

ADDIS ABABA UNIVERSITY
SCHOOL OF GRADUATE STUDIES
DEPARTMENT OF ECONOMICS

**ANALYSING THE DETERMINANTS OF FARMERS' PREFERENCE FOR
ADAPTATION STRATEGIES TO CLIMATE CHANGE:
EVIDENCE FROM NORTH SHOA ZONE OF AMHARA REGION**

BY

Negash Mulatu Debalke

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in partial fulfillment of the requirements for the Degree of Master of Science in
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Approved by the Board of Examiners:

Advisor

Date

Examiner

Date

Examiner

Date

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Abbreviations

- BIC Bayesian Information Criteria
- FAO Food and Agriculture Organization
- GDP Gross Domestic Product
- IFPRI International Food Policy Research Institute
- IPCC Intergovernmental Panel on Climate Change
- ML Maximum Likelihood
- MNLM Multinomial Logit Model
- MNPM Multinomial Probit Model
- MoFED Ministry of Finance and Economic Development
- NAPA National Adaptation Programmes of Action
- NMA National Meteorological Agency of Ethiopia
- ROL Rank-Ordered Logit
- UNEP United Nations Environmental Programme
- USAID United States Agency for International Development
- VIF Variance Inflation Factor
- WFP World Food Programme

Abstract

Studies on climate change adaptation recognize the importance of agro-ecology based research for designing context-specific policies and programs to climate change. This study, therefore, applied a case-study approach to examine farmers' preference for climate change adaptation strategies and the factors deriving their preference. Thus, households' preference for five types of climate change adaptation strategies (multiple cropping, livestock, soil conservation, irrigation, and changing planting dates) is identified and the determinants of the preference are analyzed using Rank-Ordered Logit Model. The results indicated that multiple cropping is the most preferred and frequently applied adaptation strategy to climate change, while livestock production is the least. The model also revealed that gender, age, farming experience and education level of the household head, household size, and farm and nonfarm income; farm size and farm distance to homestead; agricultural extension services and access to climate forecast information; farmers' perceptions on temperature and rainfall affect farmers' preference for the climate change adaptation strategies. Thus, policies and programs with the aim of reducing climate change impacts through adaptation need to consider important roles of these factors. The main barriers to climate change adaptation are lack of information or knowledge, shortage of money, shortage of land, and unsuitability of land and poor potential for irrigation. Although adaptation is one of the policy options for reducing the negative impacts of climate change, it is challenged by these constraints. Therefore, promoting investments and strengthening efforts to address these constraints is suggested to enhance farmers' adaptation capacity and thus adaptation to climate change.

Chapter One

Introduction

1.1. Background

The Ethiopian economy is dominated by subsistence agriculture which is characterized by small-scale farming and livestock husbandry. The sector employs 85 percent of the country's labor force and accounts for 60 percent of all exports. Approximately 80 percent of households live in rural areas and are dependent on local agriculture to meet their food needs (WFP, 2009). Recent report of MoFED showed that contribution of the sector to the overall economy of the country is estimated to be 41.6 percent of the GDP (MoFED, 2010).

Agriculture plays a significant and decisive role in the social and economic development of the country. However, owing to natural and man-made causes the country has not properly benefited from its abundant natural resources conducive to agricultural development, and consequently failed to register the desired economic development that would enable its people pull out of the quagmires of poverty. The major impediments to agricultural development are the predominance of subsistence agriculture and lack of more business/market-oriented agriculture; adverse climatic changes; failure to use agricultural land according to appropriate land use management plan and resource base; limitation in information base; lack of supply and dissemination of appropriate technology; failure to integrate relevant activities; and lack of adequate implementation capacity (MoFED, 2006).

The report of the WFP (2009) confirmed that agricultural productivity in Ethiopia is low due to low use of improved agricultural inputs, erratic rainfall, low soil fertility and environmental degradation. Ethiopia's natural resource base is heavily degraded from unsustainable farming practices and deforestation, abetted by growing population pressure. The relationship between population growth and the relatively fixed quantity of arable agricultural land makes evident the magnitude of the problems confronting Ethiopia and underlines the difficulty of improving the food security status of the country's poor. These problems coupled with extremely low household incomes will continually result in an increasing number of food insecure Ethiopians. For instance, during 2007 many of the more food-insecure areas of Ethiopia experienced major floods. Severe drought reappeared early in 2008 in the eastern half of the country. Drought conditions continued into 2009 in these parts of the country. A series of major droughts since 1973 has worn down the capacities of rural households in many parts of the country to cope with natural adversities. Each year 6-8 million chronically food insecure rural Ethiopians require food transfers to avoid severe malnutrition, because of their inability to produce or procure enough even in years of good rainfall. In any given year, an added 2-7 million acutely food insecure Ethiopians are added to the list of those needing food transfers, depending on the intensity and duration of food emergencies – droughts, flooding, conflict (WFP, 2009).

Climate change is one of the main challenging factors that determine the agricultural sector's contribution to the national economy. The sector has been historically challenged by climate variability and change. The Government of Ethiopia is making efforts to address these adverse conditions of climate change and has designed coping mechanisms. In fact some of the efforts have brought about strategies that have induced changes in the attitude of the affected local communities. Some strategic measures include the development and implementation of national environmental initiatives, as well as

policy/ program and project initiatives that directly and/or indirectly address climate change and adaptation mechanisms (NMA, 2007).

1.2. Statement of the Problem

Agriculture is a major concern in the discussions on climate change, because climate is a primary determinant of agricultural productivity. Climate can affect agriculture in a variety of ways. Temperature, radiation, rainfall, soil moisture and carbon dioxide concentration are all important variables to determine agricultural productivity. Different studies suggest that in the future climate change could bring substantial impact on agricultural production and thence on the scope for reducing poverty. The agricultural impact of climate change will most likely be unevenly distributed across regions: low-latitude and developing countries are expected to be more adversely affected due to their geographical location, the greater share of agriculture in their economies, and their limited ability to adapt to climate change while high-latitude countries are expected to benefit in terms of crop production (Zhai et al, 2004). Different studies indicated that Africa's agriculture is negatively affected by climate change. As a result, climate change has become one of the main agendas of the world where each country and individual is expected to act and take measures accordingly.

Ethiopia is heavily dependent on rain-fed and climate driven agriculture where agricultural production is essential for sustaining and enhancing the country's people welfare. Despite its high contribution to the overall economy, this sector is challenged by many factors, of which climate-related disasters like drought and flood (often causing famine), are the major ones (Deressa, 2007). Ethiopia provides a good example of the influence of climate change on a developing country's economy. The country's economy is sensitive to climate variability, particularly variations in rainfall (USAID, 2007). In addition to the nature-dependent agricultural sector of the economy, the country's geographical location and

topography in combination with low adaptive capacity can cause a high vulnerability to adverse impacts of climate change. Historically, Ethiopia has been suffering from natural catastrophes and is prone to extreme weather events. Rainfall in Ethiopia is highly erratic, and most rain falls intensively, often as convective storms, with very high rainfall intensity and extreme spatial and temporal variability.

Different studies recognized that climate change has much effect on the agricultural sector of the Ethiopian economy. This calls for the government as a whole and stakeholders and individuals in particular to take in to account the climate change issue in their decision making and day to day activities. Furthermore, policies and strategies at micro and household level regarding climate change adaptation are equally important with the macroeconomic development policies and strategies. In the case of agriculture, the most important concerns are what strategies the Ethiopian smallholder farmers can adopt to acclimatize to the changing climate and thus reduce its impacts; do the farmers clearly know that the climate is changing and it can damage their agricultural production and productivity; if that is so, do they know the adaptation measures suitable to their farming?

It is evidenced in the literature that Ethiopian farmers have already perceived the climate change and started taking measures to adapt to its impacts. Different researches have revealed the different types of adaptation measures adopted by farmers across Africa as a whole and in Ethiopia in particular. It is also shown that the most preferred adaptation strategies by farmers are mostly followed in combination with other strategies and not alone (Hassan & Nhemachena, 2008). There are also farmers who are not taking adaptation measures to the climate change (Deressa et al, 2009). It is, therefore, vital to identify both the generic and climate-specific elements of farmers' adaptation behavior and preferences in order to help and facilitate a societal or respective bodies' response not only to the current but also to the future changes in climate and the possible impacts. A better understanding of

farmers' perceptions and expectations regarding past and future climatic changes, the actual measures they took, their preferences for adaptation strategies and the factors deriving their preferences is important to inform policy for future adaptation of the agricultural sector to climate change (Nhemachena & Hassan, 2007).

According to Bekele (2004), policy and program interventions in Ethiopia are often planned without sufficient knowledge of farmers' resource endowment, priority problems and felt needs. Moreover, the same type of program is designed and implemented to work for all regions and farmers across the country. The cultural background of different people, ecological conditions, available technologies and manpower, and many other socioeconomic factors constitute a context within which rural development programs attempt to bring changes.

Furthermore, climate change adaptation policy and program design needs to consider the specific characteristics of every places and community. Policies focusing on adaptation to climate change have to aim at providing adaptation technologies through agro-ecology based research (Deressa et al, 2009). That means, one-size-fits-all recommendations are inappropriate given the differences in agroecologies and other factors among farmers in different parts or areas of the country. Beside this, the performance and application of different adaptation technologies or methods is location specific. Therefore, programs aimed at promoting adaptation technologies as part of a climate change adaptation strategy should take such important differences into account (Kato et al, 2009). As cited by Seo & Mendelsohn (2007), understanding farmers' adaptation behavior is an important goal in itself to assist planning by policymakers and private individuals (Smith, 1997; Smit et al., 2000; Smit and Pilifosova, 2001). Understanding adaptation is also highly important if one is interested in quantifying the impacts of climate change (Mendelsohn et al, 1994).

Generally, farmers in different areas or agricultural zones would possibly have different propensity and capacity to climate change impacts and adaptation processes. As it is indicated by Fussel (2007), tailoring adaptation practices to specific societies or communities according to their context may make it possible to offset the adverse impacts of climate change. IPPC (2007) also indicated that the capacity to adapt to climate change is unequal across and within societies. There are individuals and groups within all societies that have insufficient capacity to adapt to climate change. Measures or interventions at local or micro level are important and feasible in the reduction of climate change impact on farmers in a certain area. This, therefore, calls for researches at household and farm level using a case study approach which are very essential to know micro level farm and farmers' characteristics and thus help design appropriate economic policies and strategies in that local context.

In general, enough studies specific to each agroecological zones of the country have not been made though there are some efforts to examine farmers' choices of adaptation strategies to climate change and the respective determinants. A notable study is the one carried out by Deressa et al (2009) in the Nile basin of Ethiopia. Shoa Robit and the surrounding areas in the North Shoa zone of the Amhara region are among those areas which need similar studies specifically to the area. Because the area has its own specific characteristics in terms of exposition to climate change. Its agro ecology is kola, characterized by hot temperature and erratic rainfall. The area (especially the agriculture) is seriously and successively affected by climate change and its extremes. Besides, there are two rivers (Shoa Robit and Kobo River) in the area which serve different purposes for both the Shoa Robit town people and the farmers in the surrounding rural areas. Historically, the rivers were mainly used for inappropriate purposes such as waste depository, and to feed animals, wash clothes and bodies. As time goes on, the town's people and rural farmers in general started to use the rivers as recreation sites, to irrigate their

crops and vegetables. Nowadays, the rivers are decreasing from time to time in amount and losing their capacity of serving the people which sometimes resulted in societal conflict and challenges (personal observation).

Therefore, this research would contribute to the issue by identifying and analyzing the determinants of farmers' preference for adaptation strategies to the impacts of climate change in this area. It also examined farmers' perceptions regarding current and future changes in climate, their preferences for adaptation strategies as well as barriers to adaptation. The study would also contribute to the existing research on climate change adaptation and modeling of preferences.

1.3. Objectives of the Study

The main objective of the research is to determine factors that influence farmers' preference for a particular adaptation strategy to the impacts of climate change. The study has the following specific objectives:

- Knowing farmers' preference for different adaptation methods to climate change and the effects of determinants of this preference.
- Understanding farmers' perceptions towards current and future changes in the climate.
- Identifying micro-level policy recommendations and intervention areas.

1.4. Research Questions

The review of the empirical literature and findings of studies in these areas raised the following research questions that should be answered in this research work.

- How much important are the socioeconomic factors to adaptation strategy choice of farmers?
- Does the farmers' perception regarding climate change match with the actual trend?
- Is there any role climate perception variables play in selecting adaptation methods to climate change?
- Do farmers have different or uniform preferences for climate change adaptation strategies?

1.5. Significance of the Study

The study can serve different purposes beyond its academic goal. It can provide an insight for those planners and policy makers either at district, zonal or regional level regarding agricultural climate change adaptation options, the necessary factors and intervention areas to be addressed in the process of climate change adaptation. It can also highlight further researches the problems and concerns of climate change. Generally, the results of the case study can be generalized and extended at zonal or at regional level and help contribute to the nations' effort in up-scaling the performance of the agricultural sector.

1.6. Scope and Limitations of the Study

This study is limited to selected peasant associations and farmers in Shoa Robit area of the North Shoa Zone where the results will be generalized for the population of the study area as a whole. However, there could be areas with different environmental and socioeconomic settings which would change the result. The study is also limited to the adaptation methods to climate change, their determinants and barriers only, it will not go through measuring or identifying impacts of the change in the climate; the impacts are assumed to be there and are given.

One important limitation of this study is that it assumes that farmers can rank their preferences for different adaptation strategies according to their local context, while there could be farmers who can not do this task properly. The other limitation of the study is that, it takes only five adaptation methods in the choice set and aggregates some of them in one category. However, there are large number of adaptation measures that could be taken by farmers across the area and the country. The aggregation is also a problem, for instance, diversification of crop types and new varieties are under one category, while selection of each crop type is by itself a wide adaptation strategy selection process and should be addressed separately.

1.7. Organization of the Thesis

The remaining part of the thesis is organized as follows. Chapter two presents review of both the theoretical and empirical literatures. Chapter three is about data sources and collection methods, analytical method of the research, and model variables. Chapter four provides statistical evidences on important variables such as farmers' perceptions of current and future climate changes, their preferences for adaptation strategies to climate change and intervention measures, and farmers' evaluation of climate change impacts and related supports from the government. Chapter five constitutes econometric estimation, results and discussions. Finally, chapter six presents conclusions and policy implications.

Chapter Two

Literature Review

In this chapter, a well documented and organized theoretical and empirical literature is developed which would help our study to have logical flow and good theoretical framework.

2.1. Theoretical Literature Review

This section of the chapter discusses the nature and scope of climate change as well as the basic concepts about climate change adaptation from the theoretical point of view.

2.1.1. Nature and Scope of Climate Change Impact

Climate is a key natural resource on which the agricultural sector depends. Climate influences food production, water and energy availability. It sets the stage for the establishment of habitats, affects the pace of primary productivity, and influences species density and distribution. Climate, whether manifested as extreme events or persistent conditions, is experienced first as a physical phenomenon. Temperature, wind and rain all affect the biophysical environment. When extreme events such as droughts and floods occur, people suffer injuries, incur losses, habitats are destroyed and the built environment is damaged. Socio-economic systems are therefore sensitive to the frequency, intensity and persistence of these conditions, as well as potential changes in long term trends.

Climate change, today, is one of the greatest economic and environmental challenges faced by the world and every individual. The Intergovernmental Panel on Climate Change refers to climate change as any change in climate over time, whether due to natural variability or as a result of human activity. The United Nations Framework Convention on Climate Change, however, makes a distinction between climate change attributable to human activities altering the atmospheric composition, and climate variability attributable to natural causes. Climate change is a complex biophysical process. Even though it is difficult to predict precise future climate conditions, there is a scientific consensus that global land and sea temperatures are warming under the influence of greenhouse gases, and will continue to warm regardless of human intervention for at least the next two decades (IPCC, 2007).

Impact of climate change is not only limited to agricultural sector; it has multi-faceted influence on water resources, coastal zones, livestock, rangelands, human health, energy consumption and production, forest, biodiversity, and fisheries. Since the focus of this research is the agricultural sector, detailed discussion will be presented related to this sector.

Climate change is a great concern for agriculture and its effects are likely to vary between different regions and different scales (global, regional, and local). World food production varies by several percent from year to year, largely as a result of weather conditions such as the El Niño phenomenon and inter-annual climatic variability in many regions. But agriculture in some regions is more sensitive to weather than in others. Typically, sensitivity to weather is greatest firstly in developing countries, where technological buffering to droughts and floods is less advanced, and secondly in those regions where the main physical factors affecting production (soils, terrain, and climate) are less suited to farming (UNEP,1998).

The report of UNEP (1998) has also shown the types of climate change impacts likely on the agriculture sector. The impacts are categorized as follows: Changes in the location of optimal growing areas for given crops, resulting in the shift of cropping zones; Changes in crop yields; Changes in the type, location, and intensity of pests and diseases. As a consequence of one or more of the above there are changes in the mix of crops grown and hence in the type of farming, and rural land use; Changes in production, farm income, and rural employment; and Changes in rural income, contribution to national GDP, and agricultural export earnings.

Over sixty per cent of Africans remain directly dependent on agriculture and natural resources for their well-being (FAO, 2003). The report of the Intergovernmental Panel on Climate Change (IPCC, 2007) confirms that Africa is one of the most vulnerable continents to climate variability and change because of multiple stresses and low adaptive capacity. It also shows that the impacts of climate change on agriculture will likely be very severe especially for those regions or economies or people 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. The area suitable for agriculture, the length of growing seasons and yield potential, particularly along the margins of semi-arid and arid areas, are expected to decrease. This would further adversely affect food security and exacerbate malnutrition in the continent. In some countries, yields from rain-fed agriculture could be reduced by up to 50% by 2020.

Climate related hazards in Ethiopia include drought, floods, heavy rains, strong winds, frost, heat waves (high temperatures), etc. Current climate variability is already imposing a significant challenge to Ethiopia by affecting food security, water and energy supply, poverty reduction and sustainable development efforts, as well as by causing natural resource degradation and natural disasters. For

example, the impacts of past droughts such as that of the 1972/73, 1984 and 2002/03 are still fresh in the memories of many Ethiopians. Floods in 2006 caused substantial human life and property loss in many parts of the country. These challenges are likely to be exacerbated by anthropogenic climate change. According to NMA (2007) there has been a warming trend in the annual minimum temperature over the past 55 years. It has been increasing by about $0.37\text{ }^{\circ}\text{C}$ every ten years. The country has also experienced both dry and wet years over the same period. The trend analysis of annual rainfall shows that rainfall remained more or less constant when averaged over the whole country (NMA, 2007).

Causes for vulnerability of Ethiopia to climate variability and change include very high dependency on rain fed agriculture which is very sensitive to climate variability and change, under-development of water resources, low health service coverage, high population growth rate, low economic development level, low adaptive capacity, inadequate road infrastructure in drought prone areas, weak institutions, lack of awareness, etc. Vulnerability assessment based on existing information and rapid assessments carried out under NAPA has indicated that the most vulnerable sectors to climate variability and change are agriculture, water and human health. In terms of livelihood approach smallholder rain-fed farmers and pastoralists are found to be the most vulnerable. The arid, semiarid and the dry sub-humid parts of the country are affected most by drought (NMA, 2007).

In general, Ethiopia is said to have good potential in the agricultural sector. However the performance of the sector is not yet satisfactory to be able to supply the economy and population with the necessary food items. Although there are many reasons for the poor performance of the sector, the variability and change in the climate determines it highly because agriculture is mainly dependent on nature. Different studies have tried to examine the possible factors for this situation. For instance, according to Befekadu & Berhanu (2000) cited by Deressa et al (2008), the major socioeconomic constraints of crop

production in the country include inappropriate policies; declining farm size and subsistence farming due to population growth; land degradation due to inappropriate use of land, such as cultivation of steep slopes; and over cultivation and overgrazing. Additionally, tenure insecurity, weak agricultural research and extension services, lack of agricultural marketing, inadequate transport networks, inadequate use of agricultural inputs, and the use of backward technologies are other constraints. The major causes of poor production in the livestock subsector include inadequate feed and nutrition, low level of veterinary care, occurrence of diseases, poor genetic structure, inadequate budget allocation, limited infrastructure, and limited research on livestock. The major environmental problem in both crop and livestock production is recurrent droughts, hailstorms, floods, and pest incidence.

2.1.2. Adaptations to Climate Change in Agriculture

The IPCC revealed that the impacts of climate change have already been observed, and scientific researches signify that strategic and quick actions are very essential. Given the impacts of climate change on agriculture, one of the most important concerns today is the development and implementation of climate change policy. While early policy debates tended to focus on 'mitigation measures' of climate change, the concept of 'adaptation' to climate change has increasingly gained acceptance and superiority (IPCC, 2007).

Adaptation is defined as (IPCC, 2007) adjustments in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. Adaptation to climate change involves changes in agricultural practices in response to changes in climate conditions. There are various types of adaptation practices to climate change: anticipatory adaptation is adaptation that takes place before impacts of climate change are observed, also referred

to as proactive adaptation while autonomous adaptation refers to adaptation that does not constitute a conscious response to climatic stimuli but is triggered by ecological changes in natural systems and by market or welfare changes in human systems. It is also called spontaneous adaptation. Moreover, there is also planned adaptation which is the result of a deliberate policy decision, based on an awareness that conditions have changed or are about to change and that action is required to return to maintain, or achieve a desired state. Another category is private and public adaptation where the former refers to adaptation practices initiated and implemented by individuals, households or private companies which is usually in the actor's rational self-interest and the latter is initiated and implemented by governments at all levels which is usually directed at collective needs. Lastly, adaptation practices that take place after impacts of climate change have been observed are considered as reactive adaptation.

On the other hand, the UNEP (1998) has categorized adaptation methods to climate change in to on-farm adaptation, household and village adaptation, and national adaptation. On-farm adaptation includes adaptation measures exercised on and at farm level. There is a very wide array of methods in crop husbandry that have been developed both to make the most of what climate offers and to minimize the adversity that it sometimes brings. The most relevant of these are methods designed to "weather-proof" agriculture and these can often be adapted to afford some protection against climate change. We can consider these in three categories: (1) altered choice of crops, (2) altered tillage and crop management, and (3) altered inputs.

Semi-commercial farmers in all parts of the world used a wide range of coping strategies to mitigate the effects of climate change. These are regarded as Household and village adaptation. The best developed of these, and probably the best understood, are those coping strategies for drought in India and Africa. These are generally characterized by a mix of technological, economic and social responses which can

operate best for a short period (perhaps a few months). It includes many of the farm-level adaptations considered above but most noticeably adds to these an array of strategies to maintain income through redeployment of assets and labor.

There is also adaptation to climate change at national level (known as national level adaptation). While most agricultural adaptation to climate change will ultimately be characterized by responses at the local level, the encouragement of response by national policymakers will affect their speed and extent of adoption. Response at the national level will also be necessary to encourage research, training, and communication concerning the most appropriate adaptive measures. The most important of these, summarized by the IPCC (1996) are as follows: Improved training and general education of populations dependent on agriculture, particularly in countries where education of rural workers is currently limited; Identification of the present vulnerabilities of agricultural systems; Agricultural research to test the robustness of new farming strategies and develop new crop varieties; Education and communication to bring research results to farmers; Food programs and other social security programs to provide insurance against local supply changes; Transportation, distribution, and market integration to provide the infrastructure to supply food during crop shortfalls; and removing of subsidies, which can, by limiting changes in prices, mask the climate change signal in the marketplace

Historically, agriculture has shown a considerable ability to adapt to changing conditions, whether these have stemmed from alterations in resource availability, technology, or economics. If climate change is gradual, it may be that adjustment goes largely unnoticed as part of responses to more profound changes due to technology and policy and that the process is one largely of autonomous adjustment. Many adaptations will thus occur autonomously and without the need for conscious response by farmers and agricultural planners. For example, as crop yields are affected by climate,

different areas of land will be allocated to new, highest-value, uses. However, it is likely at least in some or most parts of the world that the rate and magnitude of climate change will exceed that of normal change in agriculture and that specific technologies and management styles will need to be adopted to avoid the most serious of effects. There is, therefore, much to be gained from evaluating the capability that exists in currently available technology and the potential capability that can developed in the future (UNEP, 1998).

The goal of an adaptation measure should be to increase the capacity of a system to survive external shocks or changes. The assessment of farm-level adoption of adaptation strategies is important to provide information that can be used to formulate policies that enhance adaptation as a tool for managing a variety of risks associated with climate change in agriculture (Nhemachena & Hassan, 2007). Adaptation strategies are also necessary to overcome the expected adverse impacts from higher temperature and changing precipitation patterns (Kurukulasuriya & Mendelsohn, 2007). Therefore, a key component of climate adaptation involves building resilience, where resilience is the capacity of a system to tolerate disturbance without collapsing into a qualitatively different state that is controlled by a different set of processes: a resilient system can withstand shocks and rebuild itself when necessary (FAO, 2003).

IPPC (2007) revealed that adaptation to climate change is already taking place, but on a limited basis. Societies have a long record of adapting to the impacts of weather and climate through a range of practices that include crop diversification, irrigation, water management, disaster risk management, and insurance.

Although African farmers have low capacity to adapt to changes in the climate, they have, however, survived and coped in various ways over time. Better understanding of how they have done this is essential for designing incentives to enhance private adaptation. Supporting the coping strategies of local farmers through appropriate public policy and investment and collective actions can help enhance the up take of adaptation measures that will reduce the negative consequences of predicted changes in future climate, with great benefits to vulnerable rural communities in Africa (Hassan & Nhemachena, 2008).

The UNEP (1998) indicated that knowledge of present and future climate is not by itself sufficient basis for the development of an adaptive response. Further information is needed on the likely or possible impacts of these changes. This in turn requires an understanding of the relationship between climate (including many specific climate parameters) and socio-economic activities. The understanding of adaptation to climate change can be increased by investigating adaptation to present climate as well as future climate. Adapting to present climate is not the same as adapting to future climate change, but provided that allowances are made for the differences, much can be learned about adaptation options and the process of their adoption. Studies of adaptation to current climate also make it clear that human activities are not now always as well adapted to climate as they might be. In the development context, therefore, a prudent adaptive response to the threat of climate change may be to improve adaptation to existing climate and its variability, including extreme events. Improving adaptation to current climate variability is not an alternative to preparing for adaptation to longer term changes in climate. It is an adjunct, a useful first and preparatory step that strengthens capacity now to deal with future circumstances (UNEP, 1998).

Least-developed countries have been identified as being particularly vulnerable to climate change, and planning for their adaptation has been facilitated through development of National Adaptation Programmes of Action (NAPAs). In completing a NAPA, a country identifies priority activities that must be implemented in the immediate future in order to address urgent national climate change adaptation needs. In line with this, Ethiopia has prepared its NAPA and started to design and put in place policies, strategies and programs that enhance the adaptive capacity and reduce the vulnerability of the country to climate variability and change.

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

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

Generally, adverse consequences of climate change can be reduced by formulating suitable adaptation strategies that combines indigenous knowledge, weather information, and modern risk management

methods, approaches, practices and location specific seasonal climate outlooks (Admassu et al, undated).

2.2. Empirical Literature Review

In this sub-section, a detailed review of international and national empirical research papers and articles have been conducted. The review has been made in terms of farmers' experiences and choices of adaptation methods, the determinants of their choice and analytical models that are being used to analyze the information. The review is, therefore, presented precisely in two parts as follows. The first part presents the empirical works in other parts of the world and the second part is about research works conducted specific to Ethiopia.

2.2.1. Empirical Review at International Level

A review of selected literature by Below et al (2010) about micro-level practices of African small-scale farmers for adapting to climate change shows that African smallholders are already using a wide variety of adaptive practices to deal with climate risks. The reviewers found around 104 different practices relevant to climate change adaptation and organized them in five categories: farm management and technology; farm financial management; diversification on and beyond the farm; government interventions in infrastructure, health, and risk reduction; and knowledge management, networks, and governance. Among these adjustments farm management and technology (53%) is the most practiced adaptation method, followed by knowledge management, networks, and governance (15%); diversification (14%); government interventions (13%); and farm financial management (5%).

The review has found that one of the explanations for farmers' limited adoption of technical options to adapt to climate change is their willingness and ability to accept new practices. Farmers' willingness depends on their economic interests, social and ecological values and norms, awareness of the problem, and self-perception. A farmer's ability comprises all the objectively verifiable factors that influence his or her decision, including the type and organization of the farm, farm economics, tenure, and farm size, as well as the bio-geographical conditions of the farmland and its surroundings. Furthermore, it includes specific characteristics of the farmer, that is, the farmer's age, education, and experience.

Hassan & Nhemachena (2008) have conducted a research on the determinants of African farmers' strategies for adapting to climate change. The study used a multinomial choice model to analyze data from a cross-sectional survey of over 8000 farms from 11 African countries. The study has identified the most commonly and widely used adaptation methods by African farmers. They are multiple cropping mixed with livestock rearing under dryland (52 %), multiple cropping with livestock rearing under irrigation (14%), multiple cropping without livestock under dryland (13%) and mono-cropping mixed with livestock under dryland (9 %). African farmers do not specialize in rearing livestock (i.e. planting no crops at all) whether under irrigation or dry land conditions. While specializing in livestock production is not a feature of African agriculture, they observe that specialized dryland and irrigated crop cultivation (mono-cropping) is practiced, albeit by a small share of the farming population.

This study has also indicated that specialized crop cultivation (mono-cropping) is the agricultural practice most vulnerable to climate change in Africa. Warming encourages irrigation, multiple cropping and integration of livestock with crops. Increased precipitation reduces the probability of irrigation and will benefit most African farms, especially in drier areas. Better access to markets, extension and credit

services, technology and farm assets (labor, land and capital) are critical factors for helping African farmers adapt to climate change. It also demonstrates the importance of government policies and strategic investment plans that support improved access to climate forecasting, research into the development of and information about appropriate farm-level climate adaptation technologies, access to credit, farmer education and market development, especially in areas where dryland farming currently predominates.

Additionally, Nhemachena & Hassan (2007) have also carried out a study on farmers' adaptation strategies to climate change in Southern Africa based on a cross-section database of three countries (South Africa, Zambia and Zimbabwe). Their study describes farmer perceptions to changes in long-term temperature and precipitation as well as various farm-level adaptation measures and barriers to adaptation at the farm household level. A multivariate discrete choice model is used to identify the determinants of farm-level adaptation strategies. The study identified seven important adaptation options being used by farmers which include crop diversification, using different crop varieties, changing planting and harvesting dates, increased use of irrigation, increased use of water and soil conservation techniques, and diversifying from farm to non-farm activities. The multivariate probit analysis reveals that access to credit, free extension services, farming experience, mixed crop and livestock farms, private property and perception of climate change are some of the important determinants of farm-level adaptation options. The study on perception confirms that farmers are aware of that the region is getting warmer and drier with increased frequency of droughts and changes in the timing of rains and this is supported by observed trends of temperature and precipitation. Results on barriers to adaptation options indicate that lack of credit, lack of information on climate forecast, adaptation options and other agricultural production activities; and lack of seed inputs are important constraints for most farmers (Nhemachena & Hassan, 2007).

On the other hand, Seo & Mendelsohn (2006) conducted a research to examine the way African farmers have adapted their livestock management to the range of climates occurred across the continent. The study used logit model to analyze whether farmers adopt livestock. It then used three econometric models to examine what species the farmers choose: a primary choice multinomial logit, an optimal portfolio multinomial logit, and a demand system multivariate probit. The primary animal model examines the choice of the single species that earns the greatest net revenue on the farm. The optimal portfolio model examines all possible combinations of animals that farmers can choose. The demand system model examines the probability that a farmer will choose a particular species. Using data from over 9000 African livestock farmers from ten countries, the research has revealed that farmers are more likely to choose to have livestock as temperatures increase and as precipitation decreases. Across all methods of estimating choice, livestock farmers in warmer locations are less likely to choose beef cattle and chickens and more likely to choose goats and sheep. As precipitation increases/decreases, cattle and sheep decrease/increase but goats and chickens increase/ decrease.

Furthermore, Kurukulasuriya & Mendelsohn (2007) have examined whether crop choice is affected by the climate change in African farms. A multinomial logit model is estimated using a sample of over 7000 farmers across 11 countries in Africa. The study finds that crop choice is very climate sensitive. For example, farmers select sorghum and maize-millet in the cooler regions of Africa, maize-beans, maize-groundnut, and maize in moderately warm regions, and cowpea, cowpea-sorghum, and millet-groundnut in hot regions. Moreover, farmers choose sorghum, and millet-groundnut when conditions are dry, cowpea, cowpea-sorghum, maize-millet, and maize when medium wet, and maize-beans and maize groundnut when wet. As temperatures warm, farmers will shift towards more heat tolerant

crops. Depending upon whether precipitation increases or decreases, farmers will also shift towards drought tolerant or water loving crops, respectively.

Similarly, Seo & Mendelsohn (2007) have carried out a research on a similar topic on South American farmers. They developed a multinomial logit model of farmer's choice of crops. Estimating the model across 949 farmers in seven countries, they found that both temperature and precipitation affect the crops that South American farmers choose. Farmers choose fruits and vegetables in warmer locations and wheat and potatoes in cooler locations. Farms in wetter locations are more likely to grow rice, fruits, potatoes, and squash and in dryer locations maize and wheat. Global warming will cause South American farmers to switch away from maize, wheat, and potatoes towards squash, fruits and vegetables. These cross-sectional results suggest that farmers have adjusted crop choice to fit their local climate conditions. Predictions of the impact of climate change on net revenue must reflect not only changes in yields per crop but also crop switching. The study revealed that soil types, age, own prices of crops, farmer's education and computer ownership affect the farmers' choice of crops as adaptation method to climate change (Seo & Mendelsohn, 2007).

Apata et al (2009) have examined the climate change perception and adaptation strategies of crop farmers in the south western Nigeria using the logit model. Specialized (mono) cropping is used as the base category for no adaptation and evaluates the other choices as alternatives to this option. The study has revealed that farmers' most preferred adaptation strategies are mostly followed in combination with other strategies and grouped into the following adaptation options: diversifying into multiple and mixed crop-livestock systems, and switching from crops to livestock and from dry land to irrigation, practicing zero tillage, making ridges across farms and cereal/legume intercropping. The study showed that multiple cropping mixed with livestock rearing under dry land conditions is the

dominant system (25.75%). Cereal/legume intercropping is the second most common strategy (21.28%), and multiple cropping without livestock under dry land (13.51%) comes third. Diversification from farming to non-farm is the most common adaptation practice (59%). The implication is farmers are gradually moving away from farming to non-farm activities.

This study revealed that most of the explanatory variables considered are statistically significant at 10%. The results show that altered climate change, noticed change in climate, frequency of droughts, age and sex all had no significance effect on adaptation. While the increased temperature, farm size, farming experience, educational status, access to extension and credit facilities are factors influencing adaptation positively. However, fall in temperature, change timing of rains, own heavy machines and household size are also significant factors but influence adaptation negatively. Summary of the results revealed that fall in temperature influences the probability of switching away from mono-cropping more than changes in increased temperature. Additionally, better accesses to extension and credit services seem to have a strong positive influence on adaptation. Furthermore, the choice of the suitable adaptation measure depends on factor endowments (i.e. family size, land area and capital resources).

Similarly, a study on farmers' perceptions of climate change and agricultural adaptation strategies in rural Sahel has revealed that households are aware of climate variability and identify wind and occasional excess rainfall as the most destructive climate factors. Households attribute poor livestock health, reduced crop yields and a range of other problems to climate factors, especially wind. However, when questions on land use and livelihood change are not asked directly in a climate context, households and groups assign economic, political, and social rather than climate factors as the main reasons for change. It is concluded that the communities studied have a high awareness of climate

issues, but climatic narratives are likely to influence responses when questions mention climate. Change in land use and livelihood strategies is driven by adaptation to a range of factors of which climate appears not to be the most important. This, therefore, has implications for policymaking on agricultural and economic development, that is, to focus on providing flexible options rather than specific solutions to uncertain climate (Mertz et al, 2009).

Additionally, a study on farmers' preference for adaptation methods in Uganda, using a stated preference method, shows the importance of microfinance, agricultural extension systems and basic education in farmers' adaptation decisions, and highlights a crucial need to improve local engagement in decision-making. The choice analysis showed that majority of individuals is willing to adapt to climate change and adopt new farming methods. The capital constraint has been identified here as important in the decision to adapt and as a major barrier to technology adoption. Basic education was identified as crucial to the adaptation decision. Those who were willing to adapt had higher levels of both formal and informal education. Less-educated individuals and those on lower income levels are the vulnerable segment and neglected by extension services and interventions (Jame, 2010).

Moreover, the work of Maddison (2007) on the perception of and adaptation to climate change in Africa reveals that significant numbers of farmers believe that temperature has already increased and that precipitation has declined. The factors that affect the farmers' perception of and adaptation to climate change are location, financial constraint, lack of appropriate seed, market accessibility (distance to the output market), farming experience, access to free extension advice, level of education, farm size, tenure in the form of land borrowing, current climate. Being head of the household also increases the probability that the farmer can adapt, perhaps because he or she is in control of household resources. There is, however, no evidence that gender influences the probability of adaptation.

Regarding the adaptation options, this study reveals that in all countries apart from Cameroon and South Africa the planting of different varieties of the same crop is considered to be one of the most important adaptation methods to climate change. Different planting dates are also considered an important adaptation in Egypt, Kenya and Senegal. Adopting a shorter growing season is universally practiced in Senegal but is elsewhere almost irrelevant. In Egypt, the majority of respondents have moved towards non-farming activities. In Egypt, Kenya and South Africa significant numbers of farmers have adapted by increased use of irrigation. In Burkina Faso, Kenya and Niger there is increasing use of water conservation techniques. Soil conservation techniques are increasingly practiced in Burkina Faso, Kenya, Senegal and Niger. There is also increasing use of shading and sheltering techniques in Burkina Faso, Niger and Senegal, where they have been adopted by approximately one third of respondents. Increased use of weather insurance is almost exclusive to Egypt. Prayer and ritual offerings are made in Senegal and Niger. There are however, several countries in which almost a third or more of respondents report no change in agricultural practices. These include Burkina Faso, Cameroon, Ghana, South Africa and Zambia. By contrast every Egyptian and every Ethiopian respondent claimed to have made at least one adaptation.

According to the study of Gbetibouo (2009) on South African farmers in the Limpopo river basin, the coefficient on farm size is significant and positively correlated with the probability of choosing irrigation as an adaptation measure. Indeed, large-scale farmers are more likely to adapt because they have more capital and resources. It also showed that the perception of having highly fertile soil increases the probability that farmers will change their amount of land under cultivation. The research also confirms that those farmers who have access to extension services are more likely to be aware of changing climatic conditions and to have knowledge of the various management practices that they can use to

adapt to changes in climatic conditions. Having access to extension increases the probability of choosing portfolio diversification by 4 percent. The extension is of great importance for the successful implementation of the land reform which has increased the number of new or emerging farmers who did not have the skills and information gathered by experienced farmers. Experienced farmers have an increased likelihood of using portfolio diversification, changing planting dates, and changing the amount of land under production where as wealthier households are more willing to adapt by changing their planting dates. In South Africa, households living in regions with high temperatures have an increased likelihood of adapting. These households are more likely to choose the following adaptation options: (1) portfolio diversification; (2) intensifying irrigation; and (3) changing their planting dates. A decrease in rainfall is likely to push farmers to delay their planting dates. The results also show important regional variation. Farmers in Limpopo province are more likely to adapt compared with farmers in the other provinces. Indeed, in Limpopo, the population is largely rural (82 percent), and the main rural economic activity is agriculture.

Gbetibouo has also explored the linkage between tenure system and farmers' adaptation practices. Having secured property rights increases the probability of farmers to adapt by 9 percent. With proper property rights, farmers may be able change their amount of land under cultivation to adjust to new climatic conditions. According to Lutz et al. 1994; Shultz et al. 1997 as cited by Gbetibouo (2009), land tenure can contribute to adaptation, because landowners tend to adopt new technologies more frequently than tenants, an argument that has justified numerous efforts to reduce tenure insecurity. Land ownership is widely believed to encourage the adoption of technologies linked to land such as irrigation equipment or drainage structures. Land ownership is likely to influence adoption if the innovation requires investments tied to land.

Outside Africa, Wang et al (2008) have examined how China's farmers adapt to climate change using irrigation and crop choice across 8,405 farmers in 28 provinces. A discrete choice logit model is used to model the choice of irrigation and a multinomial logit model for crop choice. The results of the adaptation analysis strongly suggest that Chinese farmers do adapt to climate by shifting to irrigation (where possible) and by switching crops. The study finds that both irrigation and crop choice decisions are climate sensitive. Chinese farmers are more likely to irrigate when facing lower temperatures and less precipitation. Farmers in warmer places are more likely to choose oil crops, maize, and especially cotton and wheat, and are less likely to choose vegetables, potatoes, sugar and especially rice and soybeans. In wetter locations, farmers are more likely to choose soybeans, oil crops, sugar, vegetables, cotton and especially rice, and they are less likely to choose potato, wheat and especially maize. The analysis of how Chinese farmers have adapted to current climate, provides insight into how they will likely adapt when climate changes. Future climate scenarios will cause farmers in China to reduce irrigation and shift crops towards oil crops, wheat, and especially cotton. In turn, farmers will shift away from potatoes, rice, vegetables, and soybeans. The analysis, however, revealed that adaptation will likely vary from region to region.

2.2.2. Empirical Review from Ethiopia

Some studies have tried to show us that Ethiopian farmers have already perceived that the climate is changing in Ethiopia and started to adapt to its negative impacts using different adaptation methods. There are many types of adaptation strategies and methods used by farmers in different parts of the country even though its application and selection could be situation and context-specific.

There is a study conducted by Deressa et al (2008) on the determinants of farmers' choice of adaptation methods and perceptions of climate change in the Nile Basin of Ethiopia. The researchers have employed two types of analytical models. The Multinomial Logit Model was used to analyze what determines the method farmers choose to adapt to climate change, whereas the Heckman Probit Model is applied to examine the farmers' perceptions of and adaptations to climate change.

According to the study, the adaptation methods used by farmers include; using different crop varieties, soil conservation, planting trees, early and late planting and irrigation. The report came up with the result that the use of different crop varieties is the most commonly used adaptation method, followed by planting trees and soil conservation whereas use of irrigation is the adaptation least practiced among the major adaptation methods identified in the Nile basin of Ethiopia. There are also many farmers who are not adapting to the climate change. Concerning the determinants of adaptation, the study reveals that the level of education, gender, age, and wealth of the head of household; access to extension and credit; information on climate, social capital, agroecological settings, precipitation and temperature all influence farmers' choices of adaptation techniques. The main barriers to adaptation include lack of information on adaptation methods, financial constraints, shortage of labor, shortage of land, and poor potential for irrigation. Regarding the farmers' perceptions of climate change, the study indicates that most of the farmers in the study are aware that temperature is increasing and the level of precipitation is declining. The results further indicate that age of the household head, wealth, information on climate change, and social capital positively influence farmers' perceptions of changes in climatic attributes. Moreover, farmers living in dega (highlands) places perceived more changes in climate.

Additionally, Claudia et al (2010) have examined factors affecting the farmers' choices of coping strategies for climate extremes in the Nile Basin of Ethiopia. The study applied the multinomial logit model to analyze the information gathered. The result shows that different socio-economic and environmental factors affect farmers' coping strategy to climate extreme events. These factors are gender of household head being male, age of the head of household (approximates experience), farm income, farm size, livestock ownership, extension on crop and livestock production, farmer-to-farmer extension, local agro ecology kola (low lands), local agro ecology weynadega (mid lands), temperature and precipitation.

On the other hand, a study on farmers' preferences for crop varieties, using choice experiment approach and Random Parameter Logit model, estimated the mean willingness to pay for each crop variety attribute, and identified household-specific and institutional factors that governed the preferences. It is founded that environmental adaptability and yield stability are important attributes for farmers' choice of crop varieties. Farmers are willing to forgo some income or output in order to obtain a more stable and environmentally adaptable crop variety. Among other things, household resource endowments (particularly land holdings and livestock assets), years of farming experience, and contact with extension services are the major factors causing household heterogeneity of crop variety preferences (Asrat et al, 2009). Traditional and contemporary coping mechanisms to climate variability and extremes in Ethiopia include changes in cropping and planting practices, reduction of consumption levels, collection of wild foods, use of inter-household transfers and loans, increased petty commodity production, temporary and permanent migration in search of employment, grain storage, sale of assets such as livestock and agricultural tools, mortgaging of land, credit from merchants and money lenders, use of early warning system, food appeal/aid, etc (NMA, 2007).

Kato et al (2009) have conducted a study on the situation of soil and water conservation technologies as a buffer against production risk in the face of climate change in the Nile Basin of Ethiopia. The study revealed that soil and water conservation technologies have significant impacts in reducing production risk in Ethiopia and could be part of the country's climate-proofing strategy. The results also show the performance of these technologies is location specific and one-size-fits-all recommendations are inappropriate given the differences in agroecologies and other factors.

Bekele (2004) has done a study with the aim of understanding farmers' perception of the relevance of different development intervention programs. Farmers' subjective ranking of agricultural problems and their preference for development intervention are elicited using a stated preference method and analyzed using the Multinomial Logit Model. The factors influencing these preferences are determined using a random utility model. The study is based on a survey conducted in the Hunde-Lafto area of the Eastern Ethiopian Highlands on 145 randomly selected farm households using semi-structured questionnaires. The study suggests that drought, soil erosion and, shortage of cultivable land are high priority agricultural production problems for farmers. Low market prices for farm products and high prices of purchased inputs also came out as major problems for the majority of farmers. Farmers' preferences for development intervention fall into four major categories, market, irrigation, resettlement, and soil and water conservation. The analysis of the factors influencing these preferences revealed that farmer's specific socio-economic circumstances, and subjective ranking of agricultural problems play a major role. It is also shown that preferences for some interventions are complimentary and need to be addressed simultaneously. Recognition and understanding of these factors, affecting the acceptability of development policies for micro level implementation, will have significant contribution to improve macro level policy formulation.

Moreover, Tsegay (2010) has done a study on climate change adaptation in Abraha wa Atsebaha Village in Tigray, Ethiopia, and demonstrates that vulnerability to climate related hazards can be resolved through holistic local level interventions. The study also showed that achieving adaptation to climate variability and change is a development process that requires all the weak points of the multifaceted subsistence production chain be addressed. The risk of disaster due to climate hazards is often greatest when a society is confronted with other seemingly unrelated dangers. The communities studied are simultaneously confronted by numerous slow-onset (creeping) environmental problems such as soil erosion, deforestation, and the disappearance of indigenous trees as witnessed in other societies. This study also showed that the kinds of interventions needed to achieve food security among subsistence peasants have to first identify the major constraints that arise due to changes in climate and the environment. As is shown in the case study, water was identified as the foremost constraint within the hierarchy of problems facing the people. It also confirmed that interventions to mitigate climatic changes must be based on the availability of local resources and the interests of local populations as farmers in the study area were active participants in solving their community's problems. Moreover, continuous delivery of inputs including technology, micro-credit, and extension services are important tool for the sustainability of food security interventions in the face of climate change.

In general, climate change adaptation has gained much attention today. Farmers nationally and internationally perceived the change in the climate and started taking different adaption measures to it. Adaption to climate change includes all the adjustments in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities.

Chapter Three

Research Methodology

3.1. Study Area, Data Sources and Collection Methods

3.1.1. Describing the Study Area

Amhara National Regional State is one of the nine regions of the country which has many zones, districts and city administrations with different natures of weather conditions and agroecological settings. According to the classification of the agro-ecological zones of Ethiopia, the Amhara region is divided into 10 major agro-ecological zones and 24 sub-agro-ecological zones. The report of Ministry of Agriculture shows that the mean annual rainfall varies between 300 and 2000 mm and the mean annual min-max temperatures also range from 7 to 25°C. This research selected farmers from Shoa Robit town and the surroundings areas as a case study (all the areas for this survey are constituents of Shoa Robit administration). Shoa Robit town was the main administrative city of Kewot district. However, at this time the town stands by itself as city administration by encompassing many rural Kebeles and villages in its surroundings. It is 220 km far away from Addis Ababa.

The administration includes 9 Kebeles of which the first 4 Kebeles are in the urban area and the remaining 5 Kebeles in rural and semi-rural areas. A source from the administrative office (2008) showed that the administration constitutes a total population of 55,270 people. From this, around 55.76 percent of the population is estimated to live in the urban areas where as the remaining 44.24 percent of the total population is living in the rural areas (administration, 2008).

The area is located around 1126 meter above sea level which is characterized by what we call Kolla agro-ecology. The area is well characterized by different levels of temperature and rainfall among different production periods or seasons. It is mainly attributed by hotter temperature throughout the year and inconsistent or erratic annual rainfall. A climate data on temperature and rainfall is collected from the NMA for 1982-1994 and 2006-2009 where data from 1995-2005 is not available. Given this data gap, average minimum and maximum temperatures are calculated. The data indicated that the area on average is characterized by a maximum and minimum temperature of 30.9⁰C and 16.1⁰C respectively (refers to average of all years). It also shows that the study area is characterized by a minimum and maximum monthly mean rainfall of 19.8mm (in June) and 219.8mm (in August) respectively over the periods mentioned above.

Mixed farming is a commonly practiced farming system. Farmers grow different types of crops such as rain-fed crops, irrigated crops, perennial /annual crops or combination of them. There are also farmers producing livestock of different types. The report indicated that the administration has dry farm land of 2739.2 hectares and irrigable land of 1242.5 hectares which is summed up to a total of 3981.7 hectares farm land. Moreover, there are two rivers Shoa Robit River and Kobo River (named by the names of the places they cross: Shoa Robit river because it passes through the town and Kobo river because it passes through one of the rural Kebeles i.e. Kobo) which serve different purposes for both the Shoa Robit town people and the surrounding farmers.

3.1.2. Data Sources and Collection Methods

The study uses a case study approach as case study methodologies are widely employed, today, in scientific research. Their increasing importance is consistent with the development of contextual approaches to climate change researches such as vulnerability assessment, increased focus on adaptation as a response to climate change, and movement toward adaptation mainstreaming or the integration of adaptation aims into ongoing policy initiatives at different levels of governance. Case study researches are based on intensive and detailed examination of an issue within its real-life context that can provide rich knowledge and help to generate new ideas for effective formulation and implementation of policies and strategies. Case study approach also aims at providing a detailed understanding of processes not readily acquired from other methods, providing methodological value through a focus on depth and enabling a deep understanding of phenomenon based on examination of an outcome or problem in a natural setting (Ford et al, 2010).

This research has used both primary and secondary data depending on the nature and availability of data. Primary data on farmers' preference for climate change adaptation strategies, different attributes of the households, their farms, institutional factors and climate perception variables are used. The research has also used secondary data on weather conditions (temperature and precipitation level) of the study area.

To collect the primary data, certain procedures are followed. The survey population consisted of all farmer households in the Shoa Robit and the surrounding rural areas in North Shoa zone of the Amhara region. As described above, this area is selected as a case study because it has its own climatic features among different areas in the zone. Among the 9 Kebeles in the study area, seven of them (5 rural and 2

urban Kebeles) are selected purposively with the discussion of Agriculture and Rural Development office experts by considering the different environmental and socioeconomic characteristics of the areas. Most importantly, the proportion of farmers in the rural and urban areas is among the criteria considered in the selection. Majority of the agricultural activities are exercised in the rural Kebeles and almost all of the people are farmers. However, majority of the population in the urban Kebeles are not farmers. We can find farmers mostly in two of the four urban Kebeles, i.e. around Charie and Monopole. Therefore, these two urban Kebeles are selected to represent farmers in the urban area.

The household sampling frame was developed to select sample households that represent population of the study area. Then, simple random sampling method was used in selecting 34 households from each Kebele, which results in a total of 238 households. However, the final dataset includes only responses of 225 households from the 7 Kebeles. This is because 13 households did not give full and reliable responses to the questions and thus omitted.

The primary data is collected using questionnaire through household level face-to-face interviews. Prior to the formal survey of the actual data, informal interviews and discussions have been conducted with farmers and key informants. The information collected from the informal survey is used to develop and appropriately design the formal questionnaire. The data is then collected by enumerators who are carefully selected and trained.

Since the research requires rank-ordered data on farmers' preference for the alternative adaptation strategies to climate change, the households have personally been interviewed systematically to capture the order of their preferences from the most preferred to the least preferred. This is done by

treating the assignment of each rank for each alternative as a choice process itself and then separating rank orderings into series of choices. Thus, the data is produced by a system in which the farmers have chosen their most preferred alternative (alternative with the highest utility) from the 5 alternative adaptation strategies. From the remaining 4 alternatives, they again picked up the alternative with the largest utility which is their second preference. Again, from the remaining 3 adaptation strategies, they selected their most preferred one i.e. their third preference. The process continued in this way until one alternative is remained; by the same token, this will be the last preference of that farmer.

The data on climate variables (temperature and rainfall) is collected from the National Meteorological Agency of Ethiopia. The collected climate data includes monthly minimum and maximum temperature measured in °C, and average monthly rainfall measured in mm for the periods 1982-1994 and 2006-2009 where data from 1995-2005 is not available.

3.2. Analytical Method: Rank-Ordered Logit Model

The analytical model used for this research is the Rank-Ordered Logit Model (ROL model hereafter). The ROL model is a generalization of the conditional logit model for ranked outcomes. Different studies used the ROL model to analyze ranked data such as: Beggs et al 1981 to model demand for electric cars; Kumar and Kant 2007 to model preferences for multiple forest values; FOK et al 2010 to model unobserved heterogeneity in ranking capabilities; Punji & Staelin 1987 to model choices for business graduate schools; Koop & Poirier 1994 to model voters' preferences; Christakis & Asch 1993 to model physicians' choice for withdrawing life support; Siikamaki 2001 to model valuation of forest benefits; Lepianka et al 2010 to model poverty; Nixon et al 2009 to model preferences for recycling electronic waste; Roheim et al 2000 to model consumer preferences for seafood.

As with the conditional logit model, the ROL model can be used with case-specific explanatory variables, alternative-specific explanatory variables, or a combination of both. The ROL model takes advantage of the added information if respondents are asked to rank each alternative instead of the most preferred. The model can also be used when individuals provide tied ranks for some alternatives or when individuals do not rank some of the least-preferred items (Long & Freese, 2006). However, for this research the ROL model is used by taking only case-specific explanatory variables when all alternatives are fully ranked without ties.

In researches of a classical setup respondents are asked to select their most preferred option out of a (selected) set of alternatives. Additionally, the analytical approaches that are frequently used in an adoption decision study that includes multiple choices are the Multinomial Logit Model (MNL) and Multinomial Probit Model (MNP). Both the MNL and MNP are useful for analyzing farmers' adaptation decisions and are also suitable for assessing different combinations of the alternative adaptation strategies, including individual strategies (Hassan & Nhemachena, 2008). Both these models use farmers preferred choices of adaptation methods from the set alternatives, not the ranked one.

However, the most preferred climate change adaptation strategies by African farmers are mostly applied in combination with other strategies and not alone (Hassan & Nhemachena, 2008). This implies that farmers must know and be able to rank the alternative adaptation options that they have according to the order of their preference and the local context. Then after, they can choose the appropriate combinations of adaptation methods and apply to respond to impacts of the change in climate.

Moreover, Beggs, Cardell, and Hausman (1981) noted that (cited by Fok et al, 2010) more information per respondent and thus an efficiency gain can be obtained if we ask the farmers for a ranking of the whole set of alternatives available to them instead of listing their preferred choices even though data on the most preferred adaptation method is sufficient to estimate the model parameters. In statistical terms, the parameters can then be estimated more efficiently (Fok et al, 2010).

According to Shikano et al (undated) using rank orderings of farmers' preferences to model estimation could help us to incorporate more information as we do not only observe the alternative that is most preferred but relative preferences for the other alternatives as well. This will increase the number of effective observations (ranking stages within respondents) on which the model estimation is carried out, while the set of parameters to be estimated remains the same. Hence, coefficient estimates will be more efficient compared to those from a first preference analysis only.

Padilla et al (2003) also confirmed that making individuals rank a series of alternatives is one way of obtaining detail information from preference surveys. Ranked data from individuals allows considerably more information to be gathered from a given survey observation than is gathered from simply the most preferred alternative. This implies that efficient estimations of the parameters of the utility function may be obtained with smaller sized samples and, therefore, that the monetary cost of the survey is substantially reduced (Padilla et al, 2003).

Therefore, a ranked-ordered data on farmers' preferences for climate change adaptation strategies is generated and the ROL model is used for analyzing the preference of farmers' for a particular adaptation strategy over a discrete set of items and the determinants of their preference.

This research assumed that based on their detail knowledge of the farming environment, agricultural problems and their past experiences, farmers can state their preferences for the alternative adaptation strategies to climate change in line with their utility maximization objective under different constraints and resource endowments. Hence, the farmers are presented with 5 randomly permutated list of possible adaptation strategies to climate change and asked systematically to know the order of their preferences for the whole set of alternative adaptation strategies (from the most preferred to the least preferred rather than asking their most preferred strategy only).

The functional relationship is, therefore, specified as follows:

$$\mathbf{ASP = F(H, F, I, C),(1)}$$

Where, ASP = Adaptation strategy preferences (rank-orderings) of farmers

H = Household characteristics

F = Farm characteristics

I = Institutional factors

C = Climate perception variables

The review of empirical literatures is used in order to identify the adaptation measures that farmers are using and will use to adapt to climate change. The adaptation measures that farmers applied may be profit driven, rather than climate change driven. Despite this missing link, like Nhemachena and Hassan (2007), this study assumes that the farmers' actions are driven by climatic factors.

As it is well indicated in the literature, farmers use different types of strategies to adapt to the impacts of climate change. To mention some of them: use of new crop varieties, livestock species, irrigation, crop diversification, change of planting dates, planting trees, diversification from farm to nonfarm

activities, water and soil conservation techniques, changed use of capital and labor, and trees planted for shade and shelter.

By considering results of researches in the literature review and my personal observation from the study area, the following five adaptation options have been selected to be used in this model and categorized as follows:

Alternative 1: Multiple Cropping (using different and new crop varieties)

Alternative 2: Livestock Production

Alternative 3: Soil Conservation

Alternative 4: Irrigation Development

Alternative 5: Changing Planting Dates (early and late planting)

These alternative adaptation strategies are represented by $j = 1. . . J$. Farmers could use these different types of adaptation strategies according to their context. Some may apply only one while other farmers could use any combination of them which would result in different level of net benefit or utility to the farmers. In order to select a particular adaptation strategy or combination of strategies, the farmers need to consider the order of their own preferences for the methods (they are expected to decide rationally).

According to McFadden (1974) cited in the literature, it is a usual practice to use a random utility framework to analyze the responses of respondents to different alternatives since their preferences are observed in terms of their choices for alternative adaptation methods. In Verbeek (2008), it is argued that the random utility framework is a widely applied framework to situations where individuals are asked to state and rank their preferences for alternative choice set. In situations where there is no

natural ordering in the alternatives and it is not realistic to assume a monotonic relationship between one underlying latent variable and the observed outcomes, a common approach is to start with a random utility framework, in which the utility of each alternative is a linear function of observed characteristics (individual and/or alternative specific) plus an additive error term (Verbeek, 2008).

The utilities for each farmer are represented by U_{i1}, \dots, U_{ij} where i represents the individual farmers and j refers to the adaptation method/s selected by them. It is assumed that the respondent makes a systematic choice and therefore knows all utilities that could be derived from the adaptation strategies ($U_{ij}, j = 1, \dots, J$). Let $y_{ij} = 1$ refers to individual i who prefers alternative j first. The choice $y_{ij} = 1$ implies that $U_{ij} \geq \max\{U_{i1}, \dots, U_{ij}\}$. Since we cannot observe U_{ij} , it needs to use a stochastic model for representing the utilities. Assuming that the respondent makes a probabilistic decision, the study uses the random utility framework to represent the preferences of the households.

The random utilities for individual i are, thus, expressed as

$$U_{ij} = V_{ij} + \varepsilon_{ij}, \dots \dots \dots (2)$$

where V_{ij} refers to the systematic component of the utility and ε_{ij} is the random component of the utility.

The systematic part of the utility is going to be determined by the observed individual characteristics, and is modeled as

$$V_{ij} = X_i' \beta_j, \dots \dots \dots (3)$$

where, X_i is an m -dimensional vector of characteristics of individual i (i.e. case-specific explanatory variables) and β_j is an m -dimensional parameter vector specific to alternative j . If we assume that all ε_{ij} 's are independent and follow a type I extreme value distribution, it will lead us to the

Multinomial Logit Model (MNL) and hence data on the most preferred item would be sufficient to estimate the model parameters.

However, in this research we asked the farmers for a ranking of the whole set of alternatives in order to get more information per respondent and thus an efficiency gain. From the ranking of the farmers, the response of respondent i is denoted by the vector

$$\mathbf{y}_i = (y_{i1} \dots y_{ij})', \dots \dots \dots (4)$$

where y_{ij} now denotes the rank that individual i assigns to item j . For example, $y_{ij} = 2$ means that the respondent considers alternative j the second most preferred option. For convenience and analysis purpose the following equivalent notation is used

$$\mathbf{r}_i = (r_{i1}, \dots, r_{ij})', \dots \dots \dots (5)$$

where r_{ij} denotes the item number that received rank j by individual i .

An observed ranking by a respondent is an implication of the complete ordering of the underlying utilities that could be derived from the respective method. A farmer will prefer an adaptation method with a higher utility over an option with a lower utility. If we observe a full ranking r_i of the given alternatives, we know that $U_{iri1} > U_{iri2} > \dots > U_{iriJ}$. Using the utility assumption made above in equation (2) and the assumption of the extreme value distribution, we obtain the ROL model. Therefore, the probability of observing a particular ranking r_i will be

$$\begin{aligned} \text{Prob}[\mathbf{r}_i; \boldsymbol{\beta}] &= \text{Pr}[U_{iri1} > U_{iri2} > \dots > U_{iriJ}] \\ &= \prod_{j=1}^{J-1} \frac{\exp(V_{irij})}{\sum_{l=j}^J \exp(V_{iril})}, \dots \dots \dots (6) \end{aligned}$$

Suppose $y_r = "a"$ which indicate that alternative "a" has rank "r"; that is alternative "a" is the r^{th} choice. Then, the probability of the farmers' first choice of adaptation strategy can be written as $\text{prob}(y_1 = a_1|x)$. Then, the probability of the farmers' second choice is written as $\text{prob}(y_2 = a_2|x, y_1 = a_1)$, since the probability of the second choice is conditional on the first choice that means if $y_1=a_1$, then $y_2 \neq a_1$. Similarly, the probability of the third choice will be conditional on the first and second choice of the farmers, hence it can be written as $\text{prob}(y_3 = a_3|x, y_1 = a_1, y_2 = a_2)$ (Long & Freese, 2006). This conditionality of the probability of a certain choice continues until the last item in the choice set is left, whose probability of being the last choice is also conditional on all choice decisions made previously.

Moreover, unbiased and consistent parameter estimates of the ROL model requires the independence of irrelevant alternatives which in turn implies the independent and homoscedastic disturbance terms of the main model. That means adding or deleting alternatives should not affect the odds among the remaining alternatives. If the IIA assumption is not satisfied, the ROL model will not be appropriate to model the farmers' preferences for climate change adaptation strategies. Therefore, we assume the Independence of the Irrelevant Alternatives (IIA).

In this study, five alternative adaptation strategies are included: multiple cropping (MC), livestock (LI), soil conservation (SC), irrigation (IR) and changing planting dates (CD) with their corresponding abbreviations. By extending the above logic to the ranking of the adaptation strategies by farmers, the probability the rank-ordering is computed as follows:

$$\begin{aligned} \text{Prob}(Y_1 = \text{MC}, Y_2 = \text{LI}, Y_3 = \text{SC}, Y_4 = \text{IR} | X) &= \text{Prob}(Y_1 = \text{MC} | X) * \text{Prob}(Y_2 = \text{LI} | X, Y_1 = \text{MC}) \\ &\quad * \text{Prob}(Y_3 = \text{SC} | X, Y_1 = \text{MC}, Y_2 = \text{LI}) \\ &\quad * \text{Prob}(Y_4 = \text{IR} | X, Y_1 = \text{MC}, Y_2 = \text{LI}, Y_3 = \text{SC}) \end{aligned}$$

where MC, LI, SC, IR represent the first four alternative adaptation strategies.

The above equation states that the probability of the specific rank ordering is the product of:

1. The probability of multiple cropping being selected from a choice set that includes all five alternatives;
2. The probability of livestock being selected from a choice set that excludes multiple cropping;
3. The probability of soil conservation being selected from a choice set that excludes multiple cropping and livestock;
4. The probability of irrigation being selected, given a choice set that excludes multiple cropping, livestock and soil conservation. Here, the last choice is not taken in to account because if the first 4 choices are known, the last choice is implied.

Using the MNL to model the probability of multiple cropping being selected first yields

$$\text{Prob}(Y_1 = \text{MC} | X) = \frac{\exp(X\beta_{\text{MC}|b})}{\sum_{j=1}^J \exp(X\beta_{j|b})}$$

where X contains case-specific variables, b is the base category (in this case the selection of base category is arbitrary), $\beta_{k,m|b}$ is the effect of the X_k on the log odds of choosing alternative m over the base category, and $\beta_{k,b|b} = 0$ for all explanatory variables k.

The probability of livestock being selected given a choice set that excludes multiple cropping requires that we subtract $\exp(X\beta_{\text{MC}|b})$, and then it will be

$$\text{Prob}(Y_2 = \text{LI} | X, Y_1 = \text{MC}) = \frac{\exp(X\beta_{\text{LI}|b})}{\{\sum_{j=1}^J \exp(X\beta_{j|b})\} - \exp(X\beta_{\text{MC}|b})}$$

Similarly, the probability of soil conservation being selected from a choice set that excludes MC and LI requires that we subtract $\exp(X\beta_{\text{MC}|b})$ and $\exp(X\beta_{\text{LI}|b})$ from the denominator:

$$\text{Prob}(Y_3 = \text{SC} | X, Y_1 = \text{MC}, Y_2 = \text{LI}) = \frac{\exp(X\beta_{\text{SC}|b})}{\{\sum_{j=1}^J \exp(X\beta_{j|b})\} - \exp(X\beta_{\text{MC}|b}) - \exp(X\beta_{\text{LI}|b})}$$

In a similar way, the probability of irrigation being selected from a choice set that excludes MC, LI and SC again requires that we subtract $\exp(X\beta_{MC|b})$, $\exp(X\beta_{LI|b})$ and $\exp(X\beta_{SC|b})$ from the denominator:

$$\text{Prob}(Y_4=IR | X, Y_1=MC, Y_2=LI, Y_3=SC) = \frac{\exp(X\beta_{IR|b})}{\{\sum_{j=1}^J \exp(X\beta_{j|b})\} - \exp(X\beta_{MC|b}) - \exp(X\beta_{LI|b}) - \exp(X\beta_{SC|b})}$$

Then, the model is fitted by maximizing the probability of observing the rank orders that were observed among all cases using the Maximum Likelihood Estimation (MLE) approach.

Finally, estimates of the ROL model can be interpreted in terms of the marginal effect, the odds ratio and the change in the predicted probabilities. Though the marginal effect at the mean is a common summary measure for categorical dependent variables, the measure has some limitations. First, given the nonlinearity of the model, it is difficult to translate the marginal effect into the change in the predicted probability if there is a discrete change in the independent variables. Second, the mean of the explanatory variables might not correspond to any observed value in the population. Finally, the measure is inappropriate for binary independent variables (Long, 1997).

Change in predicted probabilities for discrete changes in the independent variables is more effective and preferred method of interpretation that can be used for both continuous and dummy independent variables. Therefore, our interpretations in this study relied much on the change in predicted probabilities for discrete changes in the explanatory variables.

Interpretation based on predicted probabilities depends on the values of the explanatory variables. It depends on the initial value, the amount of the change and the values for all other variables. For instance, the discrete change in the predicted probability of a certain outcome for a change in X_k from the start value say, X_s , to the end value say to, X_e ,

$$\frac{\Delta \Pr(y=m|X)}{\Delta X_k} = \Pr(y=m|X, X_k = X_E) - \Pr(y=m|X, X_k = X_S)$$

where $\Pr(y=m|X, X_k)$ is the probability that $y=m$ given X , by assigning specific value to X_k . The change in the probability is interpreted as indicating that when X_k changes from X_S to X_E , the predicted probability of outcome m changes by $\Delta \Pr(y=m|X)/\Delta X_k$, holding all other variables constant.

Furthermore, to understand the nature of the overall preferences of the households in the study area for the five climate change adaptation strategies, we use the odds way of interpretation. The odds for the adaptation strategies are calculated as the exponent of the respective coefficients. The odds results of the ROL model can be interpreted as, for a unit change X_k the odds are expected to change by a factor of $\exp(\beta_k)$, holding all other variables constant. However, for our case we use the odds value for understanding the overall preference of the farmers only.

3.3. Model Variables Identification and Definitions

3.3.1. Dependent Variable

The dependent variable for the ROL model is the rankings of farmers for the five alternative adaptation strategies listed in the choice set.

3.3.2. Explanatory Variables

The identification of the model's explanatory variables is made by review of both empirical and theoretical literatures and availability of data. Thus, household characteristics, farm characteristics, climate and other factors are hypothesized to influence farmers' preferences (the probability of a specific rank-ordering) for climate change adaptation strategies.

Household characteristics: The household characteristics that are expected to have impacts on adaptation decisions and preferences of farmers are age, education level and gender of the head of the household, household size, farming experience, farm and non-farm income and television and/or radio ownership. Age, farmers' experience and education levels are measured in years and are continuous variables. Gender of household head is also expected to influence preference for adaptation techniques whose effect is controlled by inclusion of a dummy variable. Household size is a continuous variable and measured in numbers. Farmers' farm and non-farm income are also expected to influence their preference for adaptation strategies. Income is a continuous variable and measured in Ethiopian Birr. A dummy variable for TV and Radio ownership is also included.

Farm characteristics: Review of the literature revealed that farm size, distance to input market, distance to output market, and farm distance to house are supposed to affect farmers' preference or choice of adaptation techniques to climate change. Farm size is a continuous variable and is measured in hectares. Continuous variables on distance to markets (both input and output) and farm distance to house are included in the model, measured in kilometers.

Institutional factors: Some of the institutional factors usually indicated in different researches that could affect farmers' choice or preferences for adaptation strategies to climate change are provision of extension services by experts, farmer-to-farmer extension services, credit services, and access to climate forecast information. Access to extension services is assumed to increase the possibility of perceiving changes in the climate as well as the probability of adaptation and thus preferences for adaptation methods to climate change. A dummy variable is, therefore, included in the model to control for its influence. Extension activities between the farmers themselves are also expected to affect the farmers' preference and choice of adaptation methods and thus represented by a dummy

variable on farmer-farmer extension activities. Availability of credit, a dummy variable, is also hypothesized to influence farmers' preferences for adaptation strategies. Finally, a dummy variable is included whether the respondents have received climate forecast information.

Climate perception variables: researches showed that long term trends in temperature and precipitation as well as farmers' perception of long-term temperature and precipitation are expected to affect their preferences for adaptation methods. In this research, farmers' perception regarding changes in long term temperature and rainfall are included instead of the recorded data on temperature and precipitation. This is done because it is expected that farmers' adaptation decisions to climate change are based on their perceptions of temperature and rainfall change, not based on the recorded climate trend.

This is, for instance, similar with the argument of Maddison (2007) that noticing climate change increases the probability of uptake of adaptation measures. Farmers who are aware of changes in climatic conditions have higher chances of taking adaptive measures in response to observed changes. Perceiving the changes in the climate is an important precondition for farmers to take up adaptation measures. Finally, a dummy variable is included to control for the effect of whether that farmers knew other farmers who perceived the change in the climate and took adaptation measures.

Chapter Four

Descriptive Analysis

4.1. Farmers' Perceptions and Expectations of Climate Change

In this section, we analyzed farmers' perceptions on the long-term changes in temperature and rainfall. Their expectations about the future changes in temperature and rainfall are also discussed.

Farmers were asked whether they perceived long-term average changes in temperature and rainfall (including nature of the changes) for the last 20 years. However, due to ambiguous responses by respondents to the questions regarding the nature of the changes, they are only categorized in to those who perceived the change and those who didn't, as presented in Table 4.1 below. Therefore, their responses indicate that 67.56% and 92.44% of them have perceived changes in temperature and rainfall, respectively; whereas 32.44% and 7.56% of the respondents didn't perceive changes in the long-term average temperature and rainfall, respectively, for the last 20 years. The proportion of the respondents who perceived neither temperature nor rainfall changes is almost negligible. Even if there are farmers who responded "No" to both of the perception questions, they believe that there are variations in the temperature and rainfall at least in the short-term.

Table 4.1: Households' perceptions on average climate change over the past 20 years

No	Variable	Temperature		Rainfall	
		In number	In %	In number	In %
1	Percieve change	152	67.56	208	92.44
2	Don't percieve any change	73	32.44	17	7.56
	Total	225	100	225	100

Source: own calculation

In general, we can conclude that the majority of the population in the study area feels that there are changes in the long-term average temperature and rainfall over the last 20 years and this is supported by the observed trends of temperature and precipitation levels in the area even if the data we got from the NMA is only for limited years. Although some farmers are not clear about the average change, they agree that there is change in the climate. This finding, for instance, is in contrast with the survey conducted in the Nile basin of Ethiopia by Deressa et al (2009) where there are 14.4 % and 12% of farmers who said the temperature and rainfall remained the same, respectively, over the last 20 years.

In addition to their past perceptions, farmers were also asked their expectations about future changes in temperature and rainfall. As we can see from Table 4.2, 37.33% and 9.78% of the respondents have reported that they expect an increase and a decrease in the future temperature, respectively. Concerning rainfall, 33.78% and 4.89% of them reported they expect a decrease and an increase in the future rainfall, respectively. In contrast to these farmers, there are farmers who are unable to explain their expectations about the future temperature and rainfall patterns. As the result indicates, 52.89% of the respondents couldn't state their expectation about the future temperature, and 61.33% of them for rainfall. The main explanation for this as stated by the farmers themselves is that the future

temperature and rainfall patterns are determined by GOD; “we cannot know in advance the future temperature and rainfall conditions, it has its own spiritual aspect”.

Table 4.2: Households’ expectations about future climate

No	Variable	Temperature		Rainfall	
		In number	In %	In number	In %
1	Expect increase	84	37.33	11	4.89
2	Expect decrease	22	9.78	76	33.78
3	Don’t know	119	52.89	138	61.33
Total		225	100	225	100

Source: own calculation

4.2. Impact of Climate Change

This section deals with farmers’ evaluation of the level (degree) of impact inflicted by climate change. The households were asked to what extent the changes in temperature and rainfall have affected their farming system and production according to their self-valuation. The result in Table 4.3 indicates that 43.56% of the respondents reported that they are moderately affected by the change in climate. We also found that 52.89% of the farmers have been highly affected by the change in climate while the remaining 3.56% of them are less affected.

Table 4.3: Impact of climate change on farming system and production

No	Impact level	In number	In percent
1	Less affected	8	3.56
2	Moderately affected	98	43.56
3	Highly affected	119	52.89
Total		225	100

Source: own calculation

We see that 100% of farmers are affected by the changes in temperature and rainfall. This can indirectly confirm that all farmers have perceived the change in the climate at least in case of these respondents.

4.3. Evaluation of Government Support Regarding Climate Change

The survey instrument was also designed to capture farmers' self-evaluation of the level of any kind of support related to climate change that they are getting from government bodies. The results are presented in Table 4.4. For 42.22% of the respondents, the level of the support from the government is not enough; whereas, 40.45% of the surveyed farmers responded that it is enough and 17.33% percent of them are unable to evaluate it.

Table 4.4: Farmers' evaluation of government support regarding climate change

No	Support level	In number	In percent
1	Enough	91	40.45
2	Not enough	95	42.22
3	Do not know	39	17.33
	Total	225	100

Source: own calculation

Even if some proportion of the farmers responded that the support is enough, the result implies there is a gap from the side of the government concerning the support given to the farmers related to climate change.

4.4. Farmers' Actual Adaptation Strategies

In previous sections, we have seen that farmers are aware of the climate change in the past 20 years and also the possibility of future climate change. This raises the question whether the farmers are adapting or not to this change in the climate. Therefore, farmers were asked whether they have been taking adaptation measures to the long-term climate change or not. Those who said yes are also asked the adaptation measures they took to acclimatize themselves to the negative impacts of climate change. The actual adaptation measures taken by farmers are presented in Table 4.5.

Table 4.5: Adaptation measures taken by farmers in the study area

No	Adaptation Measures	Percentages
1	Changing planting dates	85.33%
2	Soil conservation measures	84.89%
3	Changing crop variety(including new varieties)	78.22%
4	Irrigate more	53.33%
5	Planting trees	41.33%
6	Reduce number of livestock	28.89%
7	Build a water harvest scheme	15.56%
8	Change from crop to livestock	11.11%
9	Other measures	11.44%
10	Did not take any of the above	14.80%

Source: own calculation

As shown in the Table 4.5, changing planting dates, soil conservation measures, and changing crop variety are the most highly practiced adaptation strategies to climate change by the farmers. Almost

85% of the farmers have changed planting dates in response to changing climatic conditions. A similar percentage of them have implemented soil conservation techniques while nearly 78% of the farmers have tried to adapt by changing their crop varieties. Moreover, strategies such as irrigation, planting trees and reducing the number of livestock are exercised by 53 %, 41% and 29% of the farmers, respectively. Shifting from crop production to livestock is the least practiced measure. Generally, around 85% of the farmers have taken at least one adaptation measure in response to the changing climatic conditions. The remaining 15% did not take any of the adaptation measures presented for them.

In addition to these farm level adaptation strategies to climate change, the households were asked for any other measure they took in their activities in response to climate change. The responses indicate that 4% of them leased their land, one farmer migrated to urban area and 7% of them tried to find and work for off-farm jobs.

These measures taken by the farmers may be profit driven, rather than climate change driven. However, we assume that their actions are motivated by the changing climatic conditions because almost all of the farmers have already perceived the change. This is, for instance, confirmed by the work of Nhemachena and Hassen (2007).

4.5. Barriers to Adaptation

As indicated before, around 15% of the households did not take any of the adaptation measures presented for them. They have explained the main reasons they encountered for not adapting to the long term change in the climate. Those who have tried to adapt to the change in climate are also

challenged by many factors because taking adaptation measure does not necessarily mean “no constraint to adaptation at all”. Therefore, Table 4.6 includes the reasons explained by all respondents.

Table 4.6: Constraints to climate change adaptation

No	Adaptation Constraints	Percentage of respondents
1	Lack of information/knowledge	34.55%
2	Shortage of money	23.95%
3	Shortage of labor	5.6%
4	Shortage of land	20.4%
5	Unsuitability of land and poor potential for irrigation	11.5%
6	Others	4%
	Total	100%

Source: own calculation

The constraints or barriers to adapt to climate change faced by the farmers in the study area are lack of information or knowledge (34.55%), shortage of money (23.95%), shortage of land (20.4%), unsuitability of land and poor potential for irrigation (11.5%), shortage of labor (5.6%) and others (4%).

Lack of information or knowledge is the main constraint to adaptation as explained by the framers. This constraint could be a manifestation of poor information system of the concerned bodies, poor training or extension services for the farmers and others. It can also imply weak research and development efforts on suitable and new agricultural practices.

Shortage of money is the second biggest constraint faced by the farmers. Since money is the medium households commonly use to make purchase of the necessary inputs and other transactions, it is expected that their adaptive capacity to climate change is limited by shortage of money. Getting credit is not an easy task for the farmers. One reason is farmers could not produce collateral to get credit. Some mentioned that they don't want to borrow money for the simple reason that they fear borrowing and servicing of the borrowed money.

Shortage of land is the third constraint that challenges the farmers. This constraint includes not only shortage in terms of size of land but also the fertility of the land, as mentioned by the farmers. They explained that their currently owned land is poor in its fertility and is losing its capacity from time to time. Increasing in the number of population in general and households' size in particular would force households to fragment and overexploit their limited farm land. This situation could limit their capacity to exercise different adaptation measures to climate change.

Lack of water for irrigation and unsuitability of the farm land to carry out adaptation strategies is the fourth constraint to adaptation. Some lands are not suitable to undertake adaptation measures such as soil and water conservation, and tree planting. Farmers cannot also grow any kind of crop they want as it is limited by the suitability of their land. Shortage of labor is also a constraint for 5.6% of the households. Others include lack of fodder, animals' death, unavailability of technologies, unwillingness to take measures and unable to adapt due to for instance age.

Lack of land suitable for irrigation is a big constraint to undertake irrigation activities. However, even those farmers who have their own irrigable land are facing difficulty to undertake irrigation due to lack of water. As mentioned in previous chapters, there are two large rivers in the study area. Few years ago, large number of farmers started using the rivers for different purposes especially for irrigation. This in combination with the changing climatic conditions made the rivers unable to serve the needs of the farmers.

4.6. Farmers' Preference for Climate Change Adaptation Strategies

As the main theme of this research is analyzing the determinants of farmers' preferences for climate change adaptation strategies, it is worthwhile to discuss and describe the nature and structure of these preferences.

To understand the overall preference of the farmers, we weight each percentage or frequencies in each rank by different weights calculated using the Rank-Order Centroid (ROC) method. This method is a simple way of giving weight to a number of items ranked according to their importance. The weights are calculated based on the following formula: $W_i = 1/M \sum_{n=i}^M 1/n$, where M is the number of items and W_i is the weight for i^{th} item. Thus, we calculate the weights for the 5 items in the 5 ranks and they are 0.46 to weight item ranked first, 0.26 to weight item ranked second, 0.16 to weight item ranked third, 0.09 to weight item ranked fourth and $= 0.04$ to weight item ranked fifth. Then, each frequency distribution is multiplied by the respective weight and finally the results are summed up to get an index

for each adaptation strategy as shown in Table 4.7. The largest index refers to the most preferred and the smallest index refers to the least preferred adaptation strategy.

Table 4.7: Weighted ranks of farmers' preferences to adaptation strategies

No	Adaptation Strategy	Ranked first	Ranked second	Ranked third	Ranked fourth	Ranked fifth	Index
1	Multiple cropping	40.00*.46	19.11*.26	16.44*.16	21.78*.09	2.67*.04	28.07
2	Livestock	0.44*.46	7.56*.26	6.67*.16	18.67*.09	66.67*.04	7.58
3	Soil conservation	23.56*.46	36.00*.26	22.22*.16	12.44*.09	5.78*.04	25.10
4	Irrigation	24.00*.46	15.56*.26	28.44*.16	20.44*.09	11.56*.04	21.94
5	Changing planting dates	12.00*.46	21.78*.26	26.67*.16	26.22*.09	13.33*.04	18.34
Total							100

Source: own calculation

According to the preference index given in Table 4.7, multiple cropping is the most preferred adaptation strategy, while soil conservation is the second most preferred strategy. Irrigation, changing planting dates and livestock are the third, fourth and fifth preferred adaptation strategies to climate change, respectively, in the study area.

If we see the frequency distribution of each adaptation strategy in the first two ranks, multiple cropping is ranked first by 40% of the households, while soil conservation and irrigation are ranked first by 23.56% and 24.00% of the respondents, respectively. Livestock is the least in the first rank where only one respondent ranked it first. Changing planting dates is ranked first by 12.00% of the households. In

the second rank, soil conservation has the largest frequency followed by changing planting dates, multiple cropping and irrigation, consecutively. Livestock still has the smallest frequency in this rank.

The way households' preferences are identified helps us here to draw some conclusions from the farmers' overall preferences discussed above. Farmers' ranking of the adaptation strategies starts from the preferred strategies that the farmers have applied and then goes to those strategies not yet applied but planned to apply them in the future.

If we assume that farmers applied only one adaptation strategy, multiple cropping, on average, is the most preferred and applied adaptation strategy. If we again assume that they applied combination of two or three adaptation strategies, multiple cropping is still the most preferred and applied adaptation strategy followed by soil conservation and irrigation, consecutively. In general, we can be sure that multiple cropping, at least, is the most commonly practiced adaptation strategy.

4.7. Farmers' Preference for Intervention Measures

Finally, the households were asked to respond to questions regarding the type of intervention areas they prefer in order to be better off in their agricultural production and cope up the challenges of climate change. In a similar fashion, we weighted the frequency distribution of each intervention area in each rank using the weights calculated above in section 4.6. Finally, we summed up the five multiplicative results of each intervention area in the 5 choices (ranks) to get the final index. The intervention area with the largest index is the most preferred area while the one with the smallest index is the last preferred intervention area. The results are presented in Table 4.8.

Table 4.8: Weighted ranks of intervention areas preferred by the farmers

N		1st	2nd	3rd	4th	5th	
o	Intervention areas	Choice	choice	choice	choice	choice	Index
1	Irrigation development	31.56*.46	18.67*.26	6.22*.16	15.56*.09	13.78*.04	22.32
2	Climate change info	6.22*.46	12.00*.26	8.00*.16	13.33*.09	15.11*.04	9.07
3	Training on agriculture	11.56*.46	9.78*.26	16.89*.16	21.33*.09	20.44*.04	13.30
4	Electricity	6.22*.46	20.44*.26	11.56*.16	1.78*.09	3.11*.04	10.31
5	Health services	25.78*.46	16.44*.26	24.44*.16	15.56*.09	11.56*.04	21.91
6	Input supply	3.11*.46	9.78*.26	21.33*.16	17.33*.09	16.89*.04	9.62
7	Potable water	13.78*.46	10.67*.26	6.67*.16	10.67*.09	8.89*.04	11.50
8	More roads	1.78*.46	2.22*.26	4.89*.16	4.44*.09	10.22*.04	2.99
	Total						100

Source: own calculation

As the result indicates, farmers' most preferred intervention area is irrigation development, followed by health services, and then training on agriculture. Then, the next most preferred intervention area is supply of potable water followed by electric power supply, input supply and information on climate change, consecutively. Development of more roads is the least preferred intervention area.

Generally, irrigation development, health services, agricultural training, input supply and electric power supply are the five most preferred intervention areas, consecutively, that households need in order to be better off in their agricultural productivity by acclimatizing to the impacts of climate change. This, therefore, could imply intervention or investment areas for any decision maker at regional, zonal, private or government level.

Chapter Five

Econometric Estimation, Results and Discussions

5.1. Model Specification and Estimation

The main theme of this research is analyzing the factors that affect the farmers' preferences for climate change adaptation strategies. For this purpose, rank-ordered data on the farmers' preferences for five adaptation strategies are generated and possible factors that could affect these preferences are identified. This observed data is fitted using the rank-ordered logistic regression. Estimation of the model parameters is done by the Maximum Likelihood method and the computer program used to perform the estimation is STATA 10.1. Much effort has been made to get ML estimates of the parameters that maximize the likelihood of observing the sample data collected.

The data for this research is a cross-sectional data which is collected from a sample of 225 households from Shoa Robit area, North Shoa Zone. The working data set for this analysis is consisted of a separate record for each adaptation strategy for each respondent, for a total of 1125 observations. Each record includes four categories:

- i. A unique identification number for each household
- ii. A set of dummy variables corresponding to the 5 different adaptation strategies.
- iii. The rank assigned by the respondent to that particular adaptation strategy and
- iv. Set of case-specific explanatory variables describing the respondent such as social, economic, institutional and demographic characteristics and climate perception variables.

The estimation is conducted by normalizing multiple cropping which is referred as the base category (reference state). Comparison of preferences and interpretations of estimates, therefore, should be made with reference to multiple cropping. The estimation results are presented and discussed in the next sections.

Before going to the discussion of the results, it is important to show how the model is specified and tests are conducted on significance of the explanatory variables and Independence of Irrelevant Alternatives (IIA) assumption.

5.1.1. Model Specification and Tests

Specification of the model is undertaken using the Hendry approach, i.e. moving from the general model to the present model selected. In the initial run, all the variables identified from the literature are included in the general model. Then, by excluding those highly insignificant variables and those expected to bring multicollinearity problem one-by-one, different models are re-estimated. As described earlier, parameterization of the model by excluding one category also helps to avoid exact multicollinearity.

The overall fitness of each model with different specification is tested by using the overall LR² tests and the Bayesian Information Criteria (BIC). Since results of the models are estimated by the same estimation command, it is preferable to use the default BIC calculation to choose the better model (source: STATA itself). By comparing BIC results of the different models fitted on the same data, the

model with the lowest BIC result is selected. Since the differences in Bayesian Information Criteria from two models indicate which model is preferred and leads to the same conclusions, the choice of which form of Bayesian Information Criteria to use is a matter of convenience. Therefore, in this research we use the BIC' measure to compare the models.

Furthermore, significance of each explanatory variable is tested using the Wald test. In the ROL model there is a reason for testing groups of coefficients. Testing that a variable has no effect on the dependent variable (i.e. farmers' preference for adaptation strategies) requires a test that four coefficients are simultaneously equal to zero. This is because each explanatory variable included in the estimation has 4 different estimates corresponding to the four adaptation strategies, excluding the base category.

Therefore, the hypothesis that variable X_k doesn't affect the dependent variable is written as

$$H_0: \beta_{k, LI/MC} = \beta_{k, SC/MC} = \beta_{k, IR/MC} = \beta_{k, PD/MC} = \beta_{k, MC/MC} = 0$$

H_a : H_0 is not true,

where, β_k is the coefficient for explanatory variable X_k . MC, LI, SC, IR and PD represent the multiple cropping, livestock, soil conservation, irrigation and changing planting dates, respectively. Because $\beta_{k, MC/MC}$ is necessarily zero, the hypothesis imposes constraints on 4 parameters.

In the initial estimation of the general model, 21 explanatory variables were included (first model). The results of measures of fitness for this model and the next three models are presented in Table 5.1. The LR chi-square result at 88 degrees of freedom is 656.52 with p-value of 0.0000. This leads to the

rejection of the null hypothesis that all parameters are simultaneously equal to 0. The Bayesian Information Criterion (BIC') result of the model is equal to -38.268 (we will use this for later comparison). However, the Wald test for each explanatory variable indicates that variables such as input market distance, ownership of television and/or radio, access to credit, knowing others who perceived and adapted to climate change and farm income are insignificant at 5 % level of significance.

Table 5.1: Measures of fitness for ROL model

<i>Measure</i>	<i>Model 1</i>	<i>Model 2</i>	<i>Model 3</i>	<i>Model 4</i>
Log-Likelihood	-747.541	-763.497	-771.560	-773.612
LR statistic	656.516	624.605	608.478	604.375
Prob>LR	0.000	0.000	0.000	0.000
BIC'	-38.268	-62.562	-102.639	-126.639

The Variance inflation factor (VIF) test for multicollinearity reveals that there is high correlation between distance to input market, distance to output market and living area of farmers. The possible reason for this is both input and output markets are almost similar for majority of the respondents. This is also the reason for the existence of high collinearity between respondents living area and distance to markets. To solve for this problem, average market distance is included and the variable urban is dropped in the next estimation (which is model 2). As the result in Table 5.1 indicates model 2 is better than model 1 because the more negative BIC' result, the better the model is.

Next, two variables (training and knowing others who adapt) are found highly correlated with variables such as climate forecast information and extension services by experts. They are, then, dropped and

the model is re-estimated (named as model 3). The BIC' result -102.639 shows that there is an improvement in the model's fitness due exclusion of these two explanatory variables.

Finally, the highly insignificant variable (ownership of Television and/or Radio) is dropped and the model is re-estimated (model 4). The new BIC' is given by -126.639 and this shows that model 4 is better than model 3. The analysis also reports global chi-square tests for the null hypothesis that all the effects of the independent variables are simultaneously equal to zero. Since the LR test statistic is 604.38 with 68 degrees of freedom and p-value of 0.0000, we reject the null hypothesis. This implies that all the variables are jointly highly significant and the model has strong power of explaining the observed data.

The test results for each explanatory variable included in the selected model 4 are given Table 5.2. Among the 16 explanatory variables included in the model, only three of them are found to be statistically insignificant to affect the dependent variable. They are market distance, farmer-to-farmer extension and credit access. The remaining 13 variables have statistically significant effect on the farmers' preferences for adaptation strategies to climate change.

Table 5.2: Wald test results for each explanatory variable (5%)

No	Variables	Chi² (4)	Prob > chi²	Evidence
1	Male	19.14	0.0007	Against Ho
2	Age	21.12	0.0003	Against Ho
3	Education level	33.24	0.0000	Against Ho
4	Farming experience	28.66	0.0000	Against Ho
5	Household size	24.76	0.0001	Against Ho
6	Farm size	17.54	0.0015	Against Ho
7	Farm distance to homestead	42.88	0.0000	Against Ho
8	Market distance	4.050	0.3987	For Ho
9	Farm income	14.42	0.0061	Against Ho
10	Nonfarm income	15.58	0.0036	Against Ho
11	Extension by experts	19.78	0.0006	Against Ho
12	Farmer-to-farmer extension	6.590	0.1591	For Ho
13	Credit access	3.880	0.4226	For Ho
14	Climate forecast	12.76	0.0125	Against Ho
15	Perceived temperature	41.11	0.0000	Against Ho
16	Perceived rainfall	12.02	0.0172	Against Ho

Furthermore, the variance inflation factors for all explanatory variables included in model 4 are less than 7 and the mean VIF is 2.08 as shown in Table A-1 of the Appendix. For most of the variables, the VIF is between 1 and 2. This result is, therefore, an indication of that multicollinearity is not a serious problem in this model.

Finally, summary statistics of the explanatory variables included in the final model is presented in Table 5.3. The summary statistics includes the minimum and maximum values of each independent variable. The mean values of the independent variables along with the respective standard deviation of that variable are also included in the statistics. Among the 16 explanatory variables, nine of them are continuous and the remaining dummy variables.

Table 5.3: Summary statistics of the independent variables

<i>No</i>	<i>Variables</i>	<i>Description</i>	<i>Min</i>	<i>Max</i>	<i>Mean</i>	<i>Std. Dev.</i>
1	Gender of the household head	Dummy, 1 if male and 0 otherwise	0.00	1.00	0.88	0.32
2	Age of the household head	Continuous	22.00	68.00	41.12	10.42
3	Education level	Continuous	0.00	12.00	3.31	3.60
4	Farming experience	Continuous	5.00	54.00	24.78	10.70
5	Household size	Continuous	2.00	10.00	5.20	1.92
6	Farm size in hectares	Continuous	0.25	2.75	1.21	0.51
7	Farm distance to home in kilometers	Continuous	0.25	17.00	5.05	3.88
8	Market distance In kilometers	Continuous	0.48	12.75	4.72	2.72
9	Farm income in birr 1000	Continuous	0.50	52.78	14.85	10.33
10	Nonfarm income in birr 1000	Continuous	0.00	40.00	1.69	4.01
11	Extension by experts	Dummy, 1if received and 0 otherwise	0.00	1.00	0.75	0.43
12	Farmer-to-farmer extension	Dummy, 1 if there is and 0 otherwise	0.00	1.00	0.89	0.31
13	Credit access	Dummy, 1if there is and 0 otherwise	0.00	1.00	0.39	0.49
14	Climate forecast	Dummy, 1 if received and 0 otherwise	0.00	1.00	0.32	0.47
15	Perceived temperature	Dummy, 1 if perceived and 0 otherwise	0.00	1.00	0.68	0.47
16	Perceived rainfall	Dummy, 1 if perceived and 0 otherwise	0.00	1.00	0.92	0.26

As it is discussed earlier, the ROL model requires the fulfillment of the assumption of the Independence of Irrelevant Alternatives (IIA), otherwise the model will be inappropriate. Different literatures suggest different ways to handle the problem of IIA and to test the fulfillment of the assumption. For instance, McFadden (1973) suggest that models with IIA assumption should be used in cases where the alternatives can plausibly be assumed to be distinct and weighted independently in the eyes of each decision maker. Similarly, Amemiya (1981) wrote that such models work well when the alternatives are dissimilar. Additionally, two most common methods, Hausman-McFadden (HM) test and Small-Hsiao (SH) test, are suggested to test the IIA by Hausman & McFadden, and Small & Hsiao, respectively.

Therefore, much care has been taken in specifying the model to include distinct adaptation strategies. Each individual's ranking of the adaptation strategies is exploded into a series of independent choice situations. That means, at the beginning the farmers picked their 1st choice from the five alternatives which is the first rank. Then, with that alternative eliminated, they picked their first choice from the remaining four alternatives; by implication this is their second rank from the whole choice set. Again, by excluding this alternative, they picked their first choice from the remaining three alternatives which is their third rank in their preference, and the process continues until one alternative is left. In this way the ranked data collection is decomposed into a series of independent choice processes. This, therefore, would help to make the consecutive choices independent from the previous choices.

Beside this, we conducted the Hausman-McFadden (HM) test on the independence of irrelevant alternatives. The chi-square results along with the degrees of freedom and probability values are presented in Table 5.4.

Table 5.4: Hausman-McFadden test of IIA assumption

Omitted Category	Chi-square	Degree of freedom	P>chi2	Evidence
Livestock	-160.89	51	1.0000	Support Ho
Soil conservation	21.87	51	0.9999	Support Ho
Irrigation	-120.72	51	1.0000	Support Ho
Changing planting dates	59.24	51	0.2001	Support Ho
Multiple cropping	38.81	51	0.8948	Support Ho

As we can see from Table 5.4, the chi-square result for all tests ranges from -160.89 to 59.24, with probability values ranging from 0.8948 to 1.0000. Two of the test statistics are negative which is common in such test and is evidence that IIA is not violated. This possibility is also noted by Long & Freese (2006) and Hausman & McFadden (1984). Therefore, based on a 5% significance level, the Hausman test failed to reject the null hypothesis of IIA which means the IIA assumption is satisfied.

This suggests that the ROL model specified in this research is appropriate to modeling the farmers' preferences for climate change adaptation strategies. Therefore, we can avoid our suspects on the estimates of the model due to the problem that might be caused by the IIA assumption.

Finally, to check the efficiency gain from ranking data, we estimated two models: the first is based on the full ranked data and the second is using only the most preferred alternative. Then, we conduct the Hausman-McFadden test of specification. The result indicates that we fail to reject the null hypothesis which states that estimates do not change systematically (because Prob>chi2 = 1.0000). That means the parameter estimates do not change systematically. Therefore, exclusion of these choices (4 rankings)

will be inefficient even if it doesn't lead to inconsistency. As a result, we prefer the ROL model with full ranking since estimates of the ROL model are both consistent and efficient.

5.2. Estimated Results of the Model

The estimated coefficients of the ROL model, along with the levels of significance, are presented in Table 5.5. The likelihood ratio statistics as indicated by X^2 statistics (LR $\chi^2(68) = 604.38$ and Prob $> \chi^2 = 0.0000$) is highly significant which suggests that the model has a strong explanatory power.

The parameter estimates of the ROL model provide only the direction of the effect of the independent variables on the dependent variable. Positive (negative) coefficients imply that the odds of ranking each adaptation strategy over multiple cropping increases (decreases) as the corresponding explanatory variable increases. That means the parameter estimates do not represent actual magnitude of change or probabilities. Therefore, we use the discrete changes in the probabilities to interpret the estimates of the ROL model.

Table 5.5: Parameter estimates of the ROL model of climate change adaptation

Explanatory Variables	Livestock		Soil Conservation		Irrigation		Changing Planting Dates	
	Coeff.	P level	Coeff.	P level	Coeff.	P level	Coeff.	P level
Gender of HH head	-0.701	0.1740	0.946	0.0353	0.628	0.1719	-0.485	0.2848
Age of HH head	0.023	0.5900	0.089	0.0071	-0.058	0.1063	-0.018	0.5919
Education level	-0.191	0.0002	-0.205	0.0000	-0.215	0.0000	-0.188	0.0000
Farming experience	-0.105	0.0107	-0.105	0.0008	0.041	0.2326	-0.007	0.8374
Household size	0.453	0.0001	-0.104	0.1937	-0.050	0.5659	0.069	0.4424
Farm size	-1.289	0.0044	-0.281	0.4177	-0.839	0.0176	-1.330	0.0003
Farm distance	0.115	0.0200	0.041	0.3054	0.252	0.0000	0.028	0.5027
Average market distance	0.005	0.9453	0.073	0.1672	0.036	0.5243	0.101	0.0841
Farm income	0.069	0.0004	0.032	0.0498	0.024	0.1588	0.013	0.4114
Nonfarm income	-0.064	0.2721	0.116	0.0078	-0.036	0.4464	0.094	0.0280
Experts extension	0.629	0.1566	-0.756	0.0257	0.494	0.1568	-0.481	0.1631
Farmer-farmer extension	-0.752	0.2547	0.729	0.1474	-0.070	0.8953	-0.128	0.8030
Access to credit	-0.037	0.9180	-0.394	0.1625	0.024	0.9346	-0.336	0.2619
Information on climate	0.126	0.7543	-0.749	0.0307	-0.172	0.6209	0.378	0.2886
Perceived temperature	-1.237	0.0009	-1.538	0.0000	-1.739	0.0000	-1.598	0.0000
Perceived rain	0.943	0.2107	0.949	0.0874	2.142	0.0006	1.142	0.0464
Constant	-2.019	0.1435	-1.271	0.2388	-0.685	0.5554	1.803	0.1042
Base category			Multiple cropping					
Number of observations			1125					
Number of groups			225					
LR chi-square, degree of freedom, <i>p</i> - value			LR chi2(68) = 604.38 Prob > chi2 = 0.0000					
Log-Likelihood			-773.6117					

5.2.1. Overall Preference of the Population

First, we examine whether respondents ranked the five adaptation strategies in the same way or whether there is a significant difference between their preferences for these adaptation strategies. If we assume that every respondent in the study had the same probability distribution of adaptation strategies preferences, a model that allowed for differences among the five types of adaptation strategies but no differences across respondents, that means a model with constant only, will be estimated. This model can be formulated as $V_{ij} = \beta_j$ for all i and j , with β_j set to 0 for the base category, i.e. multiple cropping. The working data set is consisted of a separate record for each adaptation strategy for each respondent for a total of 1125 observations.

Estimating the ROL model with constant only ($V_{ij} = \beta_j$) helps us to understand the overall preferences of the households for the adaptation strategies. Table 5.5 presents estimates of the β_j (constants) and the exponent of the coefficients. If we exponentiate the coefficient for each adaptation strategy, then we will get what we call the odds of preferring each adaptation strategy. We, therefore, use the odds to describe the nature of the overall preference of the farmers. These odds are interpreted with reference to the base category, multiple cropping. As we can see the results, the constant parameter for multiple cropping is zero because multiple cropping is used as a base category in our estimation and its coefficient necessarily equals to zero.

The Wald chi-square statistic for the model with a constant term only is 303.48 (with 4 degrees of freedom) with a p-value of 0.0000, which means that the population in the study area, in general, has statistically significant different preferences for the five adaptation strategies.

Table 5.6: Odds of overall adaptation strategies ranking by households

<i>No</i>	<i>Adaptation Strategy</i>	<i>Coefficient</i>	<i>Exp(b)</i>
1	Livestock	-1.95734	0.1412
2	Soil conservation	-0.06895	0.9334
3	Irrigation	-0.47168	0.6240
4	Changing planting dates	-0.63836	0.5282
5	Multiple cropping	0	1
		LR chi2(4) = 303.48	Prob > chi2 = 0.0000

As we can see from Table 5.6, the odds of multiple cropping is the largest which means on the average multiple cropping is the most preferred adaptation strategy while livestock is the least preferred adaptation strategy because its odds is the smallest (i.e. 0.1412) among the five odds. The second most preferred adaptation strategy is soil conservation measure followed by irrigation and then changing planting dates. This finding is similar with our result in the descriptive analysis regarding farmers' preferences for the adaptation strategies.

On the other hand, we can interpret the exponent of the coefficients as follows. The exponent of the coefficient of livestock (0.1412) indicates that the odds of preferring livestock are 0.1412 times the odds of preferring multiple cropping. Similarly, the odds of preferring soil conservation, irrigation, and changing planting dates are 0.9334, 0.6240 and 0.5282 times the odds of preferring multiple cropping, respectively.

5.2.2. Interpreting Effects of the Independent Variables

In the ROL model, the predicted probabilities are for an alternative being ranked first (Long & Freese, 2006). That means the probabilities that we estimate from our model represent the probabilities of ranking first each adaptation strategy. Since there are five adaptation strategies in the ranking, five predicted probabilities will be estimated for each strategy. Therefore, for different values of the independent variables, we have five predicted probabilities of ranking first each adaptation strategy to climate change.

The estimation of predicted probabilities based on discrete changes in the independent variables is more convenient and straightforward in the case of dummy independent variables, since they change from 0 to 1. As Long & Freese (2006) stated, for binary variables, the discrete change from 0 to 1 is the only appropriate quantity for interpretation. For the continuous independent variables, estimations of predicted probabilities are made for two types of changes in the corresponding independent variable: 1) for a unit change in the variable centered on its mean, and 2) for a standard deviation change in that variable centered on its mean.

To avoid complexities in interpretations, we hold the values of the remaining independent variables constant at their means. Therefore, our interpretations based on predicted probabilities should be understood with the assumption that “other variables remaining constant at their means”. Given these conditions, predicted probabilities are estimated and interpretations are made for all significant explanatory variables.

Before we interpret the effects of each explanatory variable on the predicted probabilities, let us first look at the probability of each adaptation strategy being preferred first at the means of all explanatory variables. These probabilities are presented in Table 5.7.

Table 5.7: Predicted probabilities at the means of all explanatory variables

No	Adaptation strategy	Probability
1	Multiple cropping	0.3588081
2	Livestock	0.02275157
3	Soil conservation	0.29519317
4	Irrigation	0.18354297
5	Changing planting dates	0.1397042

As we can see from Table 5.7, an “average” household in the sample has a probability of 0.36 of ranking multiple cropping as the preferred adaptation strategy that he/she most highly prefers while, he/she has a probability of 0.30 of ranking soil conservation first. Similarly, the probabilities of ranking irrigation, changing planting dates and livestock first are 0.18, 0.14 and 0.02, respectively. Overall, multiple cropping is the most preferred adaptation strategy followed by soil conservation while, livestock is the least preferred strategy in the study area. This result again confirms our previous finding in the descriptive analysis of farmers’ overall preferences for the adaptation strategies.

Next, we examine the effect of each independent variable on the preferences of farmers for the climate change adaptation strategies. The discrete changes in the probabilities are given in Table 5.7. For the dummy variables, only one estimate is given because they change from 0 to 1. For the continuous variables two estimates of predicted probabilities are presented. In their order of appearance, the first estimate is for a unit change in the variable centered on its mean and the second estimate represents

for a standard deviation change in that variable centered on its mean, except nonfarm income because we used the median-centered change for it.

Table 5.8: Changes in predicted probabilities for a ROL model of climate change adaptation

Explanatory Variables	Multiple cropping	Livestock	Soil conservation	Irrigation	Changing planting dates
	Gender of household head	-0.077	-0.030	0.166	0.066
Age of household head	-0.005	0.0002	0.022	-0.013	0.005
	-0.050	0.002	0.227	-0.135	0.055
Education level	0.047	-0.001	-0.022	-0.016	-0.008
	0.167	-0.005	-0.078	-0.055	-0.029
Farming experience	0.010	-0.002	0.030	0.012	0.003
	0.100	-0.019	0.252	0.130	0.029
Household size	0.007	0.011	-0.025	-0.006	0.012
	0.013	0.021	-0.048	-0.011	0.024
Farm size	0.160	-0.019	0.050	-0.069	-0.122
	0.082	-0.010	0.025	-0.036	-0.062
Farm distance	-0.023	0.001	-0.007	0.034	-0.005
	-0.090	0.004	-0.028	0.134	-0.020
Market distance	-0.015	-0.001	0.009	-0.001	0.008
	-0.041	-0.002	0.024	-0.003	0.022
Farm income	-0.006	0.001	0.004	0.001	-0.001
	-0.063	0.122	0.044	0.013	-0.006
Nonfarm income	-0.015	-0.002	0.023	-0.014	0.007
	-0.059	-0.009	0.092	-0.054	0.030
Experts extension	0.079	0.016	-0.172	0.112	-0.035
Farmer-farmer extension	-0.042	-0.028	0.144	-0.036	-0.037
Access to credit	0.057	0.003	-0.068	0.034	-0.025
Information on climate	0.062	0.007	-0.154	-0.0001	0.084
Perceived temperature	0.325	-0.003	-0.129	-0.123	-0.070
Perceived rain	-0.299	0.006	0.080	0.157	0.056

I. Gender of the household head

Gender of the household head is one of those significant variables that affect the overall preference of farmers for the climate change adaptation strategies. As we can see from Table 5.8, male-headed households have probability of preferring soil conservation as the most preferred adaptation strategy 16.6% higher than female-headed households and for irrigation 6.6% higher than female-headed households. On the other hand, the probability of ranking changing planting dates as their most preferred adaptation strategy is 12.6% lower for male headed households than female-headed households. Similarly, the predicted probabilities of ranking multiple cropping and livestock first are 7.7% and 3.0% lower for male-headed households.

Overall, male-headed households have greater preferences for soil conservation and irrigation adaptation measures to climate change than female-headed households. Since soil conservation measures and irrigation development relative to the other adaptation strategies require better skills and information on technologies to undertake them to adapt to climate change, it is more likely that male-headed households have more preference for these measures than the female counterparts. This is in line with the argument that male-headed households are more likely to get information about new technologies than female-headed households (Asfaw & Admassie, 2004). Moreover, female-headed households are more likely than male-headed households to exercise adaptation methods which are common and known by almost all farmers, such as changing planting dates and crop production.

II. Age of the household head

Adaptation strategy preference to climate change is also affected by age of the household head. For instance, a one year increase in the age of the household head that is centered on its mean results in a

2.2% increase in the probability of ranking soil conservation first, 0.02% increase in the probability of ranking livestock first and 0.5% increase in the probability of changing planting dates. On the other hand, an increase in the age of the household by one year that is centered on its mean decreases the probabilities of ranking multiple cropping and irrigation first by 0.5% and 1.3%, respectively.

Moreover, for a standard deviation increase in the age of the household head (i.e. around 10 years), the probability of preferring soil conservation increases by 22.7%, livestock by 0.2% and that of changing planting dates by 5.5% while the probabilities of multiple cropping and irrigation decrease by 5% and 13.5%, respectively. Overall, we found that age affects the probability of soil conservation, livestock and changing planting dates positively and the others negatively.

As indicated by Hassan & Nhemachena (2008) the influence of age on adaptation choices has been mixed in the literature. Some studies found that age had no influence on a farmer's decision to participate in forest and soil and water management activities while others found that age is significantly and negatively related to farmers' decisions to adopt. However, Bayard et al (2007) found that age is positively related to the adoption of conservation measures.

Even if the effects of age on the probabilities of two of the measures are negative and do not suggest important information, this could be an indication of the different implications of age and farming experience on adaptation preference. Given these situations, we justify our result with the possibility that old-aged farmers usually prefer adaptation measures which can be practiced with the limited resources at their disposal so as to smooth their household consumption pattern. As a result, it is likely that old-aged farmers prefer to practice soil conservation on their limited land and grow their common

crops by changing planting dates. They also prefer to tend or look after livestock with small efforts than the younger farmers.

In contrast to this, younger farmers are better to adopt improved technologies or methods than older farmers without fear of risks and future uncertainties. Younger farmers also have better energy to devote, better access to new information, and thus more likely to grow varieties of crops and develop irrigation. This is inline with the result that young farmers are more likely to face the risks associated with innovations (uncertainty in yield and unfamiliarity in technology) and to adopt them than their old counterparts (Asfaw & Admassie, 2004).

III. Education level of the household head

The effect of education is largest on the probability of multiple cropping where the probability of it being selected first increases by 4.7% for a one year increase in education centered on its mean and by 16.7% for a standard deviation increase in years of education.

In general, increase in years of education reduces the probabilities of ranking first all the adaptation strategies except multiple cropping. Moreover, the largest effect of education is reflected on the probability of multiple cropping followed by that of soil conservation while the least effect is on the preference for livestock.

It was expected that farmers with higher levels of education are more likely to adapt better to climate change using different methods because a farmer who has more years of education is more likely to

adopt improved methods and expected to be more efficient to understand and obtain new technologies than less-educated people.

Even though we found unexpected result that education increases the likelihood of only multiple cropping, we would explain this possibility from different angles in the context of the study area. This result informs us that education plays a great role in farmers' decision to specialize or work more intensively on specific activities. Additionally, it is common to see when educated farmer is working for jobs outside agriculture in combination with the commonly practiced farming system, i.e. crop production. On the other hand, more educated farmers are more likely to get information on new crop varieties that would make them profitable with in the changing climatic conditions. They are, therefore, more likely to specialize on producing such crops and utilize their limited farm land effectively instead of moving and looking for other alternatives such as irrigable lands.

In addition to this, crop production is mainly practiced in the area in both dryland and irrigable land. Nowadays, farmers started growing a more profitable and recently introduced crop to the area called "Masho" (its Amharic name). It is heat-tolerant crop and can grow with little rain. Since farmers fear future uncertainties/risks and are less confident to this new crop variety, education could play great role here. From our result, education has positive and significant impact on multiple cropping. This is possibly due to educated farmers who have better information about that crop and nature of the climate prefer to grow that crop intensively with less hesitation than the less-educated farmers. More educated farmers are more likely to have additional off-farm job to sustain consumption in case the crop fails. Moreover, they could have better information how the crop is growing, in which environment it can grow, what the future climate likely to be than the less educated farmer.

IV. Farming experience

Farming experience of farmers increases the likelihoods of preferring irrigation, multiple cropping, soil conservation and changing planting dates as the most preferred adaptation strategies to climate change. An increase in farming experience by one year centered on the mean increases the probabilities of selecting multiple cropping, irrigation, soil conservation and changing planting dates by 1%, 1.2%, 3.0% and 0.3%, respectively, while the probability of livestock decreases by 0.2%.

In another way, a standard deviation (10.68 years) increase in years of farming experience increases the probabilities of ranking irrigation first by 13%, multiple cropping by 10%, soil conservation by 25.2% and changing planting dates by 2.9%; whereas, the probability of livestock decreases by 1.9%.

Therefore, increase in farming experience has the largest positive effect on the probability of preferring soil conservation followed by irrigation and the smallest effect on livestock. More experienced farmers are more likely to use soil conservation, irrigation, changing planting dates and multiple cropping to adapt to climate change.

We found that farming experience has opposite effect with age of the household head for three of the adaptation strategies. Even if age of farmers is a significant factor, the direction of some of its effect does not suggest relevant particular pattern. Hassan & Nhemachena (2008) found that it is experience rather than age that matters for adapting to climate change. They also found that farming experience increases the probability of uptake of all adaptation options while age of the farmer did not seem to be of significant in influencing adaptation.

In our case farming experience enhances the use of soil conservation, irrigation, changing planting dates and multiple cropping to adapt to climate change because the more experienced farmers are the more likely they have better information on changes in climatic conditions and knowledge of crop practices.

V. Household size

Another determinant of farmers' preference for climate change adaptation strategies is the number of household members. A one unit increase in household size that is centered on its mean results in increase in the probabilities of preferring multiple cropping, livestock and changing planting dates by 0.7%, 1.1% and 1.2%, respectively.

On the other hand, a standard deviation increase in the household size (i.e. around 2 persons) raises the probabilities of preferring multiple cropping by approximately 1.3%, livestock by 2.1%, and changing planting dates by 2.4%. Furthermore, it decreases the likelihoods of preferring soil conservation and irrigation first by 1.1% and 4.8%, respectively.

Therefore, increase in household size increases the probability of adapting to climate using multiple cropping, livestock and changing planting dates. This result suggests that the strategies are labor-intensive which is more likely to happen in Ethiopia's agriculture. Assuming that households with large family size have a higher labour endowment, families with more household size can rely on their own labor for the most important activities of multiple cropping i.e. the field operation. Families with larger household size are also more likely to rear livestock because of availability of labor to tend the animals.

This result is also in line with the argument that multiple cropping and mixed farming systems are more labor intensive (Hassan & Nhemachena, 2008).

VI. Farm size of the household

Households' farm size is also a significant factor that affects farmers' preferences for the adaptation strategies to climate change. In a similar fashion, an increase in farm size by 1 hectare that is centered around its mean increases the likelihood of selecting multiple cropping as the most preferred adaptation strategy by 16% and the likelihood of soil conservation by 5%.

Additionally, a standard deviation increase in farm size (i.e. 0.51 hectare) centered on the mean increases the probabilities of ranking multiple cropping first approximately by 8.2% and soil conservation by 2.5%. A similar change in farm size decreases the probabilities of choosing livestock, irrigation and changing planting dates by 1%, 3.6% and 6.2%, respectively. Its least effect is on the preference for livestock.

In general, we can conclude that an increase in farm size increases the likelihood of adapting to climate change using multiple cropping and soil conservation. This result is expected in the sense that the more households have larger farms, the more they tend to work more intensively on their land instead of going for another alternative to adapt to climate change. They can do this by growing many types and new variety of crops and by applying soil conservation measures. Households with larger farm sizes, therefore, are more probably to diversify their crops especially under dryland conditions and help spread the negative impacts of changes in climatic conditions.

VII. Farm distance from homestead

Another significant variable that affects the farmers' preference for the adaptation strategies is the distance of their farm from their house. An increase in farm distance by one kilometer that is centered on its mean results in increase in the probabilities of selecting irrigation as the most preferred adaptation strategy by 3.4% and livestock by 0.1% while, it decreases the probabilities of multiple cropping, soil conservation and changing planting dates by 2.3%, 0.7% and 0.5%, respectively.

Similarly, a standard deviation increase in farm distance, nearly 3.88 kilometers, increases again the probability of preferring irrigation by 13.4% and decreases the probability of multiple cropping by 9%. It also decreases the probability of soil conservation and changing planting dates by 2.8% and 2% respectively, and increases the probability of livestock by 0.4%. Overall, an increase in farm distance increases the likelihood of preferring irrigation at large and secondly, it affects the preference for multiple cropping negatively, while the preference for livestock is the least affected by the change in farm distance.

This result suggests that as farm distance from their homes increases, farmers are less likely to go for field operation continuously which would have its own impact on their production and productivity. They would, therefore, prefer to rent irrigable lands near to their homes and rear livestock.

VIII. Farm income of households

Farm income of households determines significantly their preferences for climate change adaptation strategies. An increase in farm income by 1 unit (i.e. birr 1000) centered on the mean increases the

probabilities of selecting livestock, soil conservation and irrigation as the most preferred adaptation strategies to climate change by 0.1%, 0.4% and 0.1%, respectively, while the probabilities of multiple cropping and changing planting dates decrease. Again, a standard deviation increase in farm income, around birr 10308, enhances the probabilities of preferring livestock, soil conservation and irrigation by 12.2%, 4.4% and 1.3%, respectively. Generally, an increase in farm income of the households increases the likelihood of adapting to climate change using soil conservation, irrigation and livestock.

We assume that compared with the other adaptation strategies livestock, irrigation and soil conservation require more financial resources than the others. If farmers have more income, they can afford to produce livestock, develop irrigation and conserve their soil with the latest technologies. This result is reflection of the actual behavior of households; i.e. when their income increases, they tend to shift to activities which require more income. This, therefore, supports the argument that subsistence farmers are more likely to vary planting dates and diversify crops as their adaptation options instead of using those expensive methods such as irrigation, livestock and soil conservation.

IX. Nonfarm income of households

Nonfarm income of households is also found to be significant factor that affects their preferences for the adaptation strategies. Since nonfarm income has highly extreme values in the data, a centered change on the median is found more appropriate than the mean. Therefore, a unit increase in nonfarm income (i.e. birr 1000) of households centered on the median increases the probabilities of soil conservation and changing planting dates by 2.3% and 0.7%, respectively. On the other hand, it decreases the probabilities of multiple cropping, irrigation and livestock by 1.5%, 1.4% and 0.2%, respectively.

Similarly, a standard deviation increase in non-farm income (4000 birr) of households centered on the median increases the probabilities of choosing soil conservation first by about 9.2% and changing planting dates by around 3% while, it decreases the probabilities of the remaining strategies. In general, an increase in nonfarm income enhances the likelihood of adapting to climate change using soil conservation and changing planting dates.

Farmers who have sources of nonfarm income are expected to have nonfarm job which could possibly be a measure they took to climate change. If that is so, it is clear that it will affect negatively the probability of taking some adaptation measures while it could affect positively the probability of adaptation strategies which can be undertaken in combination with nonfarm jobs, such as varying planting dates. Since they have income, they can work on soil conservation with their limited land.

X. Extension services from experts

Among the institutional factors, experts' extension service is a statistically significant determinant of the model's dependent variable. As we see from Table 5.8, experts' extension services increase the probabilities of using irrigation, multiple cropping and livestock by 11.2%, 7.9% and 1.6%, respectively, to adapt to climate change. However, the probabilities of ranking soil conservation and changing planting dates first are about 17.2% and 3.5% lower for households who received extension services from experts than those who didn't, respectively.

This result implies the importance of increasing institutional support so as to encourage the use of strategies such as irrigation, livestock and multiple cropping to acclimatize to the impacts of climate change. This is because farmers who have better access to extension services have better opportunities

to get information on changing climatic conditions and the various farming practices that they can use to adapt to changes in climatic conditions. This is also in line with the finding of Nhemachena & Hassan (2007) that access to free extension services significantly increases the probability of taking up adaptation options except moving from farming to non-farming. They also found that extension services provide an important source of information on climate change as well as agricultural production and management practices.

XI. Access to climate forecast information

Access to climate forecast information also increases the likelihoods of preferring multiple cropping as the most preferred strategy by 6.2% and changing planting dates by 8.4%. Similarly, access to this information increases the probability of ranking livestock first by 0.7%, while it decreases that of soil conservation by 15.4% and irrigation by 0.0001%, almost negligible effect on irrigation.

Overall, the likelihood of adapting to climate change using multiple cropping, changing planting dates and livestock is higher for those households who received climate forecast information than those who did not. This result is, therefore, an indication of the importance of information on climate forecast to enhance climate change adaptation. Farmers who received climate forecast information are more likely to grow different crop varieties and vary their planting dates to suit the prevailing and forecasted climate conditions.

XII. Long-term temperature perception

Farmers were also requested to indicate whether they perceived changes in the long-term average temperature and rainfall. In the descriptive analysis, we have seen that most of the farmers have

perceived changes in the long-term average temperature and rainfall, though there are some farmers who perceived only short-term variations.

Perceiving the long-term change in temperature increases the probability of preferring multiple cropping to adapt to climate change by 32.5%; whereas, the probabilities of selecting soil conservation, irrigation and changing planting dates are around 12.9%, 12.3% and 7% lower for those farmers who perceived the change in the long-term average temperature than those who did not perceive it, respectively. The farmers know that increasing temperature is damaging to their production and need to respond to this through the adoption of different adaptation methods. However, perceiving the long-term temperature enhances adaptation using only multiple cropping, but of course with the largest change in the probability.

This possibility is due to the fact that farmers who perceive the warmer change in the long-term temperature are likely to grow different heat-tolerant crop varieties, the most affordable practice next to changing planting dates by subsistence smallholder farmers. Since the farmers are located in the same agroecological area and the area is also hotter, a warmer change in the temperature would not affect their farming practices highly except the usually practiced systems of multiple cropping. This is in line with the result of Kurukulasuriya & Mendelsohn (2007) where crop choice is very climate sensitive and as temperatures warm, farmers will shift towards more heat tolerant crops.

XIII. Long-term rainfall perception

The effect of perceiving the long-term change in rainfall is also presented in the last row of Table 5.8. As the result indicates, perceiving change in the long-term average rainfall has a positive effect on the

likelihood of adaptation to climate change using all the strategies except multiple cropping. That means, it increases the probability of preferring irrigation by 15.7%, soil conservation by 8%, changing planting dates by 5.6% and livestock by 0.6%. In contrast to this, perceiving the long-term change in rainfall decreases the probability of selecting multiple cropping to adapt to climate change by around 29.9%.

More clearly, the likelihoods of preferring soil conservation, irrigation and changing planting dates to adapt to climate are higher for those who noticed the change in long-term average rainfall than those who did not. This is expected result because farmers who perceive shortage or decrease in the long-term average rainfall are more likely to take adaptation measures to acclimatize to it. For example, during rainfall shortage, using irrigation is very convincing. The same is to soil conservation measures to maintain or keep moisture of their soil. Changing the planting dates according to their perception on the pattern of the rainfall is also important and expected measure.

Generally, we can conclude that noticing the change in the long-term climate has its own significant influence on the farmers' decisions about the choice of adaptation strategies to climate change. Farmers who are aware of changes in climatic conditions have higher chances of taking adaptive measures in response to the observed changes.

Chapter Six

Conclusions and Policy Implications

6.1. Conclusions

This study analyzed the determinants of farmers' preference for climate change adaptation strategies from Shoa Robit area, North Shoa Zone of the Amhara National Regional State. It also identified barriers to climate change adaptation and suggested possible intervention measures. The study uses cross-sectional data collected from 225 households in the production year 2009/2010, and applied descriptive and econometric approaches to analyze the data.

The households were asked whether they have perceived changes in the long-term average temperature and rainfall over the past 20 years. Those who responded yes were also asked if they took adaptation measures or any changes in their activities in response to the changes in the climate. The study result showed that majority of the population in the study area feels that there are changes in the long-term average temperature and rainfall over the last 20 years. Although some farmers are not clear about the average change, they agree that there is variation in the climate at least in short run.

Concerning the adaptation strategies changing planting dates, soil conservation measures, and changing crop variety are the most commonly practiced adaptation strategies to climate change by the households. Moreover, strategies such as irrigation and planting trees have been exercised by some proportion of the farmers while livestock production is the least practiced measure. In general, around

85% of the farmers have taken at least one adaptation measure in response to the changing climatic conditions. The remaining 15% did not take any of the adaptation measures.

Lack of information or knowledge and shortage of money are the main constraints to adaptation followed by shortage of land, and unsuitability of their land and poor potential for irrigation.

Farmers were also requested to indicate their expectations about future temperature and rainfall changes. The majority of the farmers expect harmful changes in both temperature and rainfall in the future.

Furthermore, the study found that all of the households have been negatively affected by the changes in temperature and rainfall. Moreover, the study tried to identify the level of support given to the farmers from the respective bodies regarding climate change. The farmers' self-evaluation result points out the need for improved and need based support to the farmers concerning climate change.

Finally, a preference revealing mechanism was employed to identify the farmers' preference for five adaptation strategies to climate change. The result indicates that multiple cropping is the most preferred and frequently applied adaptation strategy to climate change. The next most preferred adaptation strategy is soil conservation followed by irrigation and changing planting dates, consecutively, while livestock is the least preferred and used adaptation strategy of farmers in the study area.

The study, then, applied the Rank-Ordered Logit (ROL) model to examine the factors that derive households' observed preference for climate change adaptation strategies. The model's dependent variable is the rank assigned by each household for each adaptation strategy, while the explanatory variables include household, farm and institutional characteristics, and climate change perceptions of the farmers. Different statistical tests and fitness measures have been conducted to arrive at the final model. The model was also tested for Independence of Irrelevant Alternatives using the Hausman-McFadden test and no evidence is found to reject the IIA assumption.

The model parameters are estimated by using multiple cropping as a base category and the results indicated that all variables included in our estimation, except market distance, farmer-to-farmer extension and credit access, are significant determinants of farmers' preference for the climate change adaptation strategies. However, the parameter estimates of the model do not serve our purpose because they only show the direction of the effect on the dependent variable of a change in an independent variable. Therefore, we estimated changes in predicted probabilities of preferring each adaptation strategy for discrete changes in the independent variables.

All variables representing the households' characteristics (gender, age, farming experience and education level of the household head, household size, and farm and nonfarm income) are found to be significant factors that affect adaptation strategy preference of farmers. Among these variables education level, farm and nonfarm income can be influenced by policy and program interventions to enhance the farmers' adaptation to climate change.

Moreover, we found that farmers' preference for climate change adaptation strategies is sensitive to farm characteristics such as farm size and farm distance to homestead. These issues could be addressed in combination with efforts to raise income of the households. Experts' extension services on crop and livestock production and climate forecast information are also significant institutional factors influencing households' preference for the adaptation strategies.

Additionally, climate perception of the farmers' (perception on temperature and rainfall) are found to be significant factors affecting their decision regarding the choice of climate change adaptation strategies. Noticing the long-term changes in temperature and rainfall enhances the probability of taking different adaptation measures. Specifically, perceiving the long-term change in the temperature increases the likelihood of using multiple cropping to adapt to climate change, and noticing the long-term change in the average rainfall, on the other hand, enhances the chances of adapting to climate change using irrigation, soil conservation, changing planting dates and livestock.

6.2. Policy Implications

Based on the findings of the research, we arrive at the following policy implications. Strengthening efforts on enhancing the farmers' adaptive capacity to climate change is an important policy measure that should be considered. Encouraging investment at all levels on the barriers to adaptation is a good policy option. For instance, developing good information system among farmers, expanding credit facilities suitable to farmers, fostering research and development on agriculture, and promoting water conservation and irrigation schemes among farmers are suggested intervention measures. The finding confirms the important roles of research and developments in changing crop varieties that suit the

changing climatic conditions rather than sticking on common crops that frequently fail to meet the farmers' needs.

On the other hand, policies or programs aimed to reduce climate change impacts need to encourage investments on soil conservation, irrigation development, and researches on livestock and crop varieties. Supporting and training farmers on soil conservation measures, irrigation development and changing planting dates can improve adaptation practices to climate change.

Designing programs to increase the farmers' education level are important policy measures that could be taken in enhancing adaptation to climate change and thus reduce its impact on the farmers. In addition to its role of delivering knowledge, education can create opportunities for the households to gather information on new technologies or methods of production, better information on climate change and farming practices that suit to it.

Furthermore, programs that would increase farm income of households such as better supply of inputs at fair price, and creating better access to markets and transportation facilities are suggested as policy measures to help farmers adapt to climate change. Promoting investments to create job opportunities to raise farmers' nonfarm income is also suggested to enhance farmers' capacity to climate change adaptation.

We believe that better access to agricultural extension services for farmers has the potential to increase farmers' awareness of changing climatic conditions and suitable adaptation responses to it. Therefore, a policy with the objective of enhancing farmers' adaptation to climate change should take

in to account the significant roles of agricultural extension services and climate forecast information on the farmers' practices of climate change adaptation.

We argue, therefore, that information on the prevailing and forecasted climate is very helpful especially for subsistence farmers who focus on growing crops and can not afford to exercise irrigation or soil conservation, because subsistence farmers are more likely to vary planting dates and diversify crops than changing to different crops or using expensive adaptation technologies such as irrigation and soil conservation. Hence, promoting less-costly adaptation options among smallholder farmers could have the potential to positively enhance adaptation to climate change by subsistence farmers.

Generally, we suggest that government bodies at different level, meteorological departments, and agricultural offices should play important role in raising farmers' awareness of the prevailing and expected changes in the climate through proper mechanisms that are easily accessible to the farmers such as extension services, radio and/or television, social groups such as edir, farmers gatherings, and input and output traders. This awareness creation effort should be combined with the different types of crop and livestock production and management practices that farmers could take up as adaptation measures to the change in the climate.

Finally, we suggest further research and developments specific to agroecologies, and they need to move towards making farmers more resilient to damaging changes in climate.

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Appendix

Table A-1: Variance inflation factor for the explanatory variables

Variable	VIF	1/VIF
age	6.93	0.144348
exper	6.78	0.147464
farmsize	1.82	0.548731
fincome	1.62	0.616218
hsize	1.59	0.628235
farmdist	1.49	0.673046
climforeca	1.48	0.677016
ftofexten	1.45	0.689617
percraïn	1.39	0.721531
mktdist	1.34	0.744858
percitemp	1.29	0.772244
educ	1.27	0.790150
expexten	1.25	0.797004
nfincom	1.23	0.815562
creditacc	1.18	0.850433
male	1.13	0.881376
Mean VIF	2.08	

Table A-2: Survey questionnaire

Addis Ababa University

School of Economics

Questionnaire for a research entitled

“Analyzing the Determinants of Farmers’ Preference for Adaptation Strategies to Climate Change: Evidence from North Shoa Zone of Amhara region”

How are you, dear farmer? I am Negash Mulatu, an MSc student in the School of Economics at Addis Ababa University. For the partial fulfillment of my MSc Degree in Economics, I am conducting a study on farmers’ preference for adaptation strategies to climate change and the factors influencing their preference in the Shoa Robit and the surrounding areas, North Shoa zone of Amhara region. Therefore, I have prepared this questionnaire for the collection of the necessary primary data. Dear farmer, I want to remind you that an interviewer will come to you for the interview process and I request your kind cooperation and patience in providing accurate and reliable responses for the questions. Your response is anonymous and completely confidential, and only summary information will be reported in the study results. However, if you agree we will write down your contact information in case some responses are unclear. If you have any hesitation with regard to the interview, please contact me with my phone number given below.

Thank you very much, in advance, for your kind cooperation and patience.

Negash Mulatu, MSc Student

School of Economics, Addis Ababa University

This questionnaire is prepared for households that have harvested any crop or sold any livestock and its products in the last 12 months of the farming year, that is, the last full Mehere/Kiremt and the last full Belg/Bega. This period covers approximately from December 2009 to November 2010.

Given the importance of the following data for mapping and tracking purposes, please ensure it is filled out accurately.

- Name of interviewer: _____
- Date and time of interview: Date _____ Time: from _____ to _____
- Respondent households’ identification number _____
(1=interview 1, 2=interview 2, 3=interview 3.....n=interview n for each district).
- Village/Kebele code or name: _____
- Contact information of the respondent: _____ (optional)

Part 1: Household Characteristics

1. Gender of the household head? a) Female b) Male
2. Age of the household head? _____ years old
3. How many is the number of years of your formal education? _____ years
4. How many years of farming experience do you have? _____ years
5. What is the number of members of the household? _____ males and _____ females
6. Does your household have a Television/Radio? a) Yes b) No
(If your answer is no, please go to question 8)
7. If yes, have you heard information on climate change, its consequences and adaptation methods using the TV/Radio? a) Yes b) No
8. Where is your household living? a) Urban b) Rural
(If urban, please go to question 10)
9. If rural, how far is the nearest town to you? In distance _____ kms (one-way) or in time _____ hours (one-way).

Part 2: Farm and Farming Characteristics

10. Fill the following table of the characteristics of the household's farms. Since a farmer could have more than one farm in different places, write the characteristics of each farm.

No	Name of location of the farm	Size in hectare / Timad	Is it your own land? (Yes or No)	Farm distance from house? (Km or hour)
1				
2				
3				
4				
5				

11. What kinds of farming system you follow currently?
 - a) Crop farming only
 - b) Livestock rearing/herding only
 - c) Mixed farming (crop and livestock production)
 - d) Others (please specify _____)

12. How far is your house to the nearest market where you *sell* your harvest or livestock products (one-way)? (a) In distance: ____ (kms); or (b) ____ in time (hrs).
13. How far is your house to the nearest market where you *obtain* your inputs (one-way)? In distance: (a) _____ (kms); or (b) _____ in time (hrs).
14. Fill the following tables to estimate TOTAL annual farm household income in the past production year from both crop and livestock production (last 12 months, December 2009 to November 2010).

14.1. Household Income from Crop Production

No	Crop type	MEHERE Production Season				BELG Production Season			
		Quantity produced (in quintal /kilogram)	Quantity sold (in quintal or kilogram)	Price per Kg	Total Revenue (ETB)	Quantity produced (in quintal /kilogram)	Quantity sold (in quintal or kilogram)	Price per Kg	Total Revenue (ETB)
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
	Total Revenue								

14.2. Household Income from Livestock and Livestock Products

No	Livestock type	From Both Seasons			
		Quantity produced in Number	Quantity sold in Number	Price per product	Total Revenue (ETB)
1	Milk/Cheese/Butter/ Yoghurt				
2	Honey				
3	Beef				
4	Sheep				
5	Goat				
6	Pigs				
7	Egg				
8	Hides and skin				
9	Other(specify_____)				
10	Other (specify_____)				
	Total Revenue				

Part 3: Institutional Factors

15. Have you attended training for farmers in the last two years?

- a) Yes b) No

(If no, please go to question 17)

16. If your answer to the above question is yes, was the training on crop production or livestock activities?

- a) On crop production
b) On livestock activities
c) On both

17. Do you get extension services such as information or advice from extension workers?

- a) Yes b) No

(If no, please go to question 21)

18. If your answer to the above question is yes, was the extension service on crop production or livestock activities?
- a) On crop production
 - b) On livestock activities
 - c) On both
19. The extension officials who visit or contact you are from which organization?
- a) Government agency
 - b) Agriculture research station
 - c) NGO
 - d) Other (specify) _____
20. How many times did the extension workers visit you from December 2009 – November 2010?
- _____
21. Do you carry out farmer-to-farmer extension activities so as to get information or advice or knowledge? a) Yes b) No
- (If no, please go to question 23)
22. If your answer to question 21 is yes, were the extension activities on crop or livestock production?
- a) On crop production
 - b) On livestock production
 - c) On both
23. Have extension officers provided you information on expected rainfall and temperature? a) Yes b) No
24. If you get any technical assistance and advice from other sources apart from official extension workers, from where do you receive the information/advice?
- _____
25. Did you borrow money from any of the following sources during December 2009 – November 2010?

No	Source	If Yes=1, If No=0	How often? (number of times)	Total amount borrowed (in ETB)
1	Relatives			
2	Neighbors (not relatives)			
3	Farmer associations or cooperatives			
4	Commercial banks			
5	Traders			
6	Other private moneylenders			
7	Credit and saving associations			
8	Microfinance institution			
9	NGO			
10	Women/youth associations			
11	Religious institution			
12	Government office			
13	Others (specify)_____			

26. If you did not obtain a credit during December 2009 to November 2010, what is the reason?

27. Do you have an irrigable land of yourself around or near a water source?

- a) Yes b) No

28. What is your evaluation regarding the level of support and cooperation that are being made by the government body to you specific to climate change? (Please circle one answer)

- a) Not enough
b) Enough
c) I don't know

29. Fill the following table to estimate TOTAL annual nonfarm household income (in the last 12 months, December 2009 to November 2010).

Household Income from Nonfarm Activities

No	Types of income	Income obtained? (Yes or No)	Total income (ETB)
1	Nonfarm jobs		
2	From aid		
3	Gifts		
4	Remittances from city (relatives)		
5	From pension		
6	Sale of farming assets (agricultural tool, machinery, building, trees, etc)		
7	Sale of non-farming assets (TV, Fridge...)		
8	Other (specify)_____		
9	Other (specify)_____		
10	Other (specify)_____		
11	Other (specify)_____		
	TOTAL		

Part 4: Climate Change and Adaptation Options

30. Have your agricultural productions and productivity ever been affected by the change in temperature?

- a) Yes b) No

31. Have your agricultural productions and productivity ever been affected by the change in rainfall?

- a) Yes b) No

32. If your answer to questions 30 and/or 31 is yes, to what extent do you think, as to your evaluation, the change in climate has affected your farming and production?

- a) Less affected
b) Moderately affected
c) Highly affected

33. Have you noticed any long-term changes in the mean temperature over the last 20 years?

- a) Yes b) No

(If yes, is it an increase or decrease or both? Please explain _____)

If too difficult: Has the number of hot days stayed the same, increased or declined over the last 20 years? Please explain _____

34. Have you noticed any long term changes in the mean rainfall over the last 20 years?

- a) Yes b) No

(If yes, is it an increase or decrease or both? Please explain _____)

If too difficult: Has the number of rainfall days stayed the same, increased, or declined, over the last 20 years? Please explain _____

35. What measures or adjustments in your farming have you made to the long-term shifts in temperature? (Please choose and tick from below as many as you made).

- a) Change crop variety (including new varieties)
- b) Build a water harvesting or conservation scheme
- c) Implement soil conservation techniques
- d) Change planting dates
- e) Irrigate more
- f) Change from crop to livestock
- g) Buy insurance
- h) Put trees for shading
- i) Reduce number of livestock
- j) Lease your land
- k) Migrate to urban area
- l) Find off-farm job

36. What measures or adjustments in your farming have you made to the long term shifts in rainfall? (Please choose and tick from below as many as you made).

- a) Change crop variety (including new varieties)
- b) Build a water harvesting or conservation scheme
- c) Implement soil conservation techniques
- d) Change planting dates
- e) Irrigate more

- f) Change from crop to livestock
- g) Buy insurance
- h) Put trees for shading
- i) Reduce number of livestock
- j) Lease your land
- k) Migrate to urban area
- l) Find off-farm job

37. Check the answers for 36 and 37 and then ask the reasons for the ones not yet selected there.

Why did you not	Reason for not adapting (look key)
1. Change crop variety (including new varieties)	
2. Build a water harvesting or conservation scheme	
3. Implement soil conservation techniques	
4. Change planting dates	
5. Buy insurance	
6. Put trees for shading	
7. Irrigate more	
8. Change from crop to livestock	
9. Reduce number of livestock	
10. Lease your land	
11. Migrate to urban area	
12. Find off-farm job	

Key for 37: Reasons for not adapting

- lack of money = 1
- lack of information/knowledge = 2
- shortage of labor = 3
- Shortage of farming land = 4
- Other [write into the space provided above with in the table]

38. What additional measures (adaptation methods) would you consider in the future?

- _____
- _____
- _____
- _____

39. What were the main constraints/difficulties in changing your farming ways or adapting to climate change?

- _____
- _____
- _____
- _____

40. Do you know farmers who perceived the change in the climate and have taken adaptation measures to its impact? a) Yes b) No

41. What trend do you expect about the future temperature?

- a) Increase
- b) Decrease
- c) Don't know

42. What trend do you expect about the future precipitation/rainfall?

- a) Increase
- b) Decrease
- c) Don't know

43. What five services, investments, or developments would you want the government, community, private sector, or NGO to do for your household agricultural production and productivity to be better off in the face of climate change? Look at the following table and please rank 5 of them in importance [1st is the most important, 5th is the least important]. You can indicate other issues not listed there.

Issues	Who (look the key)	Ranking
1. Irrigation development		
2. Up to date information on climate change		
3. Training on agriculture		
4. Electricity		
5. Health services		
6. Input supply (fertilizer, improved seed...)		
7. Potable water		
8. More roads (including paving of new roads)		
9. Other (please specify _____)		

Key for 43 - Who will do it

- Central government = 1 - Regional government = 2 - Woreda administration = 3
- Kebele administration = 4 - Community = 5 - Private sector = 6
- Other body (please write it in the space provided above with in the table).

Part 5: Preference for Adaptation Strategies

To the interviewer: Please read to the farmers the following general information about climate change and according to the instructions at each step ask them to choose from the alternative adaptation methods to climate change as to their preference. During the choice process please try to remind the farmers their answers for question number 36 and 37 above. When choosing among these 5 alternative adaptation methods, the farmers must consider their answers for questions 36 and 37 above because it is assumed that the farmers select and apply these adaptation strategies because they found them profitable and better methods among the different methods listed.

To the farmer: Dear farmer, as you might observe the world climate is changing from time to time and imposing challenges and problems on different aspects of life of our society and the economy. Among them, agriculture (thus the farmers) is one of the most highly affected sectors especially in developing countries like Ethiopia. Agricultural productions and farmers' productivity are being negatively affected by change in the climate.

To adapt to the impacts of this change in the climate, Ethiopian farmers are taking different measures such as use of new crop varieties, rearing different livestock species, developing irrigation, diversifying their crops, changing of planting dates, planting trees, diversifying from farm to nonfarm activities, using water and soil conservation techniques, changing use of capital and labor, and planting trees for shade and shelter etc. As a farmer, I expect that you are taking adaptation measures to reduce the impacts of changes in the climate on your farming system and farm productivity. Now, I will present you five types of adaptation strategies with brief descriptions of each. Then, you will be asked to choose in consecutive steps the adaptation strategy that you most preferred from the choice set.

The following are the alternative adaptation strategies listed in a random manner. The numbering of the alternatives does not have any reason except representation.

- **Alternative 1: Multiple Cropping** (includes crop diversification and using new crop varieties/types). In this method, farmers may want to diversify their crops or grow new varieties that would enable them adapt to changes in the climate.
- **Alternative 2: Livestock Production:** - This adaptation is to mean that farmers would combine fattening and rearing of animals or livestock with crop farming to adapt to climate change. Livestock in this definition includes those animals raised by farmers for food or other products or kept for sale such as beef and dairy cattle, goat, sheep, pigs, poultry etc.
- **Alternative 3: Soil Conservation:** - This refers to the sustainable use, preservation, management and care of soil in order to make it suitable for their crops to adapt to changing climate.
- **Alternative 4: Irrigation Development:** - This alternative includes irrigation development from rivers in order to cope up with the challenges of climate change.
- **Alternative 5: Changing Planting Dates:** - This would mean that farmers will change the date of planting of their crops with respect to the change in the climate (early or late planting).

Dear farmer, now let's start the choice process. We will proceed one by one to identify your preferences for these alternative adaptation methods to the change in the climate.

- ❖ **Step 1:** From the above 5 alternative adaptation strategies, which one is your most preferred and/or your commonly applied adaptation strategy to climate change? (In case you did not apply any of them, which one do you prefer first?)_____
- ❖ **Step 2:** From the remaining 4 adaptation methods, which one do you prefer the most and/or your commonly applied adaptation method to climate change? (In case you didn't apply any of them, which one do you prefer first?)_____
- ❖ **Step 3:** Again, from the remaining three adaptation strategies, which one do you prefer first and/or apply most commonly to climate change? (In case you did not apply any of them, which one do you prefer first?)_____
- ❖ **Step 4:** Finally, we left with 2 alternatives. Then, from these two alternative adaptation methods, which one is your first preference and/or your commonly applied adaptation method to climate change? (In case you didn't apply any of them, which one do you rank first?)

Thank you very much for your time and cooperation!

Declaration

I, the undersigned, declare that this thesis is my original work and has not been presented for a degree in any university and that all the sources of materials used for the thesis have been duly acknowledged.

The examiners' comments are incorporated.

Declared by:

Name: _____

Signature: _____

Date: _____

Confirmed by:

Name: _____

Signature: _____

Date: _____