SMALLHOLDER FARMERS' PERCEPTION AND ADAPTATION STRATEGIES TO CLIMATE CHANGE: THE CASE OF JAMMA DISTRICT OF SOUTH WOLLO ZONE, ETHIOPIA

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SEBLE TADESSE

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Seble Tadesse

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HARAMAYA UNIVERSITY
POSTGRADUATE PROGRAM DIRECTORATE

We hereby certify that we have read and evaluated this Thesis entitled "**Smallholder Farmers' Perceptions and Adaptation Strategies to Climate Change: The case of Jamma district of South Wollo Zone, Ethiopia**" prepared under our guidance by Seble Tadesse. We recommend that it be submitted as fulfilling the Thesis requirement.

Lemma Zemedu (PhD.)	_____	_____
Major Advisor	Signature	Date
Mengistu Ketema (PhD.)	_____	_____
Co-Advisor	Signature	Date

As member of the Board of Examiners of the MSc. Thesis Open Defense Examination, we certify that we have read and evaluated the Thesis prepared by Seble Tadesse Mekonnen 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 and Applied Economics).

_____	_____	_____
Chairperson	Signature	Date
_____	_____	_____
Internal Examiner	Signature	Date
_____	_____	_____
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DEDICATION

I dedicated this Thesis manuscript to my beloved mother Tewabech Asfaw and all my family members for their support in the achievement of my work.

STATEMENT OF AUTHOR

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

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Name: Seble Tadesse Signature: _____

Haramaya University, Haramaya

Date of Submission: _____

BIOGRAPHICAL SKETCH

The author was born in 1991 in South Wollo Zone of Amhara National Regional State of Ethiopia. She attended her elementary education at Degollo Elementary School. She also attended her secondary and preparatory education at Degollo Secondary and Preparatory School. After successful completion of her Preparatory school education, she joined Mizan-Tepi University in 2011 and graduated with BSc degree in Agricultural Economics in June 2013. Soon after her graduation, she joined Wolkite University and served as a graduate assistant from September 2013 to September 2015 in the college of Agriculture and Natural Resource. After Two years of professional experience, she joined the School of Graduate Studies of Haramaya University to pursue her MSc degree in Agricultural and Applied Economics.

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ACRONYMS AND ABBREVIATIONS

ACCCA	Advancing Capacity to support Climate Change Adaptations
ACSI	Amhara Credit and Saving Institution
AERC	African Economic Research Consortium
CBE	Commercial Bank of Ethiopia
CSA	Central Statistics Agency
DFID	Department for International Development of the United Kingdom
FAO	Food and Agricultural Organization of the United Nation
FGDs	Focus Group Discussions
GDP	Gross Domestic Product
GHGs	Green House Gases
Ha	Hectare
IFPRI	International Food Policy Research Institute
IIED	International Institute for Environment and Development
IPCC	Intergovernmental Panel on Climate Change
JDBoARD	Jamma District Bureau of Agriculture and Rural Development
M.A.S.L	Meter Above Sea Level
MNL	Multinomial Logit
MNP	Multinomial Probit
MoA	Ministry of Agriculture
MVP	Multivariate Probit Model
NMA	National Meteorology Agency
NMSA	National Metrological Services Agency
PCGCC	Pew Center on Global Climate Change
PSNP	Productive Safety net program
SML	Simulated Maximum Likelihood
SRS	Simple Random Sampling
TLU	Tropical Livestock Unit
UNFCCC	United Nations Framework Convention on Climate Change
USEPA	United States Environmental Protection Agency
WB	World Bank

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Smallholder Farmers' Perception and Adaptation Strategies to Climate Change: The Case of Jamma District of South Wollo Zone, Ethiopia

ABSTRACT

Climate change is causing the greatest environmental, social and economic threats across the globe. Its impact has been increasing especially on agricultural activities in developing countries. It depresses crop yields through temperature increase and reductions of precipitation. Climate change mainly affected low-income countries where their adaptive capacities are perceived to be low, due to weak institutional capacity, limited engagement in environmental and adaptation issues and lack of validation of local knowledge. A better understanding of the perceptions of farmers about climate change is essential to develop appropriate adaptation measures that can alleviate the adverse effects of climate change. Therefore, the main aim of the study was to examine perceptions and adaptation strategies used by smallholder farmers in Jamma district of South Wollo Zone, Amhara Regional State, Ethiopia. The study utilized both primary and secondary data. Primary data were collected from a randomly selected 156 sample households interviewed through a structured questionnaire. Focus group discussion also used to collect the qualitative data about the perception and attitudes of smallholder farmers about climate change. The relevant secondary data were also obtained from different governmental offices. Descriptive statistics were used to provide insights into farmers' perception, types of adaptation strategies and to explain factors affecting climate change adaptation strategies. Multivariate probit model was used to analyze the determinants of households' choice of adaptation strategies. The model results confirm that sex, level of education, farming experience, household size, farm income, off/non-farm income, livestock ownership, distance from the nearest market, credit used, farmer to farmer extension and frequency of extension contact have a statistically significant impact on the choice of climate change adaptation strategies in the study area. Therefore, future policy should focus on empowering female headed households, empowering people with information and education, improving farmer's farm and off/non-farm income-earning opportunities, emphasizing on critical roles of extension service, facilitating credit utilization, introducing new technologies by considering socioeconomic and environmental settings and enhancing the adaptive capacity of smallholder farmers in the study area.

Keywords: Adaptation Strategy, Climate Change, Multivariate probit model, Perception.

1. INTRODUCTION

1.1. Background

Climate change is the most complex global challenge in the 21st century posing the greatest threat to business and governments. Human contribution to changes in climate is due to the emission of greenhouse gasses (IPCC, 2014). The main characteristics of climate change are increases in average overall temperature, changes in cloud cover and precipitation, melting of ice caps, and acidification of ocean due to seawater absorbing heat and carbon dioxide from the atmosphere (IPCC, 2012). During climate change discussion, agriculture is primarily concerned because climate is a primary determinant of agricultural production. However, expected long term changes in precipitation patterns and changing temperature are likely to have considerable negative impact on agriculture (DFID, 2004).

In many African countries, agricultural production and food security could be affected by climate change and variability. According to IPCC (2007) report, the projected yields of crops in some countries might be reduced by up to 50 percent by 2020, with smallholders being the most affected. Climate change leads a reduction in agriculture production of the smallholder farmers and would further adversely affect food security. Rainfall as one of the most important agricultural input in the Horn of Africa is influenced by weather systems that evolve in the Pacific Ocean, especially the central and east-central parts of the Pacific around the Equator. Relatively large changes in the sea's temperature create unusual weather patterns, such as drought, flood and storms (Temesgen *et al*., 2014).

Agriculture is the main sector in Ethiopia which is dominated by smallholder farming and livestock husbandry. It accounts about 36.7 percent of GDP, generates 77.5 percent of foreign exchange earnings and more than 80 percent of employment (NBE, 2017). However, the sector productivity and competitiveness are increasingly constrained by climate change. According to Temesgen *et al*. (2014) the major causes of underproduction are changes in rainfall pattern which eventually born drought and floods, which often cause famine. For instance, climate change aggravates these existing poverty and is expected to create environmental, economic and social impacts on Ethiopian people. Crop failure, food insecurity, famine, loss of property and life, mass migration and reduction of

national economic growth are mainly caused by lack of rains and recurrent occurrence of floods and droughts (World Bank, 2013).

One important method of reducing the impact of climate change by taking advantages of opportunities and reducing loss is an adaptation (IPCC, 2001). It is the adjustment in ecological and socio-economic systems to the actual or anticipated climate change in order to reduce the negative and enhance the positive impacts of climate change. Awareness and climate information are crucial in coping with or preparing for climate change. The level of smallholder farmer's knowledge of their environment could be a guide to respond effectively to the challenges of climate change.

Therefore, adaptation is important to reduce sensitivity to climate changes and variability. Whereas, mitigation responds to reduce the magnitude of climate change impact in the long run. So, smallholder farmers need to identify useful adaptation strategies and the determinant factors of their adaptation option to respond to climate change. A better understanding of farmers' perceptions of climate change and the decision-making process at grass root level is important to inform policies aimed at promoting successful adaptation strategies for the agricultural sector at the macro level.

Smallholders in Ethiopia generally face widespread problems related to inappropriate cultivation, overgrazing and deforestation, resulting in soil erosion and soil fertility decline, water scarcity, lack of pasture and livestock feed, and fuel wood crisis. This vicious cycle of "poverty, food insecurity and natural resources degradation" is driven by population growth but is being exacerbated by increasing weather variability and climate change, requiring urgent action and different approaches in the dry lands and highland areas (Dawit, 2014). Therefore, this study examined the perception of the farmers towards climate change and adaptation strategies of smallholder farmers in Jamma district.

1.2. Statement of the Problem

Climate change is a global challenge to both sustainable livelihoods and economic development due to a rapid increase in the concentration of greenhouse gases (Balama *et al.*, 2016). The increase in global surface temperature would alter the natural environmental systems by increasing the frequency of extreme weather events such as sea level rise, reducing rainfall, flood and drought.

African countries are vulnerable to climate change impact because of several factors like poverty, recurrent drought, population growth and urbanization, inequitable land distribution, over exploitation of resources, subsistence rain-fed agriculture, extreme weather events combined with a low capacity to adapt to the adverse impacts of climate change, aggravate food security risks like decline in productivity, reduced yields, and food insecurity (Aster, 2010). Climate change directly affects food production through a change in the agro ecological conditions and indirectly affects growth and distribution of incomes, and thereby, the demands for agricultural products (Kebede, 2016).

Ethiopia is one of the developing countries, its agricultural production depends on rain-fed agriculture. Thus, agricultural production is vital to sustaining and enhancing the country's people welfare. However, the sector is highly influenced by climate change and related factors (Temesgen, 2007). Ethiopian's economy is susceptible to climate variability, particularly variations in rainfall (Belachew and Zuberi, 2015). The country's geographical location and topography, nature-dependent agriculture and low adaptive capacities are the major causes of a high vulnerability to adverse impacts of climate change (Zenebe *et al*., 2011). Studies recognized that the agricultural sector of the Ethiopian economy is highly affected by climate change in the past, now and it will continue in the future (Ashenafi, 2011; EPCC, 2015; Maplecroft, 2015; HRD, 2016). This implies the need to consider climate change and variability while making decisions at different levels.

Farmers adopt many types of strategies in their agricultural activities to reduce the impact of climate change (Belaineh *et al.*, 2013; Temesgen *et al.*, 2014; Van *et al*., 2015). However, the major problem in the planning of adaptation strategies in Ethiopia are lack of knowledge of farmers, resource endowment designing and implementation of similar adaptation strategies without consideration of agro ecological setting. This means that applying similar programs for all agro ecological zones is not efficient. Due to this reason formulation of climate change adaptation policy and program design should consider the detailed characteristics of each agro ecological zones and every community. Therefore, implementations of climate change adaptation program primarily concerned by considering the different agro ecological zones and socio-economic characteristics of the farmers.

Currently, South Wollo Zone, northern highlands of the country experience increased temperature and reduced rainfalls, and hence become susceptible to more severe drought conditions. A further increase in temperature and decrease in precipitation could increase

the frequency and intensity of droughts. Also, it is a fragile highland ecosystem that is currently under stress due to increasing population pressure. An increase in temperatures and a decrease in precipitation resulted in increased number of more projected hot days, fewer number of projected cold days and decreased number of projected days with precipitation; these events may lead to increased occurrences of drought in South Wollo Zone (Legesse *et al*., 2012).

Therefore, detail investigation at micro level is an important means to determine the characteristics of smallholder farmers and thus help to design appropriate economic policies and strategies in that local context. Jamma is one of the twenty-two districts in South Wollo zone which is affected by climate change such as recurrent drought, erratic nature of rainfall and flood.

There are attempts made to study climate related issues especially perception and adaptation in different parts of the country by scholars (Temesgen, 2007; Messeret, 2009; Tagel, 2013; Negash, 2014). However, the majority of the scholars cover large highland areas of the Nile basin which covers large areas of the country and not specific to explore detail information about household level in the highlands. Furthermore, there are discrepancies of knowledge in addressing the adaptation strategies of smallholder farmers. These adaptations often vary with the behaviors of socioeconomic, agro-ecological and cultural set up of the farmers.

Moreover, there is no earlier study about climate change adaptation strategies of smallholder farmers in the study area. In this regard, this study contributes to bridge these gaps and attempts to reveal the perception of farmers about the past, current and future climate change and adaptation measures that farmers are taking to the climate change at the household level

1.3. Research Questions

This study tried to answer the following research questions:

1. What is the view of the smallholder farmers about the existence of climate change in the study area?
2. What adaptation strategies are adopted by smallholder farmers of the study area to cope with climate change?

3. What are the factors that affect the choice of climate change adaptation strategies by smallholder farmers in the study area?

1.4. Objectives of the Study

The general objective of this study is to examine climate change perceptions and adaptation strategies used by smallholder farmers and their determinant factors for the choice of adaptation strategies in the study area.

The study addresses the following specific objectives:

1. To examine the perception of smallholder farmers about climate change in the study area.
2. To identify adaptation strategies employed by smallholder farmers in response to climate change.
3. To identify factors that affect the choice of adaptation strategies by smallholder farmers in the study area.

1.5. Significance of the Study

The study examined the perception, adaptation and determinant factors of smallholder farmer's choice of climate change adaptation options to provide a meaningful insight and contribute to efforts aimed at ensuring sustainable development of farmers. Since climate change is a worldwide phenomenon the study may contribute to the national and global action to minimize the impact of climate change by providing information from the household level of perception and adaptation strategies. Understanding climate change at the local level and their reaction to climate change helps to look at better alternatives to perform sustainably within the existing situation. It serves as a guideline document for further research in the study area and to the same climatic, socio-economic and geographical areas. Furthermore, the study also assists as a base for further study in the area of climate change on economic and social development. Finally, the study helps local administration and development practitioners as they may use this study finding in their development intervention.

1.6. Scope and Limitations of the Study

The primary limitation of this study was that fact that it is limited to only one district in South Wollo Zone of Amhara Regional State. This may limit the representativeness of the study while intending to use it at zonal and other higher administrative levels, which makes the findings and the generated conclusion specifically more relevant to only the study area (district). Even though the cause and consequence of climate change and its impact is a complex phenomenon, the focus of this study is on smallholder farmers' perception and factors affecting the choice of their adaptation strategies to climate change with limited dimensions of climate change issues. The other limitation of the study is that there is no meteorological station nearby in the study area to record temperature and rainfall data. The meteorological station is located in Kombolcha, which is far from the district and temperature and rainfall data recorded on the meteorological station does not represent all the average monthly and annual climatic parameters of the study district.

1.7. Organization of the Study

This thesis is structured into five main chapters. The first chapter described the introduction of the study, which deals with the background, statement of the problem, objectives, research questions, significance, and scope and limitations of the study. The second chapter presents an overview of theoretical perspectives and empirical evidence of related literatures. The third chapter summarizes the research methodology and depicts the study area. The fourth chapter discusses the key findings of the study and the last chapter deals with conclusion and recommendations of the study.

2. LITERATURE REVIEW

This chapter includes the definitions of concepts, theoretical and empirical studies of perception and adaptation strategies of climate change.

2.1. Definitions of Conceptual Terms

This section defines concepts and terms used in assessments of livelihood adaptation to climate change and variability.

Climate: It is the "average weather," or more rigorously, as the statistical description in terms of the mean and variability of relevant quantities over a period ranging from months to thousands or millions of years. The classical period is 30 years, as defined by the World Meteorological Organization (WMO). These quantities are most often surface variables such as temperature, precipitation, and wind. Climate in a wider sense is the state, including a statistical description, of the climate system (IPCC, 2001).

Climate variability: It is the variations in the mean state and other statistics of the climate on all temporal and spatial scales, beyond individual weather events. It may result from natural internal processes within the climate system or from variations in the natural or anthropogenic external forcing (IPCC, 2001).

Climate change: It refers to as “a change in state of the climate that can be identified by changes in the mean and/or variability of its properties and that persists for an extended period, typically decades or longer” (IPCC, 2014). IPCC (2001) defines climate variability as “variations in the mean state and other statistics (such as standard deviations, the occurrence of extremes, etc.) of the climate on all temporal and spatial scales beyond that of individual weather events”.

Perception: Ban *et.al* and Hawkin (2000) define “it is the process by which we receive information or stimuli from our environment and transform it into psychological awareness.” It is someone’s ability to notice and understand things that are not obvious to other people.

Adaptation: The IPCC (2007) defines adaptation as “an adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, to moderate potential damages or to benefit from opportunities associated with climate change.”

Adaptive capacity: Adaptive capacity is the ability of a human or natural system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences (IPCC, 2007).

Mitigation: According to IPCC (2001) "it is an anthropogenic intervention to reduce the sources or enhance the sinks of Green House Gases (GHG**).**"

Smallholder farmer: There is no clear definition of smallholder farmer. According to Chamberlin (2008), smallholder farmer is a farmer whose available land is very limited. He differentiated smallholders from others on the basis of the size of landholding, wealth, market orientation and level of vulnerability to risk. Therefore, the smallholder is the one with limited land availability, poor-resource endowments, subsistence-oriented and highly vulnerable to risk. Nevertheless, the smallholder may or may not exhibit all these dimensions of smallness simultaneously.

Moreover, farmers in Ethiopia are known for their resource constraints such as capital, inputs and technology; their heavy dependence on household labor; their subsistence-orientation; and their exposure to risks such as reduced yields, crop failure and low prices (Betre, 2006; Meseret, 2012). To this end, all sampled households in this study are treated as smallholder farmers and used in this entire document.

2.2. Theoretical Review

2.2.1. Overview of Climate Change

Climate change is the change in the state of climate due to the variability of nature or human activity. Human activities directly or indirectly affect the composition of the global atmosphere which is climate change in the long run that is in addition to natural climate variability over comparable time periods (UNFCCC, 2007).

Climate change has wide-ranging effects on the environment, on socio-economic and related sectors, including water resources, agriculture and food security, human health, terrestrial ecosystems and biodiversity and coastal zones. Children, the elderly, the poor, the infirm, and tribal and indigenous populations are among the most vulnerable. It is a great concern for agriculture and its effects are likely to vary between different regions and different scales (DFID, 2004).

The impacts of climate change are not similar across the regions. This variation is due to the difference in the agro ecological zone, living standards of the society, natural resource endowment, people's response to climate change. The frequency and severity of climate related hazards are different in different countries. For example, the frequency and severity of drought were higher than a flood in West Ghana and Ethiopia (Boutin and Smit, 2016; HRD, 2016; Ndamani and Watanabe, 2016). On the other hand, farmers have perceived that a higher rate of occurrence of a flood than the drought in Uganda (Okonya *et al.*, 2013).

According to the report of the Intergovernmental Panel on Climate Change (IPCC, 2007), Africa is one of the most vulnerable continents to climate change and variability because of multiple socioeconomic factors and low adaptive capacity. The impacts of climate change on agriculture will be very severe especially for those regions whose production system is rain-dependent. Limited financial, institutional and human resources, and high ecosystem dependent economic and livelihood activities such as subsistence farming leave the poor highly vulnerable to climate change.

2.2.2. Smallholder Farmers' Perception of Climate Change

According to Berelson and Steiner (1964), perception is more complex process by which people select, organize and interpret sensory stimulation into a meaningful and coherent picture of the world. Perception of farmers about changes in temperature and rainfall pattern is a necessary prerequisite for any kind of climate change adaptation strategies including agriculture, natural resources management, and health (Fatuase and Ajibefun, 2014). Farmers were able to recognize that temperatures become increased and the volume of rainfall is reduced. However, few farmers lack to perceive a change in the climatic condition of their area to take steps to adjust their farming activities. Farmers who perceive the climate change are hypothesized to make adjustments in their farms to reduce climate change born impacts unless they do face some barriers (Taddesse, 2011).

2.2.3. Effects of Climate Change on Agriculture

According to IPCC (2001) report, agriculture and climate change are inter related processes, both of which take place on a global scale. Agriculture can either sustain or degrade the environment (IIED, 2011). Climate change and agricultural sectors are interrelated. This implies that change in climate mainly affects the agricultural sector and agriculture sector

also affects climate change through emission of greenhouses gas (GHG) from different farming practices (Adugna *et al*., 2013). Agriculture contributes about 13.5 percent to the emissions of greenhouses gas (IPCC, 2014). Similarly, climate changes have far-reaching consequences for agriculture that will unreasonably affect smallholder farmers.

Agricultural sector plays the critical role in developing countries by the provision of food security, economic development and employment creation. However, the World agricultural production varies by a greater percentage from year to year, mainly as a result of weather conditions such as the occurrence of recurrent drought and flood in many regions. Agriculture in some regions is more sensitive to weather than in others regions. Variability with increased frequency and intensity of droughts and floods is expected to negatively affect agricultural production and food security (DFID, 2004).

Climate is one of the key factors of agricultural production, providing essential inputs (water, solar radiation, and temperature) needed for plant and animal growth. However, climate change and variability pose a great threat to food security and income of millions of people around the world. Changes in weather patterns have reduced crop harvest, increased food insecurity and malnutrition as well as poverty (Taneja *et al.*, 2014). The impact of climate change is experienced through variability of rainfall within the seasons and change in temperature (Philip *et al*., 2015). Changes in temperature and rainfall regime may have significant impacts on agricultural productivity and ecosystem provisioning services provided by forests and agroforestry systems (Leslie, 2013).

Climate change adversely affects the poor and marginalized groups. The main reason is that the rural agricultural communities are dependent on the fragile agricultural activities for their means of livelihoods. They are also located in areas of high environmental risk and climatic exposure and easily affected by climate change and variability (FAO, 2012). Climate extremes have led to poor harvest and increase in food price. The most important perceived effects of climate change and variability on crop production includes the late start of rain, dry spells and drought, high temperatures, decreasing soil fertility, floods, shortening of growing season, pests and diseases (Babatolu and Akinnubi, 2016).

2.2.4. Ethiopian Agricultural Sector and Climate Change

Ethiopian economy primarily depends on agriculture. This sector is an important sector for the communities and also serves as an engine for economic growth in Ethiopia. Agricultural sector includes the production of crops, livestock husbandry, forestry, fishery etc. In line with this climate is the key determinant factor for economic growth and development. This is due to the fact that most of the population in Ethiopia is depend on rain fed-agriculture sector which exacerbated its vulnerability to climate change impact due to its geographical location, topography and low adaptive capacity (Aschalew, 2014).

Climate change is one of a significant challenge in Ethiopia by disturbing food security, water and energy supply, poverty reduction and sustainable development efforts, as well as by causing natural resource degradation and natural disasters. The effects of climate change particularly pronounced on poor people's lives directly affect their livelihoods' reduction of crop yields or destruction of infrastructure and indirectly through increasing food price and food insecurity (IPCC, 2014). The frequent climate related hazards occurred in Ethiopia include drought, floods, heavy rains, strong winds, frost, high temperatures, and etc. (Carlton *et al.,* 2016).

Climate variability coupled with the low agricultural productivity and the low technological and capital base of rural households makes the country particularly vulnerable to adverse effects of climate change. The severity of the impacts of such changes is expected to be more affect the poorest and most destitute segments of the population. Some authors have recommended that solutions to these multiple problems may be found by seeking traditional agricultural practices and incorporating them into new, science-based plans for agricultural development. Over generations, local people, especially Ethiopian, developed their own specific natural-resource management systems like conservation agricultures, integrated crop and livestock management, irrigation and check dams (Badege *et al.,* 2013).

2.2.5. Adaptation to Climate Change

Adaptation is simply changes the society needs to make to ameliorate climate change impact. The major goal of an adaptation measure is to raise the capacity of a system in order to reduce the effect of climate change (USEPA, 2012). Adaptation is necessary as mitigation effort is not sufficient to stop global warming when the effect of climate change is already

perceived by the community. The primary concern in agriculture is does the smallholder farmer really observe the change in climate through time and its impact on their production, which adaptation options are applied by smallholder farmers and what are the primary barriers for adopting new strategies. Adaptation is an adjustment to decrease the effect of climate variability and promoting sustainable development (Okonya *et al*., 2013).

In order to improve yields during low rainfall period, the development of drought-resistant crops is a crucial target. Increasing frequency of rainfall changes leading to early, mid and late season droughts are affecting the production of crops grown under resource constrained situations with a consequent effect on livelihoods of poor farmers. Ethiopian Farmers still cultivate local varieties of crops that are susceptible to viral diseases which are caused by insect vectors under drought like situations. The productivity of these local cultivars is low and often crop failures are experienced either due to rainfall extreme or disease occurrence (Nicola, 2010).

Therefore, improved high yielding short duration varieties along with proper management practices are to be introduced and promoted so as to resist climate related problem. Improved crop varieties which are tolerant to severe floods, droughts and pest/diseases, use nutrients and water efficiently and can adjust to climate change and variability. These varieties can be sown in different planting dates in a cropping season to adjust to changing monsoon time and temperatures (Prasad *et al*., 2014).

Climate change adaptation practices includes soil and water conservation practice to improve productivity, rainwater harvesting, use improved crop varieties, agroforestry, reforestation, planting tree, composting, integrated watershed management, integrated crop-livestock based diversification strategies, small scale irrigation, intercropping and promotion of improved livestock feed, herd management, engagement in off-farm income activities, adjusting planting date and crop diversification (Belaineh *et al.*, 2013; Nyasimi *et al*., 2014).

Integrating trees into the agricultural systems (cropping, pastures, fences or home gardens) is an effective strategy to protect arid areas against land degradation and reduction of biomass (Joseph, 2014). This practice intended to address issues of soil erosion and diversification of farm produce as well as agricultural yield, resilience to climate variability. Therefore, this adaptation strategy is crucial to improve soil cover and ensure green cover during the off-season (Kitalyi *et al*., 2011).

The other important climate change adaptation strategy is soil and water conservation measure. Since majority of the areas are mountainous and the crop fields are rarely flat often they are located on a hill side or in a valley side. This creates extra demand for soil and water conservation to prevent the soil and rainwater from being washed away. Soil and water conservation practice include terraces, bunds, contour cultivation, grass strips and check dams. It reduces run-off and soil erosion, which can help to increase yields, especially on steeply sloped land (Obalum *et al*., 2011).

Rain water harvesting and water management is considered as one of climate change adaptation strategies to respond the negative impact of climate change and variability, because agricultural water management practices improve water balance and availability, infiltration and retention by the soil, reduce water loss due to runoff and evaporation, and improve the quality and availability of ground and surface water (Arslan *et al.*, 2013).

Water management includes irrigation, drainage and water conservation and control stabilizes crop production by maintaining soil conditions close to the optimum for crop growth. Water management practices such as terracing can reduce runoff speed, especially on erosion-prone highlands thus reducing soil erosion. It also allows some water to seep into the soil (infiltration), improving the soil to allow more vegetation cover. This practice also increases groundwater recharge and protects the topsoil (FAO, 2014).

2.3. Review of Empirical Studies

2.3.1. Perceptions and Adaptation Strategies to Climate Change

Perception about changes in temperature and rainfall pattern is a crucial prerequisite for applying any kind of climate change adaptation options (Bewket, 2010). Empirical studies conducted in African countries such as Nyanga *et al*.(2011) in Zambia, Temesgen *et al*.(2008) in Nile-basin of Ethiopia and Slegers (2008) in Semi-arid central Tanzania show that more than 80 percent of farmers perceived that change in climate components over the last three decades (increasing temperature, reducing rainfall). When the farmers perceived the change in climate they prepare to adjust their farms in order to reduce the negative impact of climate change. Similarly, the study conducted by Babatolu and Akinnubi (2016) in the Upper and Lower Niger River Basin Development Authority Areas, Nigeria showed a

majority of the smallholder farmers perceived the change in climate and adopt different response mechanisms (such as soil and water conservation, irrigation practice, etc…)

Teka *et al*., 2012 described that rural farmers actually perceived that the reduction of their crop and livestock production and their land productivity in the past two decades. One of the primary climate hazards in Ethiopia was drought and it occurred recurrently. For instance, the farm households who perceived the change in climate used improved crop varieties, adjusting planting date, soil water conservation, crop diversification and irrigation practise to reduce the impact of climate change (Gebre *et al.*, 2015).

Farmers who actually perceive the change in climate use different climate change adaptation strategies. Van *et al*. (2015) suggest that adaptation measures taken by poor farmers are characterized by relatively simple, minimum collective action, and low-cost options. These include adjustments to planting time and diversification of crops. The main adaptation strategies of farmers identified in different studies conducted in sub-Saharan African countries including Ethiopia include a change in crop types, changing cropping and planting practices, planting short season varieties, using inter-house transfers and loans, changing planting dates, planting trees, crop diversification, soil conservation, irrigation practice, temporary or permanent migration (Bryan *et al.*, 2009; Bryan *et al.*, 2010; IFPRI, 2010; Temesgen *et al*., 2008).

Belaineh *et al.* (2013) reported that more than 95 percent of the sample households perceived that increase temperature and reduce amount of rainfall in the Eastern part of Ethiopia. The commonly used climate change adaptation options were crop diversification, soil and water conservation and water harvesting practices. On the other hand, the barriers for the choice of adaptation strategies suggest that land tenure, soil fertility, and access to extension service and credit are the most significant factors affecting the adaptation capacity of farmers (Sarr *et al.*, 2015).

2.3.2. Empirical Studies on the Determinants of Farmers' Choice of Adaptation Options

Several studies were conducted on the determinants of farmers' decision for the choice of climate change adaptation strategies in many parts of the world including Ethiopia. The decision of farmers to adopt climate change adaptation strategies mainly depends on the

availability of natural resources, level of development, technological knowledge and information about climate change. Smallholder farmers affected by multiple factors for their decision to choose climate change adaptation strategy. In the following section review of the most important empirical studies are presented.

Empirical evidence shows that being female headed households are less likely to adapt climate change adaptation strategies due to their limited access to information, land, inputs and institutions as a result of traditional social barriers (Aemro *et al*., 2012; Anbesu, 2013; Belaineh *et al*., 2013; Gebre *et al.*, 2015; Negash, 2014; Kipkoech *et al*., 2015). On the other hand, female headed households are more likely to take up adaptation options. The possible reason for this observation is that in the farming community most agricultural activities are done by women; hence, women have more farming experience and information on various management practices. They utilize their experience and information to adopt various adaptation options based on available information on climatic conditions and other factors (Nhemachena *et al*., 2014).

The more educated and experienced farmers are more likely to perceive to climate change and to up take different strategies to response the negative impact of climate change. The possible reason is educated and experienced farmers are expected to have more information and knowledge on changes in climatic conditions and the agronomic practices that they can use in response (Maddison, 2006; Hassan and Nhemachena, 2008; Aymone, 2009; Temesgen *et al*., 2009; Gadédjisso, 2015). However, the result by (Uddin *et al.*, 2014; Ndamani and Watanabe, 2016) revealed that older farmers are less likely to adopt climate change due to lack of information and incentives.

Evidence have shown that lack of accesses to climate information is one of the primary determinant factors for the choice of adaptation options. Farmers having climate information are more likely to be adopting climate change adaptation strategies. The reason could be access to climate change information such as farmers' awareness on increase in temperature and decrease in precipitation have a higher chance of taking adaptive measures in responding to the observed changes. Likewise, climate change information enables farmers to decide on the crop to grow and type variety to use (Lemmi, 2013; Kipkoech *et al*., 2015; Hailemariam *et al*., 2016). Access to timely weather information increases the probability of adopting climate change (Tiwari *et al.*, 2014).

Income of the household is another determinant factor for the choice of climate change adaptation strategies. It includes both farm and non-farm income of the households. It is expected that both wealth and income increase with farming experience. If the income and assets of the household increase, the farmers decision to choice climate change adaptation strategies increases (Ikheloa *et al*. 2013; Side, 2014). Similarly; access to credit and livestock ownership increases the likelihood of adaptation options to respond climate change impact (Temesgen *et al*., 2009; Aemro *et al*. 2012; Tesso *et al.*, 2012).

Frequency of extension contact enhances the efficiency of making adoption decisions. Farmers who have access to free extension services are significantly increases the up taking of climate change adaptation options (Temesgen *et al*., 2013; Nhemachena *et al*., 2014). Being a member of a social group and farmer to farmer extension contact have a significant and positive impact on the likelihood of using adaptation strategies. Since farmers involved in cooperatives share their knowledge, innovative ideas, discuss problems and challenges with others and engage in collaborative decision-making (Kide, 2014; Uddin *et al*., 2014).

Distance from the nearest market is the other determinant factor for the choice of climate change adaptation strategies. Side *et al*. (2016) conducted Assosa district of Benishangul Gumuz Regional State, revealed that when farmers are far from the market, the transaction cost for acquiring input and output will be high and this will, in turn, reduce the relative advantage of adopting new agricultural technologies. Distance to market, negatively affects the adoption decision for all inputs the distance constitutes indeed a constraint on the time that farmers can devote to accessing information and agricultural inputs, which in turns determines the cost of production.

A study undertaken by Aschalew (2014) showed that education, farm size, the number of the livestock, farmers-to-farmers extension and access to credit are determinants of climate change adaption strategies. They have a positive and significant relationship between adaptations to climate change in Ethiopia. Large farm size and higher farm income lead farmers to prefer soil water conservation practice as a means of climate change adaptation option (Taddesse, 2011).

The result of a study by Anbesu (2013) indicated that sex has negative and significant impacts on the perception of climate change. It also indicates that educated farmers are more likely to perceive to climate change. Family size has also the positive and significant effect

on the awareness of rainfall change, drought and drought frequency and damage of crop due to climate change. The result of the binary Logit model shows that Farm experience has positive and significant effect on the use of Crop diversification; improved crop varieties and early maturing crop variety whereas access to credit has a negative impact on these adaptation methods. Similarly, access to extension has a positive and significant effect on applying crop varieties and short maturing crop varieties. However, education, farming experience, and climate information had no statistically significant effect on adaptation strategies.

Belaineh *et al*. (2013) used a multinomial Logit model to identify determinants of climate change adaptation in Doba district of west Hararghe zone. .Findings from this study reveal that agro-ecology zone, sex of household head, plot size and frequency of extension contacts have a significant and positive influence on crop diversification and the use of SWC practices. On the other, hand family size, off-farm income and training have a significant negative influence on the above climate change adaptation strategies. Similarly, plot size, livestock (TLU) and frequency of extension contacts are significantly and positively associated with integrated crop-livestock based diversification while family size, off-farm income and training are significantly and negatively associated.

A study in Nigeria, by Ikheloa *et al*. (2013) used the Multinomial Logit Model reported that gender, household income, farm size, farming experience, education level, access to credit and extension facilities have a positive relationship with the use of crop diversification strategy, different planting and harvesting dates and soil conservation techniques.

A survey carried out in the Northern Ethiopia revealed that farmers living in different agro ecological setting had used different climate change adaptation option (Gebre *et al.*, 2015). The result noted that farming in weynadega significantly decreases the probability of using irrigation and soil and water conservation as compared to farming in Kola. Similarly, age of the household head significantly increases the probability of adopting climate change adaptation options by considering as farming experience. However, (Belaineh *et al.*, 2013; Temesgen *et al*., 2013) found that age did not have a significant impact on the probability of choosing adaptation techniques in Eastern Hararghe, Ethiopia. Similarly, education, farm income, extension services, access to credit and access to climate information had a positive and significant impact on the choice of farmers to climate change adaptation options.

Gadédjisso (2015) used the Multinomial Logit Model to understand farmers' perception and adaptation to climate change and variability in Maritime, Plateau and Savannah Regions of Togo. The results of this study revealed that increase the level of education significantly increases planting short season variety as an adaptation. As farmer experience increases the probability of uptake of crop diversification, changing planting dates and planting short season variety as adaptation measures. The results show that access to extension services, access to credit and access to climate information significantly increases the probability of taking up adaptation options.

According to the result of Apata (2012) education of the head of the household, household size, gender of the head of the house-hold being male, livestock ownership, extension for crop and livestock production, availability of credit, and temperature. The result indicates that as the size of the household significantly increases the choice adaptation options to reduce the negative impacts of climate change because various agricultural tasks are labor intensive technology. Similarly, higher endowments of labor were better to adapt climate change and variability (Oyekale and Oladele, 2012).

According to Mishra and Sahu (2014), level of education has negatively related to climate change adaptation to respond to the negative impact of climate change. The possible reason was the more educated peoples left from agriculture and searched for other occupations into the town. On the other hand, land size, experience of the farmer, free extension service, wealth and large farm size are among the factors that positively influence the adaptation decisions to climate change.

According to the result of Tagel and Veen (2013), sex of household head significantly influenced adaptations options such as using crop diversification, changing planting dates and planting trees. The findings showed that male-headed households were 18.2 percent, 12.2 percent, 5 percent and 14 percent more likely to apply use crop varieties, conserve soil, plant trees and irrigation to adapt to climate change, respectively. Age, education and household size had a significant, positive effect on adaptation to climate change. Similarly, the more educated and experienced farmers are the more likely to use improved technologies due to their knowledge to search information about climate change and adaptation options.

Generally, there are many determinant factors that influence farmers' choice of adaptation strategies. These factors include the household demographic characteristics (sex, family size, farming experience, literacy status), socio-economic (assets, on and off-farm income), institutional factors (free extension service, market distance, credit utilization) and social capital (farmer to farmer extension contact and PSNP). These are the most important variables identified by many kinds of literatures in determining whether or not a household take adaptation strategies used to cope with the impact of climate change.

Finally, we can understand that different empirical studies have been carried out to see the effect of different factors on farmers' decision behavior regarding the choice of adaptation methods to climate change. However, factors in one area different from the other area. That means a factor, which is found to enhance choice of a particular climate change adaptation option in one locality at one time, may hinder it or an irrelevant factor in another locality. Due to this reason, it is difficult to develop a universal model of the process of adaptation strategies with defined determinants and hypotheses that hold everywhere. This is difficult because the socio economic and ecological distinctiveness of the different sites, and the dynamic nature of the determinants, since there is a repeated need for analyses under different conditions.

Even though many previous studies were conducted in adaptation option of farmers and their determining factors were carried out in many countries, most of them undertaken at the macro level. This is difficult to consider the problem of the individual household (FAO, 2012). Thus, it is very important to clearly understand what is happening at household level before formulating and implementation of policy. It is better to give emphasis about farmers' perceptions and expectations regarding the past and future climatic changes, the actual measures they took, their preferences for adaptation strategies and their determinant factors for future adaptation of the agricultural sector to climate change (Nhemachena and Hassan, 2007).

2.4. Conceptual Framework of the Study

The conceptual framework used in the present study represents links between the perception of household's, choice of an adaptation strategy and their determinant factors to response climate change. There is a need to examine the interrelationship and interactions of various factors revolving around the adaptation strategy choice of smallholder farmers. The success

of climate change adaptation critically depends on the available financial resources, natural resources, knowledge, technical capability and institutional resources. In addition, many social, economic, biophysical, political context, technological and environmental trends will critically shape the future ability to adapt to climate change (PCGCC, 2004).

Smallholder farmers' choice of adaptation strategies decisions to climate change is determined by household socio-economic characteristics (on and off-farm income, land holding, livestock owner ship), demographic characteristics (sex, farming experience, level of education), institutional factors (free extension contact, access to credit, climate information and distance to the nearest market) and social capital (farmer to farmer extension contact). These are the most important variables identified by several literatures in determining whether or not a household take adaptation strategies used to cope with the impact of climate change.

Different empirical studies have been carried out the effect of different factors on farmers' decision behavior regarding the choice of adaptation methods to climate change. Some of the main features of communities or regions that appear to determine their adaptive capacity are economic wealth, technology, information and skills, infrastructure, institutions, and equity. However, the effects of the determinant factors to enhance choice of a particular climate change adaptation option in one locality at one time may hinder it or an irrelevant factor in another locality. Thus, it is difficult to develop a universal model of the process of adaptation strategies with defined determinants and hypotheses that hold everywhere. This difficulty is because of the socio economic and agro-ecological distinctiveness of the different places, and the dynamic nature of the determinants.

Generally, smallholders choose different types of climate change adaptation strategies depending on their livelihood assets, the social structures and institutions that impact them under a given climate change vulnerability. Understanding the various and dynamic adaptation strategies helps to identify appropriate strategies for intervention and to introduce new strategies that have a greater impact to reduce the adverse effect of climate change on smallholder farmers. Hence, the following analytical framework portrayed the most important variables expected to influence the farmers' choice of adaptation methods to climate change taking into account the specificity of Jamma district.

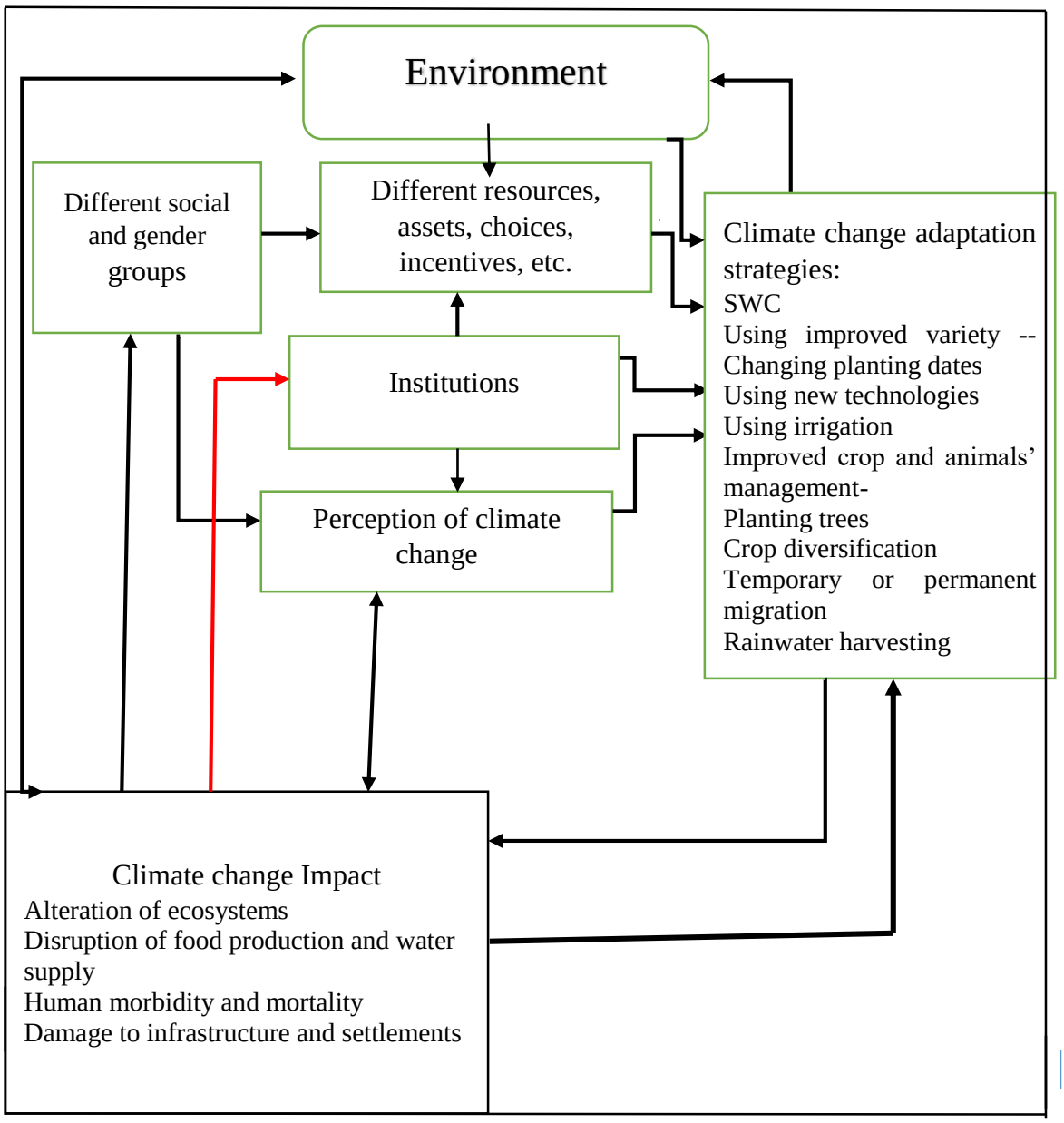


Figure 1. Conceptual framework of the study
Source: Belaineh *et al*., 2013; Seid *et al*., 2016 with modification

3. RESEARCH METHODOLOGY

This chapter includes a brief description of the study area, sample size, and sampling technique, source and data type, methods of data collection and analysis and variable definition and hypotheses.

3.1. Description of the Study Area

3.1.1. Location

Jamma is one of the districts in South Wollo Zone of Amhara National Regional State. The district is geographically located between 10º 06´ 24" to 10º 35´ 45" N and between 39º 04´ 04" to 39º 23´ 03" E. The altitude range of the district is between 1428m - 2752 meter above sea level. Jama is bordered on the southeast by the Qechene River which separates it from the North Shewa Zone, on the West by Kelala, on the East Gera Mider and Keya Gebrieal, on the north by Legahida, and on the northeast by Were Ilu (Mulugeta, 2016).

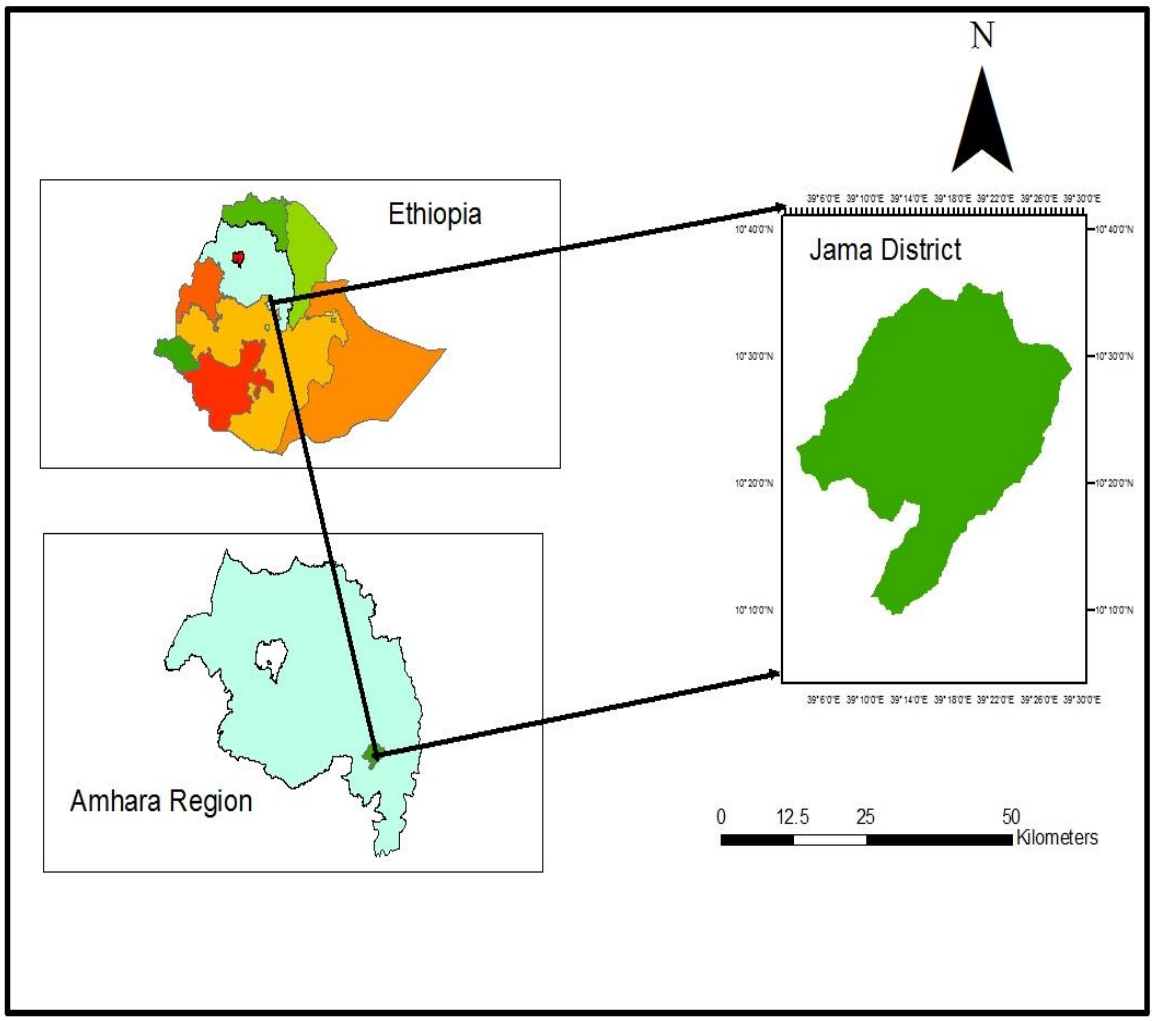
Nowadays, this district has 23 Kebeles of which 22 are rural kebele administration areas and 1 is town kebele. Dogolo is the Towns of the district which is located at about 264km from North East of Addis Ababa, and 110 km south of Zonal Town Dessie. The area is one of the less accessible places in the Region. There are few motor roads across this rugged topography (Shewangzaw, 2014).

3.1.2. Topography

The topography of the area is undulating with medium slope and widely distributed gullies in sub-water sheds. Due to rolling types of the area, the erosion hazards have a series impact on farmland (JDBoARD, 2017).

3.1.3. Demography

Based on CSA (2015), the total population of the district' was 148,168 people. Of which, 72,602 (49 percent) were males and 75,566 (51 percent) were females. The district has a population density of 147.58 persons per square kilometre. About 32,165 households are counted with having 4.39 average persons to each household (JDBoARD, 2017).



Map 1. Location of Study Area
Source: GIS Expert

3.1.4. Climate and Land Characteristics

The district has two agro-ecological zones out of which 76 percent of the area is high land (Dega) and 24 percent of the area is mid land (Woina Dega) weather condition, respectively. Rainfall mostly occurs from June to September (main rain season), locally known as "Kiremt", and February to end of April there is small rain season, which is locally known as "Belg". The small rainy season is erratic and highly variable. There is a long dry period from the October to February, and a short dry spell in June (Abdu, 2010). The average rainfall of the district is 1130 mm and the average land size per individual farmer is 1.5 ha. The altitude ranges from 2529-2610 m.a.s.l having uni-modal rainfall receiving the already explained average rainfall. Soil composition of the district by color is as follow. About 63 percent black, 10 percent red, 18 percent gray and 9 percent brown with 84.2 percent clay 6.8 percent sandy and 9 percent alluvial accumulation soil texture (Yonas, 2014).

3.1.4. Economic Activity

The economy depends on crop production supplemented by livestock rearing. About 80 percent of the districts population livelihood depends on mixed agriculture, 7.6 percent of the population dependent on crop production alone, 3 percent and 9.4 percent on handcrafts and trade, respectively. The main crops grown in the area are wheat, teff, red sorghum and pulses. Sheep, cattle and equines are the main livestock types reared. Cash is generated from the sale of livestock and livestock products more than crop sales in the area (Jamma *District* Environmental Protection, Land Administration and Land Use office report, 2016).

3.2. Sampling Technique and Sample Size

This study employed two stage sampling technique to draw the sample. At the first stage, by using stratified random sampling technique 22 rural kebeles were stratified into two agro ecological zones. There are 17 kebeles located in the highland and the remaining 5 kebeles located in the mid land. Accordingly, five Kebele were selected 4 kebeles from the highland and 1 from the mid land agro-ecologies using probability proportional to size in the district. In the second stage, a total of 156 household heads were selected by using simple random sampling (SRS) with probability proportional to size technique. Large sample size increases the accuracy of the data. Therefore, the indicated sample size is considered to be enough given the fact that the study area has more or less homogeneous characteristics in terms of farming system, availability of different infrastructure and other socio economic indicators. To identify the sampling frame of the study, list of household heads that was taken from local agricultural and administration offices in the selected five kebeles , list of households who are participate in agricultural occupation were identified from selected five kebeles by enumerators with the help of village leaders, from which the sample respondents were to be drawn.

Table 1: Sample household distribution of the selected kebele

Sample *Kebeles*	Total household Heads	Sample size	Percentage of the total sample
Amayo	873	30	19.2
Billew	867	30	19.2
Shulafaf	1165	40	25.8
Tefftef	519	18	11.5
Zerkami	1097	38	24.3

Total	4521	156	100

Source: District Agricultural Office and kebele administration, (2017)

3.3. Sources and Methods of Data Collection

In order to get reliable and valid data, the study was used both primary and secondary data sources to collect both qualitative and quantitative data. The study mainly used primary data because it gives first-hand information and the topic needs deep investigation by the primary data source. Primary data focused on demographic, socioeconomic and institutional factors were collected through household questionnaire survey and also through focus group discussion. Secondary data were also collected from different sources like journal articles, books, CSA, NMSA records from the concerned bodies and published and unpublished documents. Secondary data collected from such sources include demographic characteristics, agricultural activities, physical characteristics, rainfall and temperature data etc.

The interview schedule was first pretested on 12 randomly selected farmers and based on the result of the pre-test, some modifications were made on the questionnaire before the execution of the formal survey. Enumerators who have prior experience in data collection, know the area and communities' languages were recruited. The researcher gave training for those enumerators regarding the content of the questionnaire and data collection procedure and the interviews were conducted between March and April 2017.

The study used questionnaires as the major source of data collection tool to collect data from households by using interview method. The study prepared both open ended and closed ended questions which were developed on the basis of the objectives of the study. Majority of the households in the rural areas assumed to be illiterate and hence the questionnaire was translated into their own local language and the interviewers must gather relevant information.

The study conducted FGD for the sake of providing qualitative data which gives an insight into attitudes, events, and perceptions difficult to obtain using other data collecting procedures and also to get more information from the group discussion rather than an individual. To avoid specific group's idea dominance and empowering women, the focus groups were rearranged by sex and age. The focus group discussion was important to share experiences, problems, their choice of adaptation option and possible solutions for the future action.

3.4. Methods of Data Analysis

After the data were collected from the sample respondents, both descriptive statistics and econometric model were used depending on their importance for analyzing the data. The data were analyzed using Statistical Package for Social Science (SPSS version 20) and STATA 13 software.

3.4.1. Descriptive Statistics

The descriptive statistical tools such as, mean, percentages, graphs, frequencies and standard deviations, as well as Likert rating scale, was used to characterize farmer's perceptions on climate changes and describe various climate change adaptation measures being used by farmers.

3.4.2. Econometric Analysis

The study employed a multivariate probit model was used to identify the factors influencing farmer's choice of climate change adaptation strategies to response the negative impact of climate change in the study area. The most preferred climate change adaptation strategies by African farmers are mainly applied in combination with other strategies and not alone (Hassan and Nhemachena, 2008). The most commonly used analytical approaches used in an adoption decision studies with multiple options are multinomial logit or probit and rank-ordered logit or probit models (ACCCA, 2010; Temesgen, 2010; Aemro *et al*., 2012; Belaineh *et al.*, 2013; Negash, 2014; Gebre, 2015). The shortcomings of most of these previous studies on adoption of climate change adaptation strategies are that they do not consider the possible inter-relationships between the various adaptation strategies (Yu *et al*., 2008).

Both the multinomial logit (MNL) and multinomial probit (MNP) are important for analyzing farmer adaptation decisions when the choices are independent. However, both of them are inadequate to analyze factors affecting adaptation strategies of farm households as it does not capture correlations of error terms between different adaptation strategies. Most of the scholars who worked on climate change adaptation options preferred MNL model due to its computational friendliness in calculating the choice probabilities that are expressible in analytical form. But there is a problem in interpreting the influence of an explanatory

variable on the separate adaptation strategies especially when the choices could be made jointly. Other empirical studies used principal component analysis (Mandleni and Anim, 2011) and Ricardian model (Apata *et al*., 2011).

Furthermore, the logit model is limited in two important ways regardless of correlations of error terms. It cannot represent random taste variation and it exhibits restrictive substitution patterns due to the IIA property. Probit models deal with all three. They can handle random taste variation, they allow any pattern of substitution, and they are applicable to panel data with temporally correlated errors. Until recently, estimation of MVP models, despite its appeal, has been difficult due to computational intractability especially when the response is high dimensional. However, recent advances in computational and simulation methods made this class of models more widely used.

Multivariate probit model assumes that given a set of explanatory variables the multivariate response is an indicator of the event that some unobserved latent variable falls within a certain interval. The latent variable is assumed to arise from a multivariate normal distribution. The likelihood of the observed discrete data is then obtained by integrating over the multidimensional constraint space of latent variables. The only assumption of probit models is that they require normal distributions for all unobserved components of utility. In many, perhaps most situations, normal distributions provide an adequate representation of the random components (Chib and Greenberg, 1998).

Some recent scholars used multivariate probit regression model to analyze determinants of choice adaptation strategies to climate change (Nhemachena *et al*., 2014 and Seid *et al*., 2016; Wondimagegn and Lemma, 2016). Moreover, the sample respondents adopt several climate change adaptation strategies simultaneously in the study area. In this case, the appropriate econometric model that take care such kind of condition is multivariate probit model. For instance, this study utilized multivariate probit (MVP) econometric technique to examine the determinants of various adaptation options while allowing the correlation across error terms due to unobservable explanatory variables.

The unique feature of the study simultaneously examined the influence of the set of explanatory variables on each of the different adaptation strategies by using the model. Multivariate probit model explicitly recognizes and controls the potential correlation among adaptation options and provide an accurate estimate of relationships between each adaptation

option and its explanatory variables. The specification of Multivariate probit regression model is as follows:

The dependent variable in the empirical estimation for this study is the choice of an adaptation option(s) from the set of adaptation measures. Following Lin *et al*. (2005), the multivariate probit econometric approach for this study is characterized by a set of N distinct binary dependent variables Y_{hpj} and a matrix of covariates that can be any mixture of discrete and continuous variables. Such that:

$$Y^{*}_{hpj} = X'_{hpj}\beta_j + U_{hpj} \quad j=1, 2 \ldots N \text{ and} \tag{1}$$

$$Y_{hpj} = \begin{cases} 1 & If Y^{*}hpj > 0 \\ 0 & Otherwise \end{cases} \tag{2}$$

Where j=1, 2…N denotes the available climate change adaptation strategies; X'_{hpj} is a vector of explanatory variables, β_j denotes the vector of parameter to be estimated, and U_{hpj} vector of residual error distributed or random error terms distributed as multivariate normal distribution with zero mean and unitary variance. It is assumed that a rational h^{th} farmer has a latent variable, Y^{*}_{hpj} which captures the unobserved preferences or demand associated with the j^{th} choice of adaptation strategy. This latent variable is assumed to be a linear combination of observed household and other characteristics that affect the adoption of adaptation strategy, as well as unobserved characteristics captured by the stochastic error term.

Given the latent nature of the variable Y^{*}_{hpj}, the estimation is based on the observable variable Y_{hpj} which indicates whether or not a household adopt a specific climate change adaptation strategy. As adoption of several adaptation strategies is possible, the error terms in equation (1) 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 N^{th} type of adaptation strategies. This assumption means that equation (2) gives a multivariate probit model that jointly represents decision to adopt a particular adaptation strategy. This specification with non-zero off-diagonal elements allows for correlation across error terms of several latent equations, which represent unobserved characteristics that affect choice of alternative adaptation strategies.

3.5. Variable Definitions and Hypothesis

The actual major adaptation strategies in the study area based on asking sample households and the actions they take to respond to the negative impact of climate change include the use of improved crop varieties, using soil and water conservation practices, adjusting planting dates, crop diversification and using small scale irrigation practice.

Independent variables

The choice of explanatory variables was based on the review of past studies on climate change adaptation strategies. This study includes the demographic characteristics of the household, institutional factors, geographical location of the household, an economic and environmental condition in which the household is located. Based on this, the following explanatory variables were hypothesized to explain the determinants of smallholder farmers' choice of adaptation strategy.

Sex of household head (SexHH): It is dummy variable taking value 1, if the household head is male and 0, otherwise. Lemmi (2013) argued that being male headed household have positive effects on the adoption of soil and water conservation measures and planting trees. Similarly, Belaineh *et al*. (2013), Ikheloa *et al*. (2013), Tagel and Veen (2013); Negash (2014), and Gebre *et al*. (2015) argue that having a female head of household have negative effects on the adoption of soil and water conservation, use of new crop varieties and livestock species, crop diversification, irrigation use measures as adaptation strategy, because women may have limited access to information, land, and other financial resources due to traditional social barriers. However, the result of Nhemachena and Hassan (2014) study, indicated a contrary result to the above argument by showing that female headed households are more likely to use crop diversification, irrigation, and water conservation practices as adaptation strategies. This study hypothesized that sex affects adaptation decision of farmers either positively or negatively.

Education level of the household head (Educlev): Educational level of household head is a continuous variable measured in years of schooling. Education is necessary to provide individuals with the knowledge of how to make living better. Higher level of education is believed to be associated with access to information on improved technologies and higher productivity (Temesgen *et al*., 2014). Evidence from various sources indicates that there is

a positive relationship between the level of education of the household head and adaptation to climate change (Gebre *et al*., 2015). Balama (2016) study reveals that highly educated persons were likely to perceive that climate is changing than uneducated ones. Educated and experienced head of households is expected to have more knowledge and information about climate change and agronomic practices that they can use in response. Therefore, this study also hypothesized that farmers with a higher level of education are more likely to use new improved crop varieties, changing planting date, crop diversification and use irrigation as an adaptation measure to climate change.

Farming experience (Farmexpr): It is a continuous variable and represents the experience of the household in the farming activities. This variable is used as a proxy for age of household. The more experienced farmers in farming would have better weather forecasting ability and increased the probability of uptake of adaptation measures such as adjusting planting date (Seid *et al*., 2016). This study hypothesized that farming experience increases the probability of using adjusting planting dates, irrigation and crop diversification to adapting climate change.

Household size (HHsize): It is a continuous variable which represents the number of family members in the household head. The effect of family size on use of adaptation methods can be positive or negative. First, increase in the household size reduce labor constraints to respond to the effect of climate change and increase the probability of planting trees to adapt climate changing (Tagel, 2013; Mishar and Chandra, 2014). On the other hand, if the size of the household is large it may reduce the per capita income of the family and may put pressure on the consumption pattern (Apata, 2012; Belaineh *et al*., 2013; Poudel, 2015). Due to this reason, this study hypothesized that family size may have either positive or negative effect on the use of climate change adaptation strategies.

Land size (Land*):* It refers to the size of cultivated land measured in hectares by the household head. It is the fundamental asset of the majority of rural households. Empirical studies on adoption of agricultural technologies indicated that land size has both positive and negative effects on adoption, showing that the effect of land size on technology adoption is inconclusive (Bradshaw *et al*., 2004). In contrary, Aymone (2009) indicated that land size increases the perception and adaptation to climate change strategies as farmers with large land can avoid making some capital intensive adaptation like irrigation. Thus, this study

hypothesized that the land size may have either positive or negative effect on the use of climate change adaptation strategies.

Farm income (Farminc): It is a continuous variable which measures the amount of annual farm income generated from farm products measured in Birr. Majority of the rural household get their income from selling of agricultural products. Farm income has a great contribution to improve the livelihood of rural households by reducing pressure from agriculture and increasing the household coping strategies of natural shocks (Tatek, 2012). Farm income of the household increases the likelihood of adapting to climate change using soil conservation, irrigation and livestock production (Negash, 2013). Therefore, this study hypothesized that the more farm income generated positively affect the decision of the household to use irrigation, improved crop varieties and crop diversification to adapt climate change and variability.

Livestock ownership (TLU): Livestock is a rural household asset and continuous variable measured in terms of tropical livestock unit (TLU). It plays a very important role by serving as a store of value, generating income, as a source of traction and provision of manure to increase soil fertility maintenance (Gandure *et al.,* 2012). Households who have better possession of livestock are expected to be less vulnerable to climate change and thus, for this study better livestock ownership was hypothesized to increase adaptation to climate change by using irrigation, improved crop varieties, adjusting planting dates and soil and water conservation practices.

Off/non-farm income (Off/non): It is an annual income of the household generated from off/ non-farm activities and is measured in Birr. Negash (2014) indicated that an increase in nonfarm income enhances the likelihood of adapting to climate change using soil conservation and changing planting dates. On the other hand, Belaineh *et al*. (2013) suggested that off -farm income is negatively associated with crop diversification strategies and the use of SWC practices, integrated crop-livestock based diversification and rainwater harvesting. Therefore, this study hypothesized that off/non-farm income has either positive or negative effect in using improved crop variety, soil and water conservation, adjusting planting date and crop diversification to adapt climate change.

Frequency of extension contact (Frqeextense): It is a continuous variable which takes the number of annual visits by development agent. Good extension contact enhances the

efficiency of making adoption decisions and in the specific case of climate change adaptation. Aemro *et al*. (2012) reported a mixed effect, where an increase in extension contact increases the probability of using improved crop variety and soil and water conservation practice but decrease using crop diversification. Thus, this study is also hypothesized that farmers who get more annual extension agent visit are more likely to use adjusting planting dates, improved crop varieties and soil conservation practices to adapt climate change.

Credit utilization (Credit): It is dummy variable and takes the value 1, if the household head has utilized and 0, otherwise. Credit utilization is another important institutional factor affecting adoption of agricultural technologies. Empirical studies on adoption of agricultural technologies indicate that the relationship between the level of adoption and availability of credit is positive and significant (Yirga, 2007 and Tesso *et al.,* 2012). Empowerment of credit access or grant facilities is crucial in enhancing farmers' awareness about the change in climate and to implement adaptation options (Apata, 2011). Thus, this study hypothesized that more credit utilizer farmers are more likely to use climate change adaptation strategies.

Access to climate information (Climainfo): It is a dummy variable that takes the value1, if households have access to climate change information and 0, otherwise. Information about climate change increases the probability of adjusting planting date and harvesting time, decision on the choice of variety and time of fertilizer application, practicing soil and water conservation and planting more trees at plot level (Oyekale and Oladele, 2012). Climate change information from different sources creates awareness and favourable condition for adoption of farming practices that are suitable under climate change. Also, it is an important precondition for farmers to take up adaptation measures (Longe and Oyekale, 2013). It also increases the perception level of pastoralist and hence increases the choice of pastoralist to take adaptation measure (Kadir, 2012). Therefore, this study also hypothesized that access to climate change information positively affects the decision of farmers to take up climate change adaptation measures (such as adjusting planting dates, crop diversification, irrigation, improved varieties of crops and soil conservation practices) to reduce the negative impact of climate change.

Distance to market (Distmar): Market access is a continuous variable measured in kilometers from homes. It is another important factor affecting adoption of agricultural technologies to purchase input materials such as different seed varieties, fertilizers and

irrigation technologies. Proximity to market is an important determinant of adaptation, presumably because the market serves as a means of exchanging information with other farmers (Maddison, 2006). Therefore, it is expected that households nearer to the market take more climate change adaptation measures otherwise it affects negatively.

Agro-ecological zone (AEZ): It refers to the agro-ecological setting of farmers. Belaineh *et al*. (2013) indicated that households who are living in *Kola* agro ecology do appear to have a higher probability of selecting and using crop diversification strategies and the use of SWC practices and rainwater harvesting. Thus, this study hypothesized that agro-ecological setting of the farm household affects the choice of their adaptation strategies to respond to the negative impact of climate change.

Farmers-to-farmers extension service (Farfarext): It is a dummy variable taking the value 1 if the farmer has access to the farmer to farmer extension services and, 0 otherwise. Different farmers have different skills, knowledge, work habits, and experience. Experience sharing of farmers is very important to build up the knowledge of the farmers and will help them to take the adaptation measures to respond to the negative impacts of climate change (Juana *et al*., 2013). Therefore, this study hypothesized that farmers to farmer extension services have a positive effect on the choice of climate change adaptation option (such as use of improved crop varieties, irrigation use, crop diversification, adjusting planting dates and soil and water conservation practices).

Based on theory and empirical literature the above independent variables were hypothesized. These independent variables included in the study are those variables (household demographic characteristic, environmental, institutional and economic factors) which are hypothesized to have associations with the households' adaptation strategies.

Table 2. Summary of the explanatory variables hypothesized to affect adaptation strategies

Variable	Variable label	Variable type	Expected sign
	Dependent variable		
Yhpj	Adaptation strategies to climate change		
	Independent variables		
AEZ	Agro-ecological zone(1,if the location is high land, 0, otherwise	Dummy	+/-
SexHH	Sex of the HH(1, if the household head is male; 0, otherwise	Dummy	+/-
Educlev	Education level of HH (year of schooling)	Continuous	+
Hhsize	Number of people in the household(Number)	Discrete	+/-
Farmexpr	Farming experience of household head (Years)	Continuous	+
Farminc	Annual farm income (Birr/year)	Continuous	+
Farmsz	Size of cultivated land (Hectares)	Continuous	+/-
TLU	Livestock holding (TLU)	Continuous	+
Non/off	Amount of annual non/off farm income(Birr/year)	Continuous	+/-
Frqeexten	Frequency of annual extension contact(Number)	Discrete	+
Credit	Credit utilization (Yes/ No)	Dummy	+
Climainfo	Access to climate information(Yes/ No)	Dummy	+
Farfarext	Farmers-to-farmers extension service (Yes/No)	Dummy	+
Distmar	Distance to market in kilometers (Km)	Continuous	-

4. RESULTS AND DISCUSSION

This chapter presents the key findings of the study obtained from quantitative and qualitative data from a household survey. Section one presents and discusses demographic and socio-economic characteristics of sample respondents. Section two presents and discusses farmer's perception on climate change and identified climate change adaptation strategies used by the smallholder farmers. The last section presents the determinant factors of farmers' choice of adaptation strategies to climate change in the study area by employing multivariate probit model.

4.1. Descriptive Statistical Results

4.1.1. Demographic Characteristics of the Sample Households

For this study, a cross-sectional data were collected from a total of 156 farm households. The most common household characteristics that are expected to be associated with the choice of climate change adaptation strategies are discussed below.

Sex of the household head: The survey result presented in Table 3 show that about 71.8 percent of the sample households were male headed and the remaining 28.2 percent were female headed. This result indicates that majority of the sample respondents are male headed households.

Table 3. Distribution of sample households by sex and marital status

Demographic indicator	Frequency	Percent
Sex of the household		
Male	110	71.8
Female	46	28.2

Source: Own survey data, 2017

Household size: The average family size of the sample respondents were 5.9 with a maximum of 11 and a minimum of 2 and standard deviation of 1.9. The result shows that 71.15 percent sample households have 5 and more family members.

4.1.2. Socio-economic Characteristics of the Sample Households

Education level: With regard to educational status, among the sample respondent's illiteracy rate was lower than literacy rate. About 41.7 percent of the surveyed sample households have no formal education. On the other hand, 58.3 percent of the household heads were literate. The result implies that there is a high level of literacy rate in the study area (Table 4).

Livestock holding: Farmers in the study area are engaged in mixed farming activities, including crop production (wheat, teff, red sorghum and pulses) and rearing of domestic animals such as cows, oxen, goats, sheep and donkey. Livestock has a considerable contribution to household income and food security in the study area. Farmers generate their income by selling livestock and livestock products. Besides this, cattle provide as draft power for crop production, manure for fuel and organic fertilizer (compost), meat and milk for consumption. Sheep and goats are used to meet immediate cash demand of the household and also used for meat production. Donkeys are the most important animal for transporting agricultural products and water. In the study area, sample households on average own 5.148 livestock in (TLU) with the maximum and minimum being 13.99 and 1.973 TLU, respectively (Table 4).

Land holding: The average cultivated land owned by the sample respondents was 1.67 ha with a minimum of 0.5 and a maximum of 3.5 ha and standard deviation of 0.82 ha in the study area. It is one of the scarce resources whose supply is fixed. This total cultivated land includes own land, shared-in, shared-out, rented- in and rented-out. The average farming experience of the household heads was 32.94 years with the maximum being 57 and the minimum experience being 16 years.

Income source of sample households: Households may rely on different ranges of income generating activities. In the study area, farmers generate their income mainly from on- farm activities (sale of crops, sales of livestock and livestock products). The other sources of income for some of the sample households are handicrafts, trade, and daily labor. The survey result indicated that the average farm income of the sample respondent was 16,304.4 birr per annum with a range of 1200 to 89,000. Similarly, their income from off/non- farm activities ranged from 0 to 32,000 birr with an average of 3,626.3 birr per annum (Table 4).

Table 4.Distribution of sample households by livestock, land size and income

Socio-economic characteristics	Mean	Std. Dev.	Min	Max.
Household size (number)	5.88	1.9	2	11
Education level(years of schooling)	3.744	3.708	0	12
Livestock holding (TLU)	5.148	3.232	1.973	13.99
Land holding (Ha)	1.67	0.82	0.5	3.5
Farming experience	32.94	9.08	16	57
Farm income (Birr/10,000)	1.630	1.233	0.12	8.9
Non/Off farm income(Birr/1000)	3.626	5.754	0	32

Source: Own survey data, 2017

4.1.3. Institutional Characteristics of Sample Households

Credit: Smallholder farmers depend on credit to purchase farm inputs and to respond to the negative impact of climate change. Because it is one of the basic means of financial solution for poor rural households at the time of adverse condition and helps to undertake various activities. In the study area, smallholder farmers got credit from both formal and informal lending institutions. The formal sources of credit in the district are Amhara Credit and saving institution (ACSI), and Commercial Bank of Ethiopia (CBE).The informal lending institutions are local lenders such as relatives, friends, traders etc. The survey results show that 65.4 percent of the sample respondents utilized credit services and while the remaining 34.6 percent have not utilized credit services. Some of the non-users replied that they could not utilize credit because of repayment fright (Table 5).

Distance to nearest market: In the study area, the average distance from the nearest market of the sample respondents was about 3.4 kilometers with the minimum and maximum distance of 0.25 and 18 kilometers, respectively (Table 5).

Frequency of extension contact: The result also shows that all the sample households had contact with development agents in relation to crop production, animal husbandry, and natural resource management extension packages including climate change adaptation strategies. Nowadays, the government has been attempting to fill the available knowledge gap by building farmer training centers (FTC) in each kebele. The development agents are important means of transferring information, new agricultural technologies and improving the farmer capacity for innovations. The frequency of extension contact with the farmers

ranges from 12 to 52 times with an average contact of 28.07 times per year and standard deviation of 10.19. The agricultural extension supervisors also emphasized that they regularly organize training on different farming practice and coping strategies on climate change adaptation options (Table 5).

Climate information: Climate change information increases the household perception level and choice of adaptation strategies. Out of the total sample households surveyed, 87.6 percent reported that they have access to climate change information and only 12.4 percent of the sample households have no access to climate change information. Majority of the respondents suggested that their source of information were extension agents, radio, mobile phone and communicating with other farmers (Table 5).

Farmer to farmer extension services: The surveyed result shows that 78.9 percent of the sample households have access to farmer to farmer extension services to share information about the climatic condition, use of agricultural inputs and important farming materials with each other, whereas 21.1 percent reported the opposite. During FGD the farmers indicated that participation in farmer to farmer extension is important to share idea about construction of different soil and water conservation measures (such as tree planting, mountain tree planting, gabion etc.) and other climate change adaptation measures. (Table 5).

Table 5. Institutional characteristics of the sample households

Institutional **characteristics**	Mean	Std.	Min	Max
Distance to nearest market (Km)	3.42	2.73	.25	18
Frequency of extension contact (number)	28.07	10.19	12	52
Credit (yes)	0.654			
Climate information (yes)	0.876			
Farmer to farmer extension services(yes)	0.789			

Source: Own survey, 2017

4.2. Smallholder Farmers' Perception of Climate Change

Perception is one of the first most important steps in the process of designing some form of change in farmers' livelihood system to respond to the negative impacts of climate change. Climate change is not an outcome of a single time phenomenon; it has taken thousands of years for its beginning. Therefore, smallholder farmers' perception about climate change specifically, (temperature and rainfall pattern changes), is a necessary prerequisite for the implementation of any kind of climate change adaptation strategies. Thus, smallholder

farmers were asked whether they have perceived changes in the temperature and rainfall pattern in their locality area to examine the existing situation. It is also necessary to look at the trend of climate element from a long term data recorded at Meteorological station to use as a reference.

4.2.1. Smallholder Farmers' Perception of Temperature Change

Perception of farmers about the overall trend of average temperature in the study area was examined. Among the sampled respondents, 94.2 percent perceived long-term change in temperature in the study area over the past two decades. Out of which, 92.3 percent perceived as an increase in temperature and only 1.9 percent of sampled households perceived a decrease in temperature whereas, 5.8 percent of sample household perceived as constant. Similarly, 91.7 percent of sampled households perceived an increase in number of hot days while 3.2 percent of respondents perceived as it is decreasing and only 5.1 percent of respondents were perceived as constant over the past two decades (Table 6).

Table 6. Farmers' perception on change in temperature

Temperature change over Years	Perceived patterns of change N= 156					
	Increased		Decreased		No change	
	N	%	N	%	N	%
Average annual temperature	144	92.3	3	1.9	9	5.8
Number of hot days	143	91.7	5	3.2	8	5.1

Source: Own survey result, 2017

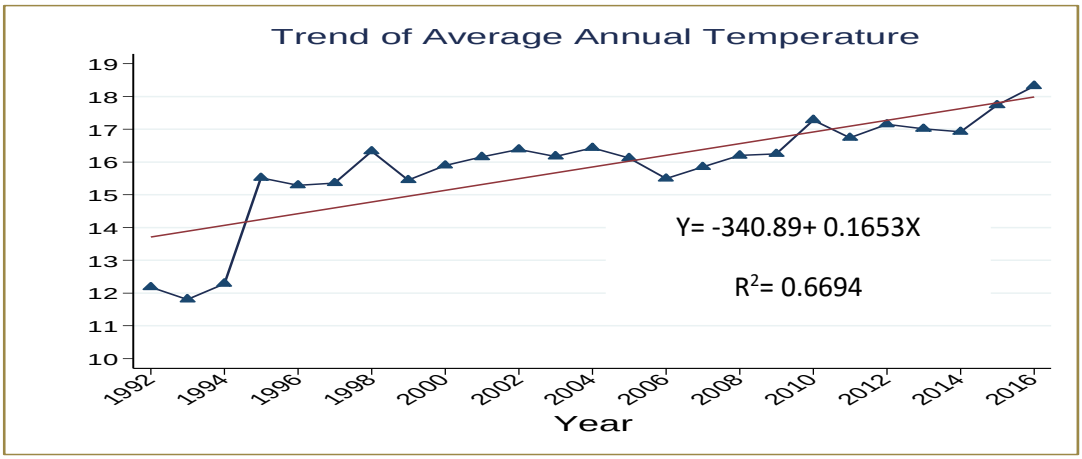


Figure 2. Trend of average annual temperature in Jamma district from 1992-2016
Source: Computed based on data obtained from National Meteorological Agency, Kombolcha branch

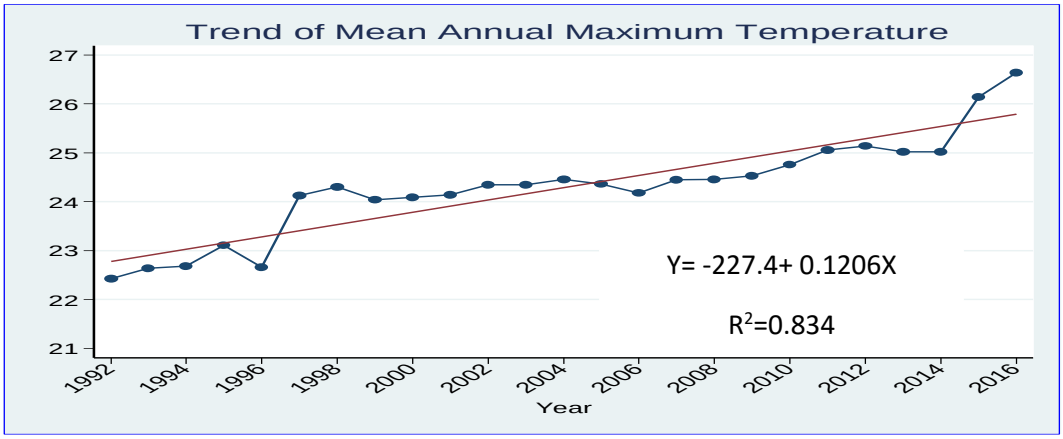


Figure 3. Trend of average annual maximum temperature in Jamma District from 1992-2016
Source: Computed based on data obtained from National Meteorological Agency, Kombolcha branch

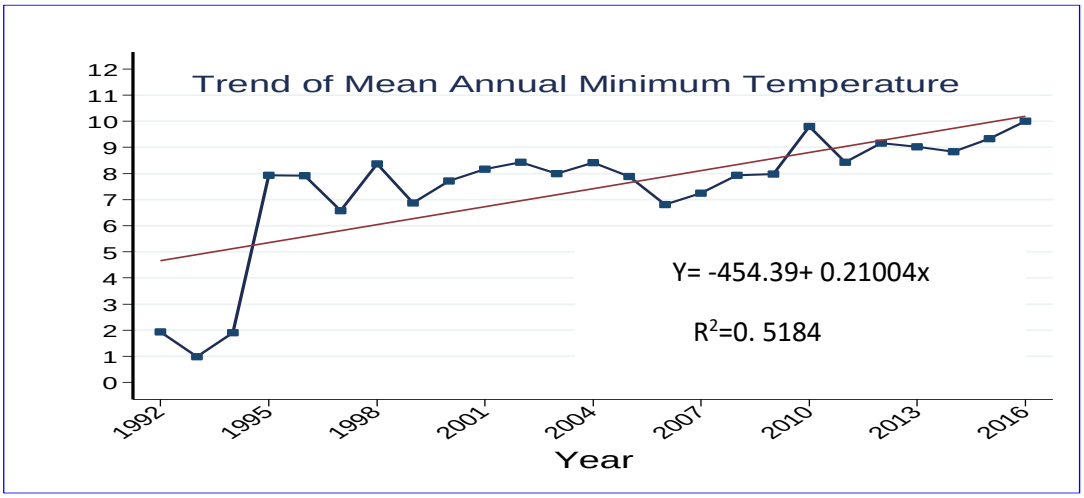


Figure 4. Trend of average annual minimum temperature in Jamma District from 1992-2016
Source: Computed based on data obtained from National Meteorological Agency, Kombolcha branch

The trend analysis of Meteorological data record of temperature from the period between 1992 -2016 showed that increasing trend in both minimum and maximum annual average temperature over the past twenty five years. Therefore, farmers' perception appears to be in agreement with the statistical record of temperature from the Meteorological station in the study area.

4.2.2. Smallholder Farmers' Perception of Rainfall

The main rainy season, *Kiremt* in the study area include months of June, July and August. Sometimes there is a short rainy season in March and April. Therefore, the perception of the smallholder farmers about change in rainfall pattern of the main rainy season (*Kiremt*) and short rainy season (*Belg*) over the past twenty years was examined. The result showed that

98.2 percent of the sampled households perceived that the *Belg* rain was decreased and only 1.8 percent of sampled households perceive that there is no change in *Belg* rain. Correspondingly, 90.4 percent of the sampled households have perceived that there was a decrease in the overall average rainfall in main rain season (*kiremt*) and the remaining 1.3 percent and 8.3 percent of the sampled households perceived that there were an increase and no change in average rainfall over the past two decades (Table 8). The result of this study indicated that farmers' perception was in accordance with the meteorological record. Outcomes of the FGDs are also in agreement with the results obtained from the survey data.

Table 7. Perception of sample respondents on rainfall patterns over years

	Increase		Decrease		No change	
	N	%	N	%	N	%
Main rain season (*Kiremt*)	2	1.3	141	90.4	13	8.3
Short rain (*Belg*)	0	0	153	98.2	3	1.8
Annual precipitation	4	2.6	138	88.5	14	8.9

Source: Own survey result, 2017

The trend analysis of the Meteorological data of rainfall over the past 25 years showed a decreasing trend in annual rainfall amount in the study area. It indicated that annual rainfall in the study area decreases by about 10.92 mm each year (Figure 6). It also indicates high variability of rainfall in the study area. The variability of rainfall is very high in the *Belg* rainy season.

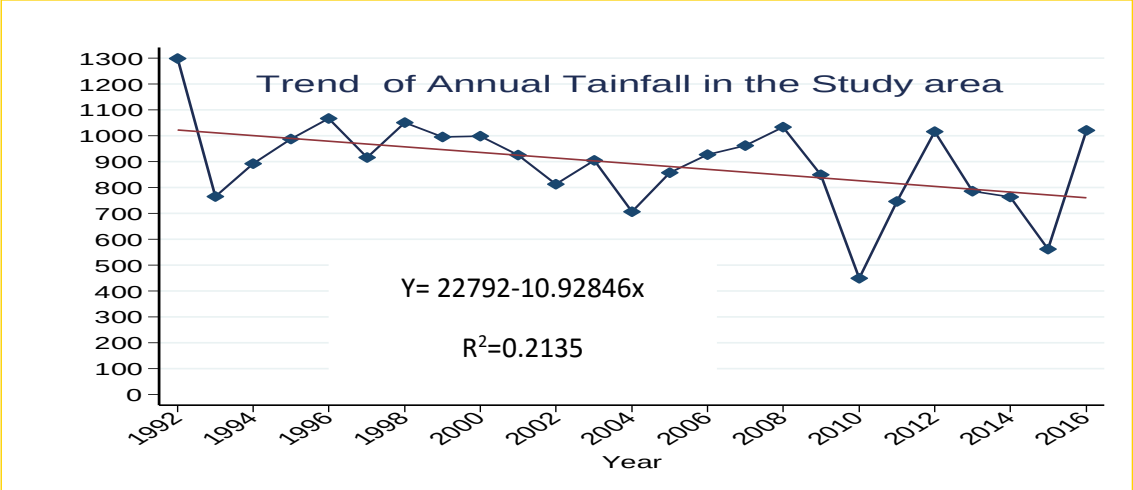


Figure 5. Trend of annual rainfall in Jamma area from 1992-2016
Source: Computed based on data obtained from National Meteorological Agency, Kombolcha branch

The sample households were also asked about their general level of perceptions of climate change with some indicators/ parameters of temperature and precipitation by using five points Likert scale. The survey result showed that 92.3 percent of the sample household perceived temperature has increased and 88.5 percent perceived a decrease in the amount of rainfall. Likewise, 91.7 percent of the sampled households perceive an increase in a number of hot days per year while 99.4 percent and 96.1 percent of sampled households perceived late start of rainfall and early cessation respectively over the past two decades (Table 8).

The survey result also showed 49.4 percent and 20.5 percent of the sample households perceived a high increase in temperature and a high decrease in the amount of rainfall over the past two decades respectively. Moreover, only 1.9 percent of the sample households indicated that temperature has been decreasing and 1.3 percent households perceive the rainfall has been increasing. Similarly about 5.8 percent and 8.3 percent of the sample households perceived no change in temperature and rainfall, respectively (Table 8).

About 91.7 percent and 92.3 percent of the sample respondents indicated that late start of precipitation and early cessation of precipitation with the highest level respectively. Similarly, the amount of rain fall in the Belg season decreased by 91.7 percent. The mean value of Likert score for the above climate change parameters are 4.4, 4.1, 4.91 and 4.85 for temperature increased, precipitation decreased, late start of precipitation and early cessation of rainfall, respectively. These result indicated that rainfall had changed with the highest variability in starting late and early cessation over the past two decades followed by temperature (Table 8).

Table 8.Sample households' climate change perception index over years

Climate change signals and pattern of changes	Level of perception (N=156)										Mean
	1		2		3		4		5		
	N	%	N	%	N	%	N	%	N	%	
Increase in temperature	0		3	1.9	9	5.8	67	42.9	77	49.4	4.4
Increase in umber of hot days	1	0.6	4	2.6	2	1.3	35	22.4	114	73.1	4.1
Decrease in precipitation	0		2	1.3	13	8.3	109	69.9	32	20.5	4.1
Early cessation of precipitation	1	0.6	3	1.9	2	1.3	6	3.8	144	92.3	4.85
Late start of precipitation	0		0		1	0.6	12	7.7	143	91.7	4.91
Decrease belg rain	0		0		2	1.7	11	7.1	143	91.7	4.9

Note: 1=strongly disagree, 2=disagree, 3=neutral, 4= agree and 5= strongly agree

Source: Own survey result, 2017

4.2.3. Climate Change Induced Hazards and Their Perceived Effects

The sample respondents were asked about their perception of climate induced hazards occurred in the study area over the past two decades. All of the respondents well recognize the climate induced shocks especially the aged farmers remember the severe drought year in Ethiopia. More over the young farmers also remember the recent drought year 2015/16. Therefore, the main climate related hazards and their level of severity in the study area is summarized in the following table (Table 9).

Table 9. Climate change induced hazards

Climate change induced hazard of HH	Level of severity					
	Low		Medium		High	
	N	%	N	%	N	%
Drought	6	3.9	25	16	125	80.1
Floods	14	9	108	69.2	34	21.8
Crop pest and animals diseases	28	18	66	42	62	40
High wind	39	25	56	35.9	61	39.1

Note. Multiple answers were observed
Source: Own survey result, 2017

The surveyed households were asked about their perceived impact of the above environmental shocks. The sample respondents observed many consequences of climate induced shocks which affect their livelihood. However, the effects of these shocks are different in different agro-ecological location. Majority of them are a shortage of water, decline in crop yield of the farmer, death of livestock and human health problem (Table 10).

Table 10**.** Effects of major climate change induced shocks on surveyed farmers.

Consequences of climate induced shocks	Number of HH who perceived	%
Decline in crop yield	99	63.5
Shortage of water	67	42.9
Death of livestock	53	34
Human health problem	41	26.3

Source: Own survey result, 2017

The respondents indicated that there is frequently occurrence of drought in the study area. This climate induced shocks severely affect both their crop and animal production. They also indicated increase in crop pest and animal disease in the study area over the past two decades. They also suggest a new crop pest and disease occurred in the study area. It affects mainly

teff, sorgum and beans. During focus group discussion, farmers said that their number of animals are gradually decreasing due to poor feeding and animal disease. The grazing land is reduced from time to time due to expansion in agricultural land and house construction. Therefore, they reduce their number of animals, as well as the animal productivity becomes very low. There is also a high prevalence of frost and the wind in the area and farmers indicated that they lost their crop as well as home particularly in the highland area. Another climate induced shock encountered by the farmers in the study area is shortage of water. They travel far away from their home to fetch drinking water as well as for their livestock.

4.3. Climate Change Adaptation Strategies of Smallholder Farmers

In the study area, farmers have adopted different strategies to respond to the negative consequences of climate change. Based on the household survey data collected from the study area, almost all farmers have observed changes in climate over time. Then after, sampled households were asked their response to reduce the impact of climate change through adaptation. Therefore, they reported that they are using improved crop varieties, soil and water conservation practices, small scale irrigation techniques, crop diversification and adjusting planting dates to reduce the negative impact of climate change.

Use of improved crop varieties, soil and water conservation practice and adjusting planting date are widely used in the study area. Smallholder farmers tried to adapt to climate change, by using soil and water conservation practice as an adaptation strategy in combination with other strategies such as planting trees, drainage system, ditch, check dam construction, stone terrace, tied ridges, thrash line and agro-forestry to manage their land.

Use of improved crop varieties

Those smallholder farmers highly depends on crop production and their adaptation strategy focuses on crop production and 63.2 percent of adaptation strategy users use drought resistant and short maturing varieties of crops as an adaptation strategy.

Soil and water conservation practice

Soil erosion is more serious problem in the study area. Therefore, soil and water conservation is the most important adaptation strategies by the majority of smallholder farmers in the study area. About, 58.6 percent of the sample respondents use soil and water conservation

practice as an adaptation strategy in combination with other strategies. The sample respondents reported that planting trees in their land reduce soil erosion as well as the leaf of the plant increases the fertility of the soil. The farmers believes that planting trees can increase rainfall in addition to its high contribution to soil conservation. Trees also provide natural shade for their livestock or as a wind or hail storm break when the temperature is hot. However, some of the respondents observed that in the cultivated land it facilitates the growth of weeds and became tidies.

Adjusting planting date

Adjusting crop production period is one of the most important adaptation options used to respond to adverse effects of climate change in the study area. From the total sampled households, about 69.5 percent of the sample respondent use adjusting crop production period as an adaptation strategy to reduce the adverse effect of climate change on their farm productivity. Farmers were adjust the time of planting date based on the information about the weather condition.

Crop diversification

The other adaptation strategies used by smallholder farmers especially in midland agro-ecological zone is crop diversification. About, 66.6 percent of the sample respondents used mixed cropping, intercropping and dividing farm lands into varying crops to reduce the negative impact of climate related shock.

Small scale irrigation practice

Smallholder farmers used small scale irrigation practice to cope the negative impacts of climate change. About 51.9 percent of the sample respondents use small scale irrigation practice as an adaptation strategy to combat the negative impact of climate change in the study area. Majority of the participants grow vegetables (e.g. onion, potato, tomato, chilly, cabbage), banana, orange and coffee in their irrigated land. However, the availability, accessibility, and scarcity of water were a great problem as reported by farmers during the focus group discussion (Table 11).

Table 11. Summary of adaptation strategies used by farmers in the study area

Adaptation strategies	Number of respondents	Percent
Use new improved crop varieties	99	63.46
Adjusting planting date	108	69.23
Crop diversification	104	66.67
Soil and water conservation practice	93	59.61
Small scale irrigation practice	81	51.92

Source: Own survey result, 2017

4.4. Factors Influencing the Choice of Climate Change Adaptation Strategies by Households

This study identified the important determinants of farmers' choice of adaptation strategies by using a multivariate probit model. As explained earlier, a multivariate probit model is applicable due to the likelihood ratio test of the independence of the disturbance term. This implies that the null hypothesis (independence of the choice of multiple adaptation strategies) is strongly rejected.

In the study area, the major climate change adaptation strategies are using new improved crop varieties, soil and water conservation practices, adjusting planting date, crop diversification and use of small scale irrigation practice. These adaptation measures help farmers guard against losses due to changes in climate elements (temperature and precipitation). Households' decision to choose particular adaptation strategies is influenced by a number of socioeconomic, institutional and environmental factors.

As indicated in Table 12, the results of multivariate probit indicated that different socio economic, institutional and environmental factors affect the households' adaptation strategy choice to climate change. The correlation coefficients of the error terms are significant (based on the t-test statistics) for any pairs of equations indicating that they are correlated. The correlation coefficients are statistically significant in 8 of the 10 cases. The likelihood ratio test of the null hypothesis of independence between the choices of adaptation options is significant at 1percent. Therefore, reject the null hypothesis (all the ρ (Rho) values are jointly equal to 0), confirming the goodness-of-fit of the model. So, the specification of multivariate probit model was appropriate and choices of climate change adaptation strategies are mutually inclusive.

The results on correlation coefficients of the error terms indicate that there is complementarity (positive correlation) and substitutability (negative correlation) between different adaptation options being used by farmers. The result supports the assumption of interdependence between adaptation strategies which may be due to complementarity in the different adaptation options and from omitted household-specific and other factors that affect uptake of all the adaptation options.

Rho values (ρ_{ij}) indicate the degree of correlation between each pair of the adaptation strategies. The SML estimation results suggested that there was positive and significant interdependence between household decisions to adapt use of soil and water conservation practices and using new improved crops varieties, crop diversification and using new improved crop varieties, small scale irrigation practice and crop diversification, small scale irrigation practices and soil and water conservation practices and crop diversification and soil and water conservation practices. On the other hand, there was negative and significant interdependence between household decisions to adapt adjusting planting date and soil water conservation practices, use of small scale irrigation practice and adjusting planting date and using crop diversification and adjusting planting date.

The multivariate probit model result also shows the likelihood of households to adopt new improved varieties of crops, soil and water conservation practices, adjust planting date, use crop diversification and small scale irrigation practices were 63.3 percent, 58.8 percent, 69.9, 66.6 percent and 51.8 percent, respectively. The joint probability of using all these adaptation strategies was 2.4 percent and the joint probability of failure to adopt all of the adaptation strategies was 3.9 percent. The finding suggested that different household socioeconomic, institutional and environmental factors are significantly determining the households' decisions to choose adaptation strategy of households

Table 12. MVP simulation results for households' decisions to climate change adaptation strategies

Explanatory variables	Use of improved crop varieties	Soil and water conservation practices	Adjusting planting date	Crop diversification	Small scale irrigation practice
	Coefficient (Std. error)	Coefficient (Std. error)	Coefficient (Std. error)	Coefficient (Std. error)	Coefficient (Std. error)
AEZ	0.341* (0.197)	-0.298**(0.145)	-0.125 (0.148)	-0.079 (0.149)	-0.093 (0.147)
SexHH	0.613* (0.350)	0.725***(0.276)	0.017 (0.272)	-0.461 (0.297)	0.669**(0.312)
Educlev	0.294***(0.106)	0.117*(0.068)	0.036 (0.063)	0.137*(0.076)	0.076*(0.036)
Hhsize	-0.081**(0.039)	0.133* (0.070)	-0.217***(0.077)	0.228**(0.080)	0.161**(0.076)
Landsize	0.164 (0.258)	-0.025 (0.204)	0.126 (0.207)	0.139 (0.219)	0.033 (0.213)
Farmexpr	0.016 (0.246)	-0.071 (0.192)	0.382**(0.191)	0.143 (0.203)	-0.263 (0.208)
Farminc	0.488***(0.177)	0.019 (0.091)	0.098 (0.130)	0.376*(0.186)	0.023 (0.097)
Non/off	0.061* (0.034)	0.012 (0.023)	-0.012 (0.025)	0.011 (0.027)	0.046* (0.027)
TLU	0.019 (0.055)	0.015 (0.044)	0.047*(0.027)	0.036 (0.048)	0.141*** (0.049)
Frqexten	0.023 (0.017)	0.112**(0.045)	0.141***(0.052)	-0.003 (0.012)	-0.008 (0.013)
Credit	0.754** (0.327)	0.522* (0.277)	0.149 (0.298)	0.370 (0.283)	-0.223 (0.290)
Climainf	0.698(0.444)	0.392* (0.231)	0.588*(0.322)	-0.416 (0.337)	-0.306 (0.379)
Farfarext	0.194 (0.458)	0.447 (0.340)	0.053 (0.344)	0.234 (0.341)	0.641*(0.384)
Distmar	-0.107* (0.064)	0.026 (0.044)	-0.016 (0.044)	-0.033 (0.049)	-0.102* (0.059)
Constant	-3.454*** (1.030)	-1.121(0.727)	-0.218 (0.731)	-1.871** (0.763)	-1.233 (0.788)

Table 12. (*Continued*)

	Rho1	Rho2	Rho3	Rho4	
Rho2	0.426* (0.178)				
Rho3	-0.201(0.219)	-0.590***(0.114)			
Rho4	0.368* (0.210)	0.590***(0.126)	-0.625***(0.119)		
Rho5	0.118(0.212)	0.631***(0.116)	-0.500***(0.132)	0.383**(0.152)	
Predicted pr.	0.633	0.588	0.696	0.666	0.518
Joint pr.(success)		0.024			
Joint pr.(failure)		0.039			
Observations		156			
Log likelihood		-310.7789			
Wald $\chi 2(70)$		183.03			
Prob > $\chi 2$		0.0000			
Rhoij = 0, P > $\chi 2(10)$		=70.6472			

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

Sex of household head: It is an important explanatory variable affecting the choice of adaptation decision of households. The sex of household is significantly and positively associated with improved varieties of crops, soil and water conservation measure and using small scale irrigation practices. Male headed households are more likely to select and use new improved varieties of crops, soil and water conservation measure and using small scale irrigation practices in the study area. This is because male-headed households are relatively flexible in search of improved varieties and in a better position to pull their labor force in order to adapt new agricultural technologies. On the other hand, female farmers spend most of their time in or close to their house, occupied with household related tasks such as cleaning, washing, cooking, making local beer, caretaking of their children, and feeding their livestock in the study area. The result is consistent with Belaineh *et al*. (2013), Ikheloa *et al*. (2013), Lemmi (2013), Tagel and Veen (2013), Negash (2014) and Gebre *et al*. (2015). However this result contradicts with the findings of Nhemachena and Hassan (2014) who argued that female headed households more likely to use adaptation strategies.

Education level of the household head: This variable positively and significantly affected use of new improved crop varieties, soil and water conservation practices, crop diversification and small scale irrigation practice as an adaptation strategies of climate change. The positive relationship between literacy status and the dependent variable shows that increase in the level of education of the household head increases the awareness of farmers about the consequence of climate change on productivity and the benefit of use of new improved crop varieties, soil and water conservation practices, small scale irrigation practice and crop diversification techniques to reduce the negative impacts of climate change.

The result suggests that being literate would improve the capacity to access information, capable to interpret it and easily understand the existing situation than illiterate farmers. This shows that the importance of human capital for the ability to combat effects of climate change in the study area. Therefore, farmers who are more educated were more likely to use new improved crop varieties, soil and water conservation practices and small scale irrigation practice than those illiterate farmers. The result is in line with Tesso *et al*. (2012), Temesgen *et al*. (2014), Gebre *et al*. (2015) and Balama (2016).

Household size: It has significant impact on the adaptation options to respond to climate change impact. The result of the model revealed that household size has positive and significant impact on the likelihood of soil and water conservation measure, crop diversification and small scale irrigation practices as an adaptation strategies of climate change. This result implies that large household size reduces the labor constraint of a household to accomplish various labour intensive agricultural tasks such as crop diversification, soil and water conservation measure and using small scale irrigation practices. Most of the time these agricultural activities are require more labor. Therefore the larger the size of the household the more likely to adapt to the above climate change adaptation strategies. Tagel (2013), Mishar and Chandra (2014) and Nhemachena *et al*. (2014) also found similar results. However, household size has significant and negative impact on the likelihood of taking adjusting planting date and use improved crop varieties as an adaptation strategies to reduce the negative impact of climate change. The possible reason is that adjusting planting date is an individual decision it does not require more labor. Similarly, use improved crop varieties is a capital intensive than labor intensive agricultural activities. Thus households with large number of families may be forced to divert to off-farm activities in an attempt to earn income in order to ease the consumption pressure imposed by a large family. This finding is in line with the finding of Apata (2012), Belaineh *et al*. (2013) and Poudel (2015).

Farm experience: It has proximity with age of the household head and has a positive and significant effect to respond to the negative impact of climate change. This implies that as age of the household head increases, the person expects to acquire more experience and knowledge to forecast the weather condition. The result revealed that more experienced farmers are more likely to adapt adjusting planting date. More experienced farmers are likely to have more information and knowledge to forecast the future climate changes and crop and livestock management practices (Nhemachena *et al*., 2014). This result is in line with the findings of Tossou (2015) and Seid *et al*. (2016).

Farm income: It has a positive and significant impact on the use of improved crop varieties and crop diversification as an adaptation strategy to respond to climate change impact. This might be because new improved crop varieties require more financial resources. Therefore, increased income from the farming activity will encourage farmers to invest in climate change adaptation strategies. The other possible reason is that when farm income would

increase, farmers purchase improved seed varieties which increase productivity of the farm household. This result is in line with Tatek (2012), Negash (2013), Gebre *et al*. (2015) and Seid *et al*. (2016).

Non/off farm income: Non/off-farm income significantly increases uptake of new improved crop varieties and using small scale irrigation practice as an adaptation options to climate change. Non/off farm income is an income generated from non-farm activities which increases the financial base of the household. Thus, it encourages farmers to purchase new varieties and irrigation technologies. This result is consistent with Temesgen *et al*. (2008) and Negash (2014). However this result contradicts with the finding of Belaineh and colleagues (Belaineh *et al*., 2013) who argued that off -farm income negatively associated with adaptation strategies (crop diversification strategies and the use of SWC practices, integrated crop-livestock based diversification and rainwater harvesting).

Distance from the market center: Distance from the market center is statistically significant and negatively correlated with the use of new improved crop varieties and small scale irrigation practices as an adaptation strategy. As expected, the market is an important determining factor for climate change adaptation method. The possible reason could be due to the fact that it serves as a means of exchanging information and source of agricultural input. When farmers are far from the market, they would not obtain better information and it is difficult to buy new improved adaption technologies and other important agricultural inputs. The result is consistent with Oyekale and Oladele (2012) and Negash (2014).

Livestock ownership (TLU): The result of the model revealed that a number of livestock owned in TLU is significantly and positively related to the use of small scale irrigation practice and adjusting planting date. The reason could be livestock is considered as an asset and serves as a store of value for the smallholder farmers. Therefore, having a large number of livestock can strengthen farmers' adaptive capacity to climate change. For instance, ownership of livestock is crucial to buy irrigation technologies and other important agricultural inputs. Finding of this study is in line with Temesgen *et al*. (2010), Gandure *et al.* (2012).

Credit utilization: The model result shows that credit utilization has significant positive impact on the likelihood of using improved crop varieties. Affordable credit access reduces financial constraint of farmers and encourage their ability to meet transaction costs associated with various adaptation options they might want to take (Nhemachena *et al*., 2014). Therefore, increase in financial resources of farmers is very important to purchase necessary inputs, associated with other equipment (such as drought tolerant varieties, improved hybrid seeds, fertilizers and new technologies). This finding is similar with results obtained by Yirga (2007), Apata (2011), Tesso *et al. (*2012) and Wondimagegn and Lemma (2016).

Frequency of extension contact with farmers: It has positive and significant impact on soil and water conservation practice and adjusting planting date. This result implies that increase in the number of annual extension visit to farmer creates more awareness about the consequence of climate change. Moreover, agricultural extension is the most important sources of information available to farmers for analyzing their adoption decision. For instance, the efficiency of making adoption decisions (adjusting planting date and soil and water conservation practice) is enhanced by frequent agricultural extension services to reduce the negative impact of climate change in the study area. Thus, farmers who get more frequent extension visit are more likely to use various climate change adaptation options. This result also confirms the result of Belaineh *et al*. (2013), Negash (2014) and Nhemachena *et al*. (2014).

Access to climate information: This explanatory variable significantly increases the likelihood of uptake of using soil and water conservation practices and changing planting date as a climate change response techniques. Madison (2006) revealed that access to climate information is an important prerequisite for farmers to uptake climate change adaptation measures. Dissemination of information about seasonal forecasts and climate change increase awareness of farmers and enhance uptake of different adaptation measures. Thus, raising awareness about climate change, available new improved varieties of crops, livestock breeds, irrigation applications, reminders about planting dates, pest and disease control mechanism and livestock vaccinations through radio and television would have greater impact in increasing climate change adaptation (Seid *et al.*, 2016). For instance, farmers who are aware of changes in climatic conditions have higher chances of taking adaptive measures

in response to observed climate changes. The result is in line with Kadir (2012), Oyekale and Oladele (2012) and Longe and Oyekale (2013)

Farmer to farmer extension contact: As expected, farmer to farmer extension has a positive and significant impact on use of small scale irrigation practice. Farmer to farmer extension is one of the most important variable for knowledge transfer, information and experience sharing to respond to the negative impact of climate change. One farmer is different from the other farmer by his or her skills, working habits, and experience. Thus, experience sharing among farmers is very important to build up their knowledge and will help them to take the adaptation measures. The result is in line with Juana *et al*. (2013).

Agro-ecological zone: Households who live in different agro ecological setting adopt different climate change adaptation strategies because of different climatic condition, soil type and other factors. The model result show that farmers in the high -land agro-ecology are more likely to choose use of new improved crop varieties but less likely to use soil and water conservation measure. The result is consistent with Temesgen *et al*. (2008) and Aemro *et al*. (2012).

5. SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1. Summary and Conclusion

Climate change is the most complex global challenge in the 21st century posing the greatest threat to business and governments. Adverse climate change impacts are considered to be strong particularly in sub Saharan Africa countries that depend on agriculture as their main source of livelihood. It leads to reduction in agricultural production of the smallholder farmers and would further adversely affect food security. Ethiopia is one of the Sub Saharan African countries that are highly vulnerable to climate change impact. This is because the country's economy is mainly dependent on rain fed agriculture which had failed to meet the growing food demands of the population.

Climate has been changing in the past and it will be expected to continue in the future. This implies that the need to understand how farmers perceive climate change and adapt in order to guide strategies for adaptation in the future. Perception about the cause, impacts and necessary response mechanisms to cope with climate change is necessary for any population in a given community. Therefore, a better understanding of local dimensions of adaptation to climatic changes is crucial in designing appropriate supportive policy to adaptation strategies of climate change.

The main objective of this study was to examine the perception of smallholder farmers about climate change, identifying the existing adaptation strategies and identifying factors affecting the choice of adaptation strategy of smallholder farmers in response to negative impact of climate change in Jamma district South Wollo Zone of Amhara Regional State. To achieve the research objectives data were collected from a total of 156 sample households selected from five Kebeles of the district. It utilized both qualitative and quantitative data sources. The primary data were collected through household survey using interview method and also through focus group discussion. Similarly, secondary data were collected from different sources like journal articles, books, CSA and NMSA records.

The study employed descriptive statistics, Likert rating scale and econometric model to analyse the collected data. Descriptive statistics were used to describe explanatory variables used against adaptation strategies. The result revealed that 92.3 percent of the sample household perceived that temperature has increased and 88.5 percent perceived that there

was a decrease in the amount of rainfall. Similarly, 91.7 percent of sampled households perceive an increase in number of hot days per year while 99.4 percent and 96.1 percent of sampled households perceived late start of rainfall and early cessation respectively over the past two decades.

Adaptation strategies implemented in the study area include use of new improved varieties (like short duration crop and drought resistance), adjusting planting date, use of soil and water conservation techniques, crop diversification (mixed cropping, intercropping and dividing farm lands in to varying crops) and use of small scale irrigation. The adoption decisions of these different adaptation strategies are interdependent because of complementarity or substitutability between the strategies.

The study used multivariate probit model to analyze factors affecting adaptation strategy choices based on data obtained from a household survey. The model allowed for the simultaneous identification of the determinants of all adaptation options, thus limiting potential problem of correlation between the error terms. Correlation results between error terms of different equations were significant (positive) indicating that households used various adaptation strategies in a complementary way, whereas it is significant (negative) indicating various adaptation strategies used by households as a substitute way.

The multivariate probit result shows that the likelihood of households to use improved crop varieties, soil and water conservation practices, adjust planting date, use crop diversification and small scale irrigation were 63.2 percent, 58.6 percent, 69.5 percent, 66.6 percent and 51.9 percent, respectively. The joint probability of using all adaptation strategies was 24.0 percent and the joint probability of failure to adopt all of the adaptation strategies was 3.9 percent.

The result of multivariate probit model revealed that agro-ecological setting of the household, sex, level of education, household size, farm income, non/off farm income, distance to market and credit utilization have a significant impact on the use of improved crop varieties to adapt climate change. The results also confirm that, sex, level of education, household size, agro-ecological setting of the household, frequency of extension contact and climate information significantly affected use of soil and water conservation practices to adapt to climate change. Similarly, household size, farming experience, livestock ownership,

frequency of extension contact, and climate information significantly affected adjusting planting dates as an adaptation strategy.

The model result also shows that level of education, household size, and farm income significantly affected farmers' use of crop diversification to adapt to climate change impacts. Moreover, sex, household size, amount of non/off farm income, livestock ownership, farmer to farmer extension contact and distance to the nearest market significantly affected farmers' use of small scale irrigation practice as a climate change adaptation strategy. Therefore, these results give information to policy makers and extension workers on how to improve farm level adaptation strategies and identify the determinants for adaptation strategies.

5.2. Recommendations

Based on the findings and results of the study the following policy measures could be recommended as a means to minimize the negative impacts of climate change and variability on rural livelihood households of Jamma district.

Empowering female headed households. In order to equally participating females with males it is important to improve awareness and allocate the appropriate work for females. Therefore, policy intervention on improving their knowledge about climate change and different adaptation strategies enhance their adaptive capacity to reduce climate change impacts.

Empowering the farmers with education. Education can create opportunities for the households to gather information on modern agricultural technologies and adaptation measures. Improving adult education and encouraging the youngsters to participate in different agricultural activities would do most to hasten adaptation and increase households' decision making regarding the crucial adaptation techniques. Thus, government has due attention for establishing and strengthening both formal and informal farmers' education and enhancing short term training by using extension agents and related professionals.

Farm income and non/off farm income have positively affect the choice of climate change adaptation strategies. Thus, improving farmer's farm and off/non-farm income-earning opportunities is of great need for smallholder farmers. So, sufficient input supply at fair price, creating better access to markets and transportation facilities are suggested as policy measures to help farmers to adapt to climate change. In addition, farmers taking part in

off/non-farm activities such as petty-trading are important in the rural areas as a policy option to reduce negative impacts of climate change.

The frequency of contact with agricultural extension and climate change information have positively affects the adoption of climate change adaptation strategies. Promoting farm-level adaptation need to emphasize on the crucial role of providing information on appropriate implementation of technologies by considering agro- ecological setting of the area and enhancing farmers' awareness on climate change. Thus, the agricultural extension service operating in different kebeles need to be strengthened further to increase the flow of information for rural smallholder farmers. The meteorological agency also better to disseminate relevant information to a specific location at the right time and the farmers better to use early planting system and short season improved crop varieties.

In general, future policy should focus on empowering female headed households, facilitating the availability of credit especially to adaptation technologies, improving farmers farm and non/off-farm income earning opportunities, improving their literacy status, and improving their access to markets, access to farmer-to-farmer extension, expanding agricultural extension package and improving their participation in different programs ensures that farmers have the information for decision making. Furthermore, policy interventions which encourage formal and informal social networks can promote group discussions, training and better information flows that help to enhance adaptation to climate change.

For further study, this paper recommends research to be undertaken on farmers' perception about climate change and determine the factors affecting farmers' information needs for climate change adaptation strategies in the household level.

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7. APPENDICES

Appendix I: Appendix tables

Appendix Table 1. Conversion factors used to estimate Tropical Livestock Unit

Animals	TLU-equivalent
Cows or Oxen	1.00
Calf	0.25
Heifer or Bull	0.75
Sheep or Goat	0.13
Sheep or goat young	0.06
Donkey (adult)	0.70
Donkey (young)	0.35
Horse/ Mule	1.10
Chicken	0.013

Source: Strock *et al*. (1991)

Appendix Table 2. Conversion factor to adult equivalent.

Age group	Male	Female
< 10	0.6	0.6
10-13	0.9	0.8
>13	1	0.75

Strock *et al*. (1991)

Appendix Table 3. Meteorological record of Monthly maximum average temperature of Jamma District (1992-2016)

National Meteorology Agency													
Station: Kombolcha													
Element: Maximum Average Temperature (0C)													
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Max Ave
1992	xx	Xx	25.8	24.8	26.0	23.0	18.6	18.9	20.5	21.0	22.2	23.5	22.43
1993	23.3	23.7	23.8	22.3	24.1	24.6	20.5	19.8	21.0	22.3	22.8	23.4	22.64
1994	xx	Xx	Xx	Xx	Xx	Xx	Xx	20.1	22.3	23.2	23.9	23.9	22.68
1995	24.2	24.9	24.8	23.4	24.0	24.9	20.2	19.6	22.0	23.0	23.4	22.9	23.11
1996	22.1	24.4	23.5	24.0	23.0	21.3	20.2	20.3	22.7	23.7	23.4	23.3	22.66
1997	23.6	25.2	25.4	24.2	26.9	23.8	20.1	21.3	24.9	24.4	24.3	25.4	24.13
1998	24.9	25.7	25.4	27.5	26.5	27.7	20.2	19.4	21.8	23.6	24.4	24.5	24.30
1999	24.4	26.6	25.9	27.3	27.6	26.5	18.8	19.5	21.8	23.0	23.6	23.6	24.04
2000	24.9	26.1	27.5	25.9	25.8	25.2	20.0	19.4	22.8	23.4	23.7	24.4	24.09
2001	24.9	25.8	25.9	25.0	25.8	24.8	19.7	20.0	24.4	24.5	24.0	24.9	24.14
2002	24.0	26.5	25.9	25.8	26.7	25.8	23.0	20.2	21.9	23.9	24.6	24.0	24.35
2003	24.5	26.7	25.6	25.5	26.8	25.9	21.7	20.7	22.6	23.9	24.1	24.3	24.35
2004	24.7	26.9	25.7	25.7	27.6	23.9	21.5	21.6	23.1	23.8	24.3	24.8	24.46
2005	24.4	27.0	26.4	25.8	24.0	24.6	20.2	21.6	23.3	25.5	24.9	24.7	24.36
2006	25.7	25.8	25.5	24.7	25.9	26.1	22.1	19.9	22.5	24.4	24.1	23.6	24.18
2007	24.7	25.4	27.1	25.5	26.5	24.6	22.8	20.1	25.1	23.7	23.6	24.4	24.45
2008	25.2	26.2	27.7	25.5	25.8	25.1	22.0	22.6	23.4	23.6	22.8	23.7	24.46
2009	23.5	25.0	27.3	26.8	26.4	27.0	21.4	21.4	23.4	23.9	24.6	23.7	24.53
2010	24.5	25.1	26.7	25.5	25.7	26.9	21.3	Xx	23.7	23.9	25.2	23.9	24.76
2011	24.1	26.0	26.4	28.6	27.7	Xx	Xx	22.3	22.2	23.9	24.2	25.2	25.06
2012	24.3	26.1	27.1	27.7	27.8	26.9	21.8	21.8	24.2	23.9	24.8	25.3	25.14
2013	25.5	26.1	26.5	26.8	27.9	26.7	21.6	21.9	23.5	23.8	24.9	25.0	25.02
2014	25.3	26.6	26.3	26.4	27.4	26.7	23.8	22.6	23.9	23.9	25.3	22.0	25.02
2015	23.3	23.6	26.4	27.5	27.3	27.8	26.5	24.5	25.5	26.8	27.1	27.4	26.14
2016	28.5	29.8	31.2	31.4	31.3	25.6	22.5	21.7	23.8	25.7	23.7	24.6	26.64

Appendix Table 4. Meteorological record of Monthly minimum average temperature of Jamma District (1992-2016)

National Meteorology Agency													
Station: Kombolcha													
Element: Monthly Minimum Average Temperature (0C)													
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Min Ave
1992	xx	xx	2.3	4.6	2.9	4.0	4.5	4.5	2.9	-0.1	-2.8	-3.3	1.9318
1993	-2.1	-0.4	2.5	2.3	0.3	3.5	2.9	2.8	0.5	-3.7	1.5	1.7	0.9819
1994	xx	xx	xx	xx	0.9	2.8	3.5	4.4	4.0	-0.1	0.7	-0.6	1.9000
1995	2.7	7.8	8.6	10.4	9.3	8.7	10.1	10.7	8.5	6.0	5.8	6.6	7.9249
1996	8.1	6.4	8.5	9.2	9.4	9.3	9.8	9.9	8.3	5.8	4.7	5.7	7.9204
1997	7.4	4.1	8.2	6.9	8.3	7.9	5.1	4.5	5.0	8.2	7.5	5.8	6.5821
1998	7.3	8.4	9.4	9.9	10.3	9.6	10.5	11.2	9.5	7.9	3.7	2.7	8.3707
1999	4.8	4.3	7.2	8.1	9.5	7.6	9.3	7.6	8.0	7.5	3.9	4.7	6.8688
2000	5.1	5.7	7.4	9.4	9.3	8.9	9.6	9.7	8.2	7.0	6.5	5.9	7.7077
2001	5.8	7.2	9.6	9.2	9.9	9.6	9.9	10.4	8.1	7.6	5.8	4.8	8.1640
2002	5.6	6.6	9.1	8.7	10.4	9.8	10.5	10.3	9.0	6.6	6.2	8.4	8.4280
2003	7.5	7.0	8.3	9.6	9.3	10.0	10.5	10.5	9.2	5.9	3.1	5.2	7.9965
2004	7.8	7.5	8.7	10.5	9.3	10.6	9.6	9.2	8.6	6.4	6.1	6.6	8.4074
2005	7.0	7.5	9.5	9.9	10.0	8.8	8.1	9.2	10.0	6.1	4.6	3.9	7.8796
2006	5.3	6.1	6.7	6.8	7.3	9.8	9.2	8.2	7.4	5.9	5.1	4.0	6.8150
2007	4.5	7.8	7.0	9.4	9.9	9.7	8.0	6.9	8.2	6.2	5.6	3.6	7.2479
2008	5.6	7.5	7.7	9.4	10.7	9.8	8.9	9.1	9.6	6.0	5.2	5.7	7.9346
2009	6.4	7.3	6.7	8.5	10.5	10.0	9.5	9.0	8.7	6.9	4.3	8.0	7.9779
2010	6.9	8.4	8.7	10.3	10.3	9.8	6.9	6.8	8.4	13.6	15.6	9.0	9.8061
2011	7.3	6.1	7.1	7.6	8.9	8.4	7.6	8.8	10.7	8.5	5.8	5.8	8.4277
2012	7.4	6.7	7.9	10.4	10.5	10.6	10.5	10.4	9.9	9.2	8.5	7.9	9.1583
2013	7.9	7.7	8.3	10.7	10.6	10.1	10.5	10.9	8.9	8.4	7.7	6.5	9.0165
2014	7.4	8.4	9.5	9.9	9.6	9.4	9.6	10.0	9.0	8.7	7.4	7.1	8.8281
2015	7.1	8.4	8.6	9.5	10.5	10.4	10.1	10.5	10.7	9.1	8.5	8.5	9.3301
2016	9.7	9.1	11.6	11.8	10.8	9.9	10.7	10.7	10.6	9.7	8.9	6.6	10.0023

Appendix Table 5. Meteorological record Monthly average rainfall of Jamma District (1992-2016)

National Meteorology Agency													
Station: Kombolcha													
Element: Average Rainfall (mm)													
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average
1992	6.8	10.7	33.7	129.5	36.6	119.6	499.7	319.1	127	16.3	0	0	1299
1993	4.4	33.6	97.1	111.4	7.5	21.9	159.2	231.7	88	10.2	0	0	765
1994	0	0	39.2	40.8	31.5	77.6	291.7	308.2	100.8	0	2.6	0	892.4
1995	0	14	86.3	98.7	50.5	62.5	288.3	276.3	93.9	0.2	0	17.1	987.8
1996	103.9	4.6	132.8	32.5	99.3	116.2	254.1	273.8	24.7	0	23.9	1.3	1067.1
1997	29.4	0	84.5	27	32	126.9	317.3	213.7	13.6	51.8	11.6	8.2	916
1998	30.9	14.7	71	29	49	28.8	392.6	308.7	79.4	45.8	0.7	0	1050.6
1999	24.1	0	28.5	8	0	35.2	434.6	397.5	47.1	16.3	0	3.6	994.9
2000	0	0	5.7	106.1	44.3	57.1	448.7	268.3	43.6	19.3	4.5	0	997.6
2001	0	3.7	76.6	12.7	33.2	44.3	450.1	275.5	19.5	4.1	0	5	924.7
2002	31.7	15	44.3	36.4	9.3	44.4	312.6	229	75.1	0	0	15.1	812.9
2003	32.8	0	124.5	90.1	0	56.7	318	216.3	56.3	0	1.6	8.1	904.4
2004	12	6.4	57.4	33.3	13.8	64.1	215.4	267.7	29.8	1.5	0	4.2	705.6
2005	4.5	1.7	51.2	25.1	64.3	68.7	319.7	289.5	29.5	0	3.2	0	857.4
2006	17.9	32.5	83.2	26.6	1	21.9	226.7	347.6	142.3	25	0	2.4	927.1
2007	27.5	41.9	31.4	44.6	0	113.6	324.6	313.6	64.5	0	0	0	961.7
2008	3.2	0	0	16.3	21.2	24.7	424.5	305.5	216.6	3.2	18.2	0	1033.4
2009	17	1.6	18.6	12.8	11	24.2	295.4	368.1	34.8	10.9	9.8	45.3	849.5
2010	0	30.7	22.8	38.2	31.4	28.7	217.8	0	63.4	0	8.6	7.2	448.8
2011	0	0	27.5	41.1	29.3	31.8	250.4	295.8	68.5	0	1	0	745.4
2012	0	0	0	7.8	12.6	6.3	412.6	576.3	0	0	0	0	1015.6
2013	X	X	0	0	19.3	27.1	241.6	312	96.7	86.9	1.3	0	784.9
2014	3.5	21.6	16.7	23.3	12.7	8.3	256.7	312.1	99	4.2	5.8	0	763.9
2015	0	2.9	19.6	0	57.6	51.9	119.3	224	68.4	1.2	3.8	12.6	561.3
2016	15.2	3.3	37.6	113.6	125.6	70.8	267.3	289.2	60.8	36.5	0.2	0	1020.1

7.2. Appendix II:

HARAMAYA UNIVERSITY
SCHOOL OF GRADUATE STUDIES
Interview Schedule

Smallholder Farmers' Perception and Adaptation Strategies to Climate Change: The Case of Jamma District of South Wollo Zone, Ethiopia

The main objective of this questionnaire is to examine Jamma Woreda Farmers perception toward climate change and to identify determinant factors for adaptation decision to response climate change. This type of local level study is important for planners as well as decision makers at different level. Therefore, the information that you provide is believed to help the concerned bodies in understanding farmers' knowledge toward climate change and factors that affect adaptation strategies to response climate change. Accordingly, you are kindly requested to give answers freely and openly. Any information you give is kept confidential. Thus, your cooperation is very essential to achieve the desired goal of the study and please feel free to convey the required information honestly.

Thank you for your cooperation in advance.

Seble Tadesse

Thank you

I. General information

1. Household Head _____
2. Name of Enumerator _____
3. Name of the respondent's Kebele Administration _____
4. Agro-ecological Zone; 1.High land 2. Mid land

II. Demographic characteristics of the household

1. Gender of the head of the household: 1. Male 0. Female
2. Age of the head of the household_____
3. Level of education 1. Literate 2. Illiterate: If literate number of years of formal schooling attained _____
4. Marital status: 1.Single 2. Married 3. Divorced 4.Widowed
5. Number of family members in the head _____
   1. below 15 years of age (children) _____.
   2. above 15 and below 65 years of age (adult) _____.
   3. above 65 years of age (old)? _____

III. Socio-economic characteristics of the household

1. Do you have your own land? 1. Yes 0. No
2. If your answer to the question 1 is yes, how much in ha is
    1. The cultivated area: _____.
    2. Grass and woodland: _____.
    3. Parcels/homestead: _____.
3. Farm experience of household head (years) _____
4. What type of farming system you follow currently?
    1. Crop production only 2. Livestock rearing only 3. Mixed farming
    4. Others (please specify).....
5. What power do you use for farming? 1. Family labor 2. Shared labor 3 Animal traction 4. Tractor 5. Other (specify) ----
6. Would you please tell me the type and yield of the crop you grown during the last production year (i.e., Tir 1, 2008E.C to Tahisas 30, 2009 E. C)? Please specify in Birr:

Crop grown	Area(ha)	Quat.produced/(Quintal)	Total estimated income in birr

7. Total income estimated from by-products of crop? _____birr
8. Total income from Selling of fruits and vegetables_____ birr
9. Dear respondent! How many of the following types of livestock do you have and how many you sold during the last one-year? ___?

No	Type	Number owned	Number sold the last one year	Price birr/animal	Total income
1	Caw				
2	Oxen				
3	Heifer				
4	Bull				
5	Calf				
6	Sheep				
7	Goats				
8	Horses				
9	Donkey				
10	Poultry				
11	Mules				
12	Beehives				

10. Did you sell livestock products last year? 1. = Yes 0. = No.
11. If your response is yes, answer the following:
    1. Milk sold per lactation period _____ birr; 2. Butter sold per lactation period ___birr
    3. Hides and skin sold in number_____; 4. Eggs____ birr 5. Honey in birr_____
    6. Other specify_____
12. Total estimated income from animal products? _____birr
13. Total estimated farm income? _____birr
14. Do you/any members of your family has any sources of non-farm and off farm income i.e. income from remittance, petty trade, employment in government or private enterprise, etc.? 1. Yes 0. No
15. If yes to Q. 14, how much money you/your family make during last production year (i.e., Tir 1, 2008E.C to Tahisas 30, 2009 E. C) from off-farm activity? Please specify in Birr: .....
16. How much was your total expenditure during last production year (i.e., Tir 1, 2008E.C to Tahisas 30, 2009 E. C)? Please specify in Birr: .....
17. Did you encounter shortage of food in the past 25 years? 1. Yes 0. No If yes how many times did you encounter food shortage in the past 25 years? _____
18. How long does it take to reach your farm from your home? In case you have more than one plot takes its average distance and/or time. (Specify one way only):
    1. Distance (in KM)..... 2. In terms of time it takes (in min).....
19. Do you have any communication devices like TV, radio, mobile phone, so on?
    1. Yes 0. No
20. If your answer for question 19 is "Yes" what types of communication devices you have?
    1. Radio 2. TV 3. Mobile Phone 4. Others specify.....
21. Do you have an irrigable land of yourself around or near a water source? 1. Yes 0. No
22. Is there scarcity of water in your local area? 1. Yes 0. No
    If yes, from where did you get drinking water during drought?

IV. Questions on Institutional Factors

23. Do you have market access nearby? 1. Yes 0. No
24. If your answer is yes, how far is it? _____km(approximately)
25. Do you have roads of vehicle that connect you with nearby towns or cities?
    1. Yes 0.No
26. Do you have human and animal health services centres at your village?
    1. Yes 0. No

27. Do you have education services centres at your village? 1. Yes 0. No
28. Is there an electric service in your village? 1.yes 0.No
29. If your answer is yes in qes.28, what is the source of the power?
    1. Water 2. Solar 3.bio fuel 4.wind 5.Other (specify) -----
30. Do you have access and use improved production inputs and technologies?
    1. Yes 0. No
31. In your farming activities have you ever faced shortage of finance? For example to purchase agricultural inputs like fertilizer, oxen, and others? 1. Yes 0. No
32. Do you have access to any formal credits in time face shortage of money?
    1Yes 0. No
33. Do you have access to informal credits (neighbours, friends, relatives etc.)?
    1Yes 0. No
34. If yes, for what purpose the credit used?
    1. Livestock purchase 2. Input purchase 3. Petty trade
    4 Meet consumptive needs (food, cloth, school fee) 5. Others ____
35. If yes to '29 & 30' what is its contribution to improve your farming income?
    1. Very important 2. Important 3. Has no effect
36. Have you default credit you get before years? 1. Yes 0. No
37. If yes for Q.33, what was the reason? 1. Loss of crops 2. Loss of animals 3. Health problem 4. others ____
38. Do you have access to agricultural extension services in your Kebele? 1. Yes 0. No
39. Do you receive any support from agricultural extension which could help to improve your farming activities? 1. Yes 0. No
40. If your answer for Q.39 is yes, how many times you visited by extension agent per year? What types of advices did you receive from extension workers? 1. Improved crop production systems 2. Improved livestock production 3. Soil and water conservation 4. Irrigation use 5. Natural resource management 6. Planting and harvesting time 7. others (please specify) ____
41. Have you ever got any kind of formal training which helps to improve your farm productivity? 1. Yes 0. No
42. Does the extension agent provide information on the climate change? 1. Yes 0. No
43. If yes, does it help you in adaptation strategy to the change in climate?
44. Did you have non-formal training of the above kind from farmers or did you give training to other farmers in your locality? (Farmers-to-farmers extension services).

1. Yes 0. No

45. Did you have access and participate in productive social safety net program (PSNP)?

46. Are you a member of any formal/informal institution in your locality? 1. Yes 0. No

1. Yes 0. No

No	Institutions/ social Relations	Member ☑	Role in the Institution	Remark
1	Idir			
3	Debo			
4	Wonfel			
5	Iqueb			
6	Cooperative			
7	Religious association			

47. If yes, Q.40, does it help you in any time of adverse condition? In what way?

1. Providing compensation 2. Providing credit 3. Job support

4. Information sharing 5. Sharing adaptation strategies

48. Do you have an access to daily weather forecast and climate change information?

1. Yes 0. No

49. What is the source of your information?

1. Radio 2.TV 3.Extension agent 4. Other farmers 5. Indigenous knowledge

V .Climate Change Perception Assessment

1. In your opinion, do you think that there is climate change in your local area?

1. Yes, very much 2. Yes 3. No, there is no 4. I do not know

2. Have you perceive any changes in rainfall patterns? 1. Yes 0. No
3. If yes what do you say about the trend of precipitation over the last twenty five years?

1. Increased 2.Decreased 3. Not changed 4.change in times of raining

5. Increase in frequency of drought 6. I don't know 7.Other (specify) ----------

4. Have you perceive any changes in temperature? 1. Yes 0. No
5. If yes what do you say about the number of hot days over years?

1. Increase 2. Decreased 3. No change 4. I don't know 6. Other (specify) -------

6. What do you think about the cause of the change in temperature?
7. Do you think that the current increase temperature continues in the future? 1. Yes 0. No
8. What do you think will be the solution in the future?
9. Do you believe that agricultural activities & the way people practice agriculture is contributing for the change in temperature and precipitation? 1. Yes 0. No
10. Which agricultural practice significantly contributing for the change?

1. Use of chemical fertilizer 2. Deforestation 3.Shifting cultivation
4. Use of pesticide chemicals 5. Chemical for crop disease 6. Other (specify)

11. Have you noticed any change in stream or river flow in your locality? 1. Yes 0. No
12. If yes, what do you think the cause of the change in stream? What are the most noticeable types of vegetation before?
13. Have you noticed any change in vegetation cover over the past 20-30 years? 1. Yes 0.No
14. If yes, what would be the cause?
15. Dear respondent the following options indicated that to what extent would you agree or disagree to the climate trend (Changes of temperature and precipitation) you indicated above?

No	Options	(1) Strongly disagree	(2) Disagree	(3) Neutral	(4) Agree	(5) Strongly Agree
1	**Temperature Change**					
1.1	Temperature increased					
1.2	No change temperature					
1.3	Decreased temperature					
1.4	Decrease rainy season temper.					
1.5	Increase dry season temperature.					
1.6	Increase number of hot days					
2	**Precipitation Change**					
2.1	Increased precipitation					
2.2	Extremely high precipitation					
2.3	No change in precipitation					
2.4	Decreased precipitation					
2.5	Extremely low precipitation					
2.6	Late start of precipitation					
2.7	Early cessation of precipitation					
2.8	Decrease Belg rain					

16. Have you experience any climate change risks in your area? 1. Yes 0. No If yes, please rank frequency and show the severity of the problem in the table below?

No	Climate induced hazards	Rank its Frequency	Severity		
			Low	Medium	High
1	Drought				
2	Floods				
3	Off-seasonal rainfall				
4	Too much rain				
5	Too little rainfall				
6	Higher temperature				
7	Frost (coolness)				
8	High winds				
9	Dieses and pests				
10	Others (specify				

17. Which of the following climate change induced shock the most affect your livelihood?

Consequences of climate induced shocks	Rank	Severity		
		Low	Medium	High
Shortage of water				
Death of livestock				
Human health problem				
Food crisis				
Destruction of infrastructure				

18. Who is affected most? 1. Women 2. Children 3. Elders 4. Male 5. All society

19. Are there any adaptation strategies you made for the change in climate (precipitation and temperature)? 1.Yes 0.No

20. If yes, what are the major adaptation mechanism and frequently used in response to long term change in precipitation and temperature?

No	Response to climate change	Rank preference	Reason
1	Using new improved variety		
2	Soil and water conservation		
3	Water harvesting		
4	Changing planting date		
5	Reduce number of livestock		
6	Improve herd management		
7	Crop diversification		
8	Put trees for shading		
9	Feed supplements		
10	Irrigation use		
11	Food consumption reduction		
12	Using new technologies		
13	Migrate to urban area		
14	Find off-farm job		
15	Others		

21. If no adaptation method used why? _____

22. What are the hindrances for use of adaptation options of combating climate change?

    1. Shortage of money to finance
    2. Lack of technical knowledge
    3. Shortage of water for irrigation
    4. Lack of long-term climate change and weather information
    5. Lack of improved seed variety
    6. If any other specify_____

Check list to guiding Focused group discussion

1. Do you feel the pattern of weather is generally changing?
2. What do you think the cause of climate change?
3. How do you identify the change in climate?
4. What are the problems related with climate change?
5. What are the impacts of climate change on agriculture and livelihood of rural people?
6. When you affected by the past drought?
7. During drought period, how people cop up the problem occurred?
8. Is there migration due to drought? If yes, where did you migrate?
9. Identify any newly appeared crop infestation and diseases in your locality
10. What are the adaptation strategies employed by farmers?
11. What are the factors that affect the adaptation strategies choice of smallholder farmers?
12. Do you think that the change in climate will continue in the future?
13. What do you recommend to be done that will enhance the fight towards climate change?