation measures and pay less attention to agriculture. Therefore, it was expected to either positively or negatively affect farmers' adaptation decision.

Livestock size (TLU): It is the amount of all livestock owned by the household. This is a continuous variable and measured in tropical livestock unit (TLU). Abrham *et al*. (2017) revealed that owning large number of livestock in tropical livestock unit increases farmers' likelihood of planting trees, adjusting planting dates, and use of SWC practices. Contrary to this, the result found by Temesgen *et al.* (2009) and Aschalew (2014) disclosed that ownership of large number of livestock in tropical livestock unit adversely affected using of irrigation as an adaptation strategy. In farming activities, animals such as oxen, cows, donkey, horse, mule and others can be seen as capital inputs and farmers who have large livestock are considered affluent. They serve as a means of plowing, harvesting and transporting inputs and outputs. It can also serve as food and can be sold to generate income and fill household's financial deficit during crop failure due to climate factors. On the other hand, production of livestock competes with crop production for labor and land. Therefore, it was expected to have either a positive or negative effect on choice of adaptation strategies.

Access to credit (CREDIT): Access to credit is about whether a farmer use credit or not. It is a dummy variable coded 1 if the farmer has access to credit and 0 otherwise. The study by Nhemachena and Hassan (2007) demonstrated that access to credit improves probability of adopting irrigation, adjusting planting date, using different crop variety, and SWC practices in response to climate change. Temesgen *et al.* (2009) also confirmed that access to credit increases the probability of using irrigation, SWC practices, and adjusting planting date in response to climate change. Additionally, Gadédjisso-Tossou (2015) stated that farmers' use of improved variety increases when they have access to credit. Access to credit mitigates the financial limitation and enables the farmer to adopt strategies that reduce the negative impact of climate change. Access to credit makes adoption of new technologies such as improved crop variety seed, water conservation and irrigation possible by the farmer. It was expected to have a positive influence on choice of adaptation options.

Extension visit (EXTCON): It is the frequency of extension visit by the development agent. It is a discrete variable measured in the number of contacts per year. Empirically, the study by Temesgen *et al.* (2009) disclosed that extension contact enhances the likelihood of using irrigation, SWC practices, planting trees, and improved variety in response to climate change. Abid *et al*. (2015), Gebru *et al.* (2015) and Aemro *et al*. (2012) also confirmed that extension visit enhances the likelihood of using improved variety. Having access to extension contact increases the probability of using drought tolerant variety, SWC practices, use of irrigation, and some others to cope with climate change. It was expected to have a positive effect on selected adaptation strategies.

Farmer-to-Farmer extension (FFEXT): This variable indicates the access to informal extension services. It involves sharing information and inputs from nearby farmers. It is a dummy variable taking the value of 1 if there is access and 0 otherwise. Temesgen *et al.* (2009) found that access to farmer-to-farmers' extension services positively affected adjusting planting date, planting trees, using improved variety, SWC practices, and irrigation in response to climate change. Such services provide the farmers with information about the agricultural adaptation practices that are most suitable to their farms which is practically tested by other farmers themselves. It also enhances the chances for farmers' decision to adapt to climate change and influence their preferences for different adaptation strategies. Hence, it serves as a source of information and experience sharing among farmers and expected to positively affect choice of adaptation strategies.

Access to climate information (CLIMINFO): It is the availability of information related to climate from different media. It is about whether farmers got climate information from radio, television, schools, newspapers and others. This is a dummy variable indicating 1 if the household head has access to climate information and 0 otherwise. The result found by Gebru *et al.* (2015) confirmed that access to climate information increases the use of irrigation and SWC practices. Abrham *et al*. (2017) also revealed that the use of SWC practices, adjusting planting date, and planting trees in response to climate change is enhanced by access to climate information. Gadédjisso-Tossou (2015) and Temesgen *et al.* (2009) as well found that access to climate information improves the use of improved variety and adjusting planting dates in response to climate change. Access to information on climate from different sources is expected to have impact on the adaptation combination of different strategies. This variable was also expected to have a positive influence on choice of adaptation strategies to climate change.

Average distance from home to the farm (DFARM): It is about how far the farm of the farmer is located on average from his/her residence. This variable is a continuous variable measured in kilometers from farmers' home to their farming place. A research done by Aschalew (2013) confirmed the higher probability of adopting irrigation and adjusting planting date when distance from home to farm is far from each other. It also found that distance from home to farm decreases the probability of using improved variety and agro-forestry. It was anticipated that a farmer whose farm is far from his/her home is less likely to frequently follow up the farm as compared to those whose farm is nearer to their home. Thus, it was expected that farmers who live near to their farm are likely to have regular follow up of their farm, hence, motivated to respond to the impact of climate change on their agricultural activities. In contrary to this, distance from farm enhances the use of some other adaptation strategies. It was therefore expected to either positively or negatively affect choice of adaptation strategy.

Distance to market (DMKT): It is about how far the market for inputs and outputs is located from farmers' residence. Distance to market is a continuous variable and represented in terms of kilometers from farmers' residence to the market. Wondimagegn and Lemma (2016) found that distance to market positively affected the use of different crop variety and adjusting planting date while it negatively affected use of SWC practices. Nhemachena and Hassan (2007) also found that distance to market positively influences use of improved variety, SWC practices, and use of irrigation. In contrary to this, Solomon *et al*. (2016) established that distances to market negatively affected use of irrigation. A farmer whose residence is too far from the agricultural input as well as output market was hypothesized to use modern agricultural input less likely than the farmers who can get the input nearby their farm. In addition, the proximity to market is important even in helping the farmer to exchange information. On the contrary, closeness to market makes the farmer to engage in activities other than farming so that it gives less time to farming and using adaptation strategies. Hence, this variable was hypothesized to either positively or negatively influences choice of adaptation strategy.

Table 2: Summary of definition, measurement and hypothesis of explanatory variables

Notation	Definition of Variable	Measurement of Variable	Expected effect				
			Y1	Y2	Y3	Y4	Y5
AE	Agro-ecological setting	Woinadega=0, Dega= 1,	+/ -	+/ -	+/ -	+/ -	+/ -
SEX	Sex of the household head	Female =0, Male=1	-	+	+/-	-	+/-
AGE	Age of the household head	Years	+/-	+/-	+	+/-	+
EDU	Education level of the household head	Years	+	+	+	+	+
FSIZE	Family size	ME	+/-	+	+/-	+	+/-
FRSIZE	Farm size	Hectare	+	+	+	+/-	+
FRINCM	Farm income	ETH. Birr	+	+	+	+	+
NFRINC	Non-farm income	ETH. Birr	+	+	+	+/-	+/-
TLU	Livestock size	TLU	+	+	+/-	-	+
CREDIT	Access to credit	No Access=0, Access to Credit =1,	+	+	+	+	+
EXTCON	Extension contact	No. of visit per year	+	+	+	+	+
FFEXT	Farmer-to-Farmer extension	No=0, Yes=1	+	+	+	+	+
CLIMINFO	Access to climate information	Have no access=0, Have access=1	+	+	+	+	+
DFARM	Distance from home to the farm	Km	+	-	-	+	+/-
DMKT	Distance to market	Km	+	+/-	+	+/-	+/-

Source: Own summary from literature review

4. RESULTS AND DISCUSSION

This section presents the major findings of analysis of data obtained from NMA, survey and focus group discussions. It is divided into four main parts. In the first section, characteristics of sample households have been presented. In the second section, analysis of perception of smallholder farmers to climate change has been argued. In the third section, farmers' choices of adaptation strategies for climate change have been presented. Finally, determinants of farmers' choice of adaptation strategies have been thoroughly discussed.

4.1. Characteristics of Sample Households

This study was based on quantitative and qualitative data collected from a total of 155 sample households interviewed during the survey. From the total household heads interviewed 10. 32% are female and the remaining 89.68% are male. The average age, education level, family size, landholding, annual farm income, and livestock ownership of sample households are 45.49 years, 3.26 years, 5.57 ME, 1.31 hectares, 19811.54 birr, and 4.75 TLU, respectively (Table 3). Regarding landholding size, majority of the respondents own small and fragmented plots. There are also households who have no land and whose main livelihood is rearing animals in communal land and purchased feed.

Table 3: Summary of household characteristics

Variables	Agro-ecology			
	Dega Freq./Mean (Std)	Woinadega Freq./Mean (Std)	Both Freq./Mean (Std)	χ^2 /t-value
Sex (1=Male)	110	29	139(89.68%)	4.21**
Age (years)	45.76 (10.78)	44.48 (10.45)	45.49 (10.69)	0.61
Education level (years)	3.12 (3.13)	3.79 (3.81)	3.26 (3.28)	1.03
Family size (ME)	5.71 (1.80)	5.06 (1.80)	5.57 (1.80)	1.86**
Landholding (hectares)	1.17 (0.57)	1.87 (1.08)	1.31 (0.75)	4.96***
Farm income (birr)	19864.69 (13090.4)	19615.06 (11811.47)	19811.54 (12792.13)	0.10
Livestock (TLU)	4.64 (2.55)	5.17 (2.68)	4.75 (2.58)	1.04

Source: Computation from own survey data, 2017

According to the χ^2 and t-test statistics results, there is a statistically significant difference in sex, family size, and landholding among the two agro-ecologies (Table 3). These household characteristics are likely to cause difference in choice of adaptation strategies to climate change among the two agro-ecologies.

Concerning institutional characteristics of sample respondents, household heads who have access to credit, farmer-to-farmer extension service, and climate information account 51.62%, 58.71%, and 58.71%, respectively. Some of the sample household heads have access to climate related information from radio, television, and school in addition to obtaining the information from the extension agent. Similarly, the average annual off-farm/non-farm income, extension visit, distance to farm, and distance to market are 1793.55 birr, 25 visits, 1.38 kilometers, and 4.02 kilometers, respectively (Table 4).

The χ^2 and t-test statistics results showed that there is a statistically significant difference in average annual off-farm/non-farm income, extension visit, and distance to farm among the two agro-ecologies (Table 4). Accordingly, these characteristics are likely to cause difference in the choice of adaptation strategies to climate change.

Table 4: Institutional characteristics of sample households

Variables	Agro-ecology			
	Dega Freq./Mean (Std)	Woinadega Freq./Mean (Std)	Both Freq./Mean (Std)	χ^2 /t-value
Access to credit(1=Yes)	65	15	80(51.62%)	1.85
Farmer-to farmer extension (1=Yes)	67	24	91(58.71%)	1.22
Access to climate information (1=Yes)	58	18	91(58.71%)	0.02
Non-farm income (Birr)	1366.20 (3036.37)	3502.94 (3329.79)	1793.55 (3202.94)	3.43***
Extension visit (number)	28.23 (18.03)	12.51 (8.17)	25 (17.67)	4.72***
Distance to farm (km)	1.20 (1.29)	2.08 (1.38)	1.38 (1.35)	3.32***
Distance to market (km)	3.96 (2.68)	4.23 (2.73)	4.02 (2.69)	0.51

Source: Computation from own survey data, 2017

The χ^2 and t-test statistics have been also used to judge whether or not there are statistically significant difference in the explanatory variables included in the analysis change with respect to the difference in the choice of each adaptation strategies to climate.

The result showed that there are statistically significant differences in some of the factors associated with using or not using of each of the major adaptation strategies by sample households. The χ^2 and t-test statistics (Table 5 and Table 6) confirmed that there are statistically significant differences in landholding, farm income, access to credit, off-farm/non-farm income, extension visit, distance to farm, and distance to market with respect to differences in the choice of adjusting planting date. There is also a statistically significant difference in family size, landholding, farm income, access to credit, and distance to farm with respect to difference in the choice of agro-forestry as adaptation strategy. Besides, there existed a statistically significant difference in education level, farm income, agro-ecological setting, access to credit, access to climate information, extension visit, and distance to farm with respect to difference in the choice of drought tolerant variety associated. Results also revealed that there is a statistically significant difference in sex, education level, farm income, livestock ownership, agro-ecological setting, access to credit, farmer-to farmer extension, off-farm/non-farm income, and extension visit in terms of difference in the choice of SWC practice. Finally, the test results verified that there is a statistically significant difference in family size, landholding, farm income, access to credit, off-farm/non-farm income, access to climate information, and distance to market associated with difference in the choice of irrigation as an adaptation strategy to climate change (Table 5 and Table 6). These variables are therefore likely to affect the choice of respective adaptation strategies to climate change. These variables are therefore likely to affect the choices of each adaptation strategies to climate change.

Table 5: Comparison for household characteristics amongst adaptation strategies

Variables	Adaptation strategies														
	Adjusting planting date (y_1) (n=155) Freq./ Mean Std			Agro-forestry (y_2) (n=155) Freq./ Mean Std			Drought tolerant variety (y_3) (n=155) Freq./ Mean Std			SWC practice (y_4) (n=155) Freq./ Mean Std			Irrigation (y_5) (n=155) Freq./ Mean Std		
	y_1=1	y_1=0	χ^2 /t-value	y_2=1	y_2=0	χ^2 /t-value	y_3=1	y_3=0	χ^2 /t-value	y_4=1	y_4=0	χ^2 /t-value	y_5=1	y_5=0	χ^2 /t-valu
Sex (Male)	78	61	2.00	52	87	0.96	66	73	0.44	95	44	15.18***	84	55	0.65
Age (years)	45.96 10.05	44.93 11.45	0.60	46.73 11.11	44.70 10.40	1.15	44.64 10.17	46.29 11.17	0.96	45.75 10.42	45.03 11.23	0.40	46.11 10.59	44.59 10.87	0.87
Education level (years)	3.51 3.47	2.97 3.05	1.02	3.28 3.42	3.25 3.21	0.06	4.04 3.48	2.54 2.93	2.91***	3.59 3.27	2.70 3.26	1.63*	3.48 3.46	2.95 3.00	0.98
Family size (ME)	5.70 1.75	5.42 1.86	0.96	6.03 1.82	5.28 1.73	2.57***	5.67 1.83	5.49 1.77	0.62	5.63 1.87	5.47 1.67	0.53	5.96 1.80	5.01 1.65	3.30***
Landholding (hectares)	1.35 0.60	1.18 0.59	1.76**	1.40 0.59	1.19 0.59	2.22**	1.26 0.62	1.28 0.59	0.29	1.31 0.61	1.20 0.58	1.17	1.39 0.54	1.10 0.65	2.95***
Farm income ('000)(birr)	22.96 13.64	16.08 10.65	3.45***	23.95 14.26	17.19 11.06	3.30***	22.48 13.21	17.30 11.93	2.56***	22.18 14.10	15.73 8.87	3.11***	22.78 13.08	15.46 11.08	3.64***
Livestock (TLU)	4.84 2.26	4.64 2.93	0.49	4.80 2.68	4.72 2.53	0.19	4.66 2.45	4.84 2.71	0.44	4.52 2.13	5.15 3.19	1.46*	4.65 2.53	4.90 2.66	0.57

Source: Computation from own survey data, 2017

Table 6: Comparison for institutional characteristics amongst adaptation strategies

Variables	Adaptation strategies														
	Adjusting planting date (y_1) (n=155) Freq./ Mean Std			Agro-forestry (y_2) (n=155) Freq./ Mean Std			Drought tolerant variety (y_3) (n=155) Freq./ Mean Std			SWC practice (y_4) (n=155) Freq./ Mean Std			Irrigation (y_5) (n=155) Freq./ Mean Std		
	y_1=1	y_1=0	χ^2 /t-value	y_2=1	y_2=0	χ^2 /t-value	y_3=1	y_3=0	χ^2 /t-value	y_4=1	y_4=0	χ^2 /t-value	y_5=1	y_5=0	χ^2 /t-value
Agro-ecology (1=Dega)	65	54	0.04	46	73	0.00	51	68	6.27**	80	39	3.53*	74	45	1.70
Access to credit(1=Yes)	52	28	7.78***	38	42	5.38***	45	35	4.09**	60	20	9.86***	55	25	6.05**
Farmer-to farmer extension (1=Yes)	50	41	0.05	37	54	0.35	47	44	0.94	68	23	12.53***	57	34	0.98
Access to information (1=Yes)	43	33	0.34	31	45	0.27	50	26	18.08***	47	29	0.12	56	20	12.69***
Non-farm income ('000)(birr)	2.27 3.60	1.22 2.57	2.07**	1.54 2.66	1.95 3.50	0.76	1.60 2.69	1.97 3.62	0.72	1.54 2.59	2.23 4.02	1.29*	2.17 3.01	1.23 3.40	1.80**
Extension visit ('0) (number)	2.78 1.88	2.20 1.58	2.10**	2.71 1.90	2.38 1.67	1.10	2.82 1.83	2.21 1.67	2.17**	2.70 1.82	2.18 1.63	1.75**	2.42 1.73	2.64 1.83	0.77
Distance to farm (km)	1.77 1.73	1.43 1.41	1.29*	1.27 1.15	1.83 1.80	2.12**	1.44 1.51	1.78 1.66	1.34*	1.51 1.42	1.80 1.87	1.06	1.66 1.63	1.55 1.55	0.42
Distance to market (km)	4.30 2.67	3.68 2.68	1.44*	3.89 2.86	4.10 2.58	0.47	3.88 2.59	4.14 2.78	0.60	4.11 2.68	3.85 2.71	0.59	3.73 2.54	4.44 2.85	1.63*

Source: Computation from own survey data, 2017

4.2. Farmers' Perception to Climate Change

According to the belief of majority of participants in the focus group discussion, todays' climate change and its' consequences are the results of umbrage of God/Allah. In addition, they respond that there is a high level of deforestation and old aged trees are being cut for the purpose of timber. According to their saying, the local government is the primary responsible body for this evil practice. Each year, new seedling will be planted. But because of poor follow up and management, almost all seedlings ceased to survive. The other practice that aggravates climate change is the production of charcoal by cutting trees in the area.

The farmers were asked about their perception to the condition of climate in their district. To do this, the two known climate attributes; the condition of temperature and rainfall have been used. Temperature and rainfall parameters in annual average temperature and annual average rainfall were used to describe farmers' perception on climate change. For the analysis of perception of farmers' to climate change, the trends of climate data recorded at meteorological station have been compared with the view of farmers about the direction of changes in temperature and rainfall. Descriptive statistics and Likert scale measurement were used to provide insights into farmers' perceptions of climate change.

4.2.1. Perception on temperature changes

The statistical records of secondary data on temperature in NMA Kombolcha sub-station for the district in the period between 1993 and 2016 showed an increasing trend. Based on the linear fitted line of average annual temperature on times in years, there is a general increase in the average annual temperature distribution in the study area (Figure 3).

On the other hand, the result computed from the survey data showed that 87.74% of the respondents perceived that there is an increase in temperature in the past 24 years. About 4.52% of respondents also perceived there is rather a decrease in temperature while 3.22% recognize that there is no change in temperature and the rest 4.52% respond they do not know about the trend of temperature (Table 7).

This survey result demonstrated that majority of the respondents recognized the increase in temperature. This accounts the response of 87.74% of respondents out of sample households.

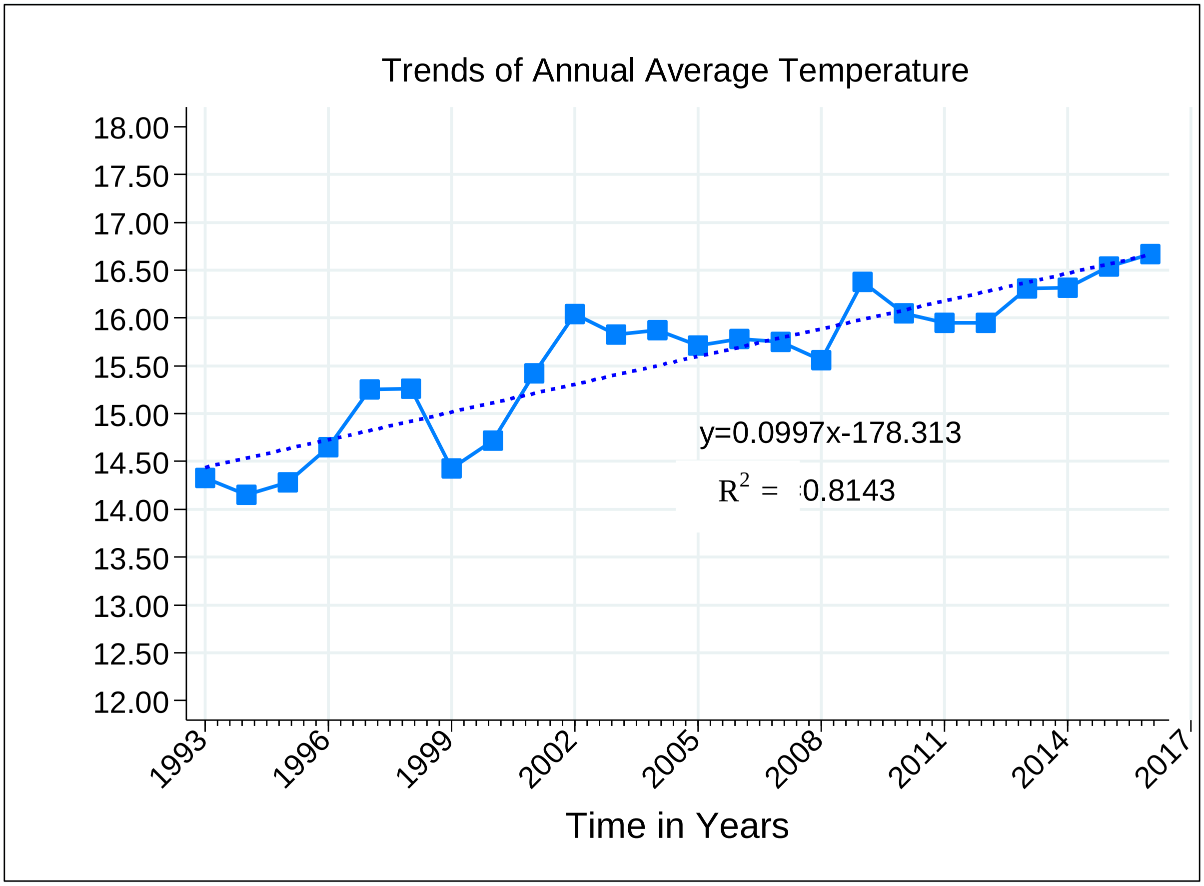

Figure 3: Trend of average annual temperature (^{0}C) in Woreillu District from 1993-2016

Source: Computed from NMA data in Kombolcha sub-station

Accordingly, this implied that the perception of majority of the respondents is in line with the fitted line for the data obtained from NMA and hence showed that farmers' actually perceived the presence of climate change considering temperature as one attribute. Adeoti *et al.* (2106) and Gadédjisso-Tossou (2015) also found that 84% and 72% of respondents perceived the increase in temperature in their particular study areas, respectively.

Table 7: Perception of farmers on annual average temperature during the last 24 years

Perceived change	Number of respondents (n=155)	Percent (%)
Increased	136	87.74
Decreased	7	4.52
No change	5	3.22
I do not know	7	4.52

Source: Own survey result, 2017

4.2.2. Perception on rainfall changes

The fitted line from NMA data on rainfall illustrated that there is a slight decrease in average rainfall distribution across years. More importantly, it is highly erratic in nature in its distribution from year to year and makes production of crop and livestock difficult (Figure 4).

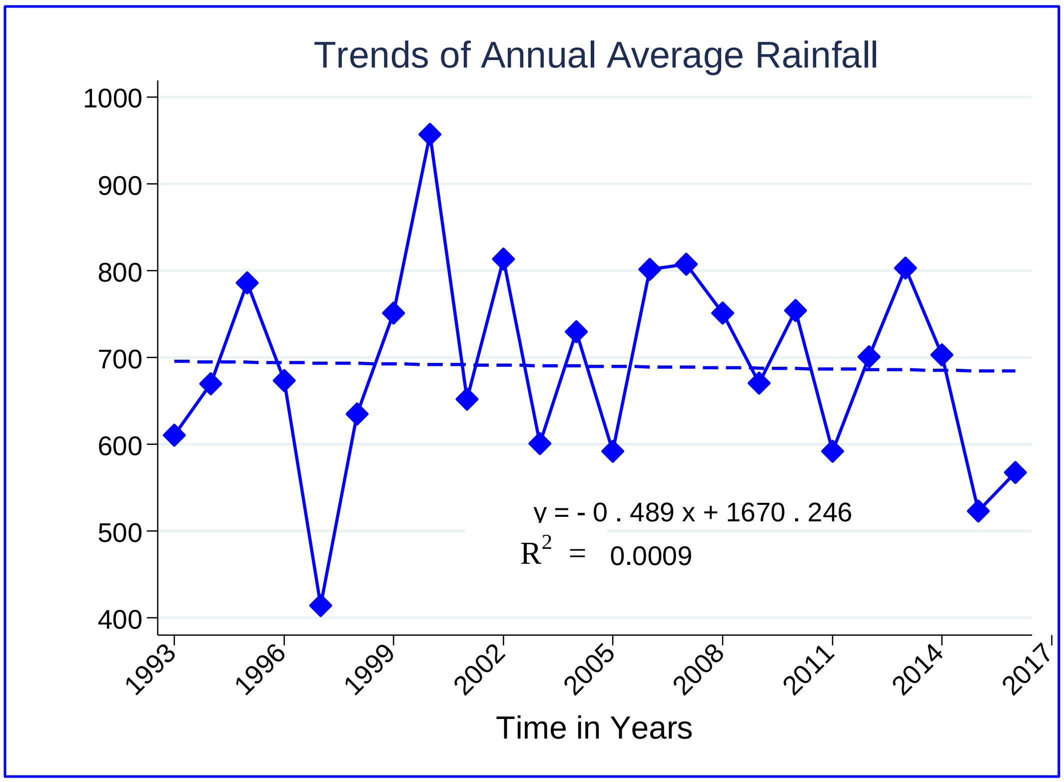

Figure 4: Trend of average annual rainfall (mm) in Woreillu District from 1993-2016
Source: Computed from NMA data in Kombolcha sub-station

Concerning the result from the survey, 83.22% of the respondents recognized that there is a decrease in rainfall. In addition, 8.39% of the respondents perceived that there is no change in the availability of rainfall while the remaining 4.52% and 3.87% believed that there is a increase in rainfall availability and they did not know, respectively (Table 8).

The result from the survey assured that majority (83.22%) of the respondents perceived as there is a decrease in rainfall. Fosu-Mensah *et al.* (2012) and Nega *et al.* (2015) also found that 87% and 94% of respondents perceived the decrease in rainfall in their respective study areas. However, according to NMA data, in addition to the decrease in rainfall, erratic nature of rainfall availability is the key climatic problem. Irregularity in rainfall distribution among months and years is the major change observed. Therefore, it can be concluded that farmers' perception on the decrease in rainfall availability is right even though its irregularity is also the key challenge and which did not in fact recognized by them.

Table 8: Perception of farmers on annual average rainfall during the last 24 years

Perceived change	Number of respondents (n=155)	Percent (%)
Increased	7	4.52
Decreased	129	83.22
No change	13	8.39
I do not know	6	3.87

Source: Own survey result, 2017

In general, perception of majority of farmers is in accordance with the climatic parameter trends of Woreillu District for temperature and rainfall. The data for temperature and rainfall trends showed that temperature is increasing and rainfall is slightly decreasing and erratic over time. The trend analysis between average annual temperature and rainfall over time indicated that average temperature and rainfall in the study area increases on average about 0.0997^0C and decreases 0.489mm each year, respectively (Figure 3 and 4). Thus, majority of farmers' perceptions appear to be in accordance with the statistical temperature and rainfall record of the area except irregular nature of the rainfall distribution. Nevertheless, there are still a significant number of farmers' (16.78%) who didn't perceive the existence of climate change in the area.

4.2.3. Likert rating scale result of climate change perception of farmers

A five point Likert scale measure was also used to measure the level of perception of sample respondents for some selected attributes of climate change. Farmers who strongly agree and who simply agree are considered perceived the change while others not.

Based on the result of this measurement, about 85.81% of the respondents perceived that there is a time to time increase in temperature and 81.29% of the respondent perceived that there is a decrease in rainfall amount time to time (Table 9). The result is in line with the trend of the fitted data. Adeoti *et al*. (2016) and Gadédjisso-Tossou (2015) also found that majority of smallholder farmers perceived the increase in temperature and the decrease in rainfall.

Majority of the respondents who accounts 94.2% also perceived that today's rainfall could not properly support full crop growth period. Wondmagegn and Lemma (2016) also asserted that 79.1% of farmers perceived that rainfall could not support production. The result of the focus group discussions confirmed that the rainfall is frequently exiting before or coming after the growing season of crop. Regarding the condition of springs, streams and ponds, 89.68% of the respondents perceived that they are drying out because of climate change. In the focus group discussions, respondents mentioned that they are forced to use irrigation by pumping water from streams using water pumps whenever the rainfall fails. This is also possible if there is access to irrigation. However, it causes pollution and drying out of streams, and most severely, loss of water for their cattle and for washing clothes. The stream *Selgi* is the victim of this event. Similarly, 87.74% of the respondents observed an increase in the number of hot periods.

Large number of respondents who account 94.19% observed an early cessation of rainfall and 89.67% of respondents observed that the starting time of rainfall is lagging behind the usual (Table 9). They declared that because of early cessation and lagging of the starting period of rainfall, they could not produce much as it was possible before. *Belg* production which was obvious in the district is totally ceased. The result also showed that about 87.74% of the respondents recognized that crop disease and pest infestation increases and becomes problem than earlier times which is also in line with Wondmagegn and Lemma (2016).

Similarly, 49.68% of the respondents recognized that the price of grain is hiking because of decreased productivity resulted from climate change. Nearly 74.2% of respondents also perceived that deforestation is becoming severe than earlier times in attempting to compensate the decrease in income and livelihoods. Forests are cleansed for timber and charcoal production and productions of traditional honey products become impossible.

Regarding migration, 52.26% of respondents perceived that the community is migrating to cities due to inability of agriculture to support their livelihood. About 39.35% of the respondents perceived that some sources of livelihoods of the community are changing due to changing climate conditions and peoples are employed in the cities as a daily laborer. About 70.97% of respondents also observed as there is an increase in irregularity of rainfall. Finally, only 30.32 % of the respondents perceived that the community is enough aware of the climate change impacts (Table 9).

Table 9: Climate change perception index of farmers for the last 24 years (%)

Climate change signals and pattern of changes	Local level perception (n=155)				
	1	2	3	4	5
There is an increase in temperature from time to time	1.29	1.93	10.97	29.68	56.13
There is a decrease in rain fall amount from time to time	1.93	4.52	12.26	33.55	47.74
Rain fall could not properly support full crop growth period	0	0	5.80	28.39	65.81
Springs, streams and pond dying out	0	5.16	5.16	50.97	38.71
There is an increase in the number of hot period	0	3.23	9.03	40.64	47.10
There is an early cessation of rainfall	0	2.58	3.23	18.71	75.48
Starting time of rainfall is lagging behind the usual	0.65	3.23	6.45	30.97	58.70
Crop disease and pest infestation increases and becomes problem than earlier times	0	1.94	10.32	52.26	35.48
The price of grain is hiking because of decreased productivity for climate change	0	26.45	23.87	27.74	21.94
Deforestation is becoming severe than earlier times to compensate the income and livelihoods	0	1.94	23.86	40.65	33.55
The community is migrating to cities due to inability of agriculture to support their livelihood	6.45	24.52	16.77	46.45	5.81
Some sources of livelihoods of the community are changing due to changing climate conditions	4.52	25.16	30.97	30.32	9.03
There is an increase in irregularity of rain fall	1.29	22.58	5.16	29.03	41.94
The community is enough aware of the climate change impacts	5.81	40.65	23.22	9.03	21.29

Note: 1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, and 5 = Strongly Agree

Source: Own survey result, 2017

4.3. Climate Change Adaptation Strategies

For this study, adaptations are adjustments or interventions, which take place in order to manage the losses or take advantage of the opportunities presented by a changing climate. It is the process of improving society's ability to cope with changes in climatic conditions across time scales, from short-term to the long-term. The goal of an adaptation measure should then be to increase the capacity of a system to survive external shocks or changes.

A number of adaptation options used by famers have been explored. Accordingly, the following adaptation strategies have been identified as a prominent adaptation strategies used in the district. These are identified by considering the number of frequencies of these adaptation strategies among farmers as compared to all other options surveyed. It is found that farmers are using adjustment of planting dates, practicing agro-forestry, using drought tolerant varieties, SWC practices, irrigation, crop diversification, and changing livestock variety which accounts the response of 54.19%, 38.71%, 48.39%, 63.22%, 59.35%, 34.19%, and 20.64% sample households, respectively to reduce the negative impact of climate change (Table 10). The use of SWC practices was the most common response among the five adaptation strategies. On the contrary, use of agro-forestry was the least used adaptation strategy among the five strategies. Respondents in the focus group discussion reasoned out that shortage of farmland is the major impediment not to use agro-forestry because large proportion of their land is allotted for production of food crops. In most cases, however, farmers use some adaptation strategies in combination with other adaptation strategies. Finally, farmers retorted that praying to God/Allah is the prominent solution to all this climate change related hazards.

Table 10: Summary of adaptation strategies used by farmers

Adaptation strategies	Number of respondents(n=155)	Percent (%)*
Adjusting planting date	84	54.19
Agro-forestry	60	38.71
Use of drought tolerant varieties	75	48.39
Soil and water conservation	98	63.22
Use of irrigation	92	59.35
Crop diversification	53	34.19
Changing livestock variety	32	20.64

Source: Own survey, 2017

Note: * Percentages cannot be added to 100 since a farmer can employ more than one adaptation strategy at a time

More interestingly, the estimated MVP model results from 155 respondents' survey data are also in line with this summary. Based on the estimated result, the likelihood of households to adopt adjusting planting date, using of agro-forestry, using of drought tolerant varieties, using of SWC practices, and using of irrigation are 54.1%, 38.9%, 47.8%, 63.4%, and 59.6%, respectively. It also showed that the joint probability of using all adaptation strategies was only 9.9% and the joint probability of failure to adopt all of the adaptation strategies was 6.3% (Table 11). These adaptation measures help farmers guard against losses due to changes in temperature and rainfall.

To use MVP model, the correlation coefficients of the error terms should be significant for any pairs of equations. The likelihood ratio test of $Rho_{ij} = 0$ is significant at 5% significance level implying that the correlation coefficient of at least one pair of adaptation strategies is statistically different from zero.

Table 11: Correlation matrix of adaptation strategies from the MVP model

	Adaptation strategies				
	Adjusting planting date (Rho1)	Agro-forestry (Rho2)	Use of drought tolerant varieties (Rho3)	Soil and water conservation (Rho4)	Use of irrigation (Rho5)
	Coefficient (Std. error)	Coefficient (Std. error)	Coefficient (Std. error)	Coefficient (Std. error)	Coefficient (Std. error)
Rho2	-0.039 (0.149)				
Rho3	0.098 (0.162)	0.256* (0.146)			
Rho4	0.266 * (0.148)	0.061 (0.156)	-0.236 (0.161)		
Rho5	0.147 (0.148)	0.338*** (0.133)	0.342** (0.149)	-0.292* (0.167)	
Predicted probability	0.541	0.389	0.478	0.634	0.596
Joint probability (Success)					0.099
Joint probability (Failure)					0.063
Likelihood ratio test of $Rho_{ij} = 0$; $P>\chi^2$ (10)					0.0186**

Note: ***, **, and * signify level of significance at 1%, 5%, and 10%, respectively.

Source: Own computation from survey data, 2017

Accordingly, the correlation coefficients of 5 combinations are statistically different from zero which demonstrates the appropriateness of the MVP model specification and choice of climate change adaptation strategies are not mutually independent (Table11). This means that complementarities (positive correlations) and substitutabilites (negative correlations) exist between different adaptation options being used by farmers. There is interdependence among adaptation options.

There is a positive correlation (complementarity) between adjusting planting date and SWC practice, agro-forestry and use of drought tolerant variety, agro-forestry and use of irrigation; and use of drought tolerant variety and use of irrigation. This implies that these combinations of adaptation strategies can be used at a time. These combinations can also supplements to each other. There is also a negative correlation (substitutability) between use of SWC practice and use of irrigation. This also implies farmers may use either of the two adaptation strategies since one can be used instead of the other.

4.4. Determinants of Farmers' Choice of Adaptation Strategies

The probability of choice of applying a variety of adaptation measures in response to climate change impact are affected by several household and institutional characteristics. The MVP model of sample farmers' adaptation strategies was estimated to identify explanatory variables affecting farmers' choice of adaptation strategies to reduce adverse effect of climate change. Table (12) presented the results of estimation of MVP model along with the levels of statistical significance of factors. The Wald $\chi^2(60)$ and $p < 0.000$ is statistically significant at 1% significance level and the null hypothesis that the coefficient of all regressors is statistically equal to zero is rejected implying the model is fit and has a strong explanatory power. The result implied that different household and institutional characteristics significantly affected their choice.

Agro-ecological setting: Agro-ecological setting statistically and significantly affected use of drought tolerant varieties as adaptation strategies to climate change. This implied that farmers' living in different agro-ecological setting used different adaptation measures in response to climate change. The change in agro-ecology from *Woinadega* to *Dega* would decrease the likelihood of using drought tolerant varieties as an adaptation strategy.

Table 12: Multivariate probit results of farmers' climate change adaptation decisions

Independent variables	Adaptation strategies				
	Adjusting planting date	Agro-forestry	Use of drought tolerant varieties	Soil and water conservation	Use of irrigation
	Coefficient (Std. error)	Coefficient (Std. error)	Coefficient (Std. error)	Coefficient (Std. error)	Coefficient (Std. error)
Agro-ecology	-0.052	0.019	-0.747***	0.273	0.271
	(0.264)	(0.269)	(0.292)	(0.281)	(0.268)
Sex	0.508	-0.599*	-0.447	1.101***	0.058
	(0.371)	(0.353)	(0.380)	(0.414)	(0.352)
Education level	0.017	0.007	0.122***	0.075*	0.029
	(0.036)	(0.036)	(0.038)	(0.039)	(0.036)
Landholding	0.114	0.350*	-0.324	0.171	0.344*
	(0.213)	(0.205)	(0.229)	(0.231)	(0.209)
Farm income	0.022*	0.021**	0.023**	0.025*	0.020*
	(0.011)	(0.010)	(0.011)	(0.014)	(0.011)
Nonfarm income	0.783***	-0.182	-0.178	-0.029	0.398*
	(0.241)	(0.232)	(0.245)	(0.246)	(0.242)
Livestock ownership	0.009	-0.049	-0.056	-0.094*	-0.066
	(0.044)	(0.047)	(0.049)	(0.053)	(0.047)
Access to credit	0.603***	0.424*	0.662***	0.523**	0.427*
	(0.233)	(0.224)	(0.240)	(0.239)	(0.230)
Extension visit	0.023***	0.007	0.012*	0.008	-0.004
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
Farmer to farmer extension	-0. 224	-0.018	-0.227	0.730***	0.108
	(0.240)	(0.243)	(0.255)	(0.253)	(0.244)
Climate information	0.045	0.050	1.031***	-0.334	0.753***
	(0.226)	(0.221)	(0.244)	(0.244)	(0.228)
Distance from farm	0.120	-0.163**	-0.119	-0.065	-0.003
	(0.072)	(0.083)	(0.074)	(0.074)	(0.072)
Constant	-2.201***	-0.514	0.006	-1.905***	-1.264**
	(0.642)	(0.568)	(0.617)	(0.679)	(0.595)
Number of observations					155
Number of simulations					100
Log likelihood					-411.69
Wald $\chi^2(60)$					152.17***
P-value					0.0000***

Note: ***, **, and * signify level of significance at 1%, 5%, and 10%, respectively.

Source: Own computation from survey data, 2017

The possible reason is that high temperature which enhances evapotranspiration loss and creates heat stress is the common feature of midlands as compared to highlands. This makes drought more severe in midlands and insists to use varieties that tolerate drought better than others. This result is in fact in line with Gebru *et al.* (2015) and Temesgen *et al.* (2009) which disclosed that agro-ecological setting affected changing crop variety. The study of Solomon *et al*. (2016) also noted that difference in agro-ecological settings significantly affected the use of climate change resilient variety in response to climate change which fortifies this finding.

Sex of the household head: Based on the result of the MVP model, sex of the household head has a significant and negative influence on the use of agro-forestry and positive influence on the use of SWC practice as an adaptation strategy. It implied that female headed households are more likely to adopt agro-forestry than male headed households while male headed households are more likely to use SWC practice than female headed households to adapt to climate change. Perhaps agro-forestry practices are commonly undertaken near home that females are more readily responsible. The other reason is the labor demanding nature of SWC practices and male are usually involved in laborious activities as compared to females. In addition, female headed households have limited access to inputs and institutions as a result of traditional social barriers. Males are highly engaged in farm activities than females and have better farm experience and information in the study area. The result is supported by Temesgen *et al.* (2009) that found male headed households adopt SWC practices more readily than female headed households. Male headed households were 9% more likely to conserve soil. However, it is contrary to Nhemachena and Hassan (2007) which found that female-headed households are more likely to take up SWC practices than male-headed households. It is also contrary to Temesgen *et al.* (2009) and Abrham *et al*. (2017) which noted that males are more likely to plant trees to adapt climate change.

Education level of the household head: The result of the MVP model showed that education level of the household head found to be significantly and positively related with using drought tolerant variety and SWC practice. Farmers who have more education level were more likely to adapt to climate change using drought tolerant varieties and SWC practices than those who do have lower education level. This result might emanate from the fact that education improves farmers’ capacity of obtaining and analyzing new information about climate change and best adaptation practices that increases the probability of adapting to climate change. More specifically, it equipped farmers with knowledge of selecting appropriate drought tolerant variety and use of SWC practices. Various studies also reported a strong and positive relationship between education and using drought tolerant variety and SWC practices. The result is in line with Solomon *et al*. (2016), Gadédjisso-Tossou (2015) and Adeoti *et al.* (2016) that confirmed as the educational level of the household head increases, the level of understanding about climate change adaptation increases so that likelihood of using drought tolerant and short season variety increases. Abrham *et al*. (2017) and Abid *et al*. (2015) also noted that education has a positive influence on the use of SWC practices because it is likely to enhance farmers' ability to receive, interpret and comprehend information relevant to make innovative decision in the farms. In addition, the result of Temesgen *et al.* (2009) as well asserted that the use of SWC practices and drought tolerant variety increase whenever education level increases.

Landholding size: Landholding size significantly and positively affected use of agro-forestry and irrigation in response to climate change. The bigger the landholding, the more likely the farmer is to adopt agro-forestry and irrigation. The possible reason is that farmers who have bigger farm size have an option to divide their farm into different enterprises. According to the focus group discussions, they reach at a consensus that farmers who have a very limited land size could not use agro-forestry. It is mostly because they produce consumption goods on the farm they have. In addition, the farm of some households with small landholding may have higher probability of not better suited for use of irrigation. This finding agrees with the result found by Nhemachena and Hassan (2007) that noted an increase in landholding increases the likelihood of applying irrigation in response to climate change. The result is contrary to Aschalew (2014) that revealed large landholding size decreases the use of irrigation while it is similar with the same author regarding the positive effect of landholding size on the use of agro-forestry in response to climate change.

Farm income: Farm income was found to be statistically significant and positively related to using adjusting planting date, agro-forestry, drought tolerant variety, SWC practices, and irrigation. This implied that farmers who have higher farm income are more likely to adapt to the change in climate using these strategies. When the main source of income in farming increase, farmers tend to invest on productivity smoothing options such as using of adjusting planting date, agro-forestry, drought tolerant variety, SWC practices, and irrigation. Farm income enables the farmer to perceive and adapt to climate change by devoting higher money for the purchase of seed and seedlings whenever the rain comes, buying a drought tolerant variety and apparatus for the use of SWC practice and irrigation at higher price. Contentedly, this result is supported by Temesgen *et al.* (2009) who confirmed that as farm income increases the probability of adopting adjusting planting date, using drought tolerant variety, using SWC practices, and irrigation increases. Aschalew (2014) also asserted that farm income increases the probability of using agro-forestry. It is also in line with Aemro *et al*. (2012) that noted as farm income increases the probability of adopting adjusting planting date, drought tolerant variety, SWC practice, and irrigation increases.

Off-farm/non-farm income: Non-farm and off-farm income is significantly and positively affected adjusting planting date and using of irrigation. The higher farmers have non-farm and off-farm income, the more likely they were to adapt climate change using irrigation and adjusting planting date. Perhaps the reason is farmers have had an optional income source that enable them withstand the effect of climate change and they are also capable of buying instruments for irrigation use. This result in fact proved the result found by Aemro *et al.* (2012) and Temesgen *et al.* (2009) which stated non-farm or off-farm income increases the likely of farmers to adjusting planting dates.

Livestock ownership: Ownership of livestock is also statistically significant and negatively associated with SWC practices. Farmers who have large number of livestock in tropical livestock unit are less likely to respond to climate change using SWC practices as an adaptation strategy. The possible conviction is that since farmers use traditional way of livestock husbandry system, it competes for land, time and labor with crop production. Cattles are also likely to destroy terraces and soil bends. In addition, ownership of large livestock implies the farmer is affluent and has alternative source of income so that he or she would give less attention for crop production. Therefore, he or she participated less in SWC practice. This result is contrary to the work of Abrham *et al*. (2017) which revealed that owning large number of livestock in tropical unit increase farmers' likelihood of using SWC practices.

Access to credit: The MVP model revealed that farmer's access to credit has a statistically significant positive effect on using of adjusting planting date, agro-forestry, drought tolerant variety, SWC practice, and irrigation. Farmers who have access to credit are more likely to adapt climate change by using these adaptation strategies. The result showed that having access to credit increases the propensity of farmers to use the five adaptation strategies in response to climate change. This is due to the fact that access to affordable credit mitigates the financial limitation of the farmer and increases their ability to meet transaction costs associated with the various adaptation options they might want to take. It enables farmers to change their management practices in response to changing climatic factors and to buy fertilizers, seedlings, drought tolerant varieties, irrigation technologies like water pumps and other inputs to smoothening production and reduce the negative impact of climate change. This result is supported by Gadédjisso-Tossou (2015) that found farmers who have access to credit are more likely to adopt planting short season varieties. It is also consistent with the work of Nhemachena and Hassan (2007) that strongly advocated the positive effect of access to credit on the probability of adopting irrigation, SWC practices, adjusting planting date, and using different crop variety in response to climate change by strengthening their financial capacity. Besides, it is in line with Temesgen *et al.* (2009) that confirmed access to credit increases the probability of using irrigation, SWC practices, and adjusting planting date in response to climate change.

Extension visit: Extension visit was found to be statistically significant and positively related to adjusting planting date and use of drought tolerant variety. This implied that having access to extension visit increases the probability of adjusting planting date and use of drought tolerant variety. Conceivably, the reason is that extension visit helps farmers to get informed about contemporary climate related issues and plays a crucial role in improving farmers' knowledge about best adaptation practices to the change in climate. Hence, it enables farmers to make decision based on substantial information. More specifically, it informs farmers when to sow and what variety to use in response to climate change. In line with this finding, the study by Temesgen *et al.* (2009) showed that extension service increases the chance of using improved variety and adjusting planting date in response to climate change. In addition, Abid *et al*. (2015), Gebru *et al.* (2015) and Aemro *et al*. (2012) also confirmed that extension visit enhances the likelihood of using improved variety.

Farmer-to-Farmer extension: Farmer-to-farmer extension has a significant and positive effect on using of SWC practices as one option to climate change adaptation. Accesses of such services enhance the chances for farmers' decision to adapt to climate by enabling them to share experience about and collectively apply SWC practices. Probably, the motive is that such services provide the farmers with information about the agricultural adaptation practices that are most suitable to their farms and practically tested by other farmer themselves. It serves as a source of information and experience sharing among farmers about SWC practices. This result is supported by Temesgen *et al.* (2009) who noted that access to farmers-to-farmers' extension services positively affected SWC practices in response to climate change.

Access to climate information: Access to climate information significantly and positively affected using of drought tolerant varieties and using of irrigation. Farmers who have access to climate related information from different media like radio and television have a higher probability of using drought tolerant varieties and irrigation as an adaptation strategy in response to climate change. Most likely, the reason is that access to climate information permits to perceive the change and choose appropriate strategies in response to climate change. Climate information notifies the situation of the existing climatic conditions to enable the farmers to use alternative adaptation strategies like drought tolerant variety and irrigation. The result is found to be the same with Gadédjisso-Tossou (2015) and Temesgen *et al.* (2009) which asserted that access to climate information increases the likelihood of using short season and improved variety in response to climate change. It is also supported by Gebru *et al.* (2015) that confirmed access to climate information increases the use of irrigation. From the focus group discussion, radio is the major source from which farmers obtain climate related information.

Average distance from home to the farm: The average distance the farm is located from the farmers' home has a statistically significant and negative effect on the use of agro-forestry in response to climate change. When the farm of a farmer is located far from his or her home, he or she is less likely to use agro-forestry in response to climate change. The reason for this might be due to the fact that farmers whose farm is far from their home could not frequently follow up their farm as compared to those whose farm is nearer to their home. In contrary to this, agro-forestry practices needs a due management and close follow ups. Therefore, those farmers whose farm is on average far from their home never use agro-forestry as an adaptation strategy because they could not easily manage these investments so that it cannot sustain. This result is in line with Aschalew (2013).

5. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1. Summary and Conclusions

Climate change has adversely affected the livelihoods of people in developing countries where a large proportion of the population is heavily dependent on agriculture. Long-term records indicate that there have been severe and repeated rise in temperature and rainfall failures resulting in severe food insecurity, including famines in Ethiopian due to significant loss of crops and livestock. Farmers should thus be able to adapt in order to reduce the negative impact of climate change.

A better knowledge on the level of perception of farmers to the changing climate and the common adaptation strategies with their determinants is, therefore, vital as it permits to policy makers to craft a host of strategies and instruments towards reducing climate change danger. It is also important to make effective increment in output, self-sufficiency in food as well as sustainable development possible.

This study was conducted to investigate farmers' perception and adaptation strategies to climate change in Woreillu District based on 24 years time series data on temperature and rainfall from NMA Kombolcha sub-office and cross-sectional survey data collected from 155 respondents. It answered the questions of what is the level of perception of farmers and the major adaptation strategies to climate change and their determining factors.

Descriptive statistics and Likert scale measurement were used to analyze farmers' perception to climate change. The results revealed that majority of the farmers are well aware of the increase in temperature and the decrease in rainfall. As per the result of the descriptive statistics, 87.74% and 83.22% of the respondents perceived the existence of climate change with its attributes temperature and rainfall, respectively. Thus, majority of farmers perceived the existing climate change in the study area. However, there are still a significant number of farmers who didn't perceive the change yet and did not perceive the erratic nature of rainfall distribution which was observed as the prominent change in the study area.

A multivariate probit model was used to identify factors affecting farmers' choice of adaptation strategies to climate change. The study found out that there are five major adaptation strategies: adjusting planting date, using of agro-forestry, using of drought tolerant variety, using of irrigation, and SWC practice with their likelihood of being adopted 54.1%, 38.9%, 47.8%, 59.6%, and 63.4%, respectively. It also showed that the joint probability of using all adaptation strategies was only 9.9% and the joint probability of failure to adopt all of the adaptation strategies was 6.3%. In fact, the choice of adaptation measures by farmers also has been affected by different factors. This study also explored the determinants of each of the five adaptation strategies. Accordingly, the result of the MVP model verified that agro-ecological setting, sex of the household head, education level of the household head, landholding size, farm income, non-farm income, livestock ownership, access to credit, extension visit, farmer-to-farmer extension, access to climate information, and average distance from home to the farm are statistically significant determinants of farmers' choice of adaptation strategies.

The strategy of adjusting planting date was positively affected by farm income, non-farm/off-farm income, access to credit and extension visit. Use of agro-forestry was also positively influenced by landholding size, farm income, and access to credit while it was negatively affected by sex and distance of farm from home. Using drought tolerant variety was positively affected by education level, farm income, access to credit, extension visit, and access to climate information but negatively affected by agro-ecological setting. The choice of SWC practice was positively associated with sex of the household head, education level, farm income, access to credit, and farmer-to-farmer extension and negatively associated with livestock ownership. Finally, the use of irrigation was positively associated with landholding size, farm income, non-farm/off-farm income, access to credit and access to climate information.

Generally, the result of this study provides applicable information for policy makers and other stakeholders about the condition of awareness level of farmers for the changing climate to commence interventions. It also identified the principal choice of adaptation strategies used by smallholder farmers that need to be capitalized to best respond to the existing climate change. Above all, it discovered the key factors to consider during intervention in order to exploit the available adaptation strategies so that promote the adaptive capacity of farmers.

5.2. Recommendations

Based on the findings of this study, the following recommendations have been made for local policy makers and stakeholders in the district.

The level of perception of farmers to climate change has a significant effect on the level of using adaptation strategies to lessen the effect of climate change. But there are still a considerable number of farmers who did not perceive the changing climate. Therefore, emphasizing on awareness creation about the changing climate is crucial.

Policy interventions aimed at mitigating the adverse effect of climate change need to focus on supporting farmers to intensively use and capitalize the existing adaptation strategies: use of drought tolerant varieties, agro-forestry, adjusting planting dates, SWC practices, and irrigation.

Intensifying efforts to improve awareness and adaptive capacity of farmers through improving provision of extension service, encouraging farmer-to-farmer extension services and motivating using of media is very critical. It is necessary to encourage informal social networks and discussions at farmers' level so that enable them to share information and experiences which are important for choice of appropriate adaptation strategies. Farmers also need to be encouraged to use different media like radio, phone, and television to get access to climate information so that they will be able respond to climate change.

Policies aimed at awareness creation about climate change and adaptation strategies need to be framed considering agro-ecological setting and gender for effectiveness of interventions. Promotion of a given adaptation strategies should consider the agro-ecological setting of the area and gender difference needs special consideration for successful use of adaptation measures by smallholder farmers.

It is necessary to design and implement policies that aim to expand adult education so that improve education level of farmers. Literate farmers could be able to easily collect, analyze and interpret relevant information about climate change and adaptation strategies. It will enable them to select appropriate adaptation strategies and farming practices to manage climate change impacts. Hence, it is essential to improve education level of farmers' through expansion of adult schools and crafting systems that allow farmers to get education.

Creating opportunities for a diversified farm and off/non-farm income sources for the farmers is important. Higher income increases the purchasing power of farmers and enables them to easily meet the cost of farm inputs like drought tolerant variety, inputs for irrigation use like water pump, seeds, seedlings and fertilizer. Hence, adequate farm inputs need to be available to improve farm income and creation of alternative off-farm income source is very imperative.

The government and other stakeholders also need to inspire farmers who have large landholding size for effective adaptation to climate change. They should suggest appropriate adaptation strategies to practice through extension. On the other side, farmers with small landholding should be encouraged for efficient use of successful adaptation to climate change. Policy interventions should also focus on transforming the livestock husbandry system from traditional way to modern. It helps to mitigate the land, time and labor requirement.

Promoting farmers' access to credit is vital to secure immediate need of money for the very purpose of purchasing farm inputs and meet the costs associated with using various adaptation strategies: adjusting planting date, using agro-forestry, using drought tolerant varieties using SWC practices, and irrigation in response to climate change. Therefore, the outreach and availability of formal credit providers that can be accessed with affordable interest rate need to be increased to improve farmers' financial capacity.

Finally, the researcher recommend that further study need to be done on the impact of each adaptation strategies in improving the livelihood of farmers and alleviate the problem of food insecurity in the district.

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7. APPENDICES

7.1. Appendix I: Appendix Tables

Appendix Table 1: Conversion factors used to calculate Tropical Livestock Units (TLU)

Animals	TLU-Equivalent
Calf	0.2
Heifer and Bull	0.75
Cows and Oxen	1
Camel	1.25
Horse and Mule	1.1
Donkey	0.7
Sheep and Goat	0.13
Chicken/Poultry	0.013

Source: Storck *et al*. (1991)

Appendix Table 2: Conversion factor used to calculate man-equivalent (ME)

Age	ME-Equivalent	
	Male	Female
<10	0	0
10-13	0.2	0.2
14-16	0.5	0.4
17-50	1	0.8
>50	0.7	0.5

Source: Storck *et al*. (1991)

Appendix Table 3: Long-term climate data of Woreillu District from 1993-2016

Year	Mean minimum temperature(^{0}C)	Mean maximum temperature(^{0}C)	Average annual temperature(^{0}C)	Annual rainfall (mm)
1993	7.3	21.4	14.4	610.7
1994	7.5	20.8	14.1	669.4
1995	6.4	22.1	14.3	785.8
1996	7.7	21.6	14.7	673.3
1997	8.6	21.9	15.3	414.2
1998	8.6	21.9	15.3	635.3
1999	7.7	21.1	14.4	751.1
2000	8.2	21.2	14.7	957.2
2001	9.6	21.2	15.4	652.0
2002	10.0	22.0	16.0	813.7
2003	10.0	21.6	15.8	601.0
2004	10.1	21.7	15.9	729.7
2005	9.7	21.7	15.7	591.9
2006	10.2	21.4	15.8	801.3
2007	9.9	21.5	15.7	807.3
2008	9.4	21.8	15.6	751.3
2009	10.5	22.3	16.4	670.6
2010	10.5	21.7	16.1	754.1
2011	10.1	21.9	16.0	592.0
2012	10.0	22.0	16.0	700.6
2013	10.2	22.4	16.3	803.2
2014	10.1	22.5	16.3	703.0
2015	10.4	22.7	16.5	523.1
2016	10.5	22.8	16.7	567.2

Source: NMA Kombolcha sub-office, 2017

7.2. Appendix II: Questionnaire for Interview Schedule

Questionnaire

I. Identification Data

1. Household Head code number …………………………….
2. Date of interview …………………………….
3. Name of Enumerator …………………………….
4. Name of the respondent's Kebele Administration ……….Village (Got) name……...…….
5. Agro-ecology: Dega ☐ Woinadega ☐
6. Checked by supervisor ………………………Signature………………….Date …………

II. Household Characteristics and Institutional Related Questions

1. Gender of the house head? a) Female b) Male
2. Age of the household head? ………. years old.
3. Educational status of the households head? a) Illiterate b) Literate ………(years of formal schooling)
4. Marital status a) single b) married c) divorced d) widowed
5. How many is the number of members of the household? ………Males and ...…Females
   5.1. Number of active household members aged between 15-64 years.
   Male…….………Female…...………Total …………………
   5.2. Age category of members of the household

	Age group	Male	Female	Total
1	<10			
2	10-13			
3	14-16			
4	17-50			
5	>50			
Total				

6. Do you own land? a) No b) Yes
   6.1. If "YES", how much is the total farm land operated including any grazing land (including rented land and excluding rented out land) during last production year (land holding size)……………….. (in hectares)
   6.2. Size of land rented in ……………. Size of land rented out………………..
7. How sloppy is your farm a) Plain b) Medium c) Very steep
8. What is the main source of household income? a) Crop production b) Livestock production c) Mixed farming d) Other (Specify)……………………..
9. How many years of farming experience do you have? …………….years
10. How much income you get from your farm during the last one year? ………………birr.

10.1.Household Income from Crop Production

S. No.	Type of Crop	*Meher* Production Season				*Belg* Production Season			
		Quantity Produced (in Quintal or Kg)	Quantity Sold (in Quintal or Kg)	Price per Kg	Total Revenue (ETB)	Quantity Produced (in Quintal or Kg)	Quantity Sold (in Quintal or Kg)	Price per Kg	Total Revenue (ETB)
1	*Teff*								
2	Wheat								
3	Barley								
4	Sorghum								
5	Maize								
6	Beans								
7	Pea								
8	Lentil								
9	Chickpea								
10	spices								
11	Other								
Total									

10.2. Household income from Livestock and Livestock Products

S.No	Type of Livestock and livestock products	From both MEHER and BELG Seasons			
		Quantity Produced in Number	Quantity Sold in Number	Price per Product	Total Revenue (ETB)
1	Milk/Butter/Cheese/Yoghurt				
2	Honey				
3	Egg				
4	Hides and skin				
5	Cow				
6	Ox				
7	Beef				
8	Calf				
9	Heifer and Bull				
10	Sheep				

11	Goats				
12	Chickens				
13	Donkeys				
14	Mule				
15	Camels				
16	Pigs				
17	Beehives				
18	Other				
Total					

10.3. Estimate the amount of income you got from byproducts of crops and livestock………………birr.

10.4. Total estimated farm income ………………….birr.

11. Do you have off-farm or non-farm income sources? a) Yes b) No

11.1. If "Yes", mention some of the major sources and how much birr you earn in the last one year.

S.No.	Type of income	Yes/No	Total Income (ETB)
1	Petty trading		
2	Remittance from relatives		
3	Salary for nonfarm jobs		
4	Gifts		
5	From aid		
6	From Pension		
7	Sales of farm assets (Machineries, building, trees, agricultural tools)		
8	Sale of Nonfarm assets (TV, Fridge, etc)		
9	Other (handcraft,…..)		
Total			

11.2. Total estimated non-farm and off farm income………………….birr

12. On average how much is your total expenditure per year? Please specify in Birr…………

13. Dear respondent! How many of the following types of livestock do you have?

Please fill in the head count column.

S.No.	Types of livestock	Head count
1	Cow	
2	Oxen	
3	Bull	
4	Heifer	
5	Calf	
5	Horses	
6	Donkey	
7	Mule	
8	Camels	
9	Goats	
10	Sheep	
11	Chicken	

14. Do you have access for credit from any sources? a) Yes b) No

14.1. If YES, did you get credit for the past one year? a) Yes b) No

14.2. If "Yes", how much money did you borrowed from any of the following sources during the past one year? Total of ………………birr

S.No.	**Source**	**Yes/No**	**How often?**	**Total Amount borrowed (ETB)**
1	Relatives			
2	Neighbors			
3	Farmers associations or Cooperatives			
4	Commercial Banks			
5	Traders			
6	Other private money lenders			
7	Saving and credit associations			
8	Microfinance institutions			
9	NGO			
10	Women /Youth associations			
11	Religious institutions			
12	Government office			
13	Other			
Total				

15. Do you have access to agricultural extension services? a) Yes b) No

15.1. If your answer for Q.15 is “Yes”, how many times the development agent/ health extension workers visit you last year …………..…………..

15.2.What types of advices did you receive from extension workers? (multiple response is possible)

a) Improved crop production systems
b) Improved livestock production
c) soil and water conservation
d) Irrigation use
e) Natural resource management
f) planting and harvesting time
g) Crop diversification
h) Using climate change tolerant variety
i) Others (please specify) …………………………

16. Does the extension agent provide you information on climate change? a) Yes b) No
17. If your answer for Q.16 is “Yes”, does it help you in choosing adaptation strategy to the change in climate? If yes, in what way...................................
18. Have you heard information on climate change and adaptation strategies from your neighbors/ farmer to farmer extension? a) Yes b) No

    18.1. If “Yes”, how many times during the past one year? …………………..
19. Have you heard information on climate change, its consequences and adaptation other than from extension agents and neighbors before?

    a) Yes b) No

    19.1. From which source you heard about climate change? (Multiple answers is possible)

    a) Television (TV) b) Radio c) Newspapers d) school/college

    e) Other (specify) …………………..
20. Did you get any training on climate related issues from any organization? a) Yes b) No If “Yes”, specify the kind of training you received. …………………………………
21. How far is your farm from your home? In distance.…….. kms (one-way) or in time ………… hours (one-way).
22. How far is your home from the nearest market that you buy farm inputs? In distance …..…… kms (one-way) or in time ………….. hours (one-way).

23. How productive is your land without fertilizer? a) High b) Medium c) Low

III. Climate Change Perception Assessment

24. Have you observed any change in climate in the last 24 years from now?
    a) Yes b) No

25. If your response for Q.24 is "Yes", how do you characterize the climate of this area in the last 24 years? ……………………………….
26. What do you say about the trend of level of temperature over the last 24 years?
    a) Increased b) Decreased c) Not changed d) I don't know
27. Which local indicators do you use to evaluate the temperature trend in the area? (Please support it with example)
    a) Prevalence of human and animal diseases that are not familiar to the area (malaria etc)
    b) Introduction of plant and animal species that were not popular in the area (goat in highlands are not common)
    c) Observation of physical structures and societal clothing styles (disappearance of ice cover in mountain peaks, frost damage become uncommon, dry up of rivers , streams, lakes, dressing light cloths etc)
    d) Habitat shift towards higher locations
    e) Other (specify)……………………………………………………………………….
28. What do you say about the trend of rainfall over the last 24 years?
    a) Increased b) Decreased c) Not changed d) I don't know
29. Which local indicator do you use to evaluate today's rainfall pattern? (multiple response is possible)
    a) Loss of some plant and animal species
    b) Increased drought and flood frequency
    c) Growing period shortened
    d) Rainfall come early or lately
    e) Decline of soil productivity/fertility
    f) Decline of agriculture yields
    g) Decreased available water
    h) Other (specify)…………………………………………………………………………

30. In terms of the frequency of drought, what trends have you observed?
    a) Increased b) Decreased c) Not changed d) I don't know
31. In terms of the frequency of flood, what trends have you observed?
    a) Increased b) Decreased c) Not changed d) I don't know
32. In terms of the frequency of frost, what trends have you observed?
    a) Increased b) Decreased c) Not changed d) I don't know
33. In terms of the frequency of others (specify), what trends have you observed?
    a) Increased b) Decreased c) Not changed d) I don't know
34. What do you think is the cause of climate change?
    a) Human actions
    b) Natural process
    c) The act of God
    d) Both human action and natural process
    e) I don't know/I have no idea. e) Other (Specify)…………………
35. Have you observed any change in the length of hot period in your life time? a) Yes b) No
36. If your answer for Q35 is Yes, how do you see it? a) Becomes shorter b) Becomes longer c) No response
37. Have you observed any change in the amount of rainfall? a) Yes b) No
38. If your response for Q37 is Yes, how do you see it? a) Increased b) Decreased c) Remaining the same d) Erratic nature
39. Dear respondent please fill the following if you are experienced with it.

	Have you experienced with the following types of climate change and variability indicators?	Response		How often? (in past decade)
		Yes	No	
1	Drought			
2	Floods			
3	Off-seasonal rainfall			
4	Too much rain			
5	Too little rainfall			
6	Higher temperature			
7	Frost (coolness)			

8	High winds			
9	Others (specify)			

40. In summary, have you observed the following climate change related impacts in last decade?

No	Climate change related impacts	Yes	No
1	Decline in crop yields		
2	Increase in crop yields		
3	Decline in livestock yields		
4	Increase in livestock production		
5	Death of livestock due to shortage of fodder and water		
6	Food shortage /insecurity		
7	Increased weed and pest pressures		
8	Communicable diseases		
9	Decrease of water quality and quantity		
10	Higher risk of crop damage from drought		

41. Likert scale measurement of perception of farmers to climate change:

No	**Statement Point**	**Scales of Agreement**				
		SA = 5	**A = 4**	**N = 3**	**D = 2**	**SD = 1**
1	There is an increase in temperature time to time					
2	There is a decrease in rain fall amount time to time					
3	Rain fall couldn't properly support full crop growth period					
4	Springs, streams and pond dying out					
5	There is an increase in the number of hot period					
6	There is an early cessation of rainfall					
7	Starting time of rainfall is lagging behind the usual					
8	Crop disease and pest infestation increases and becomes problem than earlier times					
9	The price of grain is hiking because of decreased productivity for climate change					

10	Deforestation is becoming severe than earlier times to compensate the income and livelihoods					
11	The community is migrating to cities due to inability of agriculture to support their livelihood					
12	Some sources of livelihoods of the community are changing due to changing climate conditions					
13	There is an increase in irregularity of rain fall					
14	The community is enough aware of the climate change impacts					

IV. Adaptation Strategies to Climate Change

42. Have you employed any of the following climate change impact adaptation strategies in your farm in past decades?

	Climate change adaptation	Response		If no, please specify the reason why not?
		Yes	No	
1	Using different crop varieties			
2	Changing planting dates			
3	Agro-forestry/Planting trees			
4	Adoption of drought tolerant and early maturing crop varieties			
5	Crop diversification			
6	Increased use of soil and water conservation techniques or soil erosion prevention programs			
7	Water harvesting techniques and increased use of irrigation			
8	changing fertilizer application			
9	the pastoral system or the herd composition			
10	applying different feed techniques			
11	home-garden agriculture			

12	Buying insurance			
13	Change livestock variety			
14	Mixed farming			
15	Temporary migration			
16	Seek off-farm employment			
17	Reduce number of livestock			
18	Application of agro-chemicals			
19	Fertilizer usage and application of animal manure			
20	Others (specify if any)			

7.3. Appendix III: Guiding Questions for Focus Group Discussion

1. Explain the condition of environment in your locality. Do you feel the pattern of weather is generally changing?
2. Have you ever heard about climate change? If yes, from which sources?
3. What is your observation on the climatic (temperature and rainfall) condition in your area?
4. What are your indicators to realize the presence of change in climate?
5. What is the cause of climate change (Traditional how people believe the cause)
6. What are the problems that you have ever experience because of climate change? (Drought, flood,). For how many years during the last 24 years? Which one was the most sever?
7. What are the impacts of climate change on agriculture and livelihood of rural people?
8. Do you think that the change in climate will continue in the future?
9. What are the adaptation strategies employed by farmers to minimize the adverse impact climate change?
10. Identify any indigenous crop cultivar, which is now out of production due to climatic change?
11. Identify any newly appeared crop infestation and diseases in your locality.
12. Do you sow your crops at different times or different places to avert risks of crop loss?
13. Do you switch to short maturing or drought resistance crop varieties instead of long maturing crop verities? If yes, explain the crop types and the planting/ harvesting pattern.
14. Do you perceive that there are differences in adaptive capacities across your groups?

15. What factors affect the choice of adaptation strategies by smallholder farmers?
16. What are the main hindrances for use of adaptation options of combating climate change?
17. If you perceived climate change, but not adapt what other barriers do you have?
18. What agricultural technology and Meteorological information system do you access regularly and during climatic extremes?
19. Do you have access to credit?
20. Do you have easy access to agricultural inputs such as seed?
21. Do you have sufficient knowledge about adaptation options?
22. Do you receive early warning information on short term variations and/or long-term climate change from any sources?
23. What do you recommend to be done to enhance the fight towards climate change?