SMALLHOLDER FARMERS' ADAPTATION STRATEGIES TO CLIMATE CHANGE IN ADAMA DISTRICT, OROMIA REGION, ETHIOPIA

M.Sc. THESIS

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As Thesis research advisors, we here by certify that we have read and evaluated this thesis prepared, under our guidance, by **Magarse Hundara**, entitled "**Smallholder Farmers' Adaptation Strategies to Climate Change in Adama District, Oromia Region, Ethiopia.**" We recommend that it be submitted as fulfilling the thesis requirement.

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As member of the Board of Examiners of the MSc. Thesis Open Defense Examination, we certify that we have read, evaluated the Thesis prepared by Magarse Hundara and examined the candidate. We recommended that the Thesis be accepted as fulfilling the Thesis requirement for the Degree of Master of Science in Agriculture (Agricultural Economics).

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DEDICATION

I dedicate this thesis manuscript to my parents for their partnership in the success of my life.

STATEMENT OF AUTHOR

First, I declare that this thesis is my work and that all sources of materials used for this thesis have been properly acknowledged. This thesis is submitted in partial fulfillment of the requirement for an advanced M.Sc. degree at Jimma University and to be made available at the University's Library under the rules of the Library.

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BIOGRAPHICAL SKETCH

The author was born in 1996 in Gidda Ayana District, East Wellega Zone of Oromia National Regional State of Ethiopia. She attended her elementary education at Gattira Elementary School and high school and preparatory school at ASK Secondary and preparatory School in Nekemte town. After successful completion of her preparatory school education, she joined Gambella University in 2013 and graduated with B.Sc. degree in Agricultural economics in July 2015. Soon after her graduation, she joined Gambella University and served as graduate assistant for one year in the Department of Agricultural Economics. After one year of professional experience, she joined the School of Graduate Studies of Jimma University in October 2016 to pursue her MSc degree in Agricultural Economics.

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LIST OFACCRONYMS AND ABBREVATIONS

CEI	Climate Emergency Institution
CH_4	Methane
CO_2	Carbon dioxide
CSA	Central Statistical Agency
EDRI	Ethiopian Development Research Institute
FAO	Food and Agriculture Organization
FDRE	Federal Democratic Republic of Ethiopia
FEDAD	Finance and Economic Development Office of Adama District
FGD	Focus Group Discussion
GDP	Gross Domestic Product
GHG	Green House Gas
HHs	Household Heads
IFAD	International Fund for Agricultural Development
IFPRI	International Food Policy Research Institute
IIA	Independence Irrelevant of Alternatives
IPCC	Inter-governmental Panel on Climate Change
MoA	Ministry of Agriculture
MVP	Multivariate Probit
N_2O	Nitrous Oxide
NGO	Non-Governmental Organization
NMA	National Meteorology Agency
PCGCC	Pew Center on Global Climate Change
SML	Simulated Maximum Likelihood
SSA	Sub-Saharan Africa
TLU	Tropical Livestock Unit
UNFCCC	United Nations Framework Convention on Climate Change
WB	World Bank
WFP	World Food Policy
WHO	World Health Organization
WMO	World Meteorology Organization
WRI	World Resource Institute

SMALLHOLDER FARMERS' ADAPTATION STRATEGIES TO CLIMATE CHANGE IN ADAMA DISTRICT, OROMIA REGION, ETHIOPIA

ABSTRACT

Adaptation strategies reduce the level of damages that might have otherwise occurred as results of climate change and others. An appropriate perception about climate change is a precondition for the approaching of adaptation strategies. The specific objectives of this study were first to assess the perceptions of smallholder farmers on climate change in the study area. Second to investigate the climate change adaptation strategies being practiced by smallholder farmers and lastly to identify the determinants of smallholder farmers' choice of adaptation strategies to climate change. Both primary and secondary data were employed. Primary data were collected from a randomly selected 155 sample households through interview. Focus group discussion, key informant interview and field observation were also employed as data collection tool. Relevant secondary data were also obtained from National Meteorology Agency of Adama branch. Descriptive statistics were used to analyze the characteristics of sample households and types of adaptation strategies to climate change. Likert scale was employed to examine smallholder farmers' perception to climate change. Moreover, multivariate probit model was employed to identify the determinants of smallholder farmers' choice of adaptation strategies to climate change. The result indicated that the major adaptation strategies applied by smallholder farmers in the study area were using improved crop varieties, adjusting planting date, planting tree, crop diversification, and terracing practice. Multivariate probit model result showed that the likelihood of households to adopt planting tree, terracing practice, improved varieties of crops, adjust planting date, and use crop diversification were 76.5%, 74%, 51%, 46.7%, and 40.4%, respectively. The result also showed that the joint probability of using all adaptation strategies was only 9.6% and the joint probability of failure to adopt all of the adaptation strategies was 4.1%. It was also found that educational, sex, farming experience, credit, farm income, off/non-farm income, and access to climate change related training significantly influenced choices of climate adaptation strategies. Therefore, future policy should focus on awareness creation on climate change and its adaptation strategies.

Key words: *Farmers' Perception, Likert scale, Multivariate probit, Rainfall, Temperature.*

1. INTRODUCTION

1.1 Background of the Study

Climate change is a real phenomenon. It has been recognized and realized by scientific communities that climate change has a global coverage and clearly show itself by affecting the world communities with different magnitudes (IPCC, 2014a Serkalem *et al.*, 2014; Seyoum, 2015). Since the levels of the development of the world countries are different, climate change is not affecting the global societies equally. According to the United Nations Framework Convention on Climate Change (UNFCCC) report, developed regions are the major contributors of the greenhouse gases, and they minimize the major impacts of climate change through their higher advancement of technologies. On the other hand, the developing regions are largely affected by the climate change impacts as a result of their low level of development. However, these regions are generally categorized as the least contributors of greenhouse gases because of their low level of sophisticated industries (UNFCCC, 2012).

Adaptation can be viewed as reducing the severity of many impacts when adverse conditions prevail. That is, adaptation reduces the level of damages that might have otherwise occurred. The success of adaptation depends critically on the availability of necessary resources, not only financial and natural resources, but also knowledge, technical capability, and institutional resources (PCGCC, 2004). In addition, many social, economic, technological and environmental trends also critically shape the ability of farmers to perceive and adapt to climate change. Knowledge of the adaptation methods and factors affecting farmers' choices enhances efforts directed towards tackling the challenges that climate change is imposing on farmers (Deressa *et al*., 2009). Thus, for many poor countries that are highly vulnerable, understanding farmers' response to climate change is crucial in designing appropriate adaptation strategies (Mohmud *et al*., 2008). The vulnerability of poor countries is due to weak institutional capacity, limited engagement in environmental and adaptation issues, and a lack of validation of local knowledge (Adams *et al*., 1998). Experience has shown that identified adaptation measures do not necessarily translate into changes, because adaptation strategies to climate change and physiological barriers to adaptation are local specific (IPCC, 2007). A better understanding of

the local dimensions of climate change is essential to develop appropriate adaptation measures that will mitigate adverse consequences of climatic change impact. The knowledge of the adaptation choices and factors affecting the adaptation methods to climate change enhance policy towards tackling the challenge that climate change is imposing on farm households having little adaptation capacities.

Two steps are involved in climate change adaptation; first perceiving change and then deciding whether or not to adopt a particular measure (Maddison, 2007). 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 information gained and technologies available to them will highly influence their adaptation and response capacity. 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.

Human being adapt to climate from the very beginning of their existence through different mechanisms. IPCC (2007) revealed that adaptation to climate change is already taking place, but on a limited basis, societies have a long record of adapting to the impacts of weather and climate through a range of practices that include crop diversification, using improved crop variety, water terracing, and planting tree. Although African farmers have low capacity to adapt to changes in the climate, they have, however, survived and coped in various ways over time. Better understanding of how they have done this is essential for designing incentives to enhance private adaptation (Nhemachena and Hassan, 2008).

In Ethiopia, agricultural sector is the primary economic activity. The share of agriculture in GDP is 38.8% in 2014/2015 which is decreased from the 40.1 in 2013/2014 (MoFED/NBE), and its productivity is highly influenced by the nature of climate due to the fact that the sector is rain dependent (Mengistu, 2011). However, change of climate has significant adverse implications to the economic country with connection to different climatic parameters. According to climate change scientific community, the nature of rainfall is irregular and complex to estimate (IPCC, 2014b). The same source also stated that temperature is showing increasing trend. Likewise,

averagely minimum and maximum annual temperature in Ethiopia is increased by 0.25^{o}c every ten years and 0.1^{o}c every decades respectively (Temesgen, 2010). Moreover, the increment of the temperature has been projected in the future from 1.1 to 3.1°C and 1.5 to 5.1°C by 2060s and 2090s respectively. Also National Meteorology Service (NMS, 2007) recognized that rainfall fluctuation becomes extremely increasing more than that of the past 50 years as a result of climate change. As a result of this, the futurity of smallholder farmers are particularly full of uncertainty.

The Oromia region experiences annual temperature ranging from 10^{o}C to 30^{o}C, with mean annual temperature 19^{o}c. The consequences of climate variability and climate change have severely threatened the agricultural sector and it's a potential to cause natural environmental hazards and the potential to undermine the regions as well as the country's economic development (Oromia National Regional State, 2011). Thus, with an intention of minimizing the impacts of climate change, adaptation strategies are needed (Fussel, 2007; Farber, 2011). There are many possible adaptation strategies by which households overcome the impacts of climate change in Ethiopia. Temesgen *et al.,* (2009) identified that, tree planting to be one of the major methods used by farmers to adapt to climate change in the Nile Basin of Ethiopia. Vegetation like trees and grass are valuable because the roots protect the soil from erosion. Trees are valuable during floods and droughts, and many trees together will give lower temperatures in the near area, a fresh air, and also shadow. Furthermore, the study revealed terraces are often built together with soil bunds, stone bunds, deep trenches, and special rainwater harvesting methods. Those are the most common strategies to conserve soil and water in the field. Soil and water conservation strategies are mainly used because of soil degradation and soil erosion, and because farmers due to this, want to rehabilitate their fields. According to (UNEP, 2006), Crop diversification is the strategy used to avoid risks of total crop failure rather than maximizing yields of one particular crop. Similarly, (Temesgen *et al.,* 2009) confirmed that, crop diversification is widespread and the most commonly used method to overcome the impact of climate change and variability in Ethiopia. Diversification is identified as a coping strategy that has evolved to deal with both expected rainfall uncertainty and seasonal fluctuations in rainfall (Cooper *et al*., 2008).

An appropriate perception about climate change is a precondition for the approaching of adaptation strategies (Gutu *et al.*, 2012). Belay (2012), assessed farmers 'perceptions of climate change and the extent to which these perceptions have influenced their current practices with respect to adapting with changes in temperature and precipitation. Most of the interviewed farmers for the studied *kebeles* perceived that they have observed the changing temperature and precipitation, such as reduced amount of rainfall (59.7%), increasing temperature (60%), shift in the timing of rainfall and shortened period of raining days. They also stated that these changes have been affecting their farming activities. Given this perception and depending on the farming system, farmers have practiced several adaptation mechanisms. At local level, some farmers experienced positive effects from increased precipitation while others experienced negative effects as results from interviewing farmers suggested. This is a reflection of the unclear impact of change in precipitation on crop activities in the area. It is also a reflection of the high degree of variability of the rainfall experienced in the recent past.

Like other parts of the country, the livelihoods of the rural communities of Adama district is based on rain fed agriculture. On the other hand, the study area is characterized by erratic rainfall and relatively higher temperature (FEDAD, 2014). As a result of fragmented and maladaptive practices, the already affected communities are tending to get worse. Therefore, this study has designed to assess smallholder farmers' adaptation strategies to climate change in Adama District.

1.2 Statement of the Problem

Smallholder farmers of Ethiopia are practicing rain fed agriculture and they are characterized by limited resources, communication and transportation networks and weak institutions, low adaptive capacity, limited financial resources and also lack of access to technology (Tesfaye, 2016). As a result of these complicated factors, the rural farming communities are highly suffered to climate change impacts like destroying of livestock herd, food scarcity, and great loss of ecosystem. Moreover, mass migration of peoples is other impacts (Mengistu, 2011). In the same way, both National Meteorological Agency (NMA) and Ministry of Finance and Economic Development (MoFED) of Ethiopia are stated that desertification, recurrent drought, land degradation, soil erosion, loss of bio diversity, floods, pollution, deforestation are the major

environmental harms in Ethiopian country (NMA, 2007; MoFED, 2010). Poor countries like Ethiopia are more vulnerable to climate change (Aemro *et al.*, 2012).

As stated in the background of study, the majority of Ethiopian populations are basing their livelihoods on agriculture. The long term impact of climate change is related to the pattern of rainfall and temperature which is varying on the bases of seasonally and annually (Seyoum, 2015). Though, by temperature increment and rainfall variability smallholder farmers are being impacted. According to Jensen (2011); Abrham (2012); IPCC (2014b) the current climate variability will cause people to face losses in terms of their daily work activities, will eventually lead to change in planting seasons, decline in crop yield and biomass production, increased risk of food shortage and famine.

In response to change and its associated impacts of climate change, the smallholder farmers have developed low and local based adaptation methods. However, the efforts are still characterized by disjointed and limited which cannot fully address the observed and projected climate change impacts. Similarly, Hurst *et al. (*2012) reported that climate change adaptations performed by smallholder farmers often takes place in the form of small changes and traditional ways. Also there is lack of sufficient information on the process of climate change adaptation options that are essential for policy makers, development agents and farmers. The Adama District is known by its relatively higher temperature and erratic rainfall which significantly affect smallholder farmers of the district (Bezabih *et al.*, 2010; Abrham, 2012).

Different scholar used different adaptation strategies in their study. For example Intensification of irrigation, increase use of agricultural input, use of drought crop tolerant species, adjusting planting time, crop diversification, increasing size of land, fodder tree planting, temporary migration to the high forest are used as adaptation strategies (Temesgen,2014). Also changing planting date, irrigation water use, soil and water conservation and crop variety selection are used as adaptation strategies (Adugna, 2014).

Different scientific studies on climate change adaptation strategies have been carried out using the multinomial logit model to identify the determinants of smallholder farmers' choice of adaptation strategies to climate change (Aemro *et al.*, 2012; Lemmi, 2013; Temesgen *et al.*, 2014; Weldlul, 2016; Belay *et al.*, 2017). Furthermore, various researches have been carried out

in Central Rift Valley Region of Ethiopia on climate change adaptation strategies (Abrham, 2012; Melka, *et al.*, 2015; Belay *et al*., 2017), either there is no or limited research conducted in study area on smallholder farmers' climate change adaptation strategies. Therefore, this study has the purpose of assessing the smallholder farmers' adaptation strategies to climate change in Adama District, Oromia Region, Ethiopia

1.3 Research Questions

This study addressed the following key research questions.

1. How smallholder farmers perceive climate change in the study area?
2. What are the major adaptation strategies used by smallholder farmers of the study area?
3. What are the determinants of smallholder farmers' choice of adaptation strategies to climate change in the study area?

1.4 Objectives of the Study

1.4.1 General Objective

The general objective of this study was to assess smallholder farmers' adaptation strategies to climate change in Adama District, Oromia Region, Ethiopia.

1.4.2 Specific Objectives

The specific objectives of the study were:

1. to assess the perceptions of smallholder farmers about climate change in the study area
2. to investigate the climate change adaptation strategies being practiced by smallholder farmers
3. to identify the determinants of smallholder farmers' choice of adaptation strategies to climate change

1.5 Significance of the Study

This research has focused on climate change adaptation strategies of smallholder farmers. It would assist the smallholder farmers to identify the most significant adaptation strategies which

can further enhance their productivity. Also it provides the up to date information in the study area which guides the future adaptation methods.

The perceptions and knowledge of adaptation strategies at household level in particular area may add up the information for smallholder farmers towards climate change and its adaptation. Moreover, to tackle the negative impacts of climate change, the understanding of perceptions and adaptation strategies play the major role (Legesse *et al.*, 2013).

Agricultural extension workers and district agricultural offices can use the result of this research to scale up the best practices regarding adaptation strategies. It may also assist the agricultural experts in developing climate change adaptation strategies guidelines. In addition, the results of this study are useful to make wide-ranging analysis to diminish the impacts of climate change by indicating adaptation intervention mechanisms in study area.

1.6. Scope and Limitations of the Study

This study is limited in terms of area coverage because of time and budget constraint to conduct further research in other districts. It relied on cross-sectional data to assess smallholder farmers' adaptation strategies in the study area. Same farmers were not willing to fill questionnaires and participate in focus group discussion. Same of temperature and rainfall data recorded on the meteorological is recorded in day and months. So the temperature and rainfall data recorded is not in the same measurement.

1.7. Organization of the Thesis

The thesis is organized into five chapters. The first chapter has presented the introduction of the study that includes the background, statement of the problem, objectives of the study, significance of the study, scope and limitation of the study. Chapter two presents literature review including theoretical perspectives and empirical evidences related to the main themes of the study. Chapter three discusses the methodological approach of the study that includes the method of data collection, analysis and hypothesis of the study. Results obtained from the study are presented and discussed in detail in chapter four. Finally, summary, conclusions and recommendations of the study are presented in chapter five.

2. REVIEW OF LITERATURE

This chapter presents definitions of basic terms, theoretical perspectives and empirical evidences related. The emphasis of the chapter is to give a general idea on the agro- ecological and climate system. Similarly this chapter is give consideration on the idea like causes of climate change, impacts of climate change. Perceptions of smallholder farmers towards climate change. Concepts of adaptation and adaptation strategies were presented. Additionally, socio-economic, institutional, perception of farmers on climate change and determinants of adaptation choice from empirical findings were presented. Conceptual framework also presented in this chapter.

2.1 Definitions of Basic Terms

Weather: This is defined as the short term characteristics of daily temperature, daily rainfall, and precipitation (IPCC, 2014a).

Climate change: This is the condition in which it is recognized by averagely change of climate and changing of its properties. Additionally it's characterized by permanent change for ten years or more than ten years. It may be appear because of internal which is natural force and external force which is manmade activities (IPCC, 2014a).

Perception: It is the process of receiving information and stimuli from our environment and converting them into psychological responsiveness (Uddin *et al*., 2017).

Adaptation: This refers to the mechanism or method used to discourage the extreme effect of climate change (UNFCCC, 2007).

Mitigation: It is the mechanism of decreasing greenhouse gas emission, for instance, by sighting of fuel and deforestation in relation to greenhouse gas concentration (IPCC, 2001; Said, 2014).

Adaptive capacity: It is the capability to adjust climate variation, extreme impact of climate change to minimize damage (Said, 2014).

Vulnerability: It is the feature and condition of society, system or properties that have probability to damage by risk (UNFCCC, 2007).

Smallholder farmers: Smallholder farmers are farmers who own small plots of land on which they grow subsistence crops and one or two cash crops relying largely on family labor. In different countries, they are variously described as family farmers, subsistence farmers, poor farmers and peasant farmers. Smallholder farming is characterized by small farm size, low technology and low capitalization (Seyoum, 2015).

2.2 Climate System and Agro-ecological Features of Ethiopia

The climate in the horn of Africa is mostly dominated through large-scale circulation. In Ethiopia, there are three season and country's geographical location, topography is known. First, Bega is refers to dry season starting from October to January. Second, Belg is short rainy season beginning from February to May. Third, Kiremt is known by long rainy season from June to September. The central, eastern and northern parts of the country receive bimodal pattern of rains from June to September and spring rains from March to May. The southern and south western parts of the country, receive unimodal pattern where precipitation falls from March to November (Weldlul, 2016). The highlands generally receive more precipitation than the lowlands (Daniel, 2011).

The Ethiopian climate is mainly controlled by seasonal migration of the Inter-Tropical Convergences Zone (ITCZ), which follows the position of the sun relative to the earth and associated with atmospheric circulation in conjunction with complex topography of the country (NMSA, 2001). There are five category of traditional agro-ecological climate zone based on the altitude and temperature (Weldlul, 2016).

Table 1: Physical characteristic of agro-climatic zones

Traditional climatic zone	Altitude (meter above sea level)	Average annual temperature ($_0$C)	Rainfall (millimeter per year
Wurch or cold high lands	>3200	>11.5	900-2,200
Dega or upper high lands	2,300-3,200	11.5-17.5	900- 1,200
Weynadega or mid highlands	1,500-2,300	17.5-20,0	800-1,200
Kolla or lowlands	500-1,500	20,0-27.5	200-800
Berha or desert	<500	>27.5	Under 200

Source: Weldlul (2016)

2.3 Causes of Climate Change

Internal and external forces or activities are course for climate change. The internal factors are occurring naturally and they are contributed by solar radiation, volcanic eruption. While the external force are comes by human activities like deforestation, urbanization, industry and agriculture (Tessema *et al*., 2013). For example, rising of greenhouse gas such as Carbon dioxide ($CO2_)$, Methane (CH4), Nitrous oxide (N_2O) and likes in the atmosphere is most cause of climate change and it's the result of external force. At the world level, more than half of the green house emission is from carbon dioxide. Specifically, it comes from burning of fossil fuel or petroleum. CH4 and N_2O are other source of greenhouse gas. They are caused by deforestation and agricultural activities (Yohannes and Mebratu, 2009).

Adungaw (2014) stated that land degradation and deforestation are the major causes of climate change in Ethiopia and mostly related with agricultural expansion, harvesting or extraction of wood and expansion of infrastructure. Additionally, there are different mixing of most important factors of ecological degradation which causing environmental hazards that leads to climatic change and its reverse. These factors are: 1) Natural condition factors. For example, rainfall fluctuation from time to time and place to place 2) Demographic factors. When the number of population is high, their wants of different things like farm land, construction such as house, and wood for fuel also become increase results, deforestation which is one cause of climate change. 3) Lack of environmental awareness is other cause of climate change. Also the same source found that, weak participation of peoples and community on environmental management is additional challenge and cause of climate change.

2.4 Climate Change Impacts

Climate change affects the ecology, societies and their economies. It also affects the different policy institutions and different sectors such as agriculture, mining, tourism and forestry. The least developed countries particularly Ethiopia is more influenced by climate instability for the reason of having low adaptive capacity (WB, 2009; Weldlul, 2016). As different scholars found that, agricultural production and yields are influenced by climate change directly through different climate parameter variability like rainfall, solar radiation, temperature, wind speed and humidity. Also disease, pest and also when labor force attack by malaria disease agricultural

production and yield affected in directly (Deschenes and Greenstone, 2006; Sowunmi and Kintola, 2009; Ngigi, 2009; Newton *et al.*, 2010; Said, 2014).

Furthermore, farming is depending on climatic phenomena. The extreme variability of climate influence agriculture by decreasing its product, especially affect food , it distribute disability or injury, maximize the number of peoples those are discriminate on resource because of in adequate resource endowment like water, land (IPCC 2007;2014b). Similarly, in Africa the two season (wet, dry) have to be negative effect on the well being of society, on the environment of plant and animal, on the farming practice and food furthermore on existence of water because of Africa has no well equipment to control the maximum precipitation and maximum drought at the time of wet and dry season respectively (IPCC 2007; 2014b; Julius, 2016).

In Ethiopia climate change is the great hazards for development for the reason why agriculture is the home stay of Ethiopian economy, which has connection with climate change. 70% of Ethiopian climate includes arid and semi arid which is subjected to desertification and drought. Also there are different factors for the damage of Ethiopian highlands. Namely: overgrazing, highly deforestation, in correct way of cultivation and extreme soil erosion are a serious climate variation in Ethiopia. Also erratic rainfall and coming of rain without keeping the time is known. When the rainfall is rare the Temperature become high and enhances the amount of evaporation and floods. these also results the maximization of land which is degraded, spread of disease like malaria, minimization of water in the earth's and on its upper most layer (NMA, 2007: Weldlul,2016). Currently the Ethiopian economy is growing. But Ethiopia is one of the poorest countries from the world and Subsistence farming is the common practice because of maximum level of poverty. Resource degradation is the cause for the damage. Specifically, it is the base for most damage of community livelihood (Adugnaw, 2014; Weldlul, 2016).

2.5 Farmers' Perceptions to Climate Change

Perception is the process of attaining awareness or understanding of a phenomena including climate change (Seyoum, 2015). In aiming to address the climatic instability in the future, farmer's perception and adaptation to climate change is the essential. It is known that perception of hazards or risks by rural peoples are additionally significant in arrange the climatic problem so as to organize the different adaptive measures (Weldlul, 2016). As Maddison study conducted

that, in Africa the majority of farmers perceive climate change at increasing temperature and decreasing precipitation (Maddison, 2006).

Also in most part of Ethiopia, communities perceive climate change at decreasing rainfall and increasing the frequency of drought. But it is not set from weather station. The degree of farmers' perception on climate change is varied and it is mostly depending on its impact on farmers' livelihood, socio economic back ground and management or institution (Said, 2014).

The finding conducted on farmers' perception and knowledge of climate change from central Tigray, Northern Ethiopia indicates that farmers reported untimely rain and frequent drought (Mengistu, 2011).

2.6 Adaptation and Adaptation Strategies to Climate Change

Adaptation to climate change is not new event and it's a practice taken at household level and at public or at government level. Adaptation strategies may be defined as the range of interventions taken in response to climatic stress (Makula, 2015). The adaptation practice at household level or community level is based on the different factors like availability of resource, information, technology. As a result, smallholder farmers are highly vulnerable to climatic change problem and they are less adapting to climate change (Adugna, 2014).

According to the report of Schaeffer (2014) adaptation measures are considered flexible adaptation measures, where they involve natural capital or community control or rigid adaptation measures, where adapting a sector or a community requires the construction of new and capital-intensive infrastructure. The majority of the adaptation measures require an anticipatory and planned approach and large investments. The need for planned capital-intensive adaptation is greater at high warming levels than low warming levels. Adaptation is depending on financial adaptation measures, social, economic and institutional responses. Some of the adaptation response plan include constructing flood defends, increasing the capacity of drainage and storm water systems in areas experiencing higher or more intense rainfall, change place of house, infrastructure and key livelihood assets away from flood-prone areas or slopes, enhancing and diversifying water supplies in areas experiencing reduced or more irregular rainfall, and more multifunctional land-use zones (Simon, 2011; Julius, 2016).

The climate change impact is undertaken through two major strategies (adaptation and mitigation strategies). Mitigation is activities taken to minimize green house gas emission and its future effect by reducing the current emission (Julius, 2016). Adaptation and mitigation minimize agricultural effects which caused by climate variation and they discourage vulnerability to climate change. Mitigation concentrates on the issue of minimizing or stabilizing the GHG. While adaptation is on controlling the observable effects of climate change which is results of the earlier and present GHG emissions (Di Falco *et al*., 2011). Adaptation and mitigation are not fully avoiding climatic problem by alone. But they reduce the climatic damage or risk by integrating each other (IPCC, 2013)

Autonomous and planned adaptation strategies are other adaptation strategies based on time. Autonomous or private adaptation strategies are: Activity done by private, farmers, community or organizations or firms to minimize climate change, where as planned or public sector adaptation strategies involves action done by local, regional and, national. It engage or it involve changing crop, changing crop schedule or calendar, involving new management activities for particular climate system, shifting the irrigation system, choose the cropping method, encouragement of new irrigation infra structure . Land use display and property right, water shed control (World Bank, 2010; Bruin, 2011; Manyatsi, 2014).

Adaptation is needed for protection of smallholder livelihood. Particularly the advance adaptation is to come up with extra information, adaptation methods, management of surrounding, and security in order to minimize the climate stress (IFAD, 2008). As Skrambks found that, adaptation is needed to enhance the farmer's performance to evaluate adaptive capacity and also needed to modify the knowledge of farmers towards climate change (Skrambks, 2014) and it can be improved by changing exposure, reducing sensitivity of the system to climate change impacts and maximizing the adaptive capacity of the system (OECD, 2010).

Also it is needed to encourage the agricultural yield and resilience of climate variation through developing the adaptation activities and land managing activities (Jallow, 2012).Productivity loss may be minimized when farmers are adapting agricultural adaptation measure. Adaptation to

climate change needed to reduce exposure and vulnerability (Speelman, 2015). Also adaptation to climate change may increase the food productivity (Di Falco *et al.*, 2011).

2.7 Empirical Review

Different studies with respect to the farmers' perceptions of climate change, choice of adaptation strategies and their determinants of adaptation choice were carried out in different countries. Related studies have been reviewed and presented as follows.

Legesse *et al. (*2013) conducted finding on gendered differences in perceptions of climate variability and change of sample households by using three point Likert type scale measure. From the result most of the farmers perceived the variability of temperature, rainfall and precipitation at increasing situation. However, other study uses five point scales on the farmers' perception of climate change. Results revealed that large number of farmers perceived temperature as increased, rainfall over past twenty years decreased. Also there are farmers those perceive in increase number of hot days per year and early cessation and late start of rainfall over past twenty years (Belachew and Zuberi, 2015).

Balama *et al.* (2013) revealed that the local farmers perceive the presence of climate change through frequent change and variability of rain fall and temperature. In this the farmers perceived at short rain season. Mengistu (2011) conducted a research on Farmers' perception and knowledge of climate change and their coping strategies to the related hazards in Adiha, central Tigray, Ethiopia. The author found that farmers' perception is connected with rainfall and temperature. And also the study findings reflect that farmers perceived the situations of temperature change at increase temperature, decrease temperature, altered temperature and at no change of temperature. There are also farmers those do not perceive the climate change in the situation of temperature.

Additionally, the findings of Bryan *et al*. (2011), found that more farmers' perception of long term of average temperature and rainfall at decreasing respectively. Also there are farmers those perceive long term temperature at decrease and stay the same. Moreover long term rainfall isperceived at decreased and stay the same.

Different crop varieties, soil conservation, planting tree, early and late planting and irrigation are adaptation methods (Adugna, 2014). According to Mengistu (2011) adaptation is an essential strategy to minimize the damage of climatic change and use of irrigation, planting early maturing and drought resistant crop varieties and soil and water conservation practices were the most important adaptation strategies used by the communities to reduce the impact of climate change. Planting tree is the most used by the community. And irrigation, agro-forestry or afforestation and change crop variety are the desired adaptation strategies to wards climate fluctuation (Bryan *et al.,* 2011).

Adugna (2014) found that training of climate change promote changing planting date, irrigation, and soil and water conservation as adaption strategies at different significant level. Also education is positively and significantly affects soil and water conservation practice and changing planting date as adaptation strategies because education is connected with information and knowledge. Additionally access to credit has positive relation with adaptation strategies. Access to enough credit service increase the farmers' financial resource and increase the ability of farmers to meet the transaction cost of farmers with associated adaptation strategies what they want to use. This implies access to credit is help to use different adaptation strategies in order to guard the loss from the risk of climate change.

Aemro *et al*. (2012) analyzed determinants of farm level climate change adaptation in Babile District of east Hararghe zone using multinomial logit. The result of their analysis showed that sex of the household head, age of the household head, education of the household head, livestock ownership, household farm income, non/off-farm income, access to credit, access to farmer-to-farmer extension, agro ecological zones, access to climate information, and extension contact have a significant impact on choices of climate change adaptation.

Also other study reflects that, both family size and distance to the market center affect the adaptation option negatively and the major challenges to climate change adaption are lack of information, lack of farm inputs, shortage of land, lack of money, lack of water and shortage of labor (Tessema *et al*., 2013).

Agro-ecological locations, sex, family size, plot size, off-farm income, livestock holding, frequency of extension contact and training are the determinant factors influencing adaptation

strategies and they have significant influence on different adaptation strategies like crop diversification strategies, soil and water conservation *practice,* Integrated crop-livestock based diversification strategies, Engagement in off-farm income activities, and Rainwater harvesting at different significant level (Legesse *et al.*, 2013).

2.8 Conceptual Framework

As indicated in conceptual framework of this study (Figure 1) climate change is mostly happened as a result of natural and human factors. Those two factors play their role in affecting the nature of climate change. As it is shown the conceptual framework, before starting the adaptation to climate change, the communities need to perceive that there is climate change. In other words, perception of the climate change is the first step for starting climate change adaptation activities.

Adaptation to climate change is affected by both internal and external factors. Internal factor involves socio economic and demographic factors like: sex, educational level, farm income, off/non-farm income, farm experience, total number of livestock and land holding where as the external factors involves institutional issues like: credit, participating climate change related training. Perception of farmers also affected by socio-economic and demographic as well as institutional factors like those listed above.

The framework also shows the climate change adaptation strategies and its determinants or constraints that affect adaptation strategies. Adaptation strategies including planting tree, adjusting the planting date, using improved crop variety, crop diversification and terracing practice were included for minimizing the climatic change impact.

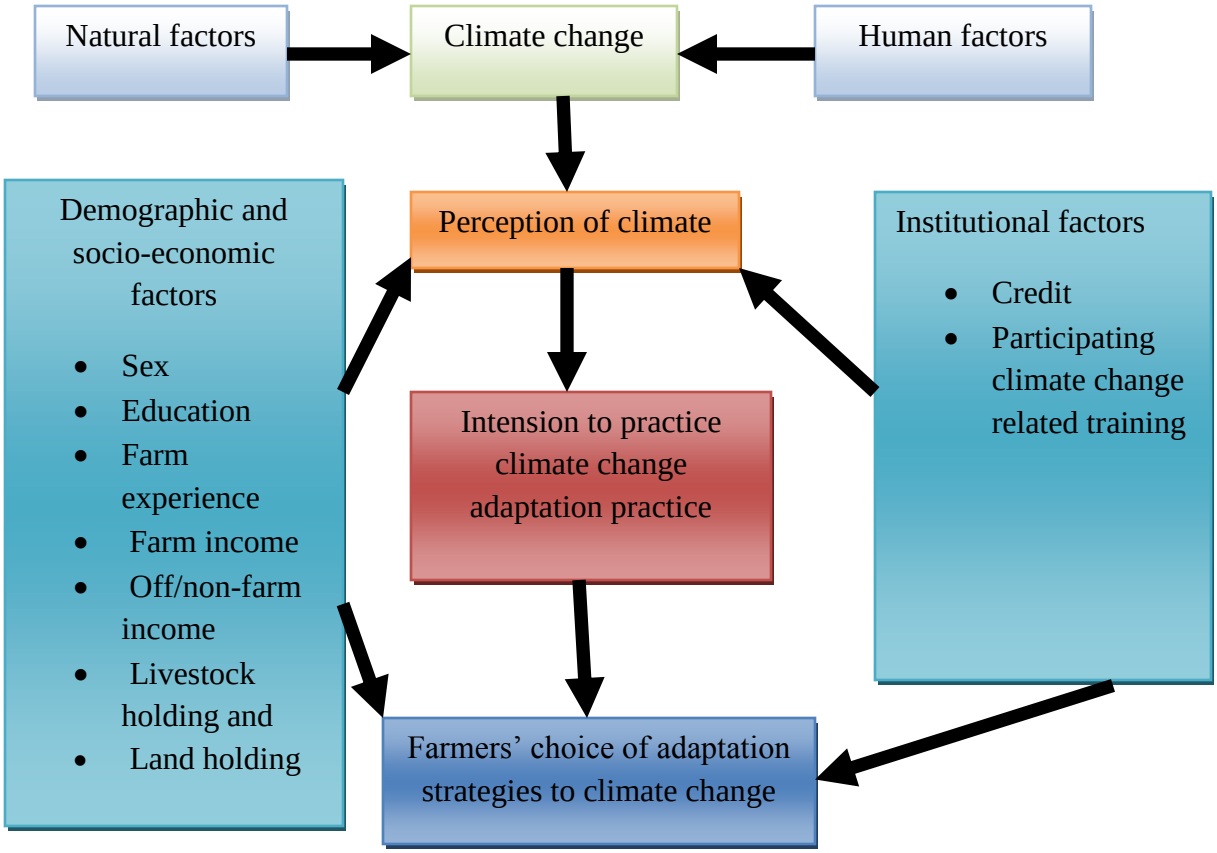


Figure 1: Conceptual framework of the study

Source: Own construction based on reviewed related literature (2018)

3. RESEARCH METHODOLOGY

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

3.1 Area Description of the Study

Location: Adama District is located in East Shewa zone of Oromia National Regional State of Ethiopia it is bounded on the south by Arsi Zone, along the southwest by Koka Reservoir, on the west by Lome, on the north by the Afar Region, and on the east by Beset District (Figure 2). It is far from the capital city of Ethiopia which is Addis Ababa by 100 km and located at the south east of the capital city (Addis Ababa). Astronomically, it is located between 08°33'35"N - 08°38'46"N latitude and 39°10'57"E – 39°30'15"E longitude (FEDAD, 2014).

Demography: According to the report of Finance and Economic Development of Adama District (FEDAD) (2014) the sum populations are 110,310 from the total males are 57,314 and females are 52,996. In this District 21,025 households are exist from total population, around 29 sector bureau, 37 rural kebeles and 4 urban kebeles.

Climate: The District is characterized by having 1500 to 2300 meter above sea level (masl), plain, smooth ground, stretch of land, among 15 – 20°C yearly mean of temperature, 700 – 800mm yearly mean of rainfall, subtropical grassland more in the District, woodland ,savanna of mixed is in dominate eastern part of the District. Also on the categorization of the wet scale semi-arid and sub humid conditions are other characteristics (Lamma, 2007). But depend on the averagely rain and temperature the tropical rainy and dry are the leading one for the classification of climate condition (Finance and Economic Development Bureau of Oromia, 2014). Naturally the tropical rainy weather is defined through tropical humid and sub humid climate while dry climate is character is arid and sub arid.

Agricultural activities: Adama District is one of agriculturally rich districts of East Shewa Zone. It is mainly practicing crop production rather than livestock that makes it similar with some of the remaining Districts (Akaki, Gimbichu, Ada, Liben and Lume) of the zone. In this

regard, some of the major crops being exercised in this District are Teff, Wheat, Barely, Maize, Sorghum and Bean. The average farmland size per household was 2.5 hectares. Cereals and pulses accounted for 96% of the cultivated land (CSA, 2012). In addition to rain fed agriculture, farmers living around the Awash River also producing some crops and fruits using various types of irrigation. The most commonly practiced irrigations are pump and hand well. With the aim of increasing their productivity, farmers of the District are using fertilizers, improved seeds, pesticides and herbicides. The soils are characterized by low water retention capacity; they are relatively fairly productive and give yields during periods of sufficient rain.

The major crop pests observed in this District are teff sheet fly, stalk bores, cut warms, African Boll Warm aphids and army warm. Similarly the crop diseases commonly observed in the District are rust, leaf viruses, wilt, leaf blights, common bacterial blight and bean chocolate spots. The most commonly employed methods maintaining soil fertility in district are organic fertilizer applications and agro forestry. More specifically the farming communities are making use of cow dung, manure, inter cropping, crop rotation, alley cropping and strip cropping. In addition to agriculture service, industry and construction are the activities of the community. However, agriculture is the most one (FEDAD, 2014).

Different agricultural practices have different time. So in the District land preparation is from March to Mid June, planting or drilling from April to Mid July, weeding Mid July to September and harvesting or collecting is from Mid October to December respectively. Agriculture activities and other developmental issues practiced in the District are mainly supervised and assisted by developmental agents. They are working in the rural kebeles for crop, plant and natural resources, animal health and reproduction as well as development of cooperative and its expansion (FEDAD, 2014).

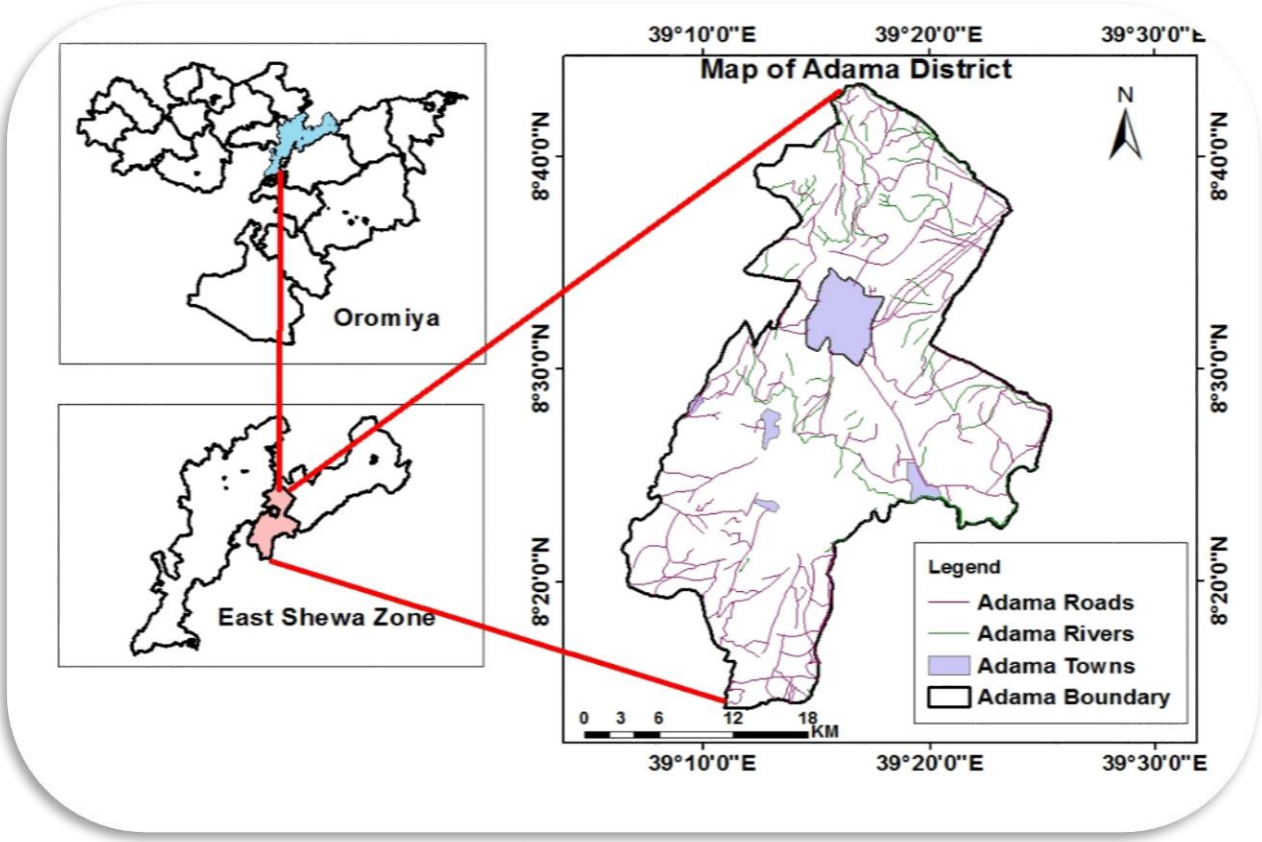


Figure 2: Map of Adama District

Source: Developed by author based Ethio GIS data using Arc Map 10.2 (2018)

3.2 Data Types and Sources

Both primary and secondary data were employed in this study. Smallholder farmers, agricultural extension workers and agricultural supervisors are sources of primary data. Unlike the primary data, the secondary were collected from meteorology station on the long term climatic data such as rainfall and temperature.

3.3 Sample Size and Sampling Techniques

Determining appropriate and representative sample size is critically important to include all the parameters of the populations. In study area, Adama District, there are about 37 rural kebeles. All of the kebeles are found in the same agro-ecological zones. As a result, simple random sampling technique was applied to select four kebeles out of 37 kebeles which is first stage

because the study area have the same agro-ecological.. This technique gives equal chance for the whole kebele to be included in the sample size. There are about 21025 households in 37 rural kebeles (FEDAD, 2014). Therefore, in order to determine the household sample size for which the questionnaires was distributed, statistical formula developed by Yamane (1967) is applied with the level of precision equal to 8% to improve the quality of the study.

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

$$n = \frac{21025}{1 + 21025(0.08)^2} = 155 \quad (2)$$

Where n is the sample size, N is the total household in the district (21025), and e is the level of precision (8%).

Therefore, as indicated in equation 2, the sample size for this study was 155 households. This means the questionnaires were filled by 155 households. Additionally in the second stage probability proportion size was applied to determine the sample respondent from four kebeles.

Table 2: Sample Kebeles by number of total households and sample size

Kebele	Total households	Sample size	Sample size in percentage (%)
Dabe Dongore	271	28	18
Kilinto	284	29	19
Goro Wagilo	433	45	29
Kachama	511	53	34
Total	1499	155	100

3.4 Data Collection Methods

3.4.1 Questionnaire

Structured questionnaire was developed, both open and closed ended questions was included. It is based on the specific objectives. Based on the specific objectives, the development of questions was divided into three sections. The first section was focus on demographic and socioeconomic characteristics of the respondents, the institutional issue also under first section.

The second section was deal with perceptions of respondents with respect to climate change. Data related to climate change adaptation strategies of smallholder farmers was organized under section three. For clarity purpose the questions was translated to *Afan* Oromo language. In this process of data collection, about four data collectors were engaged based on the experience they have and ability to fluently communicate with smallholder farmers. For clarification, they were provided one day training regarding handling of questions. The supervising role was carried by the researcher. For checking the relevance of the data pre testing was carried by distributing some question to household who was not take part in final questionnaires.

3.4.2 Key Informant Interview

One of the tools by which first hand data regarding the specific objectives was captured is interviewing individuals who are expected to be knowledgeable about the issues under investigation. Checklist was prepared focusing on specific objectives of the study. In this case, the checklist was contain perceptions of rural farmers about climate change, adaptation strategies of climate change being undertaken by farming communities and the determinants of smallholder farmers' choice of adaptation strategies to climate change. Using interview checklist, detailed interview was conducted with agricultural extension workers and agricultural supervisors at kebele and district levels. All interview process was handled by the researcher with the aim of making further investigations on the basis of the information received from the respondents. Approximately, one interview was taken about 40 minutes.

3.4.3 Focus Group Discussion

Focus group discussions are also another ways by which data was collected in participatory manner. Data specific to objective of the study were collected. It is an appropriate tool for gathering unbiased qualitative data. About four focus group discussions were carried out in which each group was consist of seven to twelve members from different categories. Those participants who participated in key informant interview and questionnaires were not part of focus group discussions. *Kebele* leaders, male headed and women headed households and youth group and other smallholder farmers were part of focus group discussions. As much as possible suitable environment was adjusted in collaboration with the participants for careful discussions. Just like the key informant interviews and questionnaires checklist was designed to orderly guide

the discussions. Each focus group discussion was managed by researcher with one employ assistant.

3.4.4 Field Observation

According to Bryman (2012) field observation is one method of data collection in which the checklist are important for data collectors. A Field observation is undertaken in sample kebeles which aided the researcher to observe overview of the ongoing process regarding climate change adaptation strategies.

3.5 Methods of Data Analysis

In data analysis descriptive statistics, likert scale and econometric model were employed.

3.5.1 Descriptive Statistics

Using descriptive statistics such as frequency distribution the collected data was interpreted in line with the stated objectives of the study. In this context, mean, standard deviation, minimum, maximum, frequency, percentage, tables and graphs were used.

3.5.2. Likert Scale

This study has employed likert scale to analyze farmers' perception to climate change. In this method, a sampled household head indicates degree of agreement for different statements related to the perceived changes of a given variable over time. A Likert scale usually consists of two parts, the item part and the evaluative part. The item part is essentially a statement about a certain perception of climate change where as the evaluative part is the response category par (agree dis-agree and neutral). Different authors used five point likert scales (lemmi, 2013; Belachew and Zuberi, 2015)

3.5.3 Econometric Model

Econometric model was applied for identifying the determinants of smallholder farmers' choice of adaptation strategies to climate change. Among different econometric models, Multinomial logit and multivariate probit model are more used in the multiple choices. The multinomial logit model considers the Independence of Irrelevant Alternatives (IIA) assumption but the

multivariate probit model does not require the Independence Irrelevant Alternatives (IIA). A shortcoming of most of the previous studies on modeling choice of climate change adaptation strategies is that they do not consider the possible inter-relationships between the various strategies. Individual can choose more than one choice. As a result of this Multivariate Probit Model (MVP) was employed to identify the determinants of smallholder farmers' choice of adaptation strategies by putting the k binary dependent variable as given below

$$Y^*_{hpj} = X^*_{hpj}B_j + U_{hpj} \quad where\ j = 1,2,3 \dots \dots \dots \dots 5 \qquad (3)$$

And

$$Y_{hpj} = \begin{cases} 1\ if\ Y^*_{hpj} > 0 \\ 0\ otherwise \end{cases} \qquad (4$$

Where j= j[th] adaptation strategy to climate change

X^*_{hpj} = is vector of explanatory variables.

B_j = is vector of parameter to be predicted.

U_{hpj}= is the random error term or stochastic variables as multivariate normal distribution with zero mean and unitary variance.

Y^*_{hpj}=variables which capture the demand related with the j[th] choice of adaptation strategies to climate change.

Y_{hpj} = is indicate the household use or not use the particular adaptation strategy. As a result of, adoption of different adaptation strategies is possible, the error terms in equation (3) are assumed to jointly follow a multivariate normal distribution, with zero conditional mean and variance normalized to unity. The off-diagonal elements in the covariance matrix represent the unobserved correlation between the stochastic component of the $j^{th}$and 5^{th} type of adaptation strategies. This assumption means that equation (4) gives a multivariate probit model that jointly represents decision to adopt a particular adaptation strategy. This specification with non-zero off-diagonal elements allows for correlation across error terms of several latent equations, which represent unobserved characteristics that affect choice of alternative adaptation strategies. This model was applied in Nhemachena and his co workers findings on the analysis of determinants of farm level adaptation measures to climate change in South Africa (Nhemachena *et al.*, 2014).

Similarly this study was employed MVP model mainly to identify the determinants of smallholder farmers' choice of adaptation strategies to climate change.

3.6 Definition of Variables and Hypotheses

3.6.1 Dependent Variable

The dependent variable of the study is the choice of climate change adaptation strategies or choice from multiple set of adaptation measures such as adjusting planting date, using improved crop variety, planting trees, crop diversification and terracing equal to one if household use adaptation strategies and zero if household not use adaptation strategies.

3.6.2 Independent Variables

Sex of household head (SEXHH): It is dummy variable and takes 1 for male household head and 0 for female household head**.** According to the finding of Aemro *et al.* (2012) the male households head are more adapt to climate change than female headed household. In the finding being male-headed households were more likely to adopt improved crop variety and crop diversification. This is so because, male-headed households are relatively flexible in search of improved crop varieties and in a better position to pull their labor force in order to adapt improved crop varieties and crop diversification. Therefore, this study hypothesized that sex of the household head affect improved crop variety and crop diversification positively as adaptation measures to climate change. Additionally, this study hypothesized that sex of household head positively affect adjusting planting date, planting tree and terracing practice as adaptation strategies.

Educational level of household head (EDNHH): This is a continuous variable and measured by number of years of schooling. It has positive relation with the adaptation options. Because the education increase the probability of choosing the different adaptation strategies and it have a great role for encourage the individual farmers in the risk taker (Temesgen, 2010; Aemro *et al.*, 2012). Education is related with awareness. The household those have awareness are more use adaptation practice. This is in line with the findings of (Seyoum, 2015). Also Said (2014) reflect that literacy status has positive and significant effect on crop diversification as adaptation strategies. Therefore, this study hypothesized that level of education affect crop diversification, adjusting planting date, planting tree, improved crop variety and terracing practice positively.

Credit (CR): It is a dummy variable and it takes 1 value for the credit user and 0 Otherwise. Household those are improve their credit are characterized by having less adaptation strategies to climate change, because they are involved in different investment like farm investment to enhance their adaptive capacity through stopping the adaptation mechanism. From this access to credit has negative relation with adaptation options and it is no significant affect. This reflects the findings of (Tessema *et al.,* 2013). So this study hypothesized credit affect planting tree and crop diversification negatively. However, access to getting of reasonable credit has positive and significant affect the adaptation strategies or adaptation options improved crop variety. The reason is why because the reasonable credit may maximize the needs or desire of smallholder farmers using of different adaptation options (Said, 2014). So this study hypothesized that the farmers those use credit service should more likely adapt different adaptation strategies using improved crop variety, adjusting panting date and terracing.

Total land holding (TLHOLD): This refers to the amount of land owned by household head. Its continuous variables and measured in hectare. Land holding has positive significant with adaptation strategies. Large size of land results decrease risk related to climate change because of this land holding and adaptation strategy are positively related (Hassan and Nhemachena, 2008). This study hypothesized that land holding has positive relation with improved crop variety and crop diversification, panting tree and adjusting planting date as adaptation measure to the climate change.

Farm income (FARMINC): This is a continuous variable and measured in birr. The study of Aemro *et al. (*2012) found that the farm income and adaptation strategies like using improve varieties and crop diversification is positively significant. Because the income of the farmers and their production and productivity has positive relation, Therefore, this study hypothesized that farmers those have more income should more choose crop diversification and using improved crop variety, planting tree and adjusting planting date as adaptation strategies to wards climate change.

Farming experience of household head (FARMEXP): It is a continuous variable and measured in years. It is refers to the experience of the household head on farming activities. The experience of the household head affects the use of adjusting planting date as an adaptation

strategy to climate change positively and significantly. An increase in the experience of a household head increases the uptake of adjusting planting dates as an adaptation strategy to reduce the impact of climate change. This is because as the farming experience of the household head increases the farmer expectation to acquire more experience in weather forecasting and that helps increase in practicing of adjusting planting dates (Said, 2014). This study hypothesized that farming experience positively affect different adaptation choice of improved crop variety, adjusting panting date, planting tree, crop diversification and terracing.

Climate change related training (CCTR): This is a dummy variable and it takes 1 for participate in training and 0 for its inverse. Climate change related training is found to be positively and significantly associated with using adjusting planting date as adaptation strategies to reduce the negative impact of climate change. This is because farmers participated on training related to climate change would have better awareness about climate change and possible adaptation strategies (Said, 2014). Therefore this study hypothesized that climate change related training positively and significantly affect choosing adjusting planting date., using improved crop variety, planting tree, crop diversification and terracing practice.

Livestock holding (LSHOLD): This is a continuous variable and measured in Total Livestock Unit (TLU). According to the conduct of Aemro *et al*. (2012) livestock holding has positive and significant impact on adaptation strategies. Specifically, it has positive and significant impact on the probability of using improved crop variety as the adaptation strategies. Because, the farmers those have livestock are purchase improved crop variety by selling their livestock. In other words livestock are used as providing source of income to purchase improved crop variety and it give service for traction (particularly oxen). So this study hypothesized that livestock ownership positively affect improved crop variety, adjusting planting date and crop diversification as climate change adaptation strategies. But it hypothesized that livestock holding affect planting tree and terracing practice.

Off/non-farm income (NONFINC): This is a continuous variable and measured in birr. It is refers to the income of household head get from nonfarm activities within a year. This study hypothesized that, off/ non-farm income positively affects improved crop variety and terracing

practice as adaptation strategies to climate change. But it hypothesized that negatively affect adjusting planting date planting tree and crop diversification.

Table 3: Summary of variables, its type, measurement and expected sign

Variables and it is measurement	Types of Variables	Measurement	Expected Sign				
Dependent Variables			ICV	APD	PLTREE	CRPDIV	TERR
Using improved crop variety (ICV) Adjusting planting date (APD) Planting trees (PLTREE) Crop diversification (CRPDIV) Terracing (TERR)	Dummy	1 for those use these adaptation strategies and 0 otherwise					
Independent variables							
Sex of household head (SEXHH)	Dummy	1 for male and 0 for female	+	+	+	+	+
Educational level of household head (EDNHH)	Continuous	Number of schooling	+	+	+	+	+
Credit (CR)	Dummy	1 for those credit user and 0 otherwise	+	+	-	-	+
Total land holding (TLHOLD)	Continuous	Hector	+	+	+	+	-
Farm income (FARMINC)	Continuous	Birr	+	+	+	+	+
Farming experience of household head (FARMEXP)	Continuous	Year	+	+	+	+	+
Climate related training (CCTR)	Dummy	1 for participate and 0 for not participate	+	+	+	+	+
Livestock holding (LSHOLD)	Continuous	Total Livestock Unit (TLU)	+	+	-	+	-
Off/non-farm income (NONFINC)	Continuous	Birr	+	-	-	-	-

4. RESULTS AND DISCUSSION

In this chapter, demographic, socioeconomic and institutional issues are presented in the first section. Farmers' perception of climate change and temperature and rainfall data analysis climate are presented in section two and three respectively. Adaptation strategies used by the farmers are presented in section four. Section five presents the results of the maximum-likelihood estimates for determinants of farmers' choice of adaptation strategies to climate change in the study area.

4.1. Demographic, Socioeconomic and Institutional Characteristics

4.1.1. Demographic and Socioeconomic Characteristics of Households

For this study, primary data were collected from a total of 155 sampled households. Demographic and socioeconomic characteristics of households were presented in (Table 4). Out of the total sample households surveyed, about 75.48% were male headed household and 24.52% were female headed indicating that the majority were male headed household. The survey results also indicated that educational status of the sample household heads in the study area ranges from 0 to grade 12 completed and mean was grade 4. The average farming experience of the household heads was 22.07 years with maximum being 51 and the minimum experience being 2 years. Farmers in the study area were engaged in mixed farming activities, including staple food crops production (such as teff, wheat, maize and soybean) and rearing of domestic animals such as cows, oxen, goats, sheep's and donkey Moreover, the survey result has revealed that, the minimum and maximum livestock holding of the sampled households in terms of tropical livestock unit (TLU) were 0 and 20 TLU respectively with the mean of 5.09 TLU.

Major sources of income in the study area were from farm and off/non-farm activities mainly from sale of crops, sales of livestock and its product. Trading and daily labor were also other sources of income for some of the sample households. Farm income of the surveyed households ranged from 2000 to 82540 birr with an average of 24235.03 birr per year. Surveyed farmers' income from non-farm activities ranged from 0 to 72000 birr with an average of 5383.94 birr per annual (Table 4). Land is a major agricultural productive asset; land holding of sampled households ranged from 0 to 6 hectares with an average size of 1.71 hectares

Table 4: Demographic and socio economic characteristics of the sample households

Variable	Min	Max	Mean	Std Dev.
Education level	0	12	4.174	3.459
Farming experience	2	51	22.077	12.436
Land holding in hectares	0	6	1.715	1.206
Farm income in birr	2000	82540	24235.03	19041.580
Livestock holding in TLU	0	20.06	5.097	3.998
Off/non-farm income in birr	0	72000	5383.942	11878.190
Sex of household head	Frequency		Percentage	
Male	117		75.48	
Female	38		24.52	

Source: Own survey result, 2018, N = 155

4.1.2. Institutional Characteristics of Sample Households

The result showed that 45.16% of the respondents reported that they were trained on issues related to climate change and its impact. Whereas, 54.84% of the respondents reported that they were not trained on issues of climate change during 2017/18 production year (Table5). This revealed that more than half of the respondents participated in this study did not attend any training related to climate change and its impacts. Similarly, the result of focus group discussions in this regard also confirm that majority of the farmers so far did not received training about climate change. Even those farmers who took that training complained that the training was not directly related to climate change. Out of the total sample households surveyed, 50.97% are credit service user, whereas 49.03% reported the opposite during 2017/18 production year.

Table 5: Institutional characteristics of sample household

Variable	Response	Frequency	Percentage
Credit service user	No	76	49.03
	Yes	79	50.97
Climate change related training received	No	85	54.84
	Yes	70	45.16

Source: Own survey result (2018)

4.2. Farmers' Perception of Climate Change

Sample households were interviewed to indicate their general perceptions of climate change with some indicative variables of climate change (temperature, rainfall and flood). To get information

about climate change and understanding farmers' view regarding climate change, looking their perception about climate change indicators are important issue. Hence, knowledge about farmers' perception on climate change dimension in the study area is an appropriate issue to be discussed. Parameters such as annual average temperature, annual maximum temperature, annual minimum temperature and annual rainfall were used from long term data from meteorology station to triangulate the farmers view towards climate change.

4.2.1 Perception of Farmers' about Temperature Changes

The interview result on the perception of long-term changes of mean annual temperature in study area is presented in (Figure 3). Regarding the nature of temperature of the past 15 years in study area, about 74.2 percent of respondents agreed that the annual temperature was increased while 23.9 and 1.9 percent of the respondents disagreed and neutral respectively to the sated statement. As it is indicated in the (Figure 3), the majority of the respondents (70.3 percent) disagreed that to the statement of annual temperature not changed in the area, while 20.6 percent says agreed and 9 percent neutral to the sated statement.

Additionally, as indicated from the survey result about 27.7%, 66.5% and 5.8% of respondents agreed, disagreed and neutral respectively to the statement of annual temperature was decreased over the last 15 years in study area (Figure 3). From this one can understand that the majority of respondents were in the views that the annual temperature was increasing in the study area over the past 15 years.

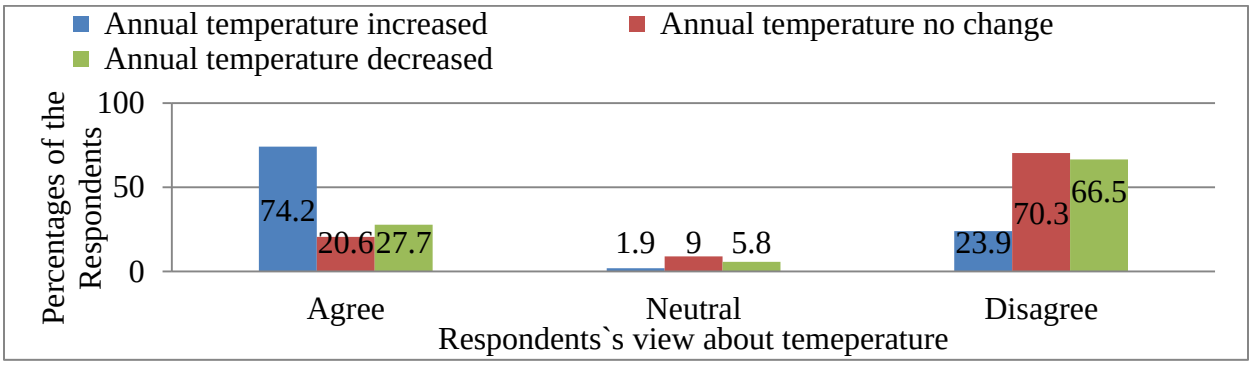
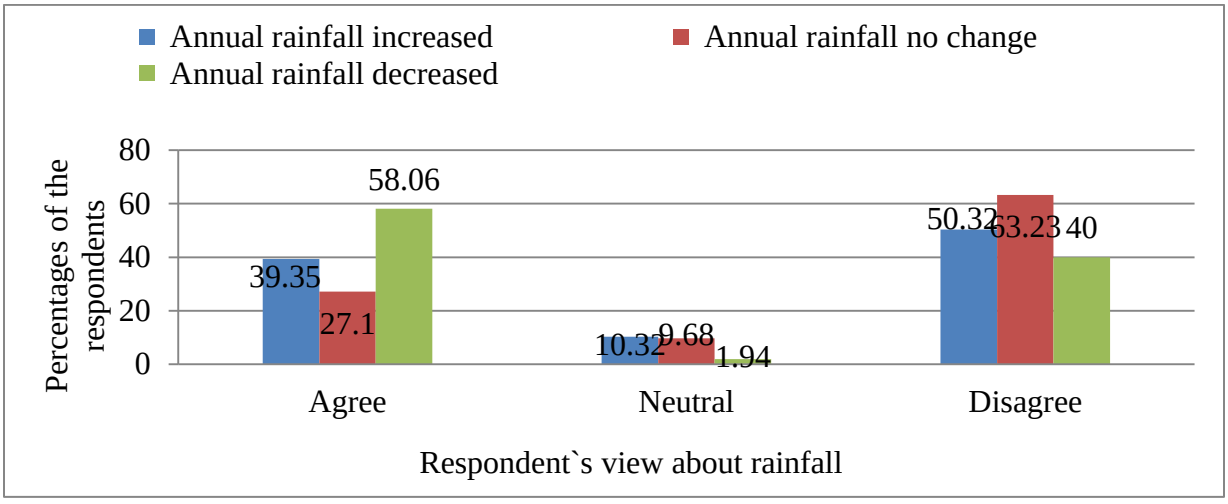


Figure 3: Perceptions of sample households about annual temperature change during the last 15 years. Source: Own survey result, 2018

4.2.2 Perception of Farmers' about Rainfall Changes

About 39.35 percent of them agreed that the annual rainfall in the area is increasing whereas, 50.32 and 10.32 percent of them disagreed and neutral respectively to the increment of rainfall in study area. , The survey results also indicated that, 27.1% agreed, 63.23% disagreed and 9.68% neutral regarding the statement of annual rainfall was not changed in the last 15 years. Additionally, from the survey result with respect to decrement of annual rainfall 58.06%, 40% and 1.94% of the respondents agreed, disagreed and neutral respectively to the statement (Figure 4). From this it can be understand that in averagely more than half (58.06%) of farmers responded that the rainfall in the last 15 years is decreased.

Figure 4: Perception of sample respondents about rainfall patterns during the last 15 years
Source: Own survey result (2018)



As indicated in (Figure 5), about 69.03%, 29.03% and 1.94 were included agreed, disagreed and neutral respectively to the statement of the rainfall comes before perceived time. Whereas 75.5%, 23.2% and 1.3% indicate the farmers' included under categorization of agreed, disagreed and neutral respectively to the statement of rainfall comes after perceived time (Figure 5). These generalized that, the coming of rainfall is varied and it is come after and before perceived time and more than three fourth of respondent agreed that the rainfall is come after perceived time.

The survey result was supported by result of focus group discussions and key informant interviews. In this case, it is to be noted that the nature of rainfall occurrence is unpredictable and varied as confirmed by the participants of both key informant interviews and focus group discussions in study kebeles.

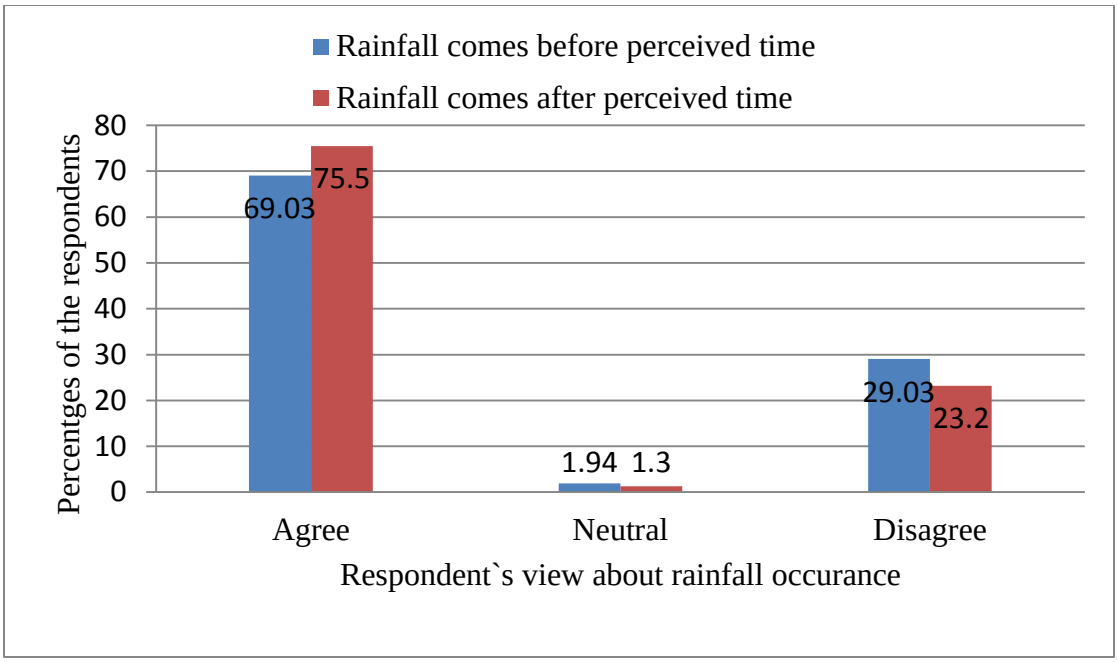


Figure 5: Perception of sample respondent about the coming of rainfall in the past.

Source: Own survey result, 2018

4.2.3 Perception of Farmers' about the Occurrence of Flood

The farmers' interviewed on the perception of flood in study area. Out of the total respondent participated in this study, about 38.7 percent agreed that the flood in the past seems less, whereas, 58.1 and 3.23 percent disagreed and neutral respectively to the issues sated. About 57.4% agreed, 39.35% disagreed and 3.23% indicate neutral about the statement of flood seems high. Additionally, from the survey result, 29.03%, 64.5% and 6.45% of respondents agreed, disagreed and neutral respectively in case of flood seems medium (Figure 6).

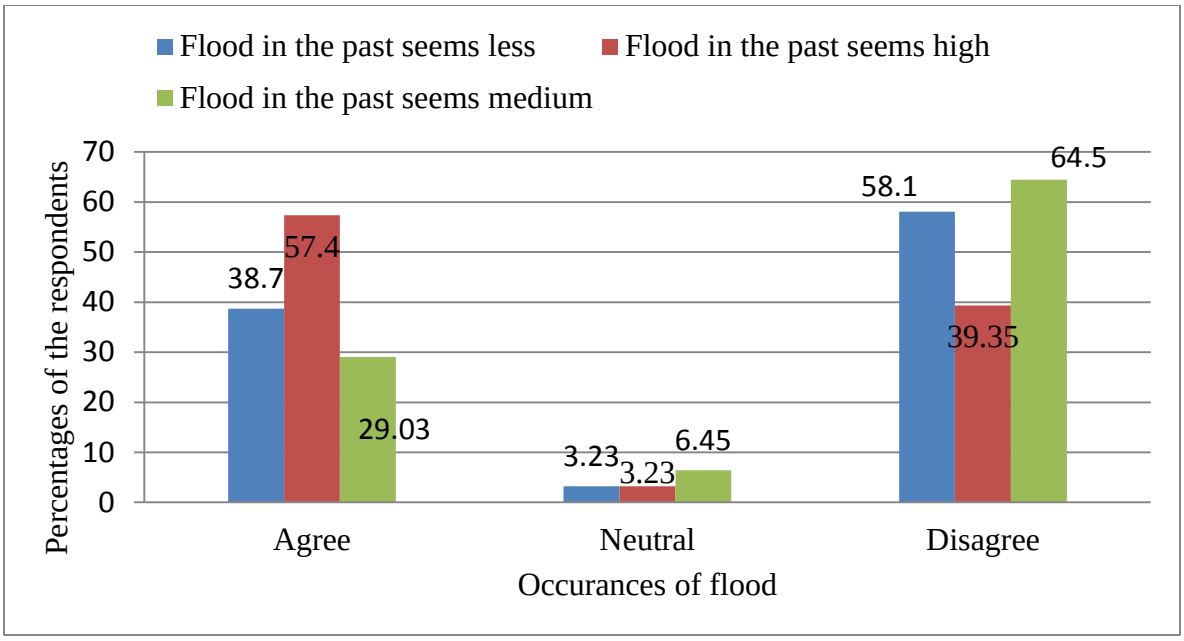


Figure 6: Perception of sample respondents about flood Occurrences during the last 15 years
Source: Own survey result (2018)

4.3 Temperature and Rainfall Data Analysis

The amount of annual mean minimum temperature the area has experienced under 2003-2017 years ranges from 13.5°C and 17°C having mean of (15.3°C), SD (1°C) and CV (5.9%) (Table 6), Consistently, the trend analysis showed that, annual mean minimum temperature has decreased by -0.037 °C per year or -0.37°C per decade in the study area for the periods of 2003 – 2017 (Figure 8).This result closely related to the study of Awetahegn (2015) in Tigray region that found a decreasing trend or negative trend was observed in minimum temperature by -0.038°C per/year or -0.38°C per decade for period of record (1995-2014). But, this result is inconsistent to the NMSA (2007) in which the average annual minimum temperature over Ethiopia has increased by about 0.37°C per decade.

On the other hands, the annual mean maximum temperature over the study area under the years of 2003-2017 ranges from 16.1°C to 31.1°C with mean (28.2°C), SD(1.2°C) and CV(4.4%). The trend analysis also indicated that annual mean maximum temperature in the study area increased by about 0.192°C per year (Figure 9).

The annual average temperature of the area ranges from 20.6 to 22.7°C (figure 7). And also the recorded mean, SD and CV were 22°C, 0.54°C and 5.2%

respectively (Table 6). Consistently, the trend analysis under the years showed that, annual average temperature of the study area increased by the rate change of 0.076 °C per year or 0.76°C per decade having the R^2 value 0.395, that implies the goodness of fit explains 39.5% of the total variations in the data. This result is compacted to IPCC (2007) which provided that, over the past 150 years, the global mean surface temperature has increased by 0.76°C. The result is also closely related to the studies of (Gebrehiwot and van derVeen, 2013) which indicated an increase in mean minimum temperatures in the Mekelle region for the period 1954–2008 was about 0.72°C per decade.

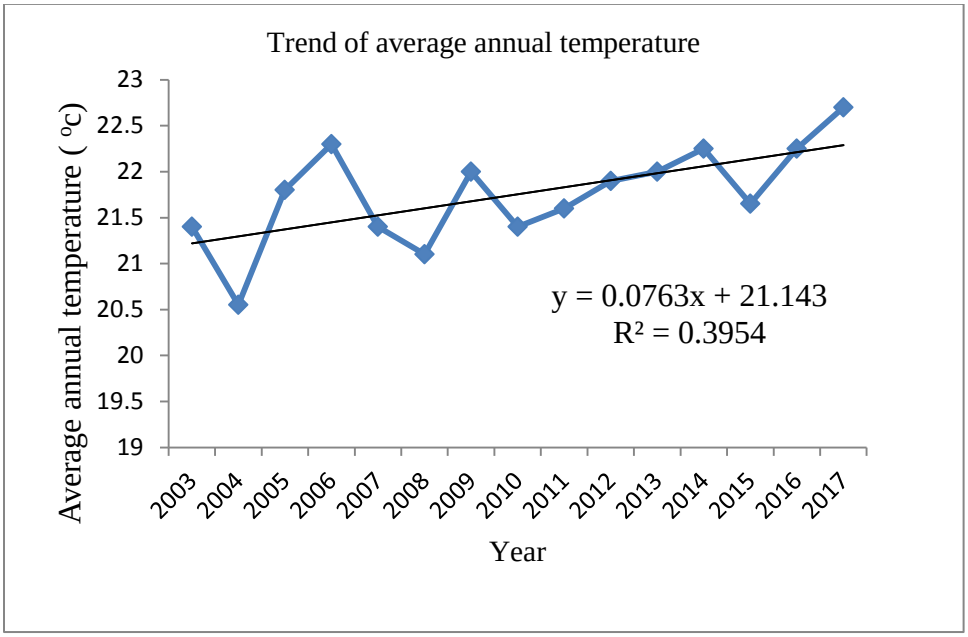


Figure 7: Trend of average annual temperature in Adama area from 2003-2017

Source: Computed based on data obtained from National Meteorological Agency, Adama branch

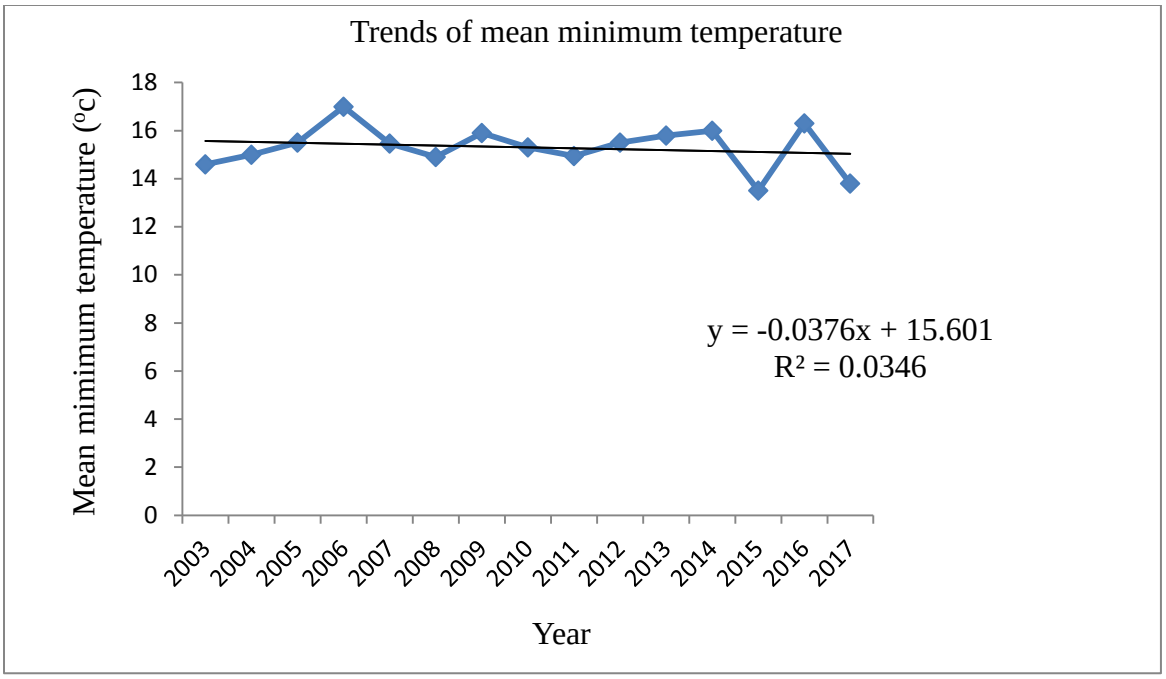


Figure 8: Trend of mean minimum temperature in Adama area from 2003-2017

Source: Computed based on data obtained from National Meteorological Agency, Adama branch

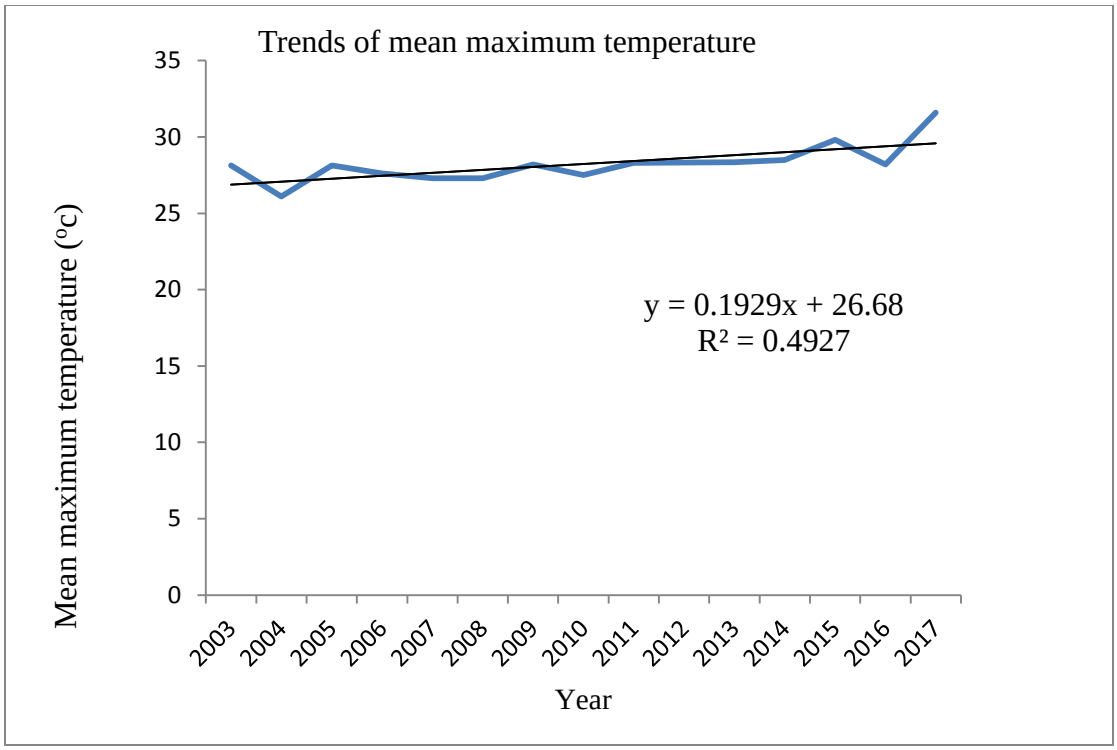


Figure 9: Trend of mean maximum temperature in Adama area from 2003-2017

Source: Computed based on data obtained from National Meteorological Agency, Adama branch

Table 6: Statistical description of rainfall, average temperature, minimum and maximum temperature for Adama District

parameters	Min	Max	Mean	SD	CV%
Rainfall	609	1371	933	216.8	23.2
MinT	13.5	17	15.3	1	5.9
MaxT	26.1	31.6	28.2	1.2	4.4
Av.T	20.6	22.7	22	0.54	2.50

Description: max =maximum, Min=minimum, SD=Standard Deviation, CV=coefficient of Variation, MaxT=maximum Temperature, MinT=minimum Temperature Ave.T=Average Temperature

Source: computed from Adama branch meteorology data

The amount of annual total rainfall the area has obtained ranges from 609mm to 1371 mm with means, SD and CV, 933mm, 216.8mm and 23.3% respectively. Based on average of total rainfall (933mm), the amount of rainfalls the area has received under the years increased in, 2003, 2007, 2008, 2010, 2012,2016 and 2017 while in ,2004,2005, 2006, 2009,2011,2013,2014 and 2015 years (Appendix 2) ,the amount of total rainfalls were decreased. As it has depicted from the trend line ,the rain fall increased by the rate change of 1.965 mm per year or 19.65 mm per decade (figure10). This result is inconsistent to the study conducted on variability and time series trend analysis of rainfall and temperature in north central Ethiopia: A case study in Woleka sub-basin from the period of 1901- 2013, which indicate the negative trend by -1.5033mm per year (Asfaw *et al*., 2018).

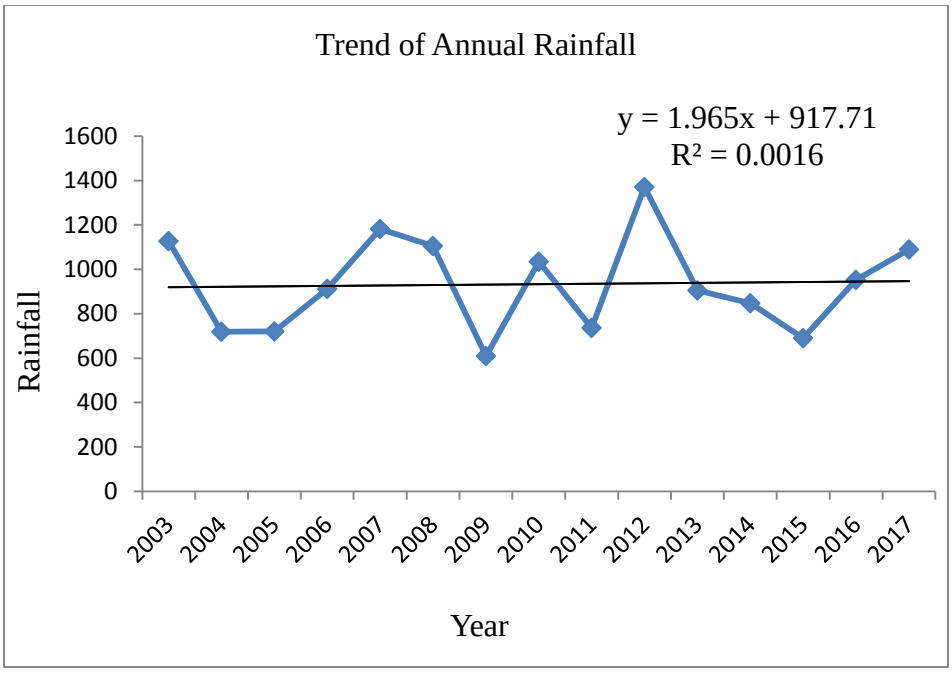


Figure 10: Trend of annual rainfall in Adama area from 2003-2017

Source: Computed based on data obtained from National Meteorological Agency, Adama branch

4.4. Climate Change Adaptation Strategies

Climate change adaptation measures are important for the agricultural production (Daba, 2018). In the study district, different adaptation strategies were employed to reduce the negative effect of climate change and to manage future patterns in climate change. Farming activities is the primary profession for almost all of the sample households. Although most of the times they combine some level of non-farming sources of income like trading were used. Based on the household survey data collected from 155 households. Accordingly, farmers were using different adaptation strategies to reduce the negative impact of climate change. These include, use of improved crop varieties, adjusting planting dates, planting tree, crop diversification and terracing practice. However, these strategies are mostly used by farmers in combining one with the other.

In most of the focus group discussions with farmers and key informants it was confirmed that the climatic variability particularly irregularity of rainfall and increasing of temperature is negatively influencing agricultural activities including livestock production and crop production. Specifically, the coldness of climate in the past year is mostly affecting the agricultural production by decreasing of its productivity. Also from focus group discussion and key

informant interview, wildlife in the forest has been affected as a result of over coldness of climate. Claiming good awareness about climatic change, it has been noticed that there was critical debate during focus group discussions on how farmers are responding to climate change challenges. In this regard there were mixed feelings: few participants were stating they have been using planting trees, others are claiming they have been using adjusting planting date, improved crop variety, cop diversification and terracing practice.

According to the views of farmers and observations made in the field showed that many of the adaptation options are not implemented in a well-managed and organized manner. In the study area, greater than half (51%) of farmers have been using improved crop varieties as adaptation strategy to reduce the adverse effect of climate change (Table7). Farmer's report showed that, different improved varieties of crops (like *teff* and maize varieties) have been using by farmers in the study area. During focus group discussion farmers' indicated that choosing of climate change adaptation strategies is depending on different criteria. For example, the criteria for choosing improved crop variety are based on short growing variety, productive, disease and pest resistant crops.

One of the most adaptation strategies used to adapt adverse effect of climate change in the study area is adjusting planting date. It is from early planting to late planting or vice versa. In the study area about 47.1% (Table 7) of sample households have been using adjusting planting date next to improved crop variety as adaptation option to reduce the adverse effect of climate change on their output. In this regard, the result of focus group discussion showed that adjusting planting date as adaptation strategy was employed depend on the availability of adequate information service about rainfall and temperature condition of the area. From this dissemination and giving up to date information about rainfall and temperature patterns on the future or the coming time is important for farmers.

Wondimagegn and Lemma (2016) found that climate change has a negative effect on environmental and natural resources causing decline in soil fertility, decline in forest resources and changes in biodiversity. Planting tree is one of the adaptation measures to minimize the negative effect of climate change. In the study area, more than three forth (76.77%) (Table 7) of farmers have been using planting tree as adaptation measure to minimize the negative effect of

climate change, it is used to minimize soil erosion, promote sustainability of environment. From the survey result, this strategy was using by the majority of the farmers. From focus group discussion it was noted that planting tree is the practice that the majority of farmers were used and they believe that planting trees can increase rainfall in addition to its high contribution in soil conservation. However, same farmers were not familiarized with planting tree as a result of water shortage of water in the area

Crop diversification is the practice of cultivating more than one variety of crops belonging to the same or different species in a given area in the form of intercropping (Makate *et al.*, 2016). Crop diversification such as mixed cropping, inter-cropping and dividing farm lands into varying crops are a common practice in the study area. The system is commonly practiced in the district where cereals (maize, soybeans), (beans, maize) and vegetable (onion, pepper and tomato) are grown together. This is also observed from the field. From group discussions made with farmers, it was noted that they have wide field knowledge on the advantages of mixing crops with varying attributes in terms of maturity period, drought tolerance, input requirements and end users of the product. From the total sampled households, more than one third (40.65%) of household have been using crop diversification as adaptation strategy to reduce the adverse effect of climate change on farm (Table 7).

During field observation it was noted that there is huge work done on Terracing practice to minimize soil erosion and to keep soil fertility. Farmers asserted that terracing practice enhance water infiltration into the ground and also close down soil erosion. So terracing practice is widely adopted by farmers. Out of the total sampled households, about three fourth (74.84%) have been using terracing practice as adaptation strategy next to planting tree (76.77) to reduce the adverse effect of climate change on farm (Table 7).

Table 7: Summary of adaptation strategies used by farmers

Adaptation strategies	Frequency	Percentage
Planting tree	119	76.77
Terracing	116	74.84
Improved crop variety	79	51
Adjusting planting date	73	47.1
Crop diversification	63	40.65

Source: Survey result (2018)
Note that a farmer can use more than one adaptation strategy.

4.5. Determinants of Smallholder Farmers' Choice of Adaptation Strategies

Multivariate probit model was employed to identify the determinants of smallholder farmers' choice of adaptation strategies to climate change. The model was selected based on the explanation illustrated in methodology part.

In order to reduce the impacts of climate change, farmers in study area employed improved varieties of crops, adjusting planting date, crop diversification, planting tree and terracing as climate change adaptation strategies. These adaptation methods were mostly applied to safeguard farmers from losses that would appear as a result of changes in climatic variation like temperature and rainfall irregularity. On the other hand, there are different factors which control households' decision to choose different adaptation choices.

The analyses in the study identified the important determinants of adoption of various adaptation options (strategies) using a multivariate probit model to provide policy information depending on the model results to upgrade the farmers in using of different adaptation strategies. Demographic, socio-economic and institutional characteristics were considered to assess whether they have influence on households' choices of the adaptation strategies or not. Results from the multivariate probit model of determinants of choice adaptation strategies using data from a cross-sectional survey of 155 sample households were presented in (Table 8).

The model fits the data reasonably because of Wald test (Wald chi2 (45) = 86.73, p=0.0002) is significant at 1%, level, which indicates that the subset of coefficients of the model is jointly

significant and that the explanatory power of the factors included in the model is satisfactory. Thus, the MVP model fits the data reasonably well. Likewise, the model is significant because the null that choice decision of the five adaptation strategies is independent was rejected at 1% significance level. The likelihood ratio test of the model is (chi2 (10) = 45.1485 Prob>chi2 = 0.0000) indicates the null that the independence between adaptation choice is rejected at 1% significance level is statistically significant and there are significant joint correlations for 4 of the 10 cases estimated coefficients across the equations in the models. Indicating that, the correctness of the multivariate probit specification and choice of climate change adaptation strategies are not mutually independent.

The results on correlation coefficients of the error terms indicate that there is complementarily (positive correlation) between different adaptation options being used by farmers. The Stimulated Maximum Likelihood (SML) estimation results stated that there was positive and significant interdependence between household choices of adjusting planting date and improved crop variety, terracing and adjusting planting date, crop diversification and plant tree, and lastly, terracing and planting tree.

The result of multivariate probit model shows that the likelihood of households to adopt, planting tree, terracing, improved crop varieties, adjust planting date, and use crop diversification were 76.5%, 74%, 51% , 46.7%, and 40.4% respectively. This indicates that, the likelihood of crop diversification choice is relatively low (40.4%) as compared to the probability of choosing adjust planting date (46.7%), improved crop varieties (51%), terracing practice (74%) and planting tree (76.5%). The joint probabilities of success or failure of the five adaptation choice also suggest that households are more likely to success to jointly choose the five adaptation strategies. The likelihood of households to jointly choose the five adaptation strategies simultaneously is 9.6%, while their failure to jointly choose is 4.1%.

On the determinants of farmers' adaptation choice of adaptation measures to climate change, results from the multivariate probit model suggest that different household, socioeconomic and farm characteristics are significant in determining the households' to choose adaptation strategies (Table 8).

Table 8: Multivariate probit results for households' climate change adaptation choice

Variable	Improved Crop variety		Adjusting Planting date		Planting tree		Crop diversification		Terracing	
	Coef.	SE	Coef.	S E	Coef.	SE	Coef.	SE	Coef.	SE
SEXHH	0.774**	0.331	0.655***	0.399	0.655**	.0.399	-0.505*	.0.308	0.508*	.0.363
EDNHH	0.140***	0.043	0.244**	0.452	-0.024	0.045	-0.020	0.040	0.025	0.042
FARMEXP	0.001	0.012	-0.340	0.014	-0.034**	.0.014	0.010	0.012	0.003	0.013
TLHOLD	-0.260	0.225	0.022	0.213	0.022	0.213	-0.074	0.266	-0.247	0.221
FARMINC	0.000**	0.000	-0.000	0.000	-0.000	0.000	0.000	0.000	0.000	0.000
LSHOLD	-0.058	0.034	-0.025	0.033	-0.025	0.033	-0.001	0.033	0.025	0.033
NONFINC	-0.000*	0.000	-0.000	0.000	-0.000*	0.000	-0.000	0.000	0.000*	0.000
CR	0.265	0.222	0.037	0.245	0.037	0.245	0.360*	.0.216	0.341	0.227
CCRTR	0.112	0.238	0.434	0.251	0.434*	0.251	0.216	0.221	0.452*	0.243
Cons.	1.394***	0.505	1.143*	0.503	1.143	0.503	-0.433	0.445	-0.280	0.584
Predicted probability	0.51		0.467		0.765		0.404		0.74	
Joint Probability of success							9.6%			
Joint probability of failure							4.1%			
/atrho21							0.317**			
/atrho31							-0.120			
/atrho41							-0.002			
/atrho51							0.061			
/atrho32							0.240			
/atrho42							0.030			
/atrho52							.0.341**			
/atrho43							.0.315**			
/atrho53							0.857***			
/atrho54							.0.222			
rho21							0.310**			
rho31							-0.129			
rho41							-0.002			
rho51							0.061			
rho32							0.235			
rho42							0.030			
rho52							.0.337**			
rho43							0.305**			

rho53	.0.661***
rho54	0.210

Multivariate probit (SML, # draws =5), Number of obs=155, Wald chi2 (45) =86.73
Log likelihood = -416.39555, Prob > chi2 =0.0002
Likelihood ratio test of rho21 = rho31 = rho41 = rho51 = rho32 = rho42 = rho52 = rho43 = rho53 = rho54 = rho65 = 0: chi2 (10) = 45.1485 Prob > chi2 =0.0000

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

Out of nine explanatory variables included in the model, four variables significantly affected improved crop variety and planting tree; three variables significantly affected terracing practice, and two variables significantly affected adjusting planting date and crop diversification at different probability levels.

Sex of household head: Sex of the household head is an important variable affecting adaptation choice decision. Sex of household head negatively influenced the likelihood of choosing crop diversification at 10% significant level, the negative coefficient for sex variable shows that female headed households are more likely to adopt crop diversification as adaptation choice. Because, women's are more intensify their efforts in homestead production through diversifying their crops mainly vegetables as adaptation options to cope up with food deficit situations and climate change impacts. The result of this study suggested that, as compared to male headed households, being female headed household increases the probability of choosing of crop diversification as climate change adaptation strategy which is consistent with the finding of (Bewket, 2013). However, as compared to female headed households, being male headed household increase the probability of choosing improved crop variety, adjusting planting date, planting tree and terracing practice. So it influenced the likelihood of choosing improved crop variety, adjusting planting date, planting tree and terracing practice positively and significantly at 5%, 1%, 5% and 10% significant level respectively. Because male headed household have high adaptive capacity than female (Legesse *et al.,* 2013)

Education: Education influenced the likelihood of choosing improved crop variety and adjusting planting date positively and significantly at 1% and 5% significant level respectively. Because as the household farmers educated their using of improved crop variety and adjusting planting date also increase. As a result of this, the production and productivity of farmers would be increased. This study is consistency with the study of Said (2014) which indicate that educational level increase the awareness of farmer about the consequence of climate change on productivity. It

also concluded that farmers with more years of schooling are more likely to adapt to climate change adaptation strategies as compared to the farmers with little or no education (Abid *et al*., 2013). From this study, farmers with more years of schooling are more likely to choose improved crop variety and adjusting planting date as adaptation measure to climate change.

Farming experience: The farm experiences of household head influenced the likelihood of choosing planting tree negatively and significantly at 5 % significant level. Because farmers those engaged in farming for long period of time more depend on their production rather than planting tree. Also information about the advantage and dis-advantage of planting tree is less. This study is inconsistency with the findings of Hassan and Nhemachena (2008) which found that having more farming experience was found to promote adaptation to climate change positively.

Farm income: The farm income influenced positively and significantly the likelihood of choosing of improved crop varieties at 5% significant level. This could be clear because use of improved crop varieties requires financial resources to purchase improved seeds and hence increased income would encourage the investment capacity. This is similar with the result of (Abebaw, 2016). Also (Aemro *et al*. 2012) found that when the farm income of the farmers increase farmers tend to invest on productivity addition options such as improved seed varieties options.

Off/non-farm income: Off/non farm income negatively influenced the likelihood of choosing both planting tree and improved crop variety at 10% significant level as adaptation strategies to wards climate change. The reason could be if Off/non- farm income of farmers' increase they may return to non-farm activities. This is in line with the finding of Fadina and Barjolle (2018) that indicate households diversify their income-generating activities to earn additional funds or stabilize their incomes. However, Off/non farm income has positive relation with terracing practice. It was influenced positively the likelihood of choosing terracing practice at 10% significant level as climate change adaptation strategies. Because in the study area flood is seems likely high. As a result of this to peoples participate in terracing practice to minimize that flood

Credit: Credit positively and significantly influenced the likelihood of choosing of crop diversification at 10% significant level as adaptation measures in order to reduce the negative effect of climate change. Access to affordable credit increases financial resources of farmers and

ability to buy crop variety and other inputs. The result is in line with finding of Lemmi (2013) and Musa (2016) indicate climate change adaptation is costly and require financial capacity and lack of money hinders farmers from getting the necessary resources and technologies which assist to adapt to climate change.

Climate change related training: This variable influenced the likelihood of choosing both terracing practice and planting tree at 10% significant level. Participation in climate change ' related training is found to be positively and significantly associated with the likelihood of choosing terracing practice and planting tree as adaptation strategies to wards climate change.
This implies that farmers participated in training related to climate change would have more awareness about climate change. This result is similar with the study by Aemro *et al*. (2012) that shows information helps farmers to make comparative decisions among alternative adaptation practices in climate change.

5. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

This chapter presents summary of the study findings, conclusion and recommendations.

5.1. Summary

This study was conducted to assess adaptation strategies to climate change of smallholder farmers in Adama District, Oromia National regional state of Ethiopia. The data were collected from a total of 155 sample household heads. Descriptive statistics, likert scale and econometric model were used to analyze the data. The result of this study revealed that majority of the farmers perceived and agreed that temperature was increased in the last 15 years. Similarly, most of the farmers taking part in this study dis-agreed on both statement of the decrement of temperature and no change in past 15 years. These generally indicate that the temperature pattern of the area was increased for the past 15 years which was confirmed by the analysis of temperature data taken from meteorology. Unlike temperature conditions, the rainfall pattern of the area over the past 15 years found to be varying and this was confirmed by the mixed feeling of the farmers living in the study area for long period of time. In fact, the result of the meteorology data with respect to rainfall pattern was showed to be increasing.

Using the data obtained from meteorology agency tests were undertaken in mean minimum and maximum temperature, average annual temperature, and annual rainfall for linear trend against time of the study area. The trend analysis of average annual temperature indicated that average annual temperature in the study area increases by about 0.076 ^{o}C per year. The trend analysis of annual rainfall indicated that annual rainfall in the study area is also increase by about 1.96 mm per year.

Different farmers have been using different adaptation strategies and in fact that a farmer can use more than one adaptation strategies. In study area adaptation strategies include, use of improved crop varieties (like short duration varieties and drought resistance varieties), adjusting planting dates, planting tree, crop diversification (mixed cropping, intercropping and dividing farm lands in to varying crops) and terracing are practicing by farmers.

This study was employed multivariate probit model to identify the determinants of smallholder farmers' choice of adaptation strategies to climate change. The stimulated maximum likelihood (SML) estimation results stated that there was positive and significant interdependence between household choices of adjusting planting date and improved crop variety, terracing and adjusting

planting date, crop diversification and planting tree and lastly terracing and planting tree has significant interdependence.

The result of multivariate probit model showed that the likelihood of households to adopt, planting tree, terracing, improved crop varieties, adjust planting date, and use crop diversification were 76.5%, 74%, 51%, 46.7% and 40.4% respectively. The result also showed that the joint probability of using all adaptation strategies was only 9.6% and the joint probability of failure to adopt all of the adaptation strategies was 4.1%.

Multivariate probit model result also confirm that, sex, education, farm income and off/non farm income were significantly influenced using improved crop variety as climate change adaptation strategies. The result also showed that, sex of household head and education were positively and significantly influenced adjusting planting date as climate change adaptation strategies. Also, sexes of household head, farm experience, climate change related training, and off/non farm income were significantly influenced the choosing of planting tree as climate change adaptation strategies. Sex of house hold head and Credit were significantly influenced crop diversification as adaptation strategies.

Additionally, sex of household head, off/nonfarm income and credit were significantly influenced terracing practice as adaptation strategies. Therefore, the results of the study would help for policy makers and development agents on different idea like on how to pick up and progress farm level adaptation strategies, on how to spot out the determinants of farmers' choice of adaptation strategies. This may be used to reduce the adverse impact of climate change and commonly help to increase agricultural production and productivity results give economic development. Also, developing more effective climate change adaptation strategies need support from the government. Such an effort needs provision of the necessary resources such as credit and information on climate change adaptation strategies and technologies, and investing in climate smart and resilient projects.

5.2.Conclusion

This study was conducted to assess adaptation strategies to climate change of smallholder farmers in study area. Farm household were characterized by different important variables. Taking into consideration all the interacting factors observed in the study the following major

conclusions are drawn. It has been noticed that the characteristics of the respondents were the asset for the future practice of climate change adaption strategies.

The perceptions of farmers about climate change parameters were more or less consistent with the meteorological data analysis except in rainfall condition in which the perception of the farmers and statistical results differ. This is because of the fact that the rainfall of the area was variable and unpredictable. Generally, the proportion of the farmers who have perceived change of climate and who did not perceived in this study does not show much variation.

Climate change is an expected event that will happen again in the future if the adaptation strategies are not practiced in well manner. Adaptation choices were significantly influenced by different variables like sex of household head, educational status, farm income and off/non-farm income, credit, climate change related training, and farm experience. It is needed to preserving of a stable ecosystem that will permit the rural households to adapt unpredicted conditions. From the views of farmers and observations made in the field it can be concluded that different climate change adaptation strategies are practiced by farmers in the study area. However, the ongoing adaptation activities practiced by farmers are not sufficient to counter attack the impacts of climate change.

Therefore development agent and agricultural office need to focus on disseminating of the information and promoting of smallholder farmers on improving their adaptive capacity. The government and non-governmental organizations should facilitate adaptation choice that will assist farmers towards appropriate adaptive methods.

5.3. Recommendations

Based on the study result the following recommendations were forwarded:

Since the sex of household head was significantly important in influencing the probability of choosing of improved crop variety, adjusting planting date, planting tree and terracing practice, the federal and regional government should give considerations to gender issues (equity sharing and participatory on development, paarticulrly, giving unique outlooks to female headed households, by giving training of technology in agriculture and other activities..

Adaptation to climate change requires credit provisions and reasonable credit would increases financial resources of farmers and ability to buy crop variety and other inputs. So development institutions enhance the credit accessibility and provision for farmers.

Agricultural offices should focus on dissemination of climatic information for farmers at required times through social medias and training which increases farmers' decision making on using different adaptation strategies to reduce the negative impact of climate change. Because participating in climate change related training may enhance the awareness of farmers to have predictions of climate related hazards and to have appropriate adaptation strategies.

Farm experience influenced negatively planting tree. So environmental policy focus on giving awareness for farmers and training the community to shape farmers attitudes in a way that they would use environmental resources.

Education plays an essential role in enhancing societal development and to enhance efforts to promote adaptive capacity of farmers. The regional and federal government should give attentions to expanding technical or practical supported education and skill based trainings to set up the capacity of overlaying the impact of climate change.

Agricultural office of the district needs support to supply different inputs for farmers which increase farm income. Hence, government and non-government institution should create outlines for supplement of required inputs at right times by right costs.

Improving off/non-farm income earning opportunities is needed. So regional government create non- farm employment to support smallholder farmers.

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7. APPENDIXES

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

Animals	TLU- Equivalent
Oxen	1.1
Cow	1

Heifer	0.5
Bull	0.6
Calves	0.2
Sheep	0.01
Goat	0.09
Donkey	0.5
Horse	0.8
Mule	0.7
Poultry	0.01

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

Appendix 2: Long-term Climate Data of Adama District from 2003-2017

Year	Mean maximum temperature(0C)	Mean minimum temperature(0C)	Annual rainfall (mm)	Average annual temperature(0C)
2003	28.14	14.6	1126.7	21.4
2004	26.1	15	719.6	20.55
2005	28.14	15.5	720.5	21.8
2006	27.6	17	912.2	22.3
2007	27.3	15.46	1182.2	21.4
2008	27.3	14.9	1105	21.1
2009	28.2	15.9	609	22
2010	27.5	15.3	1035.2	21.4
2011	28.3	14.94	736.5	21.6
2012	28.33	15.5	1370.7	21.9
2013	28.34	15.8	904.2	22
2014	28.5	16	847.8	22.25
2015	29.8	13.5	690.4	21.65
2016	28.2	16.3	951.9	22.25
2017	31.6	13.8	1089.5	22.7

Source: Adama Meteorology Station, 2018

Appendix 3: Perceptions of farmers in temperature, rainfall and flood in over the past 15 years

Perception of farmers on climate change	Scale of agreement				
	3	2	1	Total	Mean

	N	%	N	%	N	%	score	
Annual temperature increased	115	74.2	3	1.9	37	23.9	388	2.5
Annual temperature not changed	32	20.6	14	9	109	70.3	233	1.5
Annual temperature decreased	43	27.7	9	5.8	103	66.5	250	1.6
Annual rainfall increased	61	39.35	16	10.32	78	50.32	293	1.9
Annual rainfall not changed	42	27.1	15	9.68	98	63.23	254	1.64
Annual rainfall decreased	90	58.06	3	1.94	62	40	338	2.2
Rainfall comes before perceived time	107	69.03	3	1.94	37	29.03	364	2.35
Rainfall comes after perceived time	117	75.5	2	1.3	36	23.2	391	2.52
Flood in the past seems less	60	38.7	5	3.23	90	58.1	280	1.8
Flood in the past seems high	89	57.4	5	3.23	61	39.35	338	2.2
Flood in the past seems medium	45	29.03	10	6.45	100	64.5	255	1.64

3= Agree, 2= Neutral, 1= Dis-agree

Source: Own survey result, 2018

Appendix 4: Multivariate Probit Model Result

Multivariate probit (MSL, # draws = 5) Number of obs = 155
Wald chi2(45) = 86.73
Log likelihood = -416.39555 Prob > chi2 = 0.0002

	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
ICV						
SEXHH	.7743228	.2728989	2.84	0.005	.2394508	1.309195
EDNHH	.1408631	.0430469	3.27	0.001	.0564926	.2252335
FARMEXP	.0096359	.0122205	0.79	0.430	-.0143159	.0335876
TLHOLD	-.2580496	.1819491	-1.42	0.156	-.6146634	.0985641
FARMINC	.0000265	.0000117	2.27	0.023	3.66e-06	.0000494
LSHOLD	-.0478386	.0345082	-1.39	0.166	-.1154734	.0197962
NONFINC	-.0000174	.0000103	-1.69	0.092	-.0000376	2.81e-06
CRSERUSR	.1864724	.2221308	0.84	0.401	-.248896	.6218408
CCRTR	.1116271	.2297864	0.49	0.627	-.3387458	.5620001
_cons	-1.394026	.4804688	-2.90	0.004	-2.335728	-.4523246
APD						
SEXHH	.7717547	.2716429	2.84	0.004	.2393444	1.304165
EDNHH	.0791042	.0401603	1.97	0.049	.0003915	.157817
FARMEXP	-.0161025	.0119378	-1.35	0.177	-.0395	.0072951
TLHOLD	.0485341	.1720634	0.28	0.778	-.288704	.3857723
FARMINC	6.68e-07	.0000108	0.06	0.951	-.0000205	.0000219
LSHOLD	-.0154065	.0335978	-0.46	0.647	-.0812569	.0504439
NONFINC	-2.21e-06	.0000103	-0.22	0.830	-.0000224	.0000179
CRSERUSR	.1839495	.2162822	0.85	0.395	-.2399558	.6078549
CCRTR	.1045778	.2234348	0.47	0.640	-.3333463	.5425018
_cons	-.8156448	.4529532	-1.80	0.072	-1.703417	.0721271
PLNTREE						
SEXHH	.6555355	.2899069	2.26	0.024	.0873284	1.223743
EDNHH	-.0244576	.0451778	-0.54	0.588	-.1130044	.0640892
FARMEXP	-.0284002	.0137828	-2.06	0.039	-.055414	-.0013863
TLHOLD	.0191674	.1813471	0.11	0.916	-.3362664	.3746013
FARMINC	-5.58e-06	.0000115	-0.48	0.628	-.0000282	.000017
LSHOLD	-.0253099	.0330318	-0.77	0.444	-.0900511	.0394313
NONFINC	-.0000177	.0000106	-1.68	0.093	-.0000384	2.98e-06
CRSERUSR	.0266779	.2375134	0.11	0.911	-.4388398	.4921956
CCRTR	.433572	.2511635	1.73	0.084	-.0586995	.9258435
_cons	1.139327	.5032678	2.26	0.024	.15294	2.125714
CRPDIV						
SEXHH	-.5047475	.2607612	-1.94	0.053	-1.01583	.006335
EDNHH	-.020157	.0404556	-0.50	0.618	-.0994485	.0591346
FARMEXP	.0101837	.0116887	0.87	0.384	-.0127258	.0330932
TLHOLD	-.0740533	.166629	-0.44	0.657	-.4006401	.2525336
FARMINC	.0000123	.0000106	1.16	0.245	-8.47e-06	.0000331
LSHOLD	-.0009204	.0330083	-0.03	0.978	-.0656155	.0637747
NONFINC	-6.44e-06	.0000104	-0.62	0.535	-.0000268	.0000139
CRSERUSR	.3601731	.2159829	1.67	0.095	-.0631457	.7834918
CCRTR	.2066439	.2208064	0.94	0.349	-.2261287	.6394165
_cons	-.4329222	.4451865	-0.97	0.331	-1.305472	.4396273
TERR						
SEXHH	.508135	.2762577	1.84	0.066	-.03332	1.04959
EDNHH	.0251509	.0423867	0.59	0.553	-.0579254	.1082272
FARMEXP	.0028769	.012642	0.23	0.820	-.021901	.0276548
TLHOLD	-.247328	.1821464	-1.36	0.175	-.6043284	.1096725
FARMINC	5.95e-06	.0000116	0.51	0.607	-.0000167	.0000286
LSHOLD	.018504	.0327305	0.57	0.572	-.0456466	.0826546
NONFINC	.0000267	.0000156	1.71	0.087	-3.92e-06	.0000573
CRSERUSR	.3413695	.2269642	1.50	0.133	-.1034722	.7862113
CCRTR	.4525854	.2432292	1.86	0.063	-.0241352	.9293059
_cons	-.1680593	.4784298	-0.35	0.725	-1.105764	.7696457

Appendix 5: Correlation matrix

/atrho21	.2996702	.1384035	2.17	0.030	.0284043	.5709361
/atrho31	-.1204952	.1505843	-0.80	0.424	-.415635	.1746445
/atrho41	-.0017541	.1298187	-0.01	0.989	-.256194	.2526858
/atrho51	.0613063	.1403178	0.44	0.662	-.2137115	.3363241
/atrho32	.2390972	.1510549	1.58	0.113	-.0569649	.5351593
/atrho42	.0304379	.1328539	0.23	0.819	-.229951	.2908268
/atrho52	.3413395	.1591649	2.14	0.032	.0293821	.653297
/atrho43	.3152076	.1445651	2.18	0.029	.0318651	.59855
/atrho53	.7946702	.1691084	4.70	0.000	.4632238	1.126117
/atrho54	.1922395	.1535229	1.25	0.211	-.1086598	.4931389
rho21	.2910107	.1266825	2.30	0.022	.0283966	.5160464
rho31	-.1199154	.1484189	-0.81	0.419	-.3932468	.1728903
rho41	-.0017541	.1298183	-0.01	0.989	-.2507323	.2474417
rho51	.0612296	.1397917	0.44	0.661	-.2105163	.3241918
rho32	.2346429	.1427382	1.64	0.100	-.0569034	.489315
rho42	.0304285	.1327309	0.23	0.819	-.2259818	.2828956
rho52	.3286728	.141971	2.32	0.021	.0293736	.5738853
rho43	.3051672	.1311022	2.33	0.020	.0318543	.536017
rho53	.6610465	.095211	6.94	0.000	.432708	.809686
rho54	.1899059	.1479862	1.28	0.199	-.1082341	.4567041

Likelihood ratio test of rho21 = rho31 = rho41 = rho51 = rho32 = rho42 = rho52 = rho43 = rho53 = rho54 = 0:

chi2(10) = 45.1485 Prob > chi2 = 0.0000

Appendix 6: Predicted Probability

Variable	Obs	Mean	Std. Dev.	Min	Max
predprob1	155	.5114403	.2269161	.0666552	.9725751
predprob2	155	.4667188	.1833196	.1364676	.8389115
predprob3	155	.764648	.1195035	.2997063	.9753553
predprob4	155	.4043412	.1585676	.1075838	.8278525
predprob5	155	.7403254	.1386401	.3808577	.999029

Appendix 7: Joint Probability of Success and Failure

Variable	Obs	Mean	Std. Dev.	Min	Max
succfail1s	155	.096106	.0740603	.0054343	.3352796
succfail0s	155	.0410945	.03808	.0002955	.1850104

Appendix 8: Data collection tools

Jimma University

College of Agriculture and Veterinary Medicine

Department of Agricultural Economics and Agribusiness and Value Chain Management

MSc. Thesis

Smallholder Farmers' Adaptation Strategies to Climate Change in Adama District, Oromia Region, Ethiopia

Questionnaire

General Information

Date of interview _____ Name of respondent _____

Name of enumerator _____ Kebele _____

Section one: 1.1 Demographic and Socioeconomic Characteristics of the Respondent Households

1. Sex of households head 1) Male 2) Female

2. Level of education of household head? 1) Non formal education 2) Formal education

_____(years of schooling)

3. Farming experience of the household head in years _____

4. Total land holding of household head in hectare _____

5. What is the source of your income?

1) Crop production 2) Livestock production.3) both 4) other specify _____

6. If the answer of question number 5 is crop production fill the table given below

What types of crop you produce	Area allocated for crop production in hectare	Yield per hectors	Total estimate income in birr

7. If the answer for question number 5 is crop production, did you sell the crops? If yes what kinds of crop you sell? _____, and what is the total estimated income from that crop?_____

8. Total estimated Income from byproduct? _____birr

9. Livestock holding and income from livestock production, fill the table below

Livestock	Number of livestock you owned	Number of livestock you sold in last one year	One animal Birr per	Total income
Cows				
Calf				
Sheep				
Poultry				
Mule				
Donkey				
Goat				
Oxen				
Other specify				
Total				

10. Did you sell the livestock product? If yes what is the total estimated income of their product? _____ Birr

11. Total estimated farm income? _____ Birr

12. What is your estimated annual off/non farm income? _____

1.2 Institutional Issues

1. Did you use credit service? 1) Yes 2) No.

1.1. If the answer of question 1 is yes from where you received it? 1) From bank 2) from NGO 3) From Partners 4) Other specify _____

1.2 If the answer of question 1 is yes what amount of credit you received in the year of 2017/2018 _____ birr

1.3. If the answer of question 2 is no why is the reason? _____

2. Have you received any training related to climate change so far? 1) Yes 2) No

2.1. If question 2 is yes from which body you received training related to climate change? NGO, Government, other specify _____

Section two: Climate Change Perceptions of Smallholder Farmers

2.1 Have you observed any climate change in last 15 years? 1) Yes 2) no

2.2 If your answer of question 2.1 is yes what are the indicators? 1) Rainfall variability 2) temperature variability 3) Flood 4) Other specify _____

2.3 Fill the below table by ticking your group.

Statement	Agree	Disagree	Neutral
Annual rainfall increased over the past 15 years			
Annual rainfall not changed over past 15 years			
Annual rainfall decreased over past 15 years			
Rainfall comes before perceived time			
Rainfall comes after perceived time			
Annual temperature increased over the past 15 years			
Annual temperature not changed over past 15 years			
Annual temperature decreased over past 15 years			
Flood in the past 15 years is seems less			
Flood in the past 15 years is seems high			
Flood in the past 15 years is seems medium			

Section three: Climate Change Adaptation Strategies

3.1. Have you made any adaptation strategies or methods in your farming practices in response to climate change? 1, Yes 2, No,

3.2. If the answer of question 3.1 is No what is the reason? _____

3.3. If the answer of question 3.1 is yes, answer the following question.

3.3.1. Have you used improved crop variety or early maturing crop variety? 1 Yes 2) No

3.3.1.2. If the answer of question 3.3.1 is yes which one of the following you used? 1) Complete

exclusion of some crops from production due to climate change. 2) Change from local late maturing to early maturing crop species. 3) Other specify _____

3.3.1.3. If the answer for question 3.3.1 is yes by what criteria you used improved crop variety?

3.3.2. Have you used adjusting planting date? 1) Yes 2) No

3.3.2.1. If the answer of question 3.3.2 is yes from the given below which one you used? 1) Change in crop production period i.e. from early planting to late planting or vice-versa 2) Change in the time of farm operation 3) If others specify_____

3.3.3. Have you used planting tree? 1) Yes 2) No

3.3.3.1. If the answer of question 3.3.3 is yes what is the reason for 1) To minimize flood 2) For sustainability of natural resource 3) To minimize soil erosion 4) Others specify _____

3.3.4. Have you used crop diversification? 1) Yes 2) No

3.3.4.1. If your answer of question 3.3.4 is yes to adapt climate change, which option have you used? 1) Inter cropping 2) dividing farm land into different crops 3) other specify_____

3.3.5. Have you used terracing? 1) Yes 2) No

3.3.5.1. If your answer of question 3.3.5.1 is yes for what purpose you used?

Checklist for Focus Group Discussions

1. Have you observe "climate change" in the previous time? 1) Yes 2) no.

2. Have you perceive the climate change? Yes or no if yes at what temperature and rainfall you perceive?

3. What are the major and frequently used adaptation methods of climate change in your area in order to reduce the effect of climate change? Explain in details.

4. What are the determinants of smallholder farmers' choice of adaptation strategies to climate change? Explain in details.

Checklist for Key Informant Interview

1. Have you observe the climate change in the district? 1) Yes 2) no. If yes what are the indictors of the occurrence of climate change?

2. How do you evaluate the climate situation in the district over the past 15 years? And how do you evaluate the temperature, rainfall and flood over the past 15 years? And how the farmers know climate change?

3. Is climate change an important agenda for Agricultural Development Offices? If yes what are the development interventions introduced in the District or study kebeles?

4. What development interventions are carried out in the district to avert the impact of climate change?

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

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

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

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

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

12. Do you believe climate change affect, wild life, crop production, livestock and other?

Guide for Field Observation

1 What type of adaptation strategies are frequently used by farmers?

2. What do ongoing climate change adaptation looks like in smallholder farmer`s farmland?

3. What do farmers feel while practicing adaptation strategies?

4. What kinds of supports are needed for smallholder farmers to enhance their adaptive capacity?