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RURAL HOUSEHOLD VULNERABILITY TO CLIMATE CHANGE AND ADAPTATION OPTIONS OF NORTH SHOA ZONE, OROMIA REGION.

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List of Acronyms/Abbreviations

CO_2	Carbon Dioxide
CSIRO	Commonwealth scientific, Industrial and Research Organization
DA	Development Agent
ETB	Ethiopia Birr
FGLS	Feasible Generalized Least Squares
GDP	Gross domestic product
IIA	Independence of irrelevant alternatives
ILRI	International Livestock Research Institute
IFPRI	International Food Policy Research institute
IPCC	Intergovernmental panel on climate change
IRW	Internal Renewal Water
LDCs	least developed countries
MNL	Multinomial logit
MOFED	Ministry of finance and economic development
NCAR	National Center for Atmospheric Research
NEST	Nigerian Environmental study team
NMSA	National Meteorological service Agency
OLS	Ordinary Least Square
R	Rand
TLU	Tropical livestock unit
UNCTD	United Nations Conference on Trade and Development
USD	United States Dollar
VEP	Vulnerability as expected poverty approach
WoFED	Woreda of finance and economic development

Abstract

The study assesses the extent of rural household vulnerability to climate change by applying Vulnerability as Expected Poverty (VEP) approach and analyses adaptation options used by applying multinomial logit model. The VEP approach is based on estimating the probability that a given shock or set of shocks moves household consumption below poverty line or force them to stay there if they are already below poverty line. Multinomial logit model is based on the probability that households choices one method from multiple options to adapt to the negative impacts of climate change. The data was collected from rural farming households in Kuyu, Degem and Wara Jarso Woredas of North Shewa zone of Oromia regional state during 2011 production season. The study result indicates that from the total sample household 62.5 percent of the them are vulnerable to poverty, whereas 59.17 percent of them are poor. Moreover the sources of vulnerability indicates that about 52.92 percent of the households are vulnerable to poverty due to low consumption mean and about 9.58 percent of them are vulnerable due to high consumption instability. It was also observed from the study result that household head age, gender of household head, education level, land size, livestock size, farm income, non-farm income, irrigation size, ikub, fertilizer use, insecticide and pesticide use and adaptation reduce household vulnerability to climate change, whereas family size, idir and mahiber tend to increase household vulnerability to climate change. Access to extension services, all weather roads, credit and market also reduces household vulnerability to poverty. The adaptation methods identified include use of irrigation, change of planting date and plough system, use of traditional and improved crop variety, and innovative adaptation method. In this study level of education, gender, age, land size, farm income, nonfarm income, livestock size, access to credit, access to market, access to extension, access to all weather roads and social institution considered as factors that influence the farmers use of adaptation method. The analysis reveals that these variables influence farmers' use of adaptation method. This study suggests that raising awareness of climate change, encouraging farmers to use different innovative adaptation method, increasing availability of improved crop and livestock species, expansion of irrigation use, non farm income opportunities, access to credit and extension services are possible intervention areas to reduce household vulnerability.

Key words: *Vulnerability, climate change, adaptation and vulnerability as Expected Poverty.*

CHAPTER ONE

1. Introduction

1.1 Background

Changes in climate can have serious implications for household well-being, especially in the rural households that rely mainly on agricultural activity, due to its direct exposure to and dependence on climate conditions. The global current average temperature is projected to increase by a record high of 1.4 –5.8°C in the next century compared to temperature levels in 1990s (Sygna, 2005). Consequently, climate change is attracting ever more attention from the media, academics, politicians and even businesses, as evidence mounts about its scale, seriousness and the speed at which it is affecting the world.

As climate change is global concerns about its impact on agriculture in developing countries have been increasing (IPCC, 1996). Some attempts have been made to estimate this impact (Kumar and Parikh, 1998; Mendelsohn and Tiwari, 2000). Countries in Africa could be affected by climate change, particularly Ethiopia depend on rainfed agriculture and under heavy pressure from food insecurity and often famine caused by natural disasters such as drought (Mendelsohn and Tiwari, 2000).

Agriculture is the most dominant sector in Ethiopian economy. It plays a crucial role by contributing 41% of GDP, generates more than 75% of foreign exchange earnings and employs about 80% of the population (World fact book 2012). However the agricultural sector is dominated by small-scale mixed crop livestock productions with very low productivity. The major factors for the low productivity of the sector include reliance on traditional farming techniques, soil degradation caused by overgrazing and deforestation, poor complementary services such as extension, credit, marketing, infrastructure and climatic factors such as drought and flood (Yirga, 2007). These factors reduce the adaptive capacity and increase the vulnerability of farmers to climate change, which negatively affect the performance of the already weak economic sector.

Study on vulnerability and poverty in Africa puts Ethiopia as one of the country's most vulnerable to climate change and with least capacity to respond (ILRI, 2006). Ethiopia already suffers from extremes of climate, shown in the form of frequent drought and flood (Difalco *et al*, 2007). On the other hand, Ethiopian agriculture is mostly depending on rain fed, where irrigation practices counting for very small portion of the total cultivated land in the country. Thus, the change of rainfall, temperature and other climatic factors in amount and timing during the production seasons has a significant impact on crop yields and can induce food shortages and famine, hence, increase farmers' vulnerability to poverty. The implication is that vulnerability of countries and societies to the effects of climate change depends not only on the magnitude of climatic stress, but also on the sensitivity and capacity of affected societies to adapt to or cope with such stress (NEST 2004). Ethiopia has suffered at least five major national droughts since 1980 and dozens of local droughts (World Bank 2008). Cycles of drought create poverty traps for many households, constantly thwarting efforts to build up assets and increase income. World Bank survey data show that between 1999 and 2004 more than half of all households in the country experienced at least one major drought shock.

Countries have been taking different options to protect their environment from the negative results of climate change. One of the foremost policy options used for reducing the negative impact of climate change is adaptation (Adger et al. 2003; Kurukulasuriya and Mendelsohn 2006). Adaptation to climate change refers to adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities (IPCC 2001). The most adaptation method used in agriculture sector include; use of new crop varieties and livestock species that are better suited to drier conditions, irrigation, crop diversification, adoption of mixed crop and livestock farming systems, and changing planting dates (Kurukulasuriya and Mendelsohn ,2006). Study conducted in Ethiopia shows that farmers adapted to climate change by using different methods such as; Soil conservation, use of different crop varieties, Planting trees, changing planting dates and irrigation(Deressa et al. 2008).

Some studies on vulnerability to climate change and adaptation options have been conducted in Ethiopia, in particular around the Nile basin. However most of the studies were not including who are exposed to climate change and the extent of vulnerability to climate change. So this study included who are exposed to climate change and the extent of vulnerability to climate change. The vulnerability to climate change and adaptation method of kuyu, Degem and Wara Jarso was also not studied yet.

1.2 Statement of the problem

Starting some years ago the issue of climate change becomes the world burning issue and now there are various convincing evidences that the climate change is occurring and it causes various social and economic problems around the world. Despite the effects of climate change being evident at a global scale, its negative impact will be more severely felt in developing countries. This is due to the fact that economies of developing country depend on climate sensitive sector (for example agriculture and fisheries) makes the people to be more likely to suffer from the negative effect of climate change. This is because of their limited human, institutional, and financial capacity to anticipate and respond to the direct and indirect effects of climate change (IPCC 2001).

In Ethiopia rural household vulnerability to climate change is high due to the fact that rural households mainly depend on agricultural income and the agricultural sector, particularly crop production, is dominated by small-scale farmers who employ largely traditional and rain fed practices. Ethiopia is vulnerable to climate variability and climate change. The major problem in both crop and livestock production is recurrent droughts, hailstorms, floods and pest incidence). Especially, recurrent drought is highly prevalent in the country which made many people throughout the country dependent on food aid (Befekadu and Berhanu 2000).

Study conducted in the Nile basin of Ethiopia has tried to identify the major methods used by farmers to adapt to climate change, the factors that affect their choice of methods (Deressa et al. 2008c). By estimating a multinomial logit model they indicated that the level of education, gender, age and wealth of household head; access to credit; information on future climate, social capital, agro ecological settings and temperature all influence farmers' choice.

In this study area, rural households are also dependent on rain fed crop production and rearing of livestock as their livelihood. Even though these activities are more sensitive to climate change, households use these economic activities as their main source of livelihood income. These make them vulnerable to climate change. This is due to the fact that there is a serious climate changes in the area for instance; delay in time of rainfall and termination of rainy time before the appropriate time (while the crops demand rainfall), decrease in total volume of rainfall, irregularity in rainfall, and increase in temperature. Adaptation of the crop production and livestock rearing to climate change is a means that the household can use to protect themselves from vulnerability to climate change. However use of this adaptation method cannot be effective due to various factors such as lack of awareness or inadequacy of the existing awareness creation system, lack of capital/technology and other resource constraints.

As stated above some studies on vulnerability to climate change and adaptation options have been conducted in Ethiopia, particularly around the Nile basin. However most of the studies were not including who are exposed to climate change and the extent of vulnerability to climate change. In addition these studies cannot represent the present study area due to the difference in socio-economic and environmental factors, which influences rural households' vulnerability to climate change and adaptation options.

Therefore this study tries to fill the existing research gap in the literature by examining the vulnerability of household to climate change and adaptation methods used. It indicates who are exposed to climate change, the extent of household vulnerability to climate change, identify factors determine household vulnerability and adaptation methods. The above literature and (or) knowledge gap evidences to undertake this study on the analysis of rural household vulnerability to climate change and adaptation options in the study area.

1.3 Objectives of the Study

The general objective of this study is to assess rural household vulnerability to climate change and adaptation options. The specific objectives are:-

1. To examine the level of rural households' vulnerability to climate change.
2. To investigate factors behind rural households' vulnerability to climate change.
3. To identify adaptation strategies of rural households and their significance in reducing vulnerability to climate change.

1.4 Significance of the study

This study emphasized on the vulnerability of rural household to climate change and adaptation option. Rural households are almost entirely dependent on a climate sensitive economic activity, which is agriculture. This study, therefore contributes significantly to the literature by providing new and robust evidence on the vulnerability of rural household vulnerability to climate change and adaptation options used.

Given the importance of the agricultural sector in the Ethiopian economy, the findings of the study will provide an important link on how to design policy and integrate households in reducing vulnerability to poverty due to climate change. It will also inform all the other stakeholders to take a part in reducing rural household vulnerability to poverty due to climate change. In addition, such study provides a basis for further research on the impact of climate change and extremes on total GDP in the country, as well as in other countries that are reliant on agriculture.

1.5 Scope of the study

This study focuses on the implication of climate change for household susceptibility to poverty through its impact on household income/consumption. It relies on households in Kuyu, Degem and Wara Jarso *Woreda* districts of North Shewa *Zone* that are dependent on agriculture as their main source of livelihood. It investigates the impact of climatic extremes and change on household vulnerability to fall below poverty line and the role of adaptation in reducing vulnerability. For this study analysis purpose only data of the year 2011 was used.

1.6 Limitation of the study

In this study to measure the vulnerability of household to climate change and adaptation option the cross sectional data is used. The only used household data to analyze vulnerability and adaptation is the data of the year 2011, because in our country the rural households do not maintain a record related to their agricultural data and expenditure of each year. More over it is very much difficult for household to remember the data of a long time and an accurate data cannot be obtained by remembering. In addition it is impossible to obtain each households information from the other sources. Because of these constraints the study used cross sectional data which is less informative than time series data.

Vulnerability as expected poverty is used this analysis. This vulnerability measure correctly reflects a household's vulnerability only if the distribution of consumption across households, given the household characteristics at one time, represents the time-series variation of consumption of the household. Hence this measure requires a large sample in which some households experience a good period and others suffer from negative shocks. In addition this measure cannot reflect unexpected large negative shocks if cross section data is used for a normal year. So this is considered as one limitation of this study.

1.7 Organization of the report

The study is organized into five chapters. Chapter two comprise both theoretical and empirical reviews of the literature related to vulnerability of household to climate change and adaptation option, The data and methodology employed in the thesis are dealt with under chapter three before going for the econometric results and discussions presented in chapter four. Finally, the conclusions and policy implications are drawn in chapter five.

CHAPTER TWO

2. Literature review

2.1 Definition of concept

Climate change: Are the changes in components that include changes in sea-level, high water events, storminess, precipitation, temperature, atmospheric CO2 concentration, ocean circulation patterns, health of functionally linked neighboring ecosystems, as well as human responses to climate change. Of all the outcomes from changes in the atmosphere's composition and alterations to land surfaces, relative sea-level rise may be the greatest threat (Lovelock and Ellison, 2007). The impacts of climate change are not evenly distributed, in part due to the differentiated nature of hazards in different parts of the globe, but also due to differences in the ability to cope with and adapt to the negative effects and harness beneficial effects of climate shocks and stresses. The common generic conclusion is that those exposed to the most severe hazards are also those least able to cope with the associated impacts (Adger et al. 2003).

Vulnerability: The term "vulnerability" has no universally accepted definition, largely because different disciplines use the term differently to explain their areas of concern. Studies on natural hazards and epidemiology define vulnerability as the degree to which an exposed unit is susceptible to being harmed by exposure to a perturbation or stress, in conjunction with its ability (or lack thereof) to cope, recover or fundamentally adapt (become a new system or go extinct) (Kasperson et al. 2001).

IPCC(2001) defines vulnerability to climate change as the degree to which a system is susceptible, or unable to cope with adverse effects of climate change, including climate variability and extremes, and vulnerability is a function of the character, magnitude and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity".

Adaptation to climate: is the process through which people reduce the adverse effects of climate on their health and well-being, and take advantage of the opportunities that their climatic environment provides (Burton 1992, quoted in Smit et al. 2000). Adaptation involves adjustments to enhance the viability of social and economic activities and to reduce their vulnerability to climate, including its current variability and extreme events as well as longer-term climate change (Smit 1993, quoted in Smit et al. 2000). Adaptation to climate change includes all adjustments in behavior or economic structure that reduce the vulnerability of society to changes in the climate system (Smit et al. 1996, quoted in Smit et al. 2000).

According to the IPCC Third Assessment Report, adaptation "has the potential to reduce adverse impacts of climate change and to enhance beneficial impacts, but will incur costs and will not prevent all damages." Furthermore, it is argued that human and natural systems will, to some extent, adapt autonomously and that planned adaptation can supplement autonomous adaptation. However, "options and incentives are greater for adaptation of human systems than for adaptation to protect natural systems" (IPCC 2001).

Adaptability refers to the degree to which adjustments are possible in practices, processes or structures of systems to projected or actual changes of climate. Adaptation can be spontaneous or planned, and can be carried out in response to or in anticipation of change in conditions (Watson et al. 1996, quoted in Smit et al. 2000).

Adaptive capacity: is the potential or ability of a system, region, or community to adapt to the effects or impacts of climate change. Enhancement of adaptive capacity represents a practical means of coping with changes and uncertainties in climate, including variability and extremes. In this way, enhancement of adaptive capacity reduces vulnerabilities and promotes sustainable development (Smit et al., 2000). Considerable attention has been devoted to the characteristics of communities, countries, and regions that influence their propensity or ability to adapt and hence their vulnerability to risks associated with climate change. These determinants of adaptive capacity relate to the economic, social, institutional, and technological conditions that facilitate or constrain the development and deployment of adaptive measures (Adger, 1999)

2.2 Agriculture and climate change

Developing countries are more exposed and less resilient to climate hazards. Warming of 2°C could result in a 4 to 5 percent permanent reduction in annual income per capita in Africa, and south Asia as opposed to minimal losses in high-income countries and a global average GDP loss of about 1 percent (World Bank, 2009). These losses would be driven by impacts in agriculture, a sector important to the economies of both Africa and South Asia. Developing countries are expected to be more adversely affected due to their geographical location, the greater share of agriculture in their economies, reliance on ecosystem services and natural capital for production in climate-sensitive sectors, much of their population lives in physically exposed locations and economically precarious conditions and their limited ability to adapt to climate change (World Bank, 2009).

Agriculture is one of the most vulnerable sectors to climate change because of its seasonality, the narrow range of weather conditions over which crop and livestock production can occur, the presence of significant non climatic stressors that influence sensitivity to changes in climatic conditions. Rising temperatures, increased frequency and severity of extreme climatic events, and changes in the distribution, quantity, and timing of rainfall projected over the course of this century could have strong negative impacts on crop and livestock production (Padgham, 2009). These impacts will further compound the already substantial challenges facing agriculture, including increasing population pressure on the resource base, land degradation, loss of agricultural biodiversity, and damage from pests and diseases. Although there will be gains in some crops in some regions of the world, the over- all impacts of climate change on agriculture are expected to be negative, threatening global food security (IFPRI, 2009).

Climate change impacts on agriculture will, however, vary by region. Climate change impacts on subtropical and tropical regions will be predominately negative, especially where agriculture is currently marginal with respect to high-temperature and moisture-deficit conditions. The most vulnerable agricultural systems occur in arid, semi-arid, and dry sub humid regions in the developing world, home to half of the world's malnourished populations, where high rainfall variability and recurrent droughts and floods regularly disrupt food production and where poverty is pervasive. For example, according to IFPRI's projection, in developing countries predicted climate for 2050 will reduce production of most types of crops. But for developed countries, yields are affected less than those in developing countries. For a few crops, climate change actually increases developed country yields (IFPRI, 2009).

2.3 Theoretical framework

2.3.1 Measuring Vulnerability to Climate Change

There are various approaches to measure vulnerability depending on the purpose, field and threshold used for assessment of vulnerability. For example, according to IPCC Vulnerability to climate change is the degree to which geophysical, biological and socio-economic systems are susceptible to and unable to cope with adverse impacts of climate change (IPCC, 2001). Based on IPCC's definition vulnerability is measured as the probability of falling below some specified threshold, usually poverty line. The most common methods employed in vulnerability assessment are the *Econometric Method* and the *Indicator Method*, which are discussed as follows.

2.3.1.1 Econometric Method

The econometric method has its roots in the poverty and development literature. This method uses household-level socioeconomic survey data to analyze the level of vulnerability of different social groups (Deressa et al., 2008a). The method is divided into three categories: (a) Vulnerability as Expected Poverty (VEP), (b) Vulnerability as Low Expected Utility (VEU) and (c) Vulnerability as Uninsured Exposure to Risk (VER) (Hoddinott and Quisumbing, 2003). All three share common characteristics in that they construct a measure of welfare loss attributed to shocks.

2.3.1.1.1 Vulnerability as Expected Poverty (VEP)

According to vulnerability as expected poverty, vulnerability of a person is expected that person becoming poor in the future if currently not poor or expected that person continuing to be poor if currently poor (Deressa et al., 2008a). Hence, vulnerability is seen as expected poverty, and consumption (income) is used as a proxy for well-being. This method is based on estimating the probability that a given shock, or set of shocks, moves consumption by households below a given minimum level (e.g., consumption poverty line) or forces the consumption level to stay below the given minimum requirement if it is already below that level (Chaudhuri *et al.*, 2002).

This vulnerability measure is preferable in that it can be estimated with a single cross section data. Even though it is preferable the measure correctly reflects a household's vulnerability only if the distribution of consumption across households, given the household characteristics at one time, represents the time-series variation of consumption of the household (Gaihai and Imai, 2008). Hence this measure requires a large sample in which some households experience a good period and others suffer from negative shocks. In addition this measure cannot reflect unexpected large negative shocks if cross section data is used for a normal year. Moreover, if estimations are made using a single cross section, one must make a strong assumption that cross-sectional variability captures temporal variability (Hoddinott and Quisumbing, 2003).

2.3.1.1.2 Vulnerability as a Low Expected Utility (VEU)

Vulnerability is defined as the difference between the utility derived from some level of certainty- equivalent consumption, Z_{CE} at and above which the household is not considered vulnerable and the expected utility of consumption (Ligon and Schechter 2003). This certainty-equivalent consumption is analogous to a poverty line. Consumption of a household, C_i, has a distribution in different states of the world, so this measure is taken by the following formula:

Vi=Ui(ZCE)-EUi(Ci), Where U_i is a (weakly) concave, strictly increasing function.

However, measuring vulnerability as low expected utility requires specification of a particular utility function which will affect the magnitudes calculated. Hoddinott and Quisumbing (2003) added, while the magnitudes are affected by changes in functional form, it appears that the relative magnitudes of the individual components are not so affected. A more problematic concern here is that the units of measurement are units of utility (e.g., *utils*); for example a finding that Vh =0.25 means that the utility of household h is 25 percent less than would be the case if all inequality of consumption and risks in consumption were eliminated. For many policymakers this expression of magnitude may be difficult to understand. Deressa et al. (2008a) added that in this method it is difficult to account for an individual's risk preference, given that individuals are ill informed about their preferences, especially those related to uncertain events.

2.3.1.1.3 Vulnerability as Uninsured Exposure to Risk (VER)

The VER method is based on *ex post* facto assessment of the extent to which a negative shock causes welfare loss (Hoddinott and Quisumbing 2003). In this method, the impact of shocks is assessed by using panel data to quantify the change in induced consumption. In the absence of risk-management tools, shocks impose a welfare loss that materializes through reduction in consumption. The amount of loss incurred due to shocks equals the amount paid as insurance to keep a household as well off as before any shock occurs. The disadvantage of this method is that in the absence of panel data sets, estimates of impacts-especially from cross-sectional data-are often biased and thus inconclusive (Deressa et al., 2008a). Therefore, it is difficult to apply this approach with single round cross section data.

2.3.1.2 Indicator Method

Vulnerability is measured using the indicator method based on selecting some indicators from the alternative indicators and then systematically combining the selected indicators to indicate the levels of vulnerability. These levels of vulnerability may be analyzed at local, national, regional, and global scales (Deressa et al., 2008b).

Using this method at any scale two options are available to calculate the level of vulnerability. The first option is assuming that all indicators of vulnerability have equal importance and thus giving them equal weights (Deressa et al., 2008b). The second method is to avoid the uncertainty of equal weighting given the diversity of indicators used by assigning different weight. In line with the second method, many methodological approaches have been suggested to make up for the weight differences of indicators. There is no standard weighting method against which each method is tested for precision but there are attempts in giving weights even if their appropriateness is still doubtful. Luers et al., (2003) explained the weakness of the indicator approach as follows:

While the indicator approach is valuable for monitoring trends and exploring conceptual frameworks, indices are limited in their application by considerable subjectivity in the selection of variables and their relative weights, by the availability of data at various scales, and by the difficulty of testing or validating the different metrics. Perhaps most importantly, the indicator approach often leads to a lack of correspondence between the conceptual definition of vulnerability and the metrics.

2.4 Empirical review

It is necessary to have panel data of sufficient length and richness ideally to attempt estimation of vulnerability at the household level (Chaudhuri et al., 2002). However, such data are rare, particularly in developing economies like Ethiopia. Instead, the best way to estimate is use of cross-sectional household surveys with detailed data on household characteristics, consumption expenditures and income. Cross sectional data is useful to measure only variation in welfare at a point in time, but they are nonetheless an important analytical tool used to identify risks and vulnerable groups, assess the outcome and impact of shocks, and identify households that face a high risk of falling into poverty due to climate change. This is especially true if variation in welfare across households is mainly attributed to observable household characteristics. In fact the level of vulnerability of different social groups to climate change is determined by both socioeconomic and environmental factors. The socioeconomic factors most cited in the literature include the level of technological development, infrastructure, institutions, and political setups (Deressa et al., 2008b). The environmental factors mainly include climatic conditions, quality of soil, and availability of water for irrigation (Deressa et al, 2008b; O'Brien et al., 2004). The variations of these socioeconomic and environmental factors across different social groups are responsible for the differences in their levels of vulnerability to climate change. On the other hand, farmers' adaptation to climate change reduces their degree of vulnerability or change the way they are affected if their adaptation mechanisms are effective. But we have to note that household adaptation decisions depend on its adaptive capacity and perception about climate change. Adaptive capacity and perception on climate change are, in turn, shaped by socioeconomic and environmental factors.

There are various studies conducted using vulnerability as expected poverty method. For example, using cross-sectional survey data in Pakistan, Jamal (2009) showed that about 52 percent of the population was vulnerable to poverty during 2004-05. Tesliuc and Lindert (2002) used cross-sectional survey data of 2000 in Guatemala to show that three-quarters of the total poor have a vulnerability index of 0.67, which means that two out of three of the then poor households would still be poor in the coming period. Deressa et al. (2008a) applied this approach to farmers in the Nile Basin of Ethiopia using cross sectional data of 2004/5, and they concluded that vulnerability is sensitive to poverty lines.

Chaudhuri et al. (2002) noted the importance of cross sectional data in estimating household vulnerability to poverty and gave detailed methodological description and estimates from Indonesia. They stressed that despite the obvious limitations of purely cross-sectional data, a detailed analysis of these data can potentially be informative about the future. If most of the observed cross sectional variation in consumption levels across households stems from unobserved (to us) differences across households, say because of unobserved household-specific determinants of consumption levels that are persistent over time, then, clearly, we would not be able to assess household vulnerability to poverty with any degree of confidence. If, on the other hand, much of the variation can be attributed to the differences in the observable characteristics of households, then even a single cross-section can be quite helpful in answering questions about household vulnerability.

In their paper, starting with a definition of vulnerability at the household level as the probability that a household, regardless of whether it is poor today, will be consumption poor tomorrow, they provided a conceptual framework for thinking about the different dimensions of vulnerability to poverty, and then propose a simple method for empirically estimating household-level vulnerability using cross-sectional data. They also demonstrated the uses and limitations of the proposed methods through a case study using household-level data from Indonesia. From the cross sectional study in Indonesia they forwarded three main conclusions. First, the fraction of the population that faces a non-negligible risk of poverty is considerably greater than the fraction that is observed to be poor. While 22% of the Indonesian population was observed to be poor, they estimated that 45% of the population was vulnerable to poverty. Second, the distribution of vulnerability across different segments of the population can differ markedly from the distribution of poverty. They argued that this highlights the need for a distinction between poverty prevention programs-i.e., those aimed at reducing vulnerability-and poverty alleviation programs, and for differential targeting of the two. Third, they found striking differences in the sources of vulnerability for different segments of the population. For rural households and for less-educated households, the main source of vulnerability appears to be low mean consumption prospects; for urban households and for more highly educated households, on the other hand, vulnerability to poverty stems primarily from consumption volatility.

A paper by Di Falco et al. (2008) presents an empirical analysis of the determinants of adaptation strategies to climate change and their implications on farm productivity and farmers' spatial risk exposure. The analysis was based on primary data on 740 farms producing *teff* in the Nile Basin, Ethiopia. They used the Thin Plate Spline method of spatial interpolation to impute the household specific rainfall and temperature values using latitude, longitude, and elevation information of each household. The rainfall data was disaggregated at season level (*mehere* and *belg*). They conducted the econometric analysis in three steps. In the first step, a farm level yield function was estimated. Then, the error term from the first stage was used to measure risk exposure in terms of crop variability and crop failure. The role of adaptation was included in the model via a binary variable that captures the adoption of yield-related adaptation strategies. A Heckman selection procedure was used to control for the observable factors that affect adoption so as to isolate the productivity gain. Spatial specific fixed effects were also inserted.

Deressa (2007) applied the Ricardian approach that captures farmer adaptations to varying environmental factors to analyse the impact of climate change on Ethiopian agriculture. He used a cross sectional survey of 1000 farmers from 50 districts in 11 of 18 Ethiopian agro ecological *Zones*. Net farm revenue was regressed on climate, household and soil variables. Climate change was captured by change in temperature and precipitation. Marginal impact analysis showed that increasing temperature would reduce net revenue by $177.62 and $464.71 during summer and winter respectively, whereas increasing precipitation during spring would increase net revenue by $225.09. The study also examined the impact of uniform climate scenarios of increasing temperature by 2.50C and 50C; and decreasing precipitation by 7% and 14%. The result indicated that increasing temperature and decreasing precipitation are both damaging to Ethiopian agriculture, where decreasing precipitation appeared to be more damaging than increasing temperature. This study is crucial in that it clearly indicated the impact of climatic variables on farm revenue that takes in to account difference in agro-ecology and seasonal variation; adaptation and net revenue impact of predicted climate scenarios. However, the study did not incorporate the carbon fertilization effect and the role of change in future price and technology. Moreover, in this study the cost of climate change was imputed from farm net revenue used as a proxy for capitalized land value, since land market is missing in Ethiopia.

Yesuf et al. (2008) conducted an empirical analysis of the impact of climate change and adaptation on food production in the Nile Basin of Ethiopia. The study used cross section data from 1000 farms producing cereal crops in the basin and monthly rainfall and temperature data that were interpolated to get household specific values. They estimated production function into which adaptation entered as a binary variable. Finally, they concluded that climate change and climate change adaptation has significant impact on farm productivity. Extension services, both formal and farmer to farmer, as well as access to credit and information on future climate change affect adaptation decision positively and significantly. They also found that farm households with larger access to social capital are more likely to adopt yield related adaptation strategies. From this study we can get information on the important role of adaptation to climate change in stabilizing farm productivity, factors that dictate the use of adaptation options. But we get little information on how climate change affects household welfare in the coming periods and the role of adaptation in reducing household vulnerability to future climate change.

Another study conducted in the same area has tried to identify the major methods used by farmers to adapt to climate change, the factors that affect their choice of methods and perception on climate change and barriers to adaptation by Deressa et al. (2008c). They applied the general framework of utility maximizing farmers to analyse the choice of different adaptation methods. By estimating a multinomial logit model they indicated that the level of education, gender, age and wealth of household head; access to credit; information on future climate, social capital, agro ecological settings and temperature all influence farmers' choice. Recognizing the role of perception on climate change, for adoption they showed that ages of household head, wealth, information on climate change etc. have impact on farmers' perception on climate change.

Studies conducted in Ethiopia on the vulnerability of household to climate change and adaptation options used. However many of the study does not indicate the extent of vulnerability, vulnerable groups and adaptation options. In addition area where this study conducted is different from the other area in terms of; plough systems, cultural and awareness of the community on the climate change and adoption options. Therefore this study will fill these research gaps.

2.5 **Conceptual Framework**

The conceptual framework for this study depends on the IPPC's (2001) definition of vulnerability to climate change. The IPCC defines vulnerability to climate change as follows: The degree to which a system is susceptible, or unable to cope with adverse effects of climate change, including climate variability and extremes, and vulnerability is a function of the character, magnitude and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity". See figure 2.1 below.

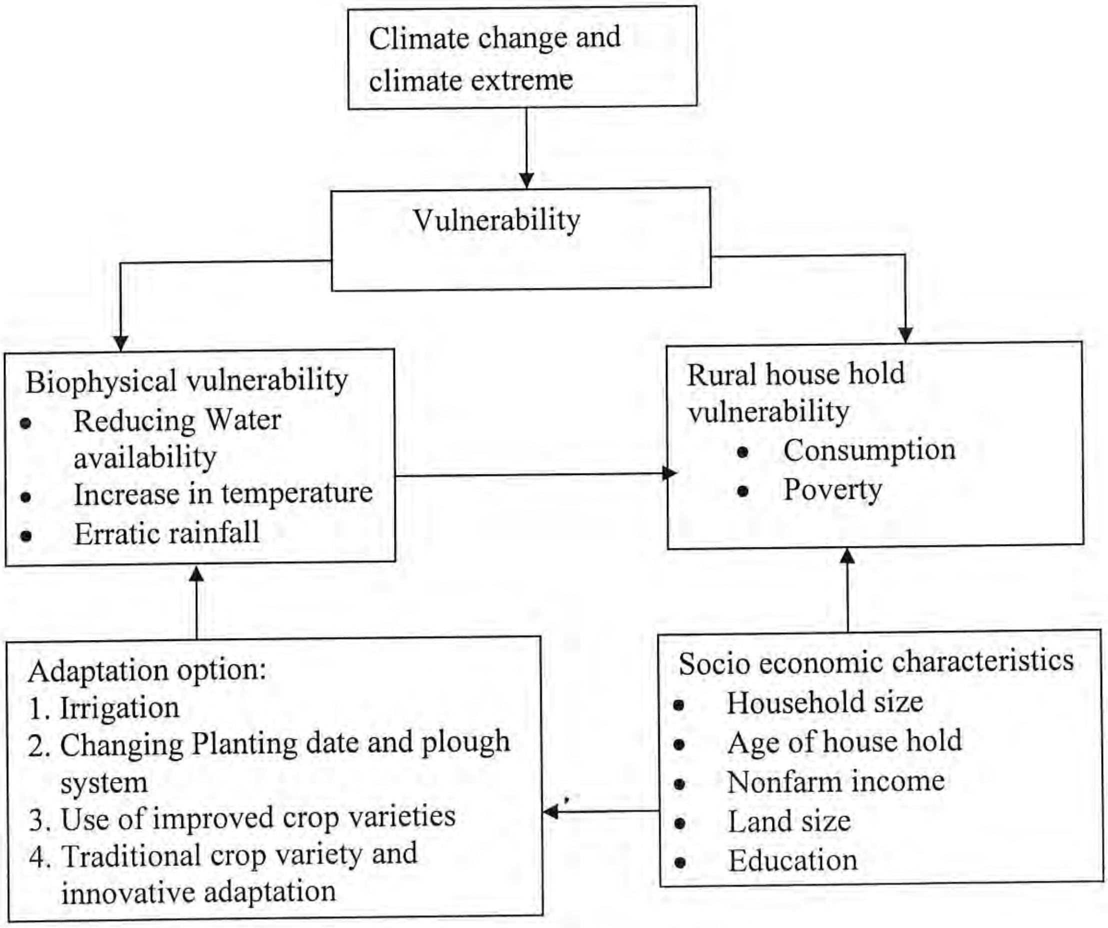


Figure 2.1 Conceptual Framework of Vulnerability Assessment

As Figure 2.1, (modified from Deressa et al., 2008b) shows farmers are exposed to both gradual climate change and extreme climate conditions. Exposure affects bio physical of the rural house hold vulnerability. Which means that exposure to higher frequencies and intensities of climatic risk highly affects outcome (e.g., productivity, income, health). Biophysical vulnerability is directly affects rural household vulnerability. Adaptation options to climate change positively influence bio physical vulnerability and also reduce rural household vulnerability that results from the socioeconomic. Individuals in a community often vary in terms of education, gender, wealth, health status, access to credit, access to information, technology, social, environmental, physical capital, political power, and so on. These variations are responsible for the variations in vulnerability levels. On the other hand, biophysical vulnerability which is the level of damage that, a given environmental stress (factor) causes on both social and biological systems (example, impact of climatic variables and soil characters on vulnerability). Therefore, vulnerability to climate change is affected by low autonomous of adaptive capacity.

CHAPTER THREE

3. Research Methodology

3.1. Description of the area

The study area is found in the Northern part of Oromia regional states north shoa zone which is far from Addis Ababa by 125 km to 200 km. The area has different agro-ecological zones: highland, midland and lowland. This study has focused on three Woredas of Oromia Region particularly; Degem, Kuyu, and Wara Jarso woreda. These Woreda are among the 14 woreda of north Shoa zone. These Woreda covers a total land size of 284,255 in hectare. From this total Degem woreda covers a total land size of 67, 020 in hectare. The topography of the Woreda is characterized by undulating plains, of which 55% of the Woreda is plain, 25% is undulating, 15% is mountainous and 5% is gorgeous. The lowest altitude is 1400 meters above sea level and the highest is 3541 meters above sea level. In terms of agroecological classification the Woreda is largely mid highland (95%) with only 5% being a low land. Mean annual rainfall in the woreda is between 938mm minimum and 1441mm maximum. Average monthly minimum temperature is 4.5^0C and maximum annual temperature are 21.2^0C (WoFED, 2011).

Kuyu Woreda covers a total land size of 97,400 in hectare. The Woreda is characterized by 33.8% highland, 50.7% is midland and 15.4% is lowland. The altitude of the area ranges between 1000 and 2620 meters above sea level. Mean annual rainfall in the woreda is between 1075mm minimum and 1657mm maximum. Mean annual minimum and maximum temperature are 6.6^0C and 22.4^0C respectively. The topography of the Woreda is mostly plain (72%) followed by mountainous (16%) and gorgeous (12%) (WoFED, 2010).

On the other hand, Wara Jarso wareda covers the total land size of 119,835 hectares. This total land size is classified interms of agroecological as 7.13% of is highland, 43.37% is midland and 49.5% is low land. The altitude of the area ranges between lowest 1080 and highest 2570 meters above sea level. Mean annual rainfall in the woreda is between 850mm minimum and 1416mm maximum. Mean annual minimum and maximum temperature are 13.6^0C and 23.6^0C respectively. The topography of the Woreda is mostly plain (47%) followed by gorgeous (33%) and mountainous 20% (WoFED, 2011).

3.2. Research design (Research Approach)

The study used cross sectional survey research, both quantitative and qualitative data collection method from primary and secondary sources were employed. The survey was made on the Bio-physical and socio economic issue in relation to household vulnerability to climate change and adaptation options in selected kebeles of the woreda.

3.3. Sampling procedure and sample size

The sample Kebeles was randomly selected from each woreda. The survey covered 6 Kebeles from three Woredas. The geographical location of the study area was taken into consideration and samples were selected from highland (dega), midland (Woine dega) and lowland (kola). Once the *Kebeles* are identified households were selected based on the total households in the *Kebele*. Sample households were selected using systematic sampling method by picking every N^{th} household starting from a random start. The survey was covered a total of 240 farming households. For this purpose list of households obtained from respective *Kebele* administration was used as sampling frame.

3.4. Data source and collection

The data used in this study were obtained from household survey of production period 2011 in rural *Kebeles* of kuyu, Degem and Wara Jarso *districts* in north Shewa zone of the Oromia regional state. To attain the aim of the study both primary data and secondary data was used as a source of information. Primary data was obtained through structured questionnaire which was used to conduct the survey and filled by trained enumerators and the researcher herself.

Secondary information and data used in the analysis is mean monthly maximum and minimum temperature and mean monthly rainfall values and type of soils. Data on rainfall and temperature was obtained from kuyu, Degem and Wara Jarso meteorological branch office.

3.5. Data Analysis

To analyze data collected on the vulnerability of household to climate change and adaptation options the empirical model is drawn from the following theoretical model.

3.5.1 Theoretical Model

Vulnerability

According to Chaudhuri, 2002 vulnerability is defined in terms of exposure to adverse shocks to welfare (such as climate change), rather than in terms of exposure to poverty. Therefore, in this study how climatic shocks and change, environmental and household characteristics affect the probability of a household to become poor, or remain poor if it is already poor was seen.

Following Chaudhuri (2002) the vulnerability level of a household *h* at time *t* is defined as the probability that the household will find itself consumption poor at time t+1:

V_{ht}=pr $(C_{ht+1}=C(X_h, \beta_{t+1}, \alpha_h, e_{h,t+1}) \leq Z \backslash X_h, \beta_t, \alpha_h, e_{ht})$...3.1

Where X_h represents a bundle of observable household characteristics, β_t is a vector of parameters describing the state of the economy at time t, and α_h and e_{ht} represent, respectively, an unobserved time-invariant household-level effect, and any idiosyncratic factors (shocks) that contribute to differential welfare outcomes for households that are otherwise observationally equivalent.

According to Chaudhuri et al. (2002), at a conceptual level, the above expression is very general in a number of respects. First, it allows for the possibility of complicated interactions between the multiple cross-sectional determinants of a household's vulnerability level. For instance, X_h could include variables such as the educational attainment of the head of the household, presence of a government poverty scheme in the community in which the household resides, as well as interactions between the two to capture potential inequities in the level of access to public programs. Second, because a household's vulnerability is defined in terms of its future consumption prospects conditional on its current characteristics, both observed and unobserved, the possibility of poverty traps and other non-linear poverty dynamics is implicitly built in. Finally, the possible contribution of aggregate shocks and unanticipated structural changes in the macro-economy to vulnerability at the household level is also incorporated through inclusion of the time-varying set of parameters, β_t..

Adaptation strategies

It is assumed that economic agents, including smallholder subsistence farmers, use adaptation methods only when the perceived utility or net benefit from using such a method is significantly greater than is the case without it. Although utility is not directly observed, the actions of economic agents are observed through the choices they make.

The probability that a household will use method *j* among the set of climate change adaptation options could then be defined as:

$$P(Y=1|X) = P(Uij > U_{ik}) \quad \text{---}3.2$$

Where P is a probability function, Uij, Uik,, and Xi are as defined above, $\varepsilon^* = \varepsilon j - \varepsilon k$ is a random Disturbance term $\beta^*_{j} = (\beta'_j - \beta'_k)$ is a vector of unknown parameters that can be interpreted as a net influence of the vector of independent variables influencing adaptation, and F ($B^* x_i$) is a cumulative distribution function of ε^* evaluated at $B^* x_i$. The exact distribution of F depends on the distribution of the random disturbance term, ε^*. Depending on the assumed distribution that the random disturbance term follows, several qualitative choice models can be estimated (Green 2000).

3.5.2 Empirical Model

3.5.2.1 Vulnerability to climate change

There are various approaches to measure vulnerability depending on the purpose, field and threshold used for assessment of vulnerability. The most common methods employed in vulnerability assessment are the *Econometric Method* and the *Indicator Method*. Based on the following comparison made between the method one methods is selected and used for this particular vulnerability study analysis.

Vulnerability is measured using the indicator method based on selecting some indicators from the alternative indicators. The indicator approach is valuable for monitoring trends and exploring conceptual frameworks, but indices are limited in their application by considerable subjectivity in the selection of variables and their relative weights, by the availability of data at various scales, and by the difficulty of testing or validating the different metrics. Perhaps most importantly, the indicator approach often leads to a lack of correspondence between the conceptual definition of vulnerability and the metrics.

The econometric approaches are consistent with the definition of vulnerability and estimate vulnerability from household level data without such strong assumption. Specifically, VEP approach produces a number analogous to a measure of the incidence or severity of poverty, since it gives an *ex ante* probability of becoming poor. Moreover, the approach can be implemented using a single round of cross section data which is not possible in other econometric methods. Therefore, this particular study used VEP framework among the econometric approaches discussed in chapter two.

The probability of a household to fall below a given consumption level due to climate change is measured by adopting vulnerability as expected poverty approach (VEP). This will help us to know the proportion of farmers that are vulnerable to climate change and hence attribute vulnerability to different factors including adaptation decision to set up policy options to reduce vulnerability.

The probability that a household will find itself poor depends not only on its expected (mean) consumption but also on the volatility (i.e. variance, from an inter-temporal perspective) of its consumption stream (Jamal, 2009). Therefore, household expected consumption and the variance of its consumption are required to quantify the level of households' vulnerability to climate change.

By assuming that consumption is log normally distributed (i.e. lnC_h is normally distributed), that enable estimation of the probability that a household with the characteristics $x_h$will be poor, i.e. household's vulnerability level. Letting $\emptyset(\cdot)$denote the cumulative density of the standard normal, the estimated probability will be given by:

$$V_h = pr(lnC_h < lnZ/x_h) = \emptyset\left(\frac{lnZ - x_{h\beta}}{\sqrt{x_h\theta}}\right) \text{-- } 3.3$$

Where **lnZ** is the log of the minimum consumption (income level) beyond which a household would be vulnerable. The above analysis is based on the assumption experiencing different climatic conditions and shocks such us drought, floods and hailstorm will increase the probability of farmers falling below a given consumption or income level or force them to stay under, if they are already under the poverty line.

From (3.3) we can get the level of vulnerability of the household to poverty, and hence we can classify households according to their level of vulnerability. So, while vulnerability is a risk and comes in degrees (between zero and one), being *vulnerable* is a state (either zero or one). Using the argument forwarded by Pritchett et al. (2000) this study will take the threshold probability level that defines a vulnerable household to be 0.5. This has two attractive features. First, 50-50 odds is a nice focal point and it makes intuitive sense to say a household is vulnerable if it faces more than 0.5 probability to be poor. Second, if a household is just at the poverty line and faces a mean zero shock then this household has a one period ahead vulnerability of 0.5. This implies that, in the limit, as the time horizon *n* goes to zero, then being in current poverty and being currently vulnerable coincide.

In this study, national poverty line of ETB 3781 per year per adult equivalent is used. Use of national poverty line is important because it reflects local conditions and serves as a basis of development planning and policy making. More over this national poverty was recently established poverty line by MOFED in 2010/2011 that reflects the current market price of goods and services.

3.5.3 Adaptation options

The multinomial logit (MNL) model is used for this analysis. This method can be used to analyze crop (Kurukulasuriya and Mendelsohn 2006) and livestock (Mendelsohn 2006) choices as methods to adapt to the negative impacts of climate change. The advantage of the MNL is that it permits the analysis of decisions across more than two categories, allowing the determination of choice probabilities for different categories (Madalla 1983; Wooldridge 2002). Moreover, Koch (2007) emphasizes the usefulness of this model by describing the ease of interpreting estimates from this model. To describe the MNL model, let y denote a random variable taking on the values {1, 2...J} for J , a positive integer, and let **x** denote a set of conditioning variables. In this case, y denotes adaptation options or categories and **x** contains household attributes like age, education, income levels, and so forth. The question is how cetirus paribus changes in the elements of **x** affect the response probabilities P(y = j / x), j =1, 2 ...mJ. Since the probabilities must sum to unity, P(y = j / x) is determined once we know the probabilities for j = 2,...J .
Let **x** be a 1× K vector with first element unity. The MNL model has response probabilities:

$$p(y = j/x) = \exp(x\beta_j) \,/\, [1 + \Sigma_{h=1}^{J} \exp(x\beta_h),\ j = 1 \ldots\ldots\ldots\ldots J] \text{------------------------} 3.4$$

Where B_j is K × 1, j=1.........J

The following possible adaptation strategies are going to be identified through survey:

1. Irrigation
2. Changing Planting date and plough system
3. Traditional and improved crop varieties
4. Innovative adaptation
5. Temporary migration

Unbiased and consistent parameter estimates of the MNL model in equation (3.2) require the assumption of independence of irrelevant alternatives (IIA) to hold. More specifically, the IIA assumption requires that the probability of using a certain adaptation method by a given household needs to be independent from the probability of choosing another adaptation method (that is, *Pj/Pk* is independent of the remaining probabilities). The premise of the IIA assumption is the independent and homoscedastic disturbance terms of the basic model in equation (3.2).

The parameter estimates of the MNL model provide only the direction of the effect of the independent variables on the dependent (response) variable, but estimates do not represent either the actual magnitude of change nor probabilities. Partial equation (3.2) with respect to the explanatory variables provides marginal effects of the explanatory variables given as:

$$\frac{\partial p_j}{\partial x_k} = p_j\left[\beta_{jk} - \sum_{h=1}^{J...1} p_j\beta_{jk}\right] \text{--3.5}$$

The marginal effects or marginal probabilities are functions of the probability itself and measure the expected change in probability of a particular choice being made with respect to a unit change in an independent variable from the mean (Green 2000).

3.5.4 Description of the Dependent and Independent variable

Description of the dependent variable

Vulnerability of household (Vh) - is the exposure of household to climate change, which is estimated according to equation 3.3. It is clear that climate change will, in many parts of the world, adversely affect socio-economic sectors. Factors of the vulnerability of household to climate change going to be seen in this study include age of household head, education of head, family size, gender of head, land size, other asset value, access to credit and etc.

Adaptation options(Y) - Is the household choice of the adaptation options, which is estimated according to equation 3.5. The adaptation methods most commonly cited in literature include the use of new crop varieties and livestock species that are more suited to drier conditions, irrigation, crop diversification, mixed crop livestock farming systems, change of planting dates, diversification from farm to nonfarm activities, increased use of water and soil conservation techniques, changed use of capital and labor, and trees planted for shade and shelter

(Kurukulasuriya and Mendelsohn 2006a; Maddison 2006; Nhemachena and Hassan2007). The adaptation methods used for this study include; irrigation, changing planting date and plough system, use of traditional and improved crop varieties, and innovative adaptation options.

Description of the Independent variable

- **Household size**- is the number of family members. Here it is expected that households with large families are more likely to adapt to climate change.
- **Gender of head** – is the sex of the households head male or female. Dummy, 1 if male 0 if female.
- **Educational of head** – years of schooling completed by head.
- **Land size** - is the size of the family farm land in hectare.
- **Access to market**: is the distance from the market where agriculture input is bought and output is sold.
- **Distance from all whether road**: is the distance of household home from roads serve in all seasons
- **Nonfarm income** - is the household income from nonfarm activity.
- **Age of household head** – Age of household in years (proxy for experience). Age of the head of household can be used to capture farming experience.
- **Access to credit** - Dummy, 1 if yes 0 otherwise. Access to credit is access to any institutional credit or individual credit. Availability of credit eases the cash constraints and allows farmers to buy purchased inputs such as fertilizer, improved crop varieties, and irrigation facilities.

CHAPTER FOUR

4. RESULTS AND DISCUSSIONS

4.1 Descriptive statistics

4.1.1 Socio-economic characteristics of household

Sex of the household head

The sex characteristic of the household head is one of the important variables that considered in this study as the determinant of the household vulnerability to climate change and adaptation to climate change.

Table 4.1 Sex of the household head

Sex of the household head						
	Highland		Mid –land		Low-land	
Sex	Number	Percentage	Number	Percentage	Number	Percentage (%)
Male	52	83.9	73	94.8	90	89.1
Female	10	16.1	4	5.2	11	10.9
Total	62	100	77	100	101	100

Source: Survey 2013

As shown in the table above male headed of the sample household in the three different agro-ecological settings, counted for 83.9 percent, 94.8 percent, and 89.1 percent in the highland, midland and lowland respectively. The remaining of the sample household is headed by female that is 16.1 percent, 5.2 percent, and 10.9 percent in the highland, midland and lowland respectively. When comparison is made in the three agro-ecology female headed is more in the highland than in midland and lowland.

Age of household head

The table below shows the age characteristics of the household head. Average age of household head is 50 years.

Table 4.2 Age of the household head

Age of household head						
	High land		Mid-land		Low -land	
Age	Number	Percentage	Number	Percentage	Number	Percentage
Less than or equal 40	19	30.6	28	36.4	30	29.7
41 to 60	28	45.2	26	33.7	47	46.5
Greater than 60	15	24.2	23	29.9	24	23.8
Total	62	100	77	100	101	100

Source: Survey 2013

As stated in the above table, relatively highest number of the household is in the age group of between the ages 41 to 60 which counts for 45.2 percent, 33.7 percent and 46.5 percent in the highland, mid-land and low-land agro-ecology respectively. The next large size of the sample household based on the age classification is found in age less than or equal to 40 which is 30.6 percent, 36.4 percent and 29.7 percent of the sample household in highland, midland and lowland respectively. Household headed by the young is relatively higher in the midland than lowland and highland as the figure shows. The rest is in age group of greater than 60 which is 24.2 percent, 29.9 percent and 23.8 percent in the highland, midland and lowland respectively. This can show us the life expectancy of the midland and highland is better than in lowland because household head in age group of greater than 60 is less in lowland relative to the former agro-ecology. Moreover for the whole sample household when this age group is compared with the other age group it is low. This can be related to the life expectancy of our country because only a less number of the household heads are in old age.

Education level of the head

Educational level of the household head is another important characteristics considered in this study. The below table present the education level of the household head.

Table 4.3 Education level of the head

Education level of the head						
	High-land		Mid-land		Low-land	
Level of education	Number	Percentage	Number	Percentage	Number	Percentage
Illiterate	31	50	51	66.2	70	69.3
Only read and write	2	3.2	4	5.2	3	3
Grade 1-4	19	30.7	10	13	17	16.8
Grade 5-8	8	12.9	12	15.6	11	10.9
Grade 9-12	2	3.2	0	0	0	0
>12	0	0	0	0	0	0
Total	62	100	77	100	101	100

Source: Survey 2013

As presented in the above table most of the sample households head are illiterate which count for 50 percent, 66.2 percent and 69.3 percent in highland, midland and lowland respectively. When compared among agro-ecology illiterate is high in lowland than midland and highland. No household head of the sample household who completed greater than grade 12 education levels in all agro-ecology. Only read and write is also counted for 3.2 percent, 5.2 percent and 3 percent in highland, midland and lowland respectively. Household head years of school completed between grades 1 to 4 is 30.7 percent, 13 percent and 16.8 percent in highland, midland and lowland respectively. Years of school completed between grade 5 to 8 count for 12.9 percent, 15.6 percent and 10.9 percent in highland, midland and lowland respectively. Only in highland 3.2 percent of the sample households are in years of school completed between grades 9 to12. In general lowland is lower in all level of years of school completed relative to highland and midland. Average years of schooling completed by households head are 1.4 years. In general the survey results show that most of the study area household heads are illiterate which has economic and social impacts.

Family size

The table below presents the family size of the household under study that classified according to the following.

Table 4.4 Family size of the sample household

Household grouped based on family size						
	High-land		Mid-land		Low-land	
Family size	Number	Percentage	Number	Percentage	Number	Percentage
Less than or equal to 4	14	22.6	19	24.7	23	22.8
5 to 8	45	72.6	51	66.2	65	64.3
Greater than 8	3	4.8	7	9.1	13	12.9
Total	62	100	77	100	101	100

Source: Survey 2013

As the above table shows most of the sample households have a family between 5 to 8 and which count for 67.08 percent of the total household. From the sample household the least in number is household who has family size greater 8 which count for 9.59 percent of the total sample household. Households, those who have family members of less than or equal to four is 22.6 percent, 24.7 percent and 22.8 percent in highland, midland and lowland respectively. Households, who have family members between 5 to 8 counts for 72.6 percent, 66.2 percent and 64.3 percent in highland, midland and lowland respectively. When compared households who have family members of 5 to 8 is high in highland than midland and lowland. Sample households, who have family members of greater than 8 is 4.8 percent, 9.1 percent and 12.9 percent in highland, midland and lowland respectively. Relatively households with large family size are in lowland than highland and midland.

The average family size in the whole sample is 6 persons per household which is comparable with regional level figure of 5 persons per household.

Income of the household

The rural household can raise income from various sources that can be classified as farm income, and non farm income.

Table 4.5 Annual farm income of the household

Household grouped based on their annual farm income level						
	High land		Mid- land		Low-land	
Farm Income (in Birr)	Number	Percentage	Number	percentage	Number	Percentage
Less than or equal to 10,000	1	1.6	2	2.6	4	3.9
10,001 to 20,000	29	46.8	35	45.4	63	62.5
20,001 to 30,000	24	38.7	32	41.6	31	30.7
Greater than 30,000	8	12.9	8	10.4	3	2.9
Total	62	100	77	100	101	100

Source: Survey 2013

As shown in the above table only less number of households are in income group of less than or equal to 10,000. Comparatively it is high in lowland which counts for 3.9 percent and in highland and midland it is 1.6 percent, and 2.6 percent respectively. The highest number of the households is in income group of "between" 10,001 to 20,000, they count for 46.8 percent, 45.4 percent and 62.5 percent in highland, midland and lowland respectively. Comparatively households in income group of "between" 10,001 to 20,000 are high in lowland than highland and midland. This means low income earners are more of from lowland. Income group of 20,001 to 30,000 count for 38.7 percent, 41.6 percent and 30.7 percent in highland, midland and lowland respectively. Households in income group of greater 30,000 counts for 12.9 percent, 10.4 percent and 2.9 percent in highland, midland and lowland respectively. Households in income group of 20,001 to 30,000 and greater than 30,000 are lower in lowlands than highland and midland. Generally the figure implies that income of the most sample household is less than or equal to 20,000. More over the average annual farm income of the sample household is 20,005.55 and when it is comparable with the average family size of 6 we can understand that the per capita income of the household is very low.

In addition to farm income, non farm income is also another important income for rural livelihood. Nonfarm income is very important especially during the period of low crop harvest. From the sample household 38.33 percent of the household have one or more non farm income. The source of their income are remittances, sale of charcoal/firewood, income from rental of land, sale of hand craft, petty trade, and employment among others. Most nonfarm income earners derive their income from petty trade 21.25 percent, followed by sale of charcoal/firewood 15.83 percent, employment 10.83 percent and land rental income 6.67 percent.

Wealth of the household

Most of the sample households are rearing animals like oxen, cows, sheep, goat, donkey, horse, poultry etc. average livestock holding per head is 8.97 TLU. Ox and cows are the most important livestock held by many for plough, milk and milk products. Most households also keep sheep, goat and poultry as other source of income especially during crop failure. The survey also included enumeration of the estimated value (in ETB) of other asset possessed by households other than land and livestock. The estimated value of other assets owned by households in the sample is ETB 15,163.31 per household. The other asset that household possess and is perhaps most important in the area is cultivable land on which they cultivate crops. Per capita land holding in the sample is 3 hectare per household. There is considerable variation in land size among households ranging from 0 to 8 hectares per household. There are also households that have access to irrigable land. About 12.08 percent of the households have access to irrigation water which lies along the small local river/spring. In the survey area crop production is conducted only during the main rainy season that runs from April /May to September/October. All the sampled population produces once in a year, except for those who have access to irrigation.

Credit facility

Credit facility provided to the rural household is another important aspect in rural livelihood improvement. Access to credit helps the rural household to use income got from credit so as to produce another income by increasing their productivity. According to the survey during the

2011 production season 39.16 percent of the sample farmers have access to credit facility. The main source of credit for the household is relative, friend, microfinance, and credit association.

Access to service

There is a difference in getting access to different facilities between the sample study. Access to infrastructure is one of the problems in the study area. Even there is a difference between sample households to have access to different facilities because sample is taken from three different woredas. At least all household have to travel 5 km (single travel) to get modern transport service, to get services of secondary schooling, banking, hospital, daily input and output market. There is a household that have to travel 15km to 30km to get some of the above mentioned services. Access to extension service is one of the most important services to the farmers at the current time. Extension services are one of the most easily available technical supports to farmers these days in Ethiopian context. All villages have access to extension services provided by nearest Development Agent (DA) Office. Farmers travel at most one kilometer to get extension services. Variation in use of extension service is, however, observed across households. For a comprehensive review, a summary of the major variables is provided in table 1 below.

Table 4.6 descriptive statistics for dependent and independent variables

Variable	Mean	Standard .Dev	Description
Vulnerability	0.62	0.48	Estimated according to equation 3.3 (dependent)
Sex of household head	-	-	Dummy, 1 if male 0 if female
Age of head	50.21	13.82	Age in years (proxy for experience)
Education of head	1.42	2.33	Years of schooling completed by head
Family size	5.95	1.87	Number of household members
Land size	3.03	1.71	Size of arable land owned in hectare
Farm income	19993.47	6733.64	Annual production in ETB
Nonfarm income	0.38	0.48	Annual non farm income
Live stock	8.96	7.39	Livestock owned by the household in TLU
Other asset value	15163.31	13837.85	Estimated value of asset in Birr
Access to credit	0.39	0.48	Amount of outstanding loan in study year
Adaptation	-	-	Dummy, 1 if the household adapted, 0 otherwise
Irrigation land	-	-	Dummy, 1 if the household has irrigation land, 0 otherwise
Access to market	-	-	Dummy,0 if distance from market is 0 to 5km, 1 otherwise
Idir	-	-	Dummy, 1 if the household is member of Idir, 0 otherwise
Ikub	-	-	Dummy, 1 if the household is member of Ikub, 0 otherwise
Mahiber	-	-	Dummy, 1 if the household is member of mahiber, 0 otherwise
Extension contact	1.75	1.83	Number of extension contacts during the last 12 months.
Fertilizer input	139	116.57	Quantity of fertilizer used in kilo gram in year 2010
Insecticide and pesticide	1.23	0.99	Quantity of insecticide and pesticide used by liter in year 2010
Access to all weather road	-	-	Dummy, 1 if household is found in less than three kilometer distance from all weather road, 0 otherwise
Rain fall change	39.78	12.61	Change of rainfall from long run average rainfall
Max temperature	-1.02	0.11	Change of max. temperature from max. long run average temperature

TLU is computed using the following conversion factors, cow and ox=1, heifer=0.75, calf=0.25, donkey=mule=0.70, horse=1, camel=1.2, goat and sheep=0.13, poultry=0.013 (Stork et al., 1992)

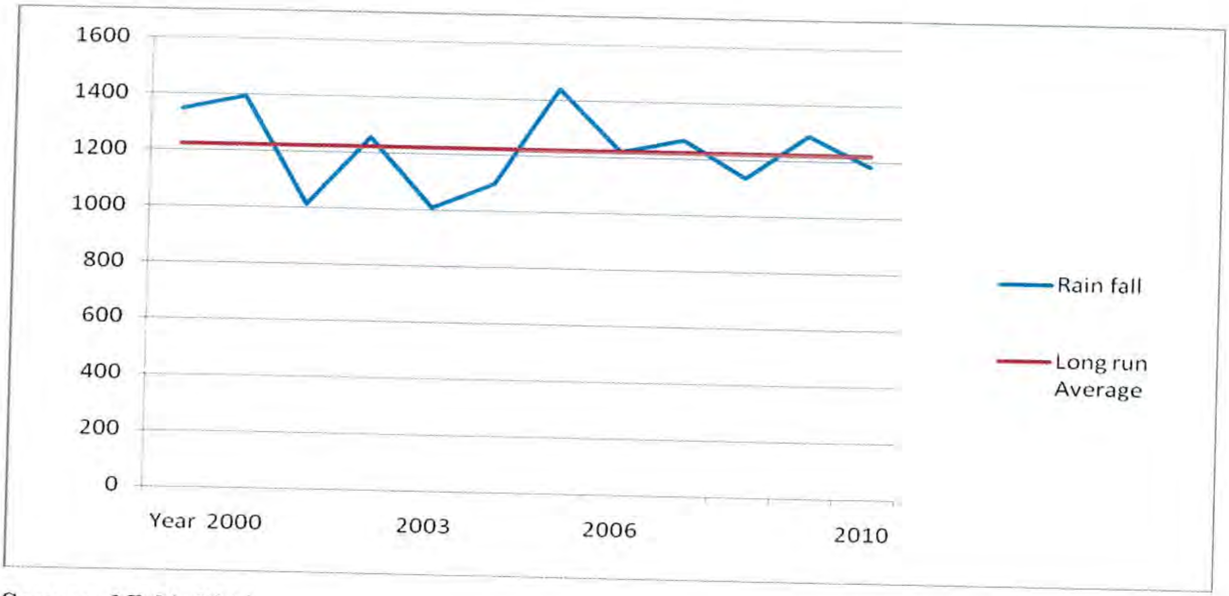
The survey also covers whether a household suffers non climatic shocks or not, so based on survey the most frequently reported shocks are input price rise beyond their expectation 39.17%, crop pest and disease 37.08%, and animal disease 23.75%. The survey result shows that these shocks have resulted in loss of household welfare. For instance, 52.08% of households reported that non climatic shocks has affected the household very negatively and 27.91% affected negatively while 20% of them are not affected by the shock at all.

4.1.2 Climate of the study Area

Rain fall

The study area is mostly midland which is accounted for 42.25% followed by 27.55% highland and the rest 30.2% is lowland. The rainfall pattern of the study area shows variability. Variance of Long run average annual rainfall is 19472.82, indicating high variability from year to year. Figure 4.1 shows deviation of mean annual rainfall from the long run average. The long run average rainfall computed for the period 2000 to 2011 is 1226.76mm. As it can be seen from figure 4.1 annual mean rainfall fluctuates around this value.

Figure 4.1 Mean Annual Rainfall Values for Selected Stations in Degem, Kuyu and Wara Jarso woreda.

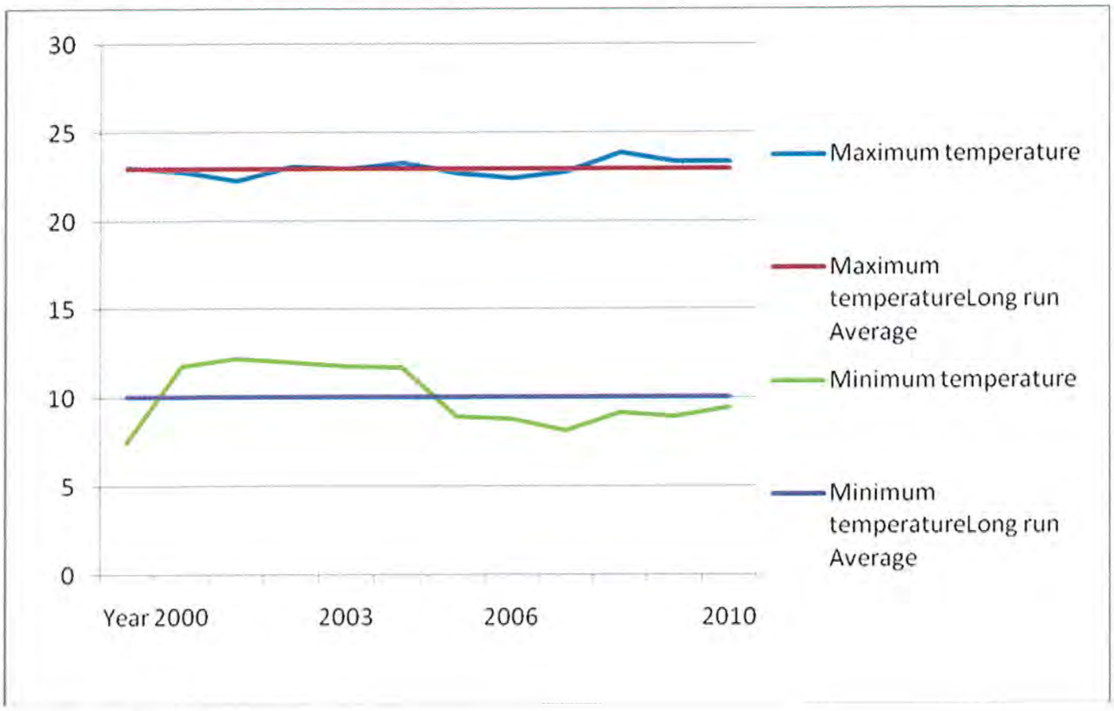


Source: NMA 2011

Temperature

In the study area long run average minimum and maximum temperature are 10.10 ^{O}C and 22.96 ^{O}C respectively. The variability of minimum and maximum temperature is 1.21^{o}c and 1.28^{o}C respectively. The difference of the study period maximum and minimum temperature from long run average is not such much, but there is fluctuations around long run average that affect crop production. See figure 4.2 below.

Figure 4.2 Mean Maximum and Minimum Temperature and Long Run Average



Source: NMA 2011

4.2 Vulnerability Analysis

Vulnerability of the household to climate change is measured based on vulnerability as expected poverty model. Consumption expenditure is used to estimate the level of vulnerability.

4.2.1 Consumption expenditure

The survey indicates that the average consumption expenditure of households is ETB 18,732.23 per year. This equals ETB 3636.032 per year per adult equivalent, which means ETB 9.96 per day per adult equivalent. Increased (higher) proportion of expenditure indicates rising living standard of households. When disaggregated for highland, midland and lowland agro ecologies, consumption expenditure of households in highland areas have higher average expenditure ETB 19126.53 relative to farmers in midland (ETB 18851.4) and lowland areas (ETB 18583.33). Consumption variance is also high in highland areas than the consumption variance in lowland and midland areas.

Table 4.7 Average Annual Household Consumption Expenditure (ETB) (2011 Price)

Agroecology	Average Consumption expenditure	Standard deviation of consumption
Highland(Degem)	19126.53	5722.6
Midland(Kuyu)	18,851.4	5593.32
Lowland(Wara Jarso)	18,583.33	5489.88
Total	18732.23	5568.56

Source: survey 2013

4.2.2 Incidence of vulnerability and poverty

The estimated vulnerability among the households shows 62.5 percent of them have 50 percent or more probability to become poor next year using ETB 3781 per year per adult equivalent as poverty line. On the other hand the incidence of poverty among the households is 59.17 percent using the same ETB 3781 as a benchmark. These show there are households that are regarded as being non poor but have high probability to become poor next year.

Vulnerability of farmers (as derived from variance of consumption) varies between highland, midland and lowland agroecologies. In highland the extent of vulnerability and poverty are 56.45 and 50 percent respectively, in midland the extent of vulnerability and poverty are equal 51.95 and 50.65 percent respectively, whereas in lowland areas these vulnerability and poverty are 74.25 and 69.3 percent respectively. Table 5 provides estimates of vulnerability and consumption poverty for households.

The vulnerability rate of 62.5 percent is more than the estimated head count poverty level of 59.17 percent. This indicates that the estimated probability of experiencing poverty in the near future is more than the observed incidence of poverty in the sample. Thus the observed incidence of poverty underestimates the fraction of population that is vulnerable to poverty. The level of underestimation is revealed by the vulnerability to poverty ratio which is 1.04 (more than 1) for the total sample. High land, midland and lowland area ratios are 1.02, 1.05 and 1.06 respectively.

Table 4.8 Estimates of Vulnerability to Poverty

	Estimate of vulnerability to poverty (households with vulnerability >0.5)		
Agroecology	Percentage of population		Vulnerability to poverty ratio
	Vulnerable	Poor	
High land(Degem)	56.45	50	1.13
Midland(Kuyu)	51.95	50.65	1.02
Lowland(Wara Jarso)	74.25	69.3	1.07

Source: survey 2013

As the above table indicates households reside in the lowland is more vulnerable to poverty than households reside in midland and highland areas.

Table 4.9 Cross-Distribution of Vulnerability and Poverty

Cross-distribution of Vulnerability and Poverty			
Poverty status	Vulnerability status in percentage		Total
	Vulnerable	Non- vulnerable	
Poor	88.73	11.27	59.17
Non-poor	21.43	78.57	40.83
Total	62.5	37.5	100

Source: Survey 2013

According to Chauduri et al. (2002) the sources of vulnerability of households are low mean consumption and high consumption volatility. To identify source of vulnerability of households, we classified the households in to three groups. The first group is those households that have vulnerability estimate below 0.50 and consumption above the poverty line. These are households that are non-vulnerable and non-poor. The second group is households that are non-poor but vulnerable. These households are vulnerable because of high consumption volatility; were we able to eliminate the variability in their consumptions, these households would be no longer vulnerable. The third group is households that are vulnerable as well as poor. These are households that are vulnerable due to low consumption prospect. These households have vulnerability level above 0.5, and their vulnerability stems primarily from their low levels of mean consumption, in that reduction in consumption volatility would still leave them vulnerable. The study result indicates that the first group those households that have vulnerability estimate below 0.50 and consumption above the poverty line is 78.57 percent of the total non poor household, where as non poor but vulnerable is accounted for 21.43 percent of the total non poor household. The third group is those household vulnerable as well as poor is 88.73 percent of the total poor household.

peak times. Here it is expected that households with large families are more likely to adapt to climate change.

The study result shows that size of household increases the probability of some adaptation and decreases the probability of other adaption method. Family size significantly increases use of innovative adaptation, where as it insignificantly increases changing planting date and plough system. A unit increase in number of family size would result in a less than one percent increase in the probability of use of innovative adaptation that is statistically significant at 5 percent and a 1.5 percent increase in changing planting date and plough system, though it is not statistically significant. On the other hand family size decreases the probability of adapting to climate change through irrigation and use of traditional and improved crop variety by 2 percent and 0.6 percent respectively. Irrigation is statistically significant at 10 percent and use of traditional and improved crop variety is statistically not significant.

Education of head: Education of the head of household increases the probability of adapting to climate change. As can be observed in Table 4.13, education significantly increases irrigation, changing planting date and plough system, use of improved crop variety, use of traditional crop variety and innovative adaptation option as an adaptation method. A unit increase in number of years of schooling would result in a 1.3 percent increase in the probability of irrigation, a 1.8 percent increase in use of traditional and improved crop variety; both are statistically significant at 5 percent. On the other hand a unit increase in number of years of schooling would insignificantly decrease use of innovative adaptation and insignificantly increase changing planting date and plough system.

Wealth

Farm income: A one birr increase in farm income would result in increase in innovative adaptation by less than one percent and statistically significant at 5 percent. The farm income of the households surveyed has a positive, but insignificant impact on irrigation and use of traditional and improved crop variety. It has a negative and insignificant impact on changing planting date and plough system.

Nonfarm income: In addition to farm income, nonfarm income increases the household use of innovative adaptation and change in planting date and plough system, though it is statistically not significant. Nonfarm income showed a negative relationship with the adoption of improved crop variety and irrigation, although these results are statistically not significant. The reason for the negative relationship is that if farming is less productive, the household attention can be on increasing the non farm income than effected by farming activity.

Land size: The land size of the household is positively related to all adaptation option except to change of planting date and plough system. A unit increase in a hectare of land size would result in a 1 percent, 2 percent and 0.6 percent increase in the probability of irrigation, use of traditional and improved crop variety and innovative adaptation respectively, even though they are statistically not significant. On the other hand it negatively related to change of planting date and plough system, but statistically not significant. Sometimes it is very difficult to households to manage their large land size especially to change the planting date and plough system than households that have small land size.

Livestock holding: Livestock plays a very important role by serving as a store of value and by providing traction (especially oxen) and manure required for soil fertility maintenance (Yirga 2007). According to this study livestock size are positively related to change of planting date and plough system and innovative adaptation and statistically significant at 10 percent and 5 percent respectively. It is also positively related to traditional and improved crop variety, but statistically not significant. On the other hand livestock holding negatively related to irrigation, though statistically not significant. Most of the time to change planting date, plough system and other innovative adaptation method size of the livestock plays crucial role, that is especially oxen are used to complete farm with a short time during rainfall becomes very late, to change plough system oxen are used and similar reason can be rise for innovative adaptation.

Other asset value: The asset value of the household is also negatively related to the irrigation, change planting date and plough system and traditional and improved crop variety, even though the marginal impacts are not significant. Innovative adaptation options, even though the marginal impacts are not significant. However it has positive and insignificant influence on innovative adaptation.

Access to service

Access to credit: Availability of credit eases the cash constraints and allows farmers to buy purchased inputs such as fertilizer, improved crop varieties, and irrigation facilities. Research on adaption of agricultural technologies indicates that there is a positive relationship between the level of adoption and the availability of credit (Yirga 2007; Pattanayak et al. 2003). However the study result indicates that access to credit both increases and decreases household adaptation options. Households that have access to credit are more likely to use irrigation, change planting date and plough system and use of traditional and improved crop variety. Access to credit increases this adaptation because they can use fund they get to acquire material that assists them in irrigation and different traditional and improved crop. However it is statistically significant on irrigation and traditional and improved crop variety. On the other hand it negatively related to use of innovative adaptation.

Extension Service: Access to extension service is the most important role to adapt climate change. Extension on crop and livestock production and information on climate represent access to the information required to make the decision to adapt to climate change. Various studies in developing countries, including Ethiopia, report a strong positive relationship between access to information and the adoption behavior of farmers (Yirga 2007), and that access to information through extension increases the likelihood of adapting to climate change (Maddison 2006; Nhemachena and Hassan 2007). Thus this study result also indicates an increase in extension contact by one increases innovative adaptation option by 0.06 percent, traditional and improved crop variety by 1.15 percent, change of planting and plough system by 2.5 percent and irrigation by 0.22 percent. However, only traditional and improved crop variety is statistically significant at 10 percent.

Social institutions

Social institutions such as *Idir*, *Ikub*, and Mahiber are important factor that affect household adaptation method. Strong social capital guarantees better access to capital and information. Theoretically we expect households that have strong social capital are more likely to use adaptation method. However the study result indicates that social capital positively related to some adaptation method and negatively related to the other adaptation method. Household who is a member of Idir and ikub is more likely to use change of planting date and plough system, improved crop variety, traditional crop variety and innovative adaptation option as an adaptation method than household who is not a member of idir and ikub. Mahiber and ikub are positively related to all adaptation method except innovative adaptation. However, only use of traditional and improved crop variety is statistically significant at 10 and 5 percent respectively. Idir is negatively related to all adaptation method except change planting date and plough system. However all are statistically not significantly.

Environmental factors

Rainfall: The study result shows that one millimeter decrease in season rainfall below long run average increases household adaptation through irrigation, traditional and improved crop variety and innovative adaptation. One millimeter decrease in season rainfall below long run average increase household adaptation using irrigation by 0.21 percent, change planting and plough system by 0.39 percent, use of traditional and improved crop variety by 0.02 and innovative adaptation by 0.22 percent. However only adaption through irrigation, and change planting and plough system is statistically significant at 5 percent.

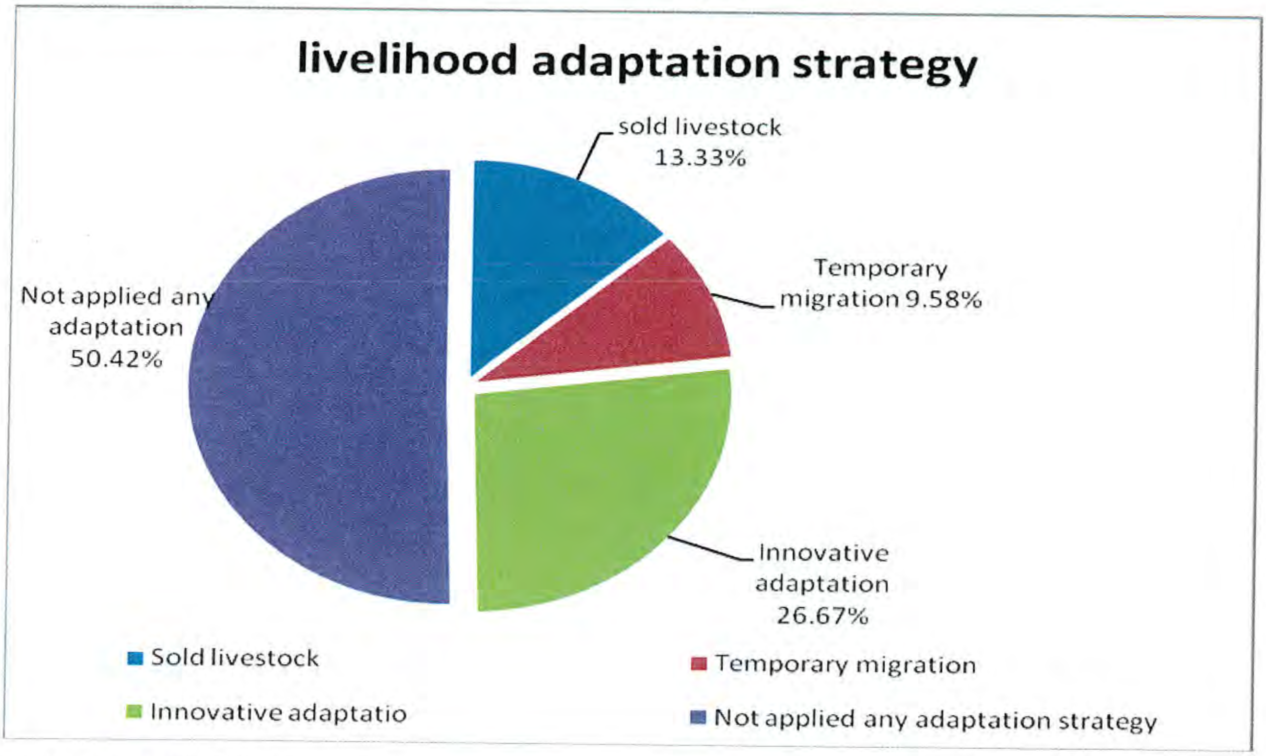
Temperature: Households are observed with maximum temperature, over the survey period were more likely to adapt to climate change. The study result indicates 1^{0}C increase in season temperature above long run average increases the probability of using innovative adaptation option and traditional and improved crop variety, even though they are statistically not significant. On the other hand 1^{0}C increase in season temperature above long run average decreases the probability of using irrigation and statistically significant at 1 percent. In addition

$1^{0}C$ increase in season temperature above long run average decreases the probability of using change in planting date and plough system, but statistically not significant.

4.4.3 Livestock adaptation strategies

Livestock rearing is adapted to climate change through temporary migration, sold livestock, and innovative adaptation options as depicted in figure below.

Figure 4.4 Livestock adaptation Strategies of the sample household



Source: survey 2013

Livelihood adaptation to climate change could be practiced by farmers through selling livestock, temporary migration and innovative adaptation. Livelihood adaptation option mostly used in the study area is innovative adaptation which is 26.67 percent of the sample households, where as 13.33 percent and 9.58 percent of the sample household could sold livestock and temporary migrate respectively. The mostly practiced livelihood innovative adaptation option is feeding livestock grass used to make shelter for livestock or household, brought water and grass for their livestock from other locality(i.e distant area, specially from all season river area), or sometimes took their livestock to the area where water is available which is very far from their locality, eating meat of their livestock if there is a high probability of livestock death due to harsh climate and feeding their livestock in home during the extreme of sunny and hot season. Moreover the rest 50.42 percent of the surveyed household reported not to have taken any adaptation method for a number of reasons such as lack of awareness, lack of an access for temporary migration, lack of capital and lack of confidence to live without a livestock. This tells us that most of the household are lost their livestock due to climate change.

Table 4.14 Comparison of livestock adaptation method based on agro-ecological settings

Livestock adaptation among agro-ecological settings						
Agro-ecology	Sold live stock		Temporary migration		Innovative adaptation	
	No.	%age	No.	%age	No.	%age
Highland	7	11.29	4	6.45	11	17.74
Midland	10	12.98	7	9	19	24.67
Lowland	15	14.85	12	11.88	34	33.66

Source: survey 2013

As stated in the above table the livestock adaptation option is classified based on the agro-ecological setting and in all zones the three adaptation method is used. From the sample household of highland, midland and lowland, 11.29 percent, 12.98 and 14.85 percent of them sold livestock to adapt to climate change. Even though the percentage of household sold livestock in all agro-ecology is related, in low land it is higher than other areas.

From the sample household of highland, midland and lowland, 6.45 percent, 9 percent and 11.88 percent of them temporary migrate to adapt their livestock to climate change. This data shows that the option is more of used by lowland household and followed by midland and highland respectively.

When we see the innovative adaptation method among the different agro-ecology from the sample household of each agro-ecology 17.74 percent, 24.67 percent and 33.66 percent of them use this adaptation in highland, midland and lowland respectively. This indicates the method is highly used in lowland than other agro-ecology and followed by midland.

4.4.4 Factors determining farmers' choice of livestock adaptation

Table 4.15 Marginal effects from the multinomial logit climate change adaptation model

Explanatory variable	Sold livestock		Temporary migration		Innovative adaptation option	
	Coefficient	p value	Coefficient	p value	Coefficient	p value
Age of head	.0032317	0.155	.0009093	0.625	.005821	0.073
Sex of head	.0453977	0.491	.0316074	0.386	-.0884523	0.435
Education of head	.0204694	0.045	.0094714	0.186	.0298271	0.060
Family size	.036257	0.491	.036257	0.005	-.0317006	0.208
Farm income	1.88e-06	0.733	4.20e-07	0.923	4.80e-06	0.525
Nonfarm income	.0687881	0.203	.0131316	0.704	-.0216696	0.754
Asset value	-1.73e-06	0.363	-8.74e-08	0.949	-2.50e-06	0.315
Livestock size	-.0024653	0.482	.0027637	0.166	-.0021252	0.650
Land size	.0093152	0.619	-.0299888	0.035	.0309526	0.250
Ikub	-.0503529	0.333	.0583227	0.368	-.0945727	0.225
Rainfall change	-.0017197	0.049	-.0013538	0.414	-.0077155	0.016
Maximum temperature	.1724149	0.446	.077128	0.662	.4312789	0.205
Idir	-.0353424	0.485	.0011134	0.973	-.0096921	0.892
Mahiber	.0866958	0.060	-.0208659	0.500	.1114854	0.076
Access to credit	.0246289	0.606	-.008178	0.796	.0125533	0.849
Extension contact	.0161622	0.223	.0083963	0.370	..0140178	0.461
Access to market	-.042701	0.536	.0088721	0.882	-.109237	0.269
All weather road	.0366616	0.616	-.0064506	0.887	.1031396	0.306

Household Characteristics

Age of the household head: Age of the household head, which represents experience, affected adaptation to climate change. The result shows that age of household positively related to sales of livestock and innovative adaptation method, where as it negatively related to temporary migration. A unit age increases in age of the household head results in increase in the probability of innovative adaptation method by 0.58 percent which is statistically significant at 10 percent and increase sales of livestock by 0.32 percent, though it is statistically not significant. On the other hand unit age increases in age of the household head results decreases in household livestock adaptation to climate change through temporary migration by less than 1 percent and statistically not significant.

Sex of the head of household: The study result indicates that male headed household is more adapt to climate change than female headed household. Male-headed households are 4.5 percent more likely to adapt through sale of livestock, 3.16 percent more likely to temporary migrate and 8.8 percent less likely to use innovative adaptation method than female headed household. However all are statistically not significant.

Family size: Size of household increases the probability of adapting to climate change through the temporary migration and innovative adaptation option. One increase in size of household increases the probability of temporary migration'and sale of livestock by 3.62 percent each, but only temporary migration is statistically 1 percent. Family size negatively related to innovative adaptation by 3.17 percent, though it is statistically not significant.

Education of head: Education of the head of household increases the probability of adapting to climate change. A unit increase in number of years household head schooling increases sales of livestock by 2 percent, temporary migration by 0.9 percent and innovative adaptation by 2.98 percent. Statically it is significant at 5 percent for sales of livestock and at 10 percent for innovative adaptation. Temporary migration is statistically not significant.

Wealth

Farm income: The farm income of the households surveyed has a positive effect on household adaptation through all adaptation method, though it is statistically not significant.

Nonfarm income: Nonfarm income increases the household sales of livestock, though it is statistically not significant. A unit increase in nonfarm income increases the probability of adaptation through sales of livestock and temporary migration by 6.87 and 1.31 percent respectively. A unit increase in non farm income decreases the household livestock adaptation through innovative adaptation option by 2.16 percent. They are statistically not significant. This is due to the fact that if there is nonfarm income and the livestock is affected by climate change, the farmers may prefer to maximize their non farm income than spending their time and cost on adapting livestock to climate change.

Land size: The land size of the household is positively related to sales of livestock and innovative adaptation method. A unit increase in a hectare of land size would result in a 0.9 and 3.09 percent, increase in the probability of sales of livestock and innovative adaptation option respectively, even though it is not statistically significant. On the other hand unit increase in a hectare of land size would result in a 2.99 percent decrease in household temporary migration and statistically significant at 5 percent.

Other asset value: The asset value of the household is negatively related to the sales of livestock, temporary migration and innovative adaptation options, even though the marginal impacts are not significant. A unit increase in asset value decrease household sales of livestock and innovative adaptation by less than one percent.

Access to service

Access to credit: Availability of credit eases the cash constraints and allows farmers to buy purchased inputs such as fertilizer, improved crop varieties, and irrigation facilities. Research on adaption of agricultural technologies indicates that there is a positive relationship between the level of adoption and the availability of credit (Yirga 2007; Pattanayak et al. 2003). Household that have access to credit are more likely to adopt livestock through sale of livestock and innovative adaptation. On the other hand households that have access to credit are less likely to temporarily migrate, though statistically not significant.

Extension Service: Access to extension service is the most important role to adapt climate change. Extension on crop and livestock production and information on climate represent access to the information required to make the decision to adapt to climate change. Various studies in developing countries, including Ethiopia, report a strong positive relationship between access to information and the adoption behavior of farmers (Yirga 2007), and that access to information through extension increases the likelihood of adapting to climate change (Maddison 2006; Nhemachena and Hassan 2007). The study result indicates that an increase in extension contact by one increases adaptation through sales of livestock, temporary migration and innovative adaptation option by 1.61, 0.83 and 1.4 percent respectively. However it is statistically not significant.

Social institutions

Social institutions such as *Idir*, *Ikub*, and Mahiber are important factor that affect household adaptation method. Strong social capital guarantees better access to capital and information. Theoretically we expect households that have strong social capital are more likely to use adaptation method. However the study result indicates that social capital positively related to some adaptation method and negatively related to the other adaptation method. Household hold who is a member of Idir and ikub are less likely to sale livestock and use innovative adaptation option than household who is not a member of idir and ikub, though they are statistically not significant. On the other hand idir and ikub are positively related to temporary migration as an adaptation method, though it is statistically not significant. Mahiber is positively related to sales of livestock and innovative adaptation method and statistically significant at 10 percent. On the other hand Mahiber is negatively related to temporary migration as an adaptation method, though it significantly not significant.

Environmental factors

Rainfall: The study result shows that one millimeter decrease in season rainfall below long run average increases household adaptation using sale of livestock, temporary migration and innovative adaptation options. The result is statistically significant at 5 percent for sale of livestock and innovative adaptation options. One millimeter decrease in season rainfall below long run average increase household adaptation using sale of livestock by 0.17 percent, temporary migration 0.13 percent and innovative adaptation 0.77 percent. However it is not significantly influence temporary migration.

Temperature: Households are observed with maximum temperature, over the survey period were more likely to adapt to climate change. The study result indicates one millimeter increase in season temperature above long run average increases household adaptation using sale of livestock, temporary migration and innovative adaptation method. 1°C increase in maximum temperature increases household livestock adaptation using sale of livestock, temporary migration and innovative adaptation by 17.24, 7.71 and 43.12 percent respectively.

CHAPTER FIVE

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 CONCLUSIONS

Based on household survey data in Degem, Kuyu and Wara jarso, this study analyzed the probability of farmers falling below consumption poverty line due to climatic conditions and shocks namely mean seasonal rainfall and temperature. In this analysis household consumption expenditure that consists consumption expenditure is used as a proxy for welfare. Like poverty analysis vulnerability of households is attributed to both household and environmental characteristics. By assuming consumption is log normally distributed household probability to fall below poverty line of ETB 3781 is estimated by using the Vulnerability as Expected Poverty approach.

Regression results show that about 59.17 percent of the households are observed to be poor during the survey. Computed using 0.5 as a threshold above which a household is called vulnerable, about 62.5 percent of the households are also vulnerable to poverty during the coming year. An attempt to show the sources of vulnerability indicates that about 52.92 percent of the households are vulnerable to poverty due to low consumption mean and about 9.58 percent of them are vulnerable due to high consumption instability.

The study has also attempted to see the correlates of household vulnerability to poverty by assuming household vulnerability is linearly related with household, social and environmental characteristics. It was observed that household head age, gender of household head, education level, land size, livestock size, farm income, non-farm income, idir, ikub, irrigation size, use of fertilizer, and use of insecticide and pesticide reduce household vulnerability to climate change, whereas family size, marital status, mahiber, increase in temperature and decrease of rainfall tend to increase household vulnerability to climate change. Access to extension services, access to credit, access to market and access to all weather roads also reduces household vulnerability to poverty.

The most important lesson from this study is that increasing mean consumption (income) of households is not the only way to reduce vulnerability but reducing instability of consumption is also important.

More over the household adaptation method is included in this study. The households' adaptation method is seen from crop adaptation strategies and livestock adaptation strategies. Farmers adapted to climate change by using different methods, of which the major ones included in this study are; use of irrigation, change planting date and plough system, improved crop variety, traditional variety and innovative adaptation option as crop adaptation method, whereas sale of livestock, temporary migration and innovative adaptation method as livestock adaptation method. Household who did not use any of the adaptation method is due to lack of information on adaptation method and lack of capital as a main constraint to adaptation. The study uses the multinomial logit (MNL) model to investigate the factors guiding household choices of climate change adaptation methods. In the model, the dependent variables include four adaptation options as crop adaptation and three adaptation options as livestock adaptation and the explanatory variables include different household, institutional, and social factors. The MNL was run and tested for the assumption of the independence of irrelevant alternatives (IIA). The marginal effects from the MNL, which measure the expected change in probability of a particular choice being made with respect to a unit change in an independent variable, were presented for their ease of interpretation. The results from the marginal analysis indicate that most of the household variables, wealth attributes, institutional factors (availability of information), and social capital influences adaptation method of the study area.

5.2 RECOMMENDATIONS

Based on the study result the following recommendations are forwarded:

- The study results suggest that interventions that enable farmers to meet the daily minimum requirement are not enough by itself, unless there are interventions that reduce instability of consumption. This study proposes that expansion of irrigation use, non farm income opportunities, access to credit and extension services are possible intervention areas to reduce household vulnerability.

- The study results on the factors that influence households' adaptation to climate change in the study area suggest a number of different policy options. These options include raising awareness of climate change and the appropriate adaptation methods, facilitating the availability of credit, creating opportunities for off-farm employment, increasing availability of improved crop in the market, and livestock species that are better suited to drier conditions, encouraging informal social networks, and investing in irrigation.

- It is also suggested the policy options that encouraging farmers to use different innovative adaptation options which is suited to the actual condition of the environment is another mechanism in reducing household vulnerability to poverty.

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Table 4.10 Vulnerability Estimates for Selected Household Characteristics

Vulnerability Estimates For Selected Household Characteristics [percentage of vulnerable population]		
Over all vulnerable population		62.5
Family size	1-2	16.67
	3-4	20
	5-8	70.80
	More than 8	100
Age of household head	<=60	76.40
	More than 60	20.97
Education of household head	Illiterate	62.11
	1-4	69.56
	5-8	48.39
	9-12	33.33
Nonfarm income	Yes (1)	61.49
	No (0)	63.04
Land size(ha)	0-1	77.5
	1-3	71.26
	More than 3	49.56
Extension contacts	0-3	70.47
	3-6	27.66

Source: survey 2013

Vulnerability falls with increase in age of household head as shown in the table. Vulnerability is higher for household head age below or equal to 60. The vulnerability level of the household based on age of the head shows that about 76.40 percent of the household head with age less than or equal to 60, and about only 20.97 percent of household head with age greater than 60 are vulnerable to poverty. Moreover, in these two age limits the incidence of poverty is 69.10 and 27.42 percent respectively. Regarding education and vulnerability of household, as education of household head increases the level of vulnerability decreases. For household heads that are illiterate their vulnerability is about 62.11 percent, but for households with head's education years between of 9-12 the level of vulnerability decreases to 33.33 percent. These results suggest the importance of education in reducing household vulnerability.

In such community like the study area with high level of agricultural practices, ownership of land play an important role in determining the levels of poverty and vulnerability. Among the households per capita land holding is, in general, small even if some of them occupy big plots of land. The estimates show that land size owned distinguishes vulnerable and non vulnerable households. The degree of vulnerability rise as household land size decreases. This means households that have large land size are less vulnerable. As it is evident from table 4.10 only 49.56 percent of households that have more than 3 hectares of land are vulnerable, but for households that have less than 1 hectares of land the extent of vulnerability is more than 77.5 percent. Regarding family size Vulnerability rises with increase in family size. All sample household with greater than 8 family sizes is vulnerable to poverty and only less than 21.42 percent of household with less than or equal to 4 family sizes is vulnerable to poverty.

Table 4.10 also shows that number of extension contacts made by farmers is another variable that has implication for household vulnerability to poverty. According to this estimation vulnerability estimate of households that have less extension contact is more vulnerable to poverty than household that have more extension contacts.

4.3 Factors determining vulnerability

An econometric model is estimated to show the impact of various household and environmental factors on household vulnerability to poverty. Assuming linear relationship between household and environmental factors there are 22 variables that are included in the model. Model information shows the model is suitable for the problem at hand. Adjusted R squared is 0.99. Before inclusion of variables in to the econometric framework the variables are refined by

ANOVA to see difference in mean values of variables between vulnerable and non vulnerable households. Table 4.11 gives model information and the OLS estimates of coefficients of the model.

Household consumption is often modeled as a linear function of household characteristics. By assuming vulnerability is also linearly related with household and environmental characteristics the estimated vulnerability function is as presented below. Most of the variables are significant with expected signs. The result is discussed in some detail in table 4.11. To avoid the possible hetroskedasticity problem Feasible Generalized Least Square (FGLS) estimates are provided. The model is free of multicollinearity problem as mean VIF is 1.98.

Table 4.11 Correlates of Estimated Vulnerability Level of Households

Estimated vulnerability function-FGLS Estimates (Dependent variable vulnerability level of households: Equation 3.3)		
Variables	Coefficients	t-statistics
Intercept Constant	.4877316	500.50
Gender of household head	-.0029118	-14.37*
Age of household head	-.0005324	-84.33*
Education of household head	-.0017582	-59.41*
Family size	.0327161	674.73 *
Land size	-.0025715	-44.47**
Livestock size	-.0006701	-74.86*
Other asset value	-4.91e-07	-102.01**
Farm income	-1.86e-06	-197.03*
Nonfarm income	-.0069751	-74.64**
Access to credit	-.0148887	-118.82*
Irrigation size	-.0005974	-2.82**
Adaptation	-.0015337	-10.09*
Rainfall change	.0000768	10.91*
Maximum temperature	-.0120673	-18.89*
Idir	.0170262	123.54*
ikub	-.0104626	-62.16*
Mahiber	.0086197	71.39**
Extension service	-.0006311	-17.19*
Access to market	-.0043021	-18.29*
Fertilizer	-.0000301	-35.24*
Insecticide and pesticide	-.0015197	-15.85*
Access to all weather road	-.0255696	-117.87*

*, **, *** Indicates estimates are significant at 1, 5 and 10 percent respectively

Household characteristics

Gender of the head of household: The vulnerability of the household to poverty expected to be determined by the gender of the household head. The study result indicates that male headed household is less vulnerable to poverty than female headed household. Male-headed household is less vulnerable to poverty than female headed household by 0.2 percent and the result is significant at 1 percent. This is because of the fact that access to information by male is more than access to information by female.

Age of household head: The age structure of the household head is another area that should get due consideration since it has an important implication on economic productivity, experience and asset endowment. The mean age of household age is 46.4 for the vulnerable group and 56.46 for the non-vulnerable group and the difference is statistically significant. Probably as a farmer gets older, he/she can acquire farming experience through their life that could have a positive contribution in raising their living standards. Similar pattern emerges from this study; as head age increases by one year household vulnerability to poverty decreases by 0.05 percent approximately and is significant at 1 percent.

Household head Education: A number of studies have indicated that the household head is a highly influential decision maker in the Ethiopian family. This suggests that his/her education level does matter for the welfare of the family. The result of the study also indicates that the education level attained by the household head is low. Tangibly, average numbers of years of school attended by the vulnerable group household head is 0.57, whereas it is 2.35 for the non vulnerable. Household head education is thus a significant factor that explains difference in household vulnerability levels. The econometric result also indicates that household head education reduces household vulnerability to poverty. As head years of education increases by 1 year, household vulnerability to poverty decreases by 0.17 percent and is significant at 1 percent significant level.

Family size: There are two controversial views on the relationship between family size and the welfare of the household. The first argument states that households who have larger family size are supposed to be better off than those having smaller family size, since there are advantages in consumption economies of scale and availability of more working labor force to generate income (Adane and Bezabih, 2003). In contrast to this there is another convincing argument that as family size increases the probability that a household falls below poverty line due to having more people leading to disguised unemployment due to scarcity of capital and also due to increased dependency ratio. The finding of the study has supported the second idea in that as the family size increases vulnerability of households to poverty also increases. As family size increases by 1 on average household vulnerability to poverty increases by about 3.27 percent and the estimate is significant at 1 percent significance level.

Wealth of household

Livestock holding: According to Yirga (2007 cited in Deressa et al, 2008), livestock holding plays important role by serving as a store of value, and thus insurance against risks. It also true in this study that is livestock holding has a negative impact on the vulnerability of the household. The analysis indicates that as livestock holding increases by one unit, household vulnerability to poverty is decreased by 0.07 percent and the estimate is significant at 1 percent significance level.

Land size holding: Another important asset held by households is farm land on which they conduct their production. Households in rural areas heavily depend on land for their livelihood. It directly affects the poverty status of households since it indicates their income potential. The result of this study also confirms this by revealing that households that have larger land size are less vulnerable to poverty. As land size increases by one hectare vulnerability of households decreases by 0.26 percent and the estimate is significant at 1 percent significant level. More importantly, the possession of irrigable land by the household is also found to be negatively related with household vulnerability. According to the estimation household posses irrigable land is less vulnerable than household does not possess irrigable land by less than 1 percent and the result is significant at 5 percent significance level.

Other Assets holding: Households with tangible assets can use those assets to improve their welfare, both by using the asset to help the household work more efficiently and increase their income, or through the ability to sell off the assets when the household experiences a shock or there is a downturn in the economy (Ganesh, 2006). Moreover, the amount of assets owned by household reflects the income potential of the household. In this study also households that have large asset profile are assumed to be less vulnerable, because they have more production and consumption options that increase their welfare. In the analysis household non land and livestock assets are included as regressors. The result of the study also shows that the estimated value of assets owned by the household are found to be a significant determinant of vulnerability. A one unit increase in value of asset decrease household vulnerability to poverty by less than 1 percent and it is statistically significant at 5 percent.

Farm income: The farm income of the household is the most important determinant of the household vulnerability to poverty. The farm income of the households surveyed has a negative impact on the vulnerability of household to poverty. The study result indicates that a one birr increase in household farm income reduces household vulnerability to poverty by less than one percent and it is statistically significant at 1 percent.

Non-farm income: Involvement in non-farm income generating activities is also another source of income for the rural poor and reduces the incidence of vulnerability. Sale of charcoal, land rental income, petty trade and labor sale are the important source of income in the study areas. The involvement of households in non-farm income activities reduce household susceptibility to fall below poverty line. In the model non-farm income is found to have influential impact on the level of vulnerability. Households that have alternative source of income other than agriculture show less exposure to poverty. The analysis shows households that have a reasonable non farm income are 1.9 percent less vulnerable than household with small or no nonfarm-income and the estimate is significant at 5 percent significant level.

Access to service

Access to credit: households who have an access to credits are assumed to be less vulnerable than household without having such access. The study result also support this assumption that household with access to credit is less vulnerable to poverty by 1.48 percent than household with no such access. The result is also statistically significant at 1 percent.

Access to market: Proximity to market is important factor that affect household welfare. Schooling, market, input shop etc. are among major social infrastructures that have strong linkage with poverty and vulnerability. Indicators that have been used for access to markets, roads and services in different studies include the distance or walking time to the nearest woreda town, market, input supply shop etc. (Chamberlin et al., 2006). In this study market access is measured as whether household travels less than 5 Km a single trip or more to access a market. The result shows that households that are closer to market centers are less vulnerable to poverty. The analysis shows that households that travel less than 5km are 0.43 percent less vulnerable than households that travel more than 5km and the estimate is significant at 1 percent significant level.

Access to all weather roads: Distance from all weather roads has an impact on household vulnerability to poverty. Households that travel less than 3 km to get all weather roads are 2.55 percent less vulnerable than households that travel more than 3km and statistically significant at 1 percent.

Extension Service: Access to extension service is the most important role to minimize vulnerability of household to poverty. The study result indicates an increase in extension contact by one decrease vulnerability of household to poverty by 0.06 percent and it is statistically significant at 1 percent.

Social institutions

Social institutions such as *Idir*, *Ikub*, and Mahiber are important factor that affect household welfare. Strong social capital guarantees better access to capital and information. Theoretically we expect households that have strong social capital are less vulnerable to poverty. However the study result indicates that only ikub supports this theory. Household hold who is a member of ikub tends to reduce their vulnerability by the 1.04 percent and statistically significant at 1 percent. Household who is a member of mahiber and idir is more vulnerable than household who is not a member. When household becomes a member of mahiber their vulnerability to poverty increases by less than 1 percent and statistically significant at 5 percent. When household becomes a member of idir their vulnerability to poverty tends to increase by 1.7 percent. The appropriate reason for the increase in the vulnerability of household as they become the member of mahiber and idir includes the people contact in this may not provide(exchange) information that assist them in vulnerability reduction; they may spend their expensive time because of this institution especially during production season.

Environmental factors

Rainfall: Variation in rainfall is expected to significantly explain household level of vulnerability. Since most of agriculture in the study area is rain fed, shortage of rain during production season reduces household production that increases their vulnerability to poverty. On the other hand extreme increase in rainfall above the need at some season and absence of rainfall during production season may cause reduction in productivity. The study result indicates one millimeter decrease in season rainfall below long run average increases household vulnerability by less than 1 percent and statistically significant at 1 percent significant level. Therefore, decrease in rainfall increases vulnerability of farmers to poverty line by reducing crop productivity.

Temperature: Increase in mean maximum temperature increase respiration loss of plants that increase water requirements of plants. This implies that increase in season mean maximum temperature above long run average increases household vulnerability to poverty. The study result indicates that $1^{O}C$ increase in mean maximum temperature above the long run average increases household vulnerability to poverty by 1.2 percent and statistically significant at 1 percent.

Adaptation:

It is estimated that household uses different adaptation options is less vulnerable to poverty than household who do not uses adaptation options. The study result also indicates that household who uses adaptation option is less vulnerable to poverty by 0.15 percent than household who do not use any adaptation and it is statistically significant at 1 percent significant level.

Fertilizer:

Use of agricultural inputs such as fertilizer is other important variable that define household exposure to poverty. Using fertilizer increases productivity and thus reduces downward fluctuation of production that in turn reduces vulnerability to poverty. According to the study result use of fertilizer reduces household vulnerability to poverty by less than 1 percent and statistically significant at 1 percent.

Insecticide and pesticide:

Insecticide and pesticide is also another important input that is used in production to kill crop pests and disease. Using this input it is possible to increase the productivity. The estimation result indicates that use of one more liter insecticide and pesticide reduces household vulnerability to poverty by 0.15 percent and significant at 1 percent.

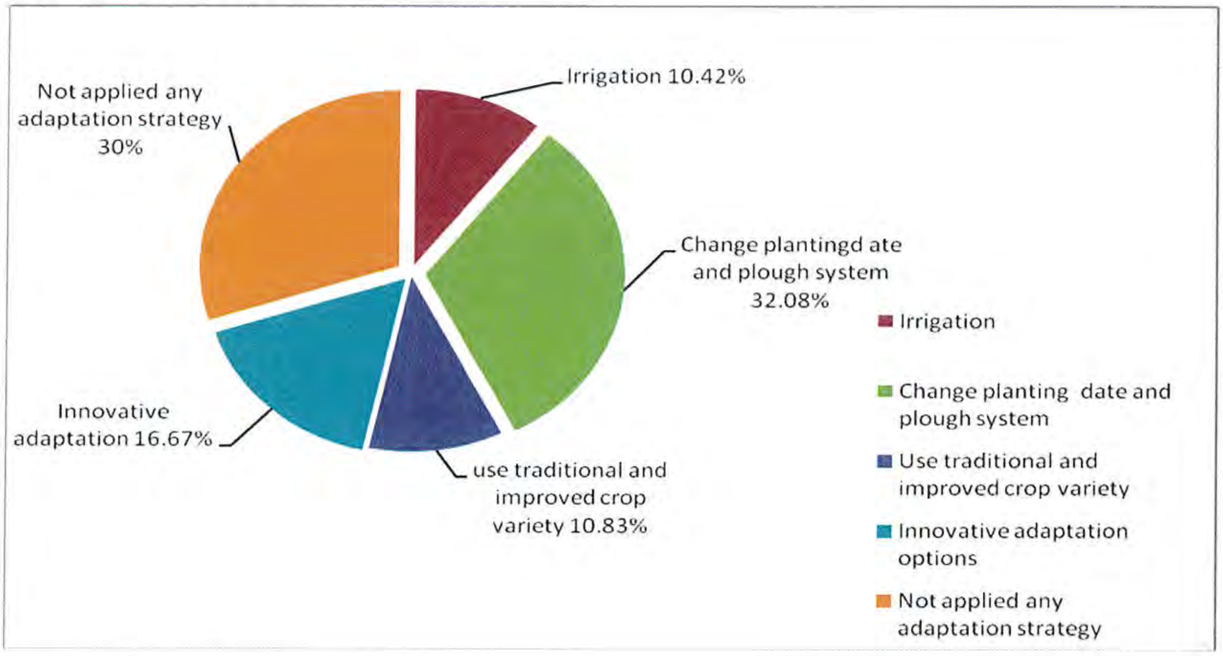
4.4 Adaptation strategies

Households included in the sample study uses various adaptation methods to adapt the crop production and livestock rearing to climate change and to keep the pace of the production. The adaptation method used by household is determined by various socio-economic and environmental factors discussed in the following sections.

4.4.1 Crop adaptation strategies

Sample household adapt crop production to climate change by using irrigation, change of planting date and plough system, use traditional and improved crop variety and innovative adaptation options.

Figure 4.3 Crop adaptation strategy of sample



Source: Survey 2013

As indicated in figure 4.3 to adapt their crop production change of planting date and plough system is the most commonly used method whereas use of irrigation is the adaptation least practiced among the major adaptation method identified in the study area. That is 32.08 percent of the sample household adapt to climate change through change of planting date and plough system and followed by use of innovative adaptation option that is 16.67 percent of the total sample household. Greater use of change of planting date and plough system as an adaptation method could be associated with the ease of access to information by farmers, lower expense and sometimes could be seen as the only option particularly during the rainfall becomes very late. Traditional and improved crop variety is the third adaptation option used in the study area which is accounted for 10.83 percent of the sample household.

This innovative adaptation option is the option that farmers simply uses from their local experiences this includes; planting short duration crop, increasing variety of crop and planting vulnerable resistant crop in farm land more prone to climate effect. The limited use of improved crop variety could be attributed to lack of access to information, limited availability of improved crop in local market and expensiveness of the improved crop variety. Beside about 30 percent of the surveyed household reported not to have taken any adaptation method for a number of reasons such as lack of awareness, lack of money, shortage of labour and shortage of capital.

Table 4.12 Comparison of crop adaptation method based on agro-ecological settings

Crop adaptation among agro-ecological settings								
Agro-ecology	Irrigation		Change planting date and plough system		Use traditional and improved crop variety		Innovative adaptation	
	No.	%age	No.	%age	No.	%age	No.	%age
Highland	7	11.29	24	38.7	7	11.29	8	12.9
Midland	2	2.6	23	29.9	9	11.69	15	19.48
Lowland	16	15.8	30	29.7	10	9.9	17	16.8

Source: Survey 2013

As shown in the above table 11.29 percent of the sample household from the highland, 2.6 percent of the sample household from the midland and 15.8 percent of the sample household from the lowland uses irrigation as the crop adaptation option to the climate change. The difference shows that irrigation is more of used in the lowland than highland and midland. This is because of the availability of irrigable land more of in the lowland than other area.

Change in planting date and plough system is used in all agro-ecological areas as crop adaptation method. The result shows 38.7 percent of the sample household from highland, 29.9 of the sample household from midland and 29.7 percent of the sample household from the lowland adapt crop production to climate change through change of planting date and plough system. Change of planting date and plough system is more of used by household reside in highland relative to households in lowland and midland.

Traditional and improved crop variety is another method of crop adaptation that 11.29 percent of the sample household from high land, 11.69 percent of the sample household from midland and 9.9 percent of the sample household from lowland uses this adaptation method. Relative to other locations this adaptation method is less used in lowland.

Innovative adaptation option is the type of adaptation this born by the society and not adapted from another society. As stated in the above table 12.9 percent, 19.4 percent and 16.8 percent of the sample household in highland, midland and lowland uses this adaptation method respectively. Relatively this adaptation method is more of used in midland.

4.4.2 Factors determining Farmers' choice of Crop Adaptation

Different household characteristics, infrastructure, and institutional factors influence the use of adaptation methods by farmers. The most commonly cited household characteristics include age, education, farming experience, marital status, gender of the head of household, and wealth. Institutional factors include access to extension and credit; and infrastructure includes distance to input and output markets (Maddison 2006; Nhemachena and Hassan 2007). In this study the variables presented in table 4.13 below are considered as an explanatory variable of household crop adaptation to climate change.

Table 4.13 Marginal effects from the multinomial logit climate change crop adaptation model

lanatory able	Irrigation		Change planting date and plough system		Use traditional and improved crop variety		Innovative adaptation option	
	Coefficient	p value	Coefficient	p value	Coefficient	p value	Coefficient	p value
of head	.002756	0.065	.0978496	0.413	.00508	0.011	.0058718	0.051
of head	.0171582	0.0627	.0034534	0.388	-.0625679	0.405	.1220695	0.046
cation of head	.013684	0.031	.0160829	0.377	.0181504	0.041	-.0042752	0.790
ily size	-.0206008	0.066	.015079	0.47	-.0068944	0.632	.0000159	0.020
n income	4.43e-06	0.161	-5.54e-06	0.572	7.47e-07	0.867	.0000159	0.020
farm income	-.0013736	0.963	.0573568	0.481	-.051636	0.182	.0336983	0.601
ifall change	-0.0021613	0.014	-.0038914	0.028	-.0002971	0.868	-.0022334	0.438
imum perature	-.5214793	0.002	-.2691344	0.476	.1831587	0.321	.2594437	0.380
r asset value	-3.13e-07	0.744	-1.70e-06	0.569	-7.82e-07	0.558	1.08e-06	0.589
	-.0028183	0.187	.0007466	0.087	.002979	0.182	.0002934	0.040
l size	.0109215	0.351	-.0492136	0.126	.0242308	0.128	.0063809	0.792
	.0459154	0.342	.0730697	0.495	.0519231	0.022	-.0947655	0.134
	-.0438093	0.197	.0659623	0.420	-.0126915	0.765	-.0636824	0.321
iber	.0244453	0.365	.0680677	0.357	.0661757	0.091	-.0408	0.469
ss to credit	.0085854	0.054	.0229546	0.764	.0418044	0.021	-.0727921	0.193
nsion service	.0022256	0.776	.0253508	0.269	.0115969	0.063	.0060443	0.720
ss to market	.0335758	0.067	.1209114	0.343	.1252032	0.007	-.1512535	0.038
veather road	.0424737	0.193	.0720686	0.511	.1000547	0.223	.0020208	0.980

Household Characteristics

Age of the household head: Age of the household head, which represents experience, affected adaptation to climate change. On the one hand, studies in Ethiopia have shown a positive relationship between number of years of experience in agriculture and the adoption of improved agricultural technologies (Kebede, Kunjal, and Coffin 1990), while a study by Shiferaw and Holden (1998) indicates a negative relationship between age and adoption of improved soil conservation practices. The study result shows that age of household head positively related to all adaptation method. A unit increases in age of the household head results in a significant percent increase in the probability of irrigation by 0.2 percent, innovative crop adaptation by 5 percent; both are significant at 10 percent. And also a unit increases in age of household head results in a 0.39 percent increases in use of traditional and improved crop varieties and statistically significant at 5 percent. It also influences changing of planting date and plough system positively, but statistically not significant.

Gender of the head of household: Male-headed households are more likely to adapt to climate change than female-headed household. One study indicates that male-headed households are more likely to get information about new technologies and undertake risky businesses than female-headed households (Asfaw and Admassie 2004). Moreover, Tenge De Graffe and Heller (2004) argue that having a female head of household may have negative effects on the adoption of soil and water conservation measures, because women may have limited access to information, land, and other resources due to traditional social barriers.

The result of this study also indicates that male headed household is more adapt to climate change than female headed household. Male-headed households are 1.7 percent more likely to use irrigation and 12 percent more likely to use innovative adaptation option, they are statistically significant at 10 and 5 percent respectively. Male headed households are more likely to adopt through change of planting date and plough system, where as male headed households are less likely to adopt through use of traditional crop variety and improved crop variety, even though they are statistically not significant.

Family size: The influence of household size on use of adaptation methods can be seen from two angles. The first assumption is that households with large families may be forced to divert part of the labor force to off- farm activities in an attempt to earn income in order to ease the consumption pressure imposed by a large family (Yirga 2007). The other assumption is that large family size is normally associated with a higher labor endowment, which would enable a household to accomplish various agricultural tasks. For instance, Croppenstedt, Demeke, and Meschi (2003) argue that households with a larger pool of labor are more likely to adopt agricultural technology and use it more intensively because they have fewer labor shortages at

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```
hettest

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
         Ho: Constant variance
         Variables: fitted values of wlnpce

         chi2(1)      =     8.09
         Prob > chi2  =   0.0045

. vif

    Variable |       VIF       1/VIF
-------------+----------------------
wfarmincome2 |      4.24    0.236049
accesstoma~t |      3.36    0.297639
wfertilize~2 |      2.92    0.342079
  wlandsize2 |      2.92    0.342913
accesstoal~s |      2.81    0.356045
winsectici~2 |      2.68    0.373804
wfamilysize2 |      2.45    0.408565
wrainfallc~2 |      2.32    0.430159
 wageofhead2 |      2.25    0.444794
   wmaxtemp2 |      1.64    0.610532
  adaptation |      1.58    0.631558
        ikub |      1.54    0.649454
irrigation~d |      1.41    0.709145
weducation~2 |      1.41    0.709332
        idir |      1.41    0.710163
wextension~2 |      1.34    0.746183
wassetvalue2 |      1.31    0.762696
       wtlu2 |      1.29    0.772335
nonfarminc~e |      1.29    0.774005
 sexofhhhead |      1.14    0.879724
      credit |      1.11    0.901301
     mahiber |      1.08    0.925562
-------------+----------------------
    Mean VIF |      1.98

. reg vuln sexofhhhead ageofhead familysize educationofhead landsize tlu farmincome
nonfarmincome assetvalue credit irrigation
> land adaptation rainfallchange maxtemp idir ikub mahiber extensioncontact
accesstomarket fertilizersupply insecticideandpest
> icidesupply accesstoallweatherroads

      Source |       SS       df       MS              Number of obs =     240
-------------+------------------------------           F( 22,   217) =57618.73
       Model |  1.02582455    22  .046628389           Prob > F      =  0.0000
    Residual |  .000175609   217  8.0926e-07           R-squared     =  0.9998
-------------+------------------------------           Adj R-squared =  0.9998
       Total |  1.02600016   239  .004292888           Root MSE      =   .0009

------------------------------------------------------------------------------
        vuln |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
 sexofhhhead |  -.0029118   .0002027   -14.37   0.000    -.0033113   -.0025124
   ageofhead |  -.0005324   6.31e-06   -84.33   0.000    -.0005448   -.0005199
  familysize |   .0327161   .0000485   674.73   0.000     .0326205    .0328117
educationo~d |  -.0017582   .0000296   -59.41   0.000    -.0018165   -.0016998
    landsize |  -.0025715   .0000578   -44.47   0.042    -.0026855   -.0024576
         tlu |  -.0006701   8.95e-06   -74.86   0.000    -.0006877   -.0006525
  farmincome |  -6.97e-06   1.78e-08  -391.84   0.000    -7.00e-06   -6.93e-06
nonfarminc~e |  -.0191069   .0001358  -140.75   0.022    -.0193744   -.0188393
  assetvalue |  -4.91e-07   4.82e-09  -102.01   0.032    -5.01e-07   -4.82e-07
```

credit	-.0148887	.0001253	-118.82	0.000	-.0151357	-.0146418
irrigation~d	-.0005974	.0002116	-2.82	0.045	-.0001804	-.0010144
adaptation	-.0015337	.000152	-10.09	0.000	-.0018333	-.0012341
rainfallch~e	.0000768	7.03e-06	10.91	0.000	.0000629	.0000906
maxtemp	-.0120673	.0006387	-18.89	0.001	-.013326	-.0108085
idir	.0170262	.0001378	123.54	0.000	.0167545	.0172978
ikub	-.0104626	.0001683	-62.16	0.000	-.0107944	-.0101309
mahiber	.0086197	.0001207	71.39	0.034	.0083817	.0088576
extensionc~t	-.0006311	.0000367	-17.19	0.000	-.0007035	-.0005588
accesstoma~t	-.0043021	.0002352	-18.29	0.001	-.0047656	-.0038386
fertilizer~y	-.0000301	8.53e-07	-35.24	0.001	-.0000284	-.0000318
insecticid~y	-.0015197	.0000959	-15.85	0.000	-.0017087	-.0013308
accesstoal~s	-.0255696	.0002169	-117.87	0.000	-.025142	-.0259972
_cons	.4877316	.0009745	500.50	0.000	.4858109	.4896523

```
mfx compute, predict(outcome(1))

Marginal effects after mlogit
      y  = Pr(cropadaptation==1) (predict, outcome(1))
         =  .05513011
------------------------------------------------------------------------------
variable |      dy/dx    Std. Err.     z    P>|z|  [    95% C.I.   ]      X
---------+--------------------------------------------------------------------
sexofh~d*|   .0171582      .03535    0.49   0.627  -.052118  .086434   .895833
ageofh~d |    .002756       .0015    1.84   0.065  -.000175  .005686   50.2167
family~e |  -.0206008       .0112   -1.84   0.066   -.04255  .001349   5.95417
educat~d |    .013684      .00636    2.15   0.031   .001223  .026145     1.425
landsize |   .0109215      .01171    0.93   0.351  -.012034  .033877   3.03958
     tlu |  -.0028183      .00214   -1.32   0.187  -.007003  .001367   8.96729
farmin~e |   4.43e-06      .00000    1.40   0.161  -1.8e-06  .000011   19993.5
nonfar~e*|  -.0013736      .02953   -0.05   0.963  -.059256  .056509   .383333
assetv~e |  -3.13e-07      .00000   -0.33   0.744  -2.2e-06  1.6e-06   15163.3
  credit*|   .0085854      .02736    0.31   0.754  -.045038  .062209   .391667
rainfa~e |  -.0021613      .00133   -1.62   0.104  -.004768  .000446   39.7827
 maxtemp |  -.5214793      .17198   -3.03   0.002  -.858547 -.184412  -1.02738
    idir*|  -.0438093      .03397   -1.29   0.197  -.110386  .022768   .495833
    ikub*|   .0459154      .04828    0.95   0.342  -.048712  .140543   .241667
 mahiber*|   .0244453      .02697    0.91   0.365  -.028412  .077303   .491667
extens~t |  -.0022256      .00781   -0.29   0.776  -.017523  .013072      1.75
  market*|   .0335758      .05869    0.57   0.567  -.081449  .148601   .295833
allwea~s*|  -.0424737      .03265   -1.30   0.193  -.106458  .021511   .270833
------------------------------------------------------------------------------
(*) dy/dx is for discrete change of dummy variable from 0 to 1

. . mfx compute, predict(outcome(2))

Marginal effects after mlogit
      y  = Pr(cropadaptation==2) (predict, outcome(2))
         =  .41889792
------------------------------------------------------------------------------
variable |      dy/dx    Std. Err.     z    P>|z|  [    95% C.I.   ]      X
---------+--------------------------------------------------------------------
sexofh~d*|   .0978496      .11946    0.82   0.413  -.136284  .331983   .895833
ageofh~d |   .0034534        .004    0.86   0.388  -.004388  .011295   50.2167
family~e |    .015079      .03179    0.47   0.635  -.047237  .077395   5.95417
educat~d |   .0160829      .01819    0.88   0.377  -.019575  .051741     1.425
landsize |  -.0492136      .03218   -1.53   0.126  -.112293  .013866   3.03958
     tlu |   .0007466      .00523    0.14   0.887   -.00951  .011003   8.96729
farmin~e |  -5.54e-06      .00001   -0.56   0.572  -.000025  .000014   19993.5
nonfar~e*|   .0573568      .08144    0.70   0.481   -.10227  .216984   .383333
assetv~e |  -1.70e-06      .00000   -0.57   0.569  -7.6e-06  4.2e-06   15163.3
  credit*|   .0229546      .07644    0.30   0.764  -.126866  .172775   .391667
rainfa~e |   .0038914      .00362    1.08   0.282  -.003195  .010977   39.7827
 maxtemp |  -.2691344      .37801   -0.71   0.476  -1.01002  .471756  -1.02738
    idir*|   .0659623      .08177    0.81   0.420  -.094299  .226224   .495833
    ikub*|   .0730697      .10715    0.68   0.495  -.136935  .283074   .241667
 mahiber*|   .0680677      .07396    0.92   0.357  -.076897  .213032   .491667
extens~t |   .0253508      .02293    1.11   0.269  -.019581  .070283      1.75
  market*|   .1209114      .12753    0.95   0.343  -.129036  .370859   .295833
allwea~s*|   .0720686      .10961    0.66   0.511  -.142757  .286895   .270833
------------------------------------------------------------------------------
(*) dy/dx is for discrete change of dummy variable from 0 to 1

. . mfx compute, predict(outcome(3))

Marginal effects after mlogit
      y  = Pr(cropadaptation==3) (predict, outcome(3))
         =  .08380436
```

variable	dy/dx	Std. Err.	z	P>|z|	[95%	C.I.]	X
sexofh~d*	-.0625679	.07517	-0.83	0.405	-.209901	.084765	.895833
ageofh~d	.00508	.00199	2.56	0.011	.001187	.008973	50.2167
family~e	-.0068944	.01441	-0.48	0.632	-.035146	.021357	5.95417
educat~d	.0181504	.00888	2.04	0.041	.000743	.035558	1.425
landsize	.0242308	.01592	1.52	0.128	-.006971	.055433	3.03958
tlu	.002979	.00223	1.33	0.182	-.001399	.007357	8.96729
farmin~e	7.47e-07	.00000	0.17	0.867	-8.0e-06	9.5e-06	19993.5
nonfar~e*	-.051636	.03866	-1.34	0.182	-.127415	.024143	.383333
assetv~e	-7.82e-07	.00000	-0.59	0.558	-3.4e-06	1.8e-06	15163.3
credit*	.0418044	.04215	0.99	0.321	-.040805	.124413	.391667
rainfa~e	-.0002971	.00179	-0.17	0.868	-.003796	.003202	39.7827
maxtemp	.1831587	.18475	0.99	0.321	-.178945	.545262	-1.02738
idir*	-.0126915	.0424	-0.30	0.765	-.095801	.070418	.495833
ikub*	-.0519231	.04073	-1.27	0.202	-.131757	.027911	.241667
mahiber*	.0661757	.03915	1.69	0.091	-.010566	.142918	.491667
extens~t	.0115969	.01037	1.12	0.263	-.008723	.031917	1.75
market*	-.1252032	.04668	-2.68	0.007	-.216698	-.033709	.295833
allwea~s*	.1000547	.0821	1.22	0.223	-.060861	.260971	.270833

(*) dy/dx is for discrete change of dummy variable from 0 to 1

. . mfx compute, predict(outcome(4))

Marginal effects after mlogit
      y = Pr(cropadaptation==4) (predict, outcome(4))
         = .17713696

variable	dy/dx	Std. Err.	z	P>|z|	[95%	C.I.]	X
sexofh~d*	.1220695	.06118	2.00	0.046	.002158	.241981	.895833
ageofh~d	.0058718	.00301	1.95	0.051	-.000034	.011777	50.2167
family~e	-.0420173	.02275	-1.85	0.065	-.086614	.00258	5.95417
educat~d	-.0042752	.01604	-0.27	0.790	-.035709	.027158	1.425
landsize	.0063809	.02424	0.26	0.792	-.041131	.053892	3.03958
tlu	-.0002934	.00392	-0.07	0.940	-.007986	.007399	8.96729
farmin~e	.0000159	.00001	2.33	0.020	2.6e-06	.000029	19993.5
nonfar~e*	.0336983	.0645	0.52	0.601	-.092718	.160114	.383333
assetv~e	1.08e-06	.00000	0.54	0.589	-2.8e-06	5.0e-06	15163.3
credit*	-.0727921	.05587	-1.30	0.193	-.182291	.036707	.391667
rainfa~e	-.0022334	.00288	-0.78	0.438	-.007878	.003412	39.7827
maxtemp	.2594437	.2955	0.88	0.380	-.319716	.838604	-1.02738
idir*	-.0636824	.06421	-0.99	0.321	-.189531	.062166	.495833
ikub*	-.0947655	.06317	-1.50	0.134	-.218582	.029051	.241667
mahiber*	-.0408	.05636	-0.72	0.469	-.151266	.069666	.491667
extens~t	.0060443	.01686	0.36	0.720	-.027007	.039095	1.75
market*	-.1512535	.07307	-2.07	0.038	-.294462	-.008045	.295833
allwea~s*	.0020208	.08199	0.02	0.980	-.158678	.16272	.270833

(*) dy/dx is for discrete change of dummy variable from 0 to 1
mfx compute, predict(outcome(1))

Marginal effects after mlogit
      y = Pr(liveadapt==1) (predict, outcome(1))
         = .1262158

variable	dy/dx	Std. Err.	z	P>|z|	[95%	C.I.]	X
sexofh~d*	.0453977	.06595	0.69	0.491	-.083853	.174648	.895833
ageofh~d	.0032317	.00227	1.42	0.155	-.001218	.007682	50.2167
family~e	-.0125451	.01822	-0.69	0.491	-.048251	.023161	5.95417

educat~d	.0204694	.0102	2.01	0.045	.000477	.040462	1.425
landsize	.0093152	.01875	0.50	0.619	-.027425	.046056	3.03958
tlu	-.0024653	.00351	-0.70	0.482	-.009337	.004406	8.96729
farmin~e	1.88e-06	.00001	0.34	0.733	-8.9e-06	.000013	19993.5
nonfar~e*	.0687881	.05399	1.27	0.203	-.037038	.174614	.383333
assetv~e	-1.73e-06	.00000	-0.91	0.363	-5.5e-06	2.0e-06	15163.3
credit*	.0246289	.04773	0.52	0.606	-.068922	.11818	.391667
rainfa~e	-.0017197	.00227	-0.76	0.449	-.006167	.002728	39.7827
maxtemp	.1724149	.23674	0.73	0.466	-.291581	.63641	-1.02738
idir*	-.0353424	.05064	-0.70	0.485	-.13459	.063906	.495833
ikub*	-.0503529	.05199	-0.97	0.333	-.152244	.051538	.241667
mahiber*	.0866958	.04608	1.88	0.060	-.003627	.177019	.491667
extens~t	.0161622	.01326	1.22	0.223	-.009827	.042152	1.75
market*	-.042701	.06904	-0.62	0.536	-.178009	.092607	.295833
allwea~s*	.0366616	.07308	0.50	0.616	-.106569	.179892	.270833

(*) dy/dx is for discrete change of dummy variable from 0 to 1

. . mfx compute, predict(outcome(2))

Marginal effects after mlogit
y = Pr(liveadapt==2) (predict, outcome(2))
= .06799277

variable	dy/dx	Std. Err.	z	P>|z|	[95%	C.I.]	X
sexofh~d*	.0316074	.03642	0.87	0.386	-.039782	.102996	.895833
ageofh~d	.0009093	.00186	0.49	0.625	-.002739	.004557	50.2167
family~e	.036257	.01292	2.81	0.005	.01094	.061574	5.95417
educat~d	.0094714	.00716	1.32	0.186	-.004566	.023509	1.425
landsize	-.0299888	.01419	-2.11	0.035	-.057795	-.002183	3.03958
tlu	.0027637	.00199	1.39	0.166	-.001146	.006674	8.96729
farmin~e	4.20e-07	.00000	0.10	0.923	-8.0e-06	8.9e-06	19993.5
nonfar~e*	.0131316	.03461	0.38	0.704	-.054706	.08097	.383333
assetv~e	-8.74e-08	.00000	-0.06	0.949	-2.8e-06	2.6e-06	15163.3
credit*	-.008178	.0317	-0.26	0.796	-.070317	.05396	.391667
rainfa~e	-.0013538	.00166	-0.82	0.414	-.004603	.001895	39.7827
maxtemp	.077128	.17639	0.44	0.662	-.268581	.422837	-1.02738
idir*	.0011134	.03319	0.03	0.973	-.063939	.066166	.495833
ikub*	.0583227	.06482	0.90	0.368	-.068713	.185358	.241667
mahiber*	-.0208659	.03094	-0.67	0.500	-.081502	.03977	.491667
extens~t	.0083963	.00937	0.90	0.370	-.009971	.026764	1.75
market*	.0088721	.05969	0.15	0.882	-.108124	.125869	.295833
allwea~s*	-.0064506	.04549	-0.14	0.887	-.095607	.082706	.270833

(*) dy/dx is for discrete change of dummy variable from 0 to 1

. . mfx compute, predict(outcome(3))

Marginal effects after mlogit
y = Pr(liveadapt==3) (predict, outcome(3))
= .27190429

variable	dy/dx	Std. Err.	z	P>|z|	[95%	C.I.]	X
sexofh~d*	-.0884523	.11329	-0.78	0.435	-.310504	.133599	.895833
ageofh~d	.005821	.00324	1.80	0.073	-.000532	.012174	50.2167
family~e	-.0317006	.02519	-1.26	0.208	-.081078	.017677	5.95417
educat~d	.0298271	.01585	1.88	0.060	-.001235	.060889	1.425
landsize	.0309526	.02689	1.15	0.250	-.021747	.083652	3.03958
tlu	-.0021252	.00468	-0.45	0.650	-.011303	.007053	8.96729
farmin~e	4.80e-06	.00001	0.64	0.525	-1.0e-05	.00002	19993.5
nonfar~e*	-.0216696	.06911	-0.31	0.754	-.157125	.113786	.383333

adaptation submmssion

assetv~e	-2.50e-06	.00000	-1.00	0.315	-7.4e-06	2.4e-06	15163.3
credit*	.0125533	.06585	0.19	0.849	-.116518	.141624	.391667
rainfa~e	-.0077155	.0032	-2.41	0.016	-.013994	-.001437	39.7827
maxtemp	.4312789	.33997	1.27	0.205	-.235058	1.09762	-1.02738
idir*	-.0096921	.07126	-0.14	0.892	-.149366	.129982	.495833
ikub*	-.0945727	.078	-1.21	0.225	-.24744	.058295	.241667
mahiber*	.1114854	.06283	1.77	0.076	-.011657	.234627	.491667
extens~t	.0140178	.01901	0.74	0.461	-.023248	.051283	1.75
market*	-.109237	.09891	-1.10	0.269	-.303102	.084628	.295833
allwea~s*	.1031396	.10078	1.02	0.306	-.094378	.300658	.270833

(*) dy/dx is for discrete change of dummy variable from 0 to 1

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Rural Household Vulnerability to Climate Change and Adaptation Option of three districts adjacent to Abay gorge

Household survey Questionnaire

***Note**: Introduce yourself and explain the purpose of the household survey. Tell respondents that the data obtained through this survey will be used only for the academic purpose" that is study on the title, for the partial fulfillment of the Master degree in Environment and Development.*

I. General Information regarding data source

1. Name District:____
2. Name of Peasant Association:___________________________________
3. Village : ____
4. Distance from all weather road____________________________________

4. Name or Code of the **respondent** (he/she must be head of the household): _______________________

II. Household/respondent Characteristics

1. Age of respondents: _______ in years
2. Sex of the respondent : 1= Male 2= Female
3. Education level of the respondent:___________(in years, 0 if illiterate, 1 if basic education)
4. Religion of the respondent: 1= Muslim 2= Protestant 3=Orthodox 4= other specify _____________
5. Nationality of the respondent: 1=Oromo 2=Tigre 3= Amhara 4= Other specify _____________
6. Marital status: 1= Married 2= Unmarried 3= Divorce 4= Widowed
7. Family Size: Male: ______ Female _______ Total: ______*(including household head)*
8. **Table A. Family Characteristics**

List of family member **Code (A1)**	Sex **Code (A2)**	Age **Code(A3)**	Educational level **Code(A4)**	Occupation[¥¥] **Code (A5)**

Code A1: M1= Member 1, M2=Member2, M3=Member3 etc

Code A2, 1=Male: 2= Female

Code A5: 1=Crop production and livestock rearing 2=Daily labor 3= contract employee 4=student 5=Trade 6=Others Specify__________________________

¥¥ ***Note*** that this question will be asked for members' more than15 years old

III. Household economic activity and climate change

1. Did you produce crop in a year 2011? 1=Yes 2=No

Table B. Crop production (Year 2011)

Type of crop	Land size Cultivated (Timad/Gemzi)	Amount produced (In Kg)	Amount consumed (In Kg)	Amount sold (in Kg)	Average price (birr/Kg)
Teff					
Barley					
Wheat					
Sorghum					
Maize					
Millet					
Oats					
Bean(Bakela)					
Field pea (Ater)					
Haricot beans					
Chickpeas					
Lentils					
Niger seed					
Linseed					
other pulses					
Potato					
Other root crops					
Cabbage					
Tomatoes					
Red peppers (berbere)					
Others specify ________					

2. Did you use fertilizers in year 2011? 1=yes 2=No

   If yes to Qesn. 2 the quantity you used____________kg

3. Did you apply pesticide and insecticide to your crop production in year 2010? 1=Yes 2=No

   If yes to Qesn.3 the quantity you used_____________litre

4. Do you or your families own the livestock? 1=Yes 2=No

Table C. If Yes, fill the following table on Livestock holding (Year 2011)

Type of animals	Owned Quantity (In Number)	Sold (Number)	Average price (In Birr)	Income saved (In Birr)
Oxen				
Cows				
Goats				
Sheep				
Donkey				
Horse				
Mule				
Calf				
Hen				
Heifers				
Bee colonies				
Other Specify ________				

5. Did you or your family got livestock products in year 2011? 1= Yes 2= No

Table D. If Yes, fill the following table on Live stock products

Type of Livestock products	Units of measurement	Quantity Produced	Amount consumed	Amount sold	Average price (In Birr)
Milk	Litter				
Skin	In Number				
Meat	Kg				
Butter	Kg				
Honey	Kg				
Egg	In Number				
Others specify____________					

6. Do you own land? 1=Yes 2=No

Table E. If Yes, provide the following information regarding land use

S .No	Land use	Land size (Timad)
1	Home garden	
2	Cultivated field	
3	Grazing land	
4	Wood (Bush land)	
5	Other, Specify_______________	

7. Does your house hold possess other assets? 1=Yes 2=No

Table F. if Yes, fill the following table on other asset (in year 2011)

Other Asset	Owned Quantity (in number)	Average unit Price
Bicycle		
Water pump		
Radio /TV		
Mobile/phone		
Cart		
Weaving equipment		
Motor bike		
House		
Bed (modern)		
Chairs		
Tables		
Shelf /cupboard/bifie		
Others specify ____________		

8. Do you or your family members have source of income other than agriculture income?
1=Yes 2=No

Table G. if Yes, fill the following table on Source of non farm income in 2011

Source of non farm income	Income(in Birr)		Amount of Income saved
	In cash	In kind (value of it in birr)	
Trade/petty trade			
Remittance			
Non government donations			
Income from rental of land			
Sale of charcoal/fire wood			
Sale of handcraft			
Employee			
Other specify ______			
Total			

9. Is there any of the credit giving institution/ individuals in your nearest area?
1=Yes 2=No

Table H. If Yes, fill the following table on availability of Credit (In year 2011)

Credit No.	Type of credit institution/ Individuals	Amount of loan Received. (In Birr)	Loan duration	Use of money **(Code H1)**
	Relatives			
	Friends			
	Microfinance institution			
	Bank			
	Credit association			
	Other Specify ______			

Code=H1: 1=Acquisition of agricultural input 2=Agricultural investment 3=Household consumption 4=Investment 5=others Specify______

10. During the last 20 years have you observed change in climate elements? 1= Yes 2 =No

11. If yes to Qesn.10 how does it affect your harvest in 2011 compared with the previous year production season?

1=Increasing 2= Decreasing 3= Same

Table I. Climate change (In year 2011)

Climate Element	How climate Elements has change? **(Code I1)**	Effect of climate element Change on crop production **(CodeI2)**	Other effect of climate element **(Code I3)**
Temperature			
Precipitation			
Drought (frequency)			
Flood (frequency)			
Other specify ___			

Code= I1. 1=Increase 2=Decrease 3= No change
I2. 1= Increase 2=Decrease 3=No effect
I3. 1= Livestock loss 2= Other asset loss 3= Occurrence of Disease
4= Other specify___________

12. Other than climate change what does affect your production during the year 2011?
1= Crop pest (eg. *Ramoo in local language*) 2= crop disease (*eg. wagii*)
3= due to cold weather 4= animal disease 5=other specify ___________
13. How did the non climate shocks affect your livelihood?
1= Very negatively 2= negatively 4= Not affected at all

14. Adaptation options

14.1 crop Production adaptation strategies

1. Have you experienced change in temperature over the last five years? 1=Yes 2=No
2. If Qesn. 1 is Yes, which one of the following adaptation strategies did you use mostly?
1=Irrigation
2= Change planting and harvesting date
3= Changing plough system
4= using improved crop variety
5= Using traditional crop variety
6= If any other adaptation options (specify) ___________
7= No measurement taken

Have you experienced decrease in precipitation over the last five years? 1=Yes 2=No
If Qesn. 3, is Yes, which one of the following adaptation strategies did you use mostly?
1=Irrigation
2= Change planting and harvesting date
3= Changing plough system
4= using improved crop variety
5= Using traditional crop variety
6= If any other adaptation options (specify) ___________
7= No measurement taken

Have you experienced irregularities (off set and on set) in rain fall over last five years? 1=Yes 2=No
If Qesn. 5, is Yes, which one of the following adaptation strategies did you use mostly?

1=Irrigation
2= Change planting and harvesting date
3= Changing plough system
4= using improved crop variety
5= Using traditional crop variety
6= If any other adaptation options (specify) ____________
7= No measurement taken

7. Have you experienced increase in precipitation over last five years? 1=Yes 2=No
8. If Qesn. 7, is Yes, which one of the following adaptation strategies did you use mostly?
1=Irrigation
2= Change planting and harvesting date
3= Changing plough system
4= using improved crop variety
5= Using traditional crop variety
6= If any other adaptation options (specify) ____________
7= No measurement taken

9. Have you experienced drought over last five years? 1=Yes 2=No
10. If Qesn. 9, is Yes, which one of the following adaptation strategies did you use mostly?
1= Irrigation
2= Change planting and harvesting date
3= Changing plough system
4= planting draught tolerant crop variety
5= Adopt water harvesting technique
6= If any other adaptation options (specify) ____________
7= Any measurement was not taken

1. Have you experienced flood over the last five years? 1=Yes 2=No
2. If Qesn. 11, is Yes, which one of the following adaptation strategies did you use mostly?
1= Change planting and harvesting date
2= Changing plough system
3= temporary migration
4= Construction of dam
5= If any other adaptation options (specify) ____________
6= Any measurement was not taken

. Which of the below adaptation options you have been used mostly for the change in other climate elements?
1=Irrigation
2= Change planting and harvesting date
3= Changing plough system
4= using improved crop variety
5= Using tradition variety
6= If any other adaptation options (specify) ____________

7= No measurement taken

14. If your answer in adaptation option above is "any measurement was not taken", what is the reason?
    1= Lack of awareness
    2= lack of capital/technology
    3= lack of other resources
    4= if any other reason______________________________

15. If you were used adaptation options have you benefited from it?
    1=highly benefited
    2=benefited
    3= less benefited
    4= Not benefited

14.2. Livestock adaptation Strategies

1. Have you experienced drought over last five years? 1=Yes 2=No
2. If Qesn.1, is Yes, which one of the following adaptation strategies did you used mostly?
    1= Sold livestock and other asset
    2= Temporary migration
    3=Permanent migration
    4= Adopt water harvesting technique
    5= If any other adaptation options (specify) ____________
    6= Any measurement was not taken
3. Have you experienced flood over last five years? 1=Yes 2=No
4. If Qesn. 3, is Yes, which one of the following adaptation strategies did you used mostly?
    1= Sold livestock and other asset
    2= Temporary migration
    3=Permanent migration
    4= Constructing dam
    5= If any other adaptation options (specify) ____________
    5= Any measurement was not taken
5. Have you experienced decrease in precipitation over the last five years? 1=Yes 2=No
6. If Qesn. 5, is Yes, which one of the following adaptation strategies did you used mostly?
    1= Sold livestock and other asset
    2= Temporary migration
    3=Permanent migration
    4= If any other adaptation options (specify) ____________
    5= Any measurement was not taken
7. Have you experienced increase in precipitation over the last five years? 1=Yes 2=No
8. If Qesn. 7, is Yes, which one of the following adaptation strategies did you used mostly?
    1= Sold livestock and other asset
    2= Temporary migration
    3=Permanent migration
    4= If any other adaptation options (specify) ____________
    5= Any measurement was not taken

9. If your answer in adaptation option above is "any measurement was not taken", what is the reason?
   1= Lack of awareness
   2= lack of capital/technology
   3= lack of other resources
   4= if any other reason____________________________
10. Do you have an access to an extension service? 1=yes 2= No
11. If Yes to Qesn.10 how many contact did you got in year 2011? ____________

Table J. Source of Knowledge and input in adaptation to climate change

Adaptation strategies	If applied a given strategy(ies) over last five years**(code J1)**	Source of knowledge **(Code J2)**	Source of input **(codeJ3)**	Benefit **(Code J4)**
Application of fertilizer				
Conserve soil techniques				
Water harvest techniques				
Use micro-dam for irrigation				
Adjusting planting and harvesting date				
Improved livestock breeds				
Improved livestock management				
Use land race crop variety				
Use improved crop variety				
Other specify-------------				

Code J1: 1=yes **2=no**

Code J2: 1= parents 2= Neighbors 3= Extension service 4= Mass media (radio, TV, newspapers) 5=Farmers cooperative/ union 6= Other social groups *(eg.* ***idir , ikub…., mahiber)***
7=other (Specify) ____________

J3: 1= government agencies (includes Agricultural offices) 2= Neighbors 3= local market 4= private sector 5= Non/governmental organizations (NGOs) 6= Farmers cooperative/ union 7= parents 8= Other social groups *(eg.* ***idir , ikub…., mahiber)***
9=others specify____________

J4. 1= Very benefited 2=benefited 3= Less benefited 4= Not benefited

2. Social capital

Are you a member of *Idir*? 1= yes 2= no

Are you a member of *Ikub*? 1= yes 2= no

Are you a member of *Mahiber* (religious social gathering) 1= yes 2= no

Are you a member of other social organization? 1= yes 2= no

In total in how many social organization or gathering are you joined as member? ______ (in number).

THANK YOU FOR YOUR KINDFULL COOPERATION