

**ADDIS ABABA UNIVERSITY  
SCHOOL OF ECONOMICS**

**ANALYSING HOUSEHOLD VULNERABILITY TO CLIMATE CHANGE  
AND ADAPTATION OPTIONS: EVIDENCE FROM ADAMA AND LUME  
WOREDAS, ETHIOPIA**

**BY**

**BEDASO TAYE WAKEYO**

**A THESIS SUBMITTED TO THE SCHOOL OF ECONOMICS IN  
PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE  
OF MASTER OF SCIENCE IN RESOURCE AND ENVIRONMENTAL  
ECONOMICS**

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**“Analyzing Household Vulnerability to Climate Change  
and Adaptation Options: Evidence from Adama and  
Lume Woredas, Ethiopia.”**

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## **ACKNOWLEDGMENTS**

I am deeply grateful to Dr. Alemu Mekonnen, my advisor, for his invaluable comments and suggestions. His contributions to this thesis and his profound contribution to my knowledge are very much appreciated.

I am also extremely indebted to Dr. Dejene Aredo for his comment on the early stage of this work and providing me every necessary materials and cooperation to my works. My special thanks are also due to BDS-CDR staff members especially Mr. Kaleb S, Belay F, and Tsedenia for their special cooperation and help. My heartfelt thanks also go to my friend Alemayehu Ethiopia for he has been along with me at every stage of the work, without which the completion of the work was impossible. Mohammed Hoji, Birku Reta, Gemechu Mulatu, Talila Taye, Dhabi Badada also deserves the very best for they have been with me during data collection and entering stages.

Above all I am very grateful to super Savior, God for enabling me to fulfill my work, indeed! My especial thanks also go to my parents, especially my dad and mom, for their moral and financial assistance.

Finally, I would like to express my deep gratitude to Environmental Economics Policy Forum for Ethiopia (EPPFE) for granting me financial assistance to conduct my thesis.

## Table of Contents

<b>ACKNOWLEDGMENTS</b> .....	<b>i</b>
<b>List of Tables</b> .....	<b>iv</b>
<b>List of Figures</b> .....	<b>iv</b>
<b>Acronyms</b> .....	<b>v</b>
<b>ABSTRACT</b> .....	<b>vi</b>
<b>CHAPTER ONE</b> .....	<b>1</b>
<b>INTRODUCTION</b> .....	<b>1</b>
1.1 Background.....	1
1.2 Statement of the Problem .....	2
1.3 Objectives of the Study .....	6
1.4 Scope and Significance of the Study.....	6
1.5 Organization of the Thesis.....	7
<b>CHAPTER TWO</b> .....	<b>8</b>
<b>REVIEW OF LITERATURE</b> .....	<b>8</b>
<b>2.1 Climate change and Agriculture</b> .....	<b>8</b>
<b>2.2 Measuring Vulnerability to Climate Change</b> .....	<b>11</b>
2.2.1 Econometric Method.....	11
2.2.1.1 Vulnerability as Expected Poverty (VEP) .....	11
2.2.1.2 Vulnerability as a Low Expected Utility (VEU) .....	12
2.2.1.3 Vulnerability as Uninsured Exposure to Risk (VER).....	13
2.2.2 Indicator Method .....	14
<b>2.3 Empirical Literature</b> .....	<b>15</b>
<b>2.4 Summary of the Literature Review</b> .....	<b>22</b>
<b>CHAPTER THREE</b> .....	<b>25</b>

<b>CONCEPTUAL FRAMEWORK AND METHODOLOGY OF THE STUDY.....</b>	<b>25</b>
<b>3.1 Conceptual Framework.....</b>	<b>25</b>
<b>3.2 Analytical Framework.....</b>	<b>26</b>
<b>3.3 Empirical Model and Sources of Data .....</b>	<b>31</b>
3.3.1 Empirical Model.....	31
3.3.2 Data Sources and Sampling Technique .....	35
<b>CHAPTER FOUR.....</b>	<b>38</b>
<b>RESULTS AND DISCUSSIONS .....</b>	<b>38</b>
4.1 The Study Area .....	38
4.2 Descriptive statistics.....	39
4.2.1 Characteristics of the sample population .....	39
4.3 Climate of the study Area .....	44
4.4 Consumption Expenditure and Estimates of Vulnerability .....	48
4.4.1 Incidence of Vulnerability and Poverty .....	49
4.5 Econometric Results .....	58
<b>CHAPTER FIVE.....</b>	<b>68</b>
<b>CONCLUSION AND POLICY IMPLICATIONS .....</b>	<b>68</b>
<b>6. REFERENCES .....</b>	<b>71</b>
<b>APPENDIX I: SUPPLEMENTARY FIGURES AND TABLES.....</b>	<b>77</b>
<b>APPENDIX II: SURVEY QUESTIONNAIRE .....</b>	<b>80</b>
<b>I. Household Questionnaire .....</b>	<b>80</b>
<b>II. Community Questionnaire .....</b>	<b>80</b>

<b>CONCEPTUAL FRAMEWORK AND METHODOLOGY OF THE STUDY.....</b>	<b>25</b>
<b>3.1 Conceptual Framework.....</b>	<b>25</b>
<b>3.2 Analytical Framework.....</b>	<b>26</b>
<b>3.3 Empirical Model and Sources of Data .....</b>	<b>31</b>
3.3.1 Empirical Model.....	31
3.3.2 Data Sources and Sampling Technique .....	35
<b>CHAPTER FOUR.....</b>	<b>38</b>
<b>RESULTS AND DISCUSSIONS .....</b>	<b>38</b>
4.1 The Study Area .....	38
4.2 Descriptive statistics.....	39
4.2.1 Characteristics of the sample population .....	39
4.3 Climate of the study Area .....	44
4.4 Consumption Expenditure and Estimates of Vulnerability .....	48
4.4.1 Incidence of Vulnerability and Poverty .....	49
4.5 Econometric Results .....	58
<b>CHAPTER FIVE.....</b>	<b>68</b>
<b>CONCLUSION AND POLICY IMPLICATIONS .....</b>	<b>68</b>
<b>6. REFERENCES .....</b>	<b>71</b>
<b>APPENDIX I: SUPPLEMENTARY FIGURES AND TABLES .....</b>	<b>77</b>
<b>APPENDIX II: SURVEY QUESTIONNAIRE .....</b>	<b>80</b>
<b>I. Household Questionnaire .....</b>	<b>80</b>
<b>II. Community Questionnaire .....</b>	<b>80</b>

## List of Tables

Table 1 Survey <i>Woredas</i> and <i>Kebeles</i> .....	36
Table 2 Description of dependent and independent variables .....	42
Table 3 Major shocks suffered by households.....	43
Table 4 Average annual household consumption Expenditure (ETB) (2009 price).....	49
Table 5 Estimates of Vulnerability to Poverty.....	50
Table 6 Estimates of Relative Vulnerability to Poverty.....	51
Table 7 Cross-Distribution of Vulnerability and Poverty .....	51
Table 8 Sources of vulnerability for the households.....	52
Table 9 Vulnerability Estimates for Selected Household Characteristics.....	54
Table 10 Vulnerability Estimates for Selected Environmental Characteristics.....	57
Table 11 Correlates of Estimated Vulnerability Level of Households .....	59
Table 12 Analysis of variance (ANOVA table).....	77
Table 13 Nutritional (Calorie) Based Adult Equivalence Scales.....	78

## List of Figures

Figure 1 Conceptual Framework of Vulnerability Assessment .....	25
Figure 2 Mean Annual Rainfall Values for Selected Stations in Adama and Lume <i>Woreda</i> . .....	44
Figure 3 Mean Maximum and Minimum Temperature and Long Run Average.....	45
Figure 4 Relationships between Total Crop Produced and Rainfall for the Last Decade in Adama <i>woreda</i> (1999-2009).....	46
Figure 5 Adaptation Strategies and Practices of Households .....	47
Figure 6 Coping Strategies Of Households. ....	48
Figure 7 Normal Probability Plot of Residuals from Linear Consumption Equation .....	78
Figure 8 Plot of Vulnerability versus Per Capita Consumption .....	79

## Acronyms

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ANOVA	Analysis of Variance
CSIRO	Commonwealth scientific, Industrial and Research Organization
DA	Development Agent
DAP	Diammonium phosphate
E.C	Ethiopian Calendar
FGLS	Feasible Generalized Least squares
IFPRI	International Food Policy Research Institute
ILRI	International Livestock Research Institute
NMSA	National Meteorological Service Agency
IPCC	Inter governmental Panel on Climate Change
IRW	Internal Renewal Water
NCAR	National Center for Atmospheric Research
GDP	Gross Domestic Product
CO <sub>2</sub>	Carbon Dioxide
NGO	Non Governmental Organization
OLS	Ordinary Least Squares
PCE	Per Capita Expenditure
ETB	Ethiopian Birr
USD	United States Dollar
MoFED	Ministry of Finance and Economic Development
TLU	Tropical Livestock Unit
VEP	Vulnerability as Expected Poverty
VER	Vulnerability as Exposure to Risk
VEU	Vulnerability as low Expected Utility
WB	World Bank

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## ABSTRACT

*The study assesses the extent of household vulnerability to climate change by applying Vulnerability as Expected Poverty (VEP) approach. 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. The data is collected from rural farming households in Adama and Lume Woredas of East Shewa zone during 2009 production season. The result shows that about 68 percent of farmers are vulnerable to poverty, while 62 percent of them are observed to be poor. About 52 percent of the households are vulnerable to poverty due to low consumption prospect and 16 percent of them are vulnerable due to high consumption volatility. The study also indicates that change of rainfall and temperature from long run averages, frequency of drought and soil characteristics are major reasons for farmers' vulnerability to poverty. On the other hand, education of head, livestock and land size, irrigation size, quantity of fertilizer used and number of extension contacts are found to reduce household vulnerability to climate change. Proximity to facilities such as road and market also reduces farmers' vulnerability. But, higher family size and exposure to non climatic shocks such as death of household head and input price rise increase vulnerability. On top of that, the estimated incidence of poverty is less than the fraction of population that is vulnerable to poverty. This calls for differential intervention for poverty reduction and poverty prevention, in addition to consumption stabilization and increasing measures. On the other hand expansion of extension services, irrigation practices, non farm income opportunities, improving farmers' access to fertilizer use and increasing household capacity to cope or mitigate shocks and risks are important intervention areas to reduce vulnerability.*

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

## CHAPTER ONE

### INTRODUCTION

#### 1.1 Background

Agriculture is the main sector of the Ethiopian economy. It contributes 40% of GDP, generates more than 90% of foreign exchange earnings and employs about 85% of the population (Kumar and Quisumbing, 2010). However, the agricultural sector is dominated by small scale mixed crop and livestock production which is characterized by low productivity. The major factors responsible for low productivity include reliance on obsolete farming techniques, soil degradation caused by over grazing and deforestation, poor complementary services such as extension, credit, marketing, infrastructure and climatic factors such as drought and flood (Deressa et al., 2008a). These factors reduce the adaptive capacity or increase the vulnerability of farmers to future climate change and variability, which negatively affect the performance of the already weak agriculture.

A recent mapping on vulnerability and poverty in Africa (ILRI, 2006), puts Ethiopia as one of the countries most vulnerable to climate change and with least capacity to respond. Ethiopia already suffers from extremes of climate, manifested in the form of frequent drought and flood (Difalco *et al*, 2007). On the other hand, Ethiopian agriculture is largely rainfed, with irrigation practices accounting for negligible portion of the total cultivated land in the country. Thus, the amount and temporal distribution of rainfall, temperature and other climatic factors during the growing seasons has an important influence on crop yields and can induce food shortages and famine, hence, increase farmers' vulnerability to poverty.

More importantly, studies in Ethiopia show that frequency of droughts and its spatial coverage have increased over the past few decades (Deressa et al., 2008a). According to World Bank (2008) Ethiopia has experienced at least five major national droughts since 1980, along with literally dozens of local droughts. 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. These shocks are a major cause of transient poverty: had households been able to smooth consumption, then poverty in 2004 would have been at least 14% lower- a figure that translates into 11 million fewer people below the poverty line (World Bank, 2008).

On top of that, the average annual minimum temperature over the country has been increasing by about  $0.25^{\circ}\text{C}$  every ten years while average annual maximum temperature has been increasing by  $0.1^{\circ}\text{C}$  every decade. There is also a decreasing precipitation over the country (NMSA, 2001). The past trends of increasing temperature, decreasing precipitation and increasing frequency of droughts are predicted to sustain in the future in the tropics of which Ethiopia is one (IPCC, 2001 in Deressa et al., 2008a). Therefore, the country's agriculture is exposed to adverse climate conditions and thus vulnerable to climate change.

## **1.2 Statement of the Problem**

Agriculture being the mainstay of the Ethiopian economy is dominated by small scale, mixed crop and livestock farmers. It accounts for about 40 percent of GDP and for the vast majority of employment in the country. Moreover, Ethiopia is highly dependent on the agricultural sector for income source, foreign currency and food security. Crop production in the country is estimated to

contribute on average about 60 percent of the total agricultural value, while livestock accounts for about 27 percent and forestry and other subsectors account for only 13 percent (Deressa *et al.*, 2008c). However, the agricultural sector, particularly crop production, is dominated by small-scale farmers who employ largely traditional and rainfed practices- a state which renders Ethiopia vulnerable to climate variability and climate change. The major problem in both crop and livestock production is recurrent droughts, hailstorms, floods and pest incidence (Befekadu and Berhanu 2000). Especially, recurrent drought is highly prevalent in the country which made many people throughout the country dependent on food aid. Thus, future efforts should emphasize increasing understanding of the complex interdependence between the climatic conditions and Ethiopian agriculture, in addition to addressing the other socioeconomic and technological problems.

Estimating vulnerability to climate change and tracking its correlates is important because a capable social policy should go beyond poverty alleviation in the present, and examine poverty prevention in the future. A poverty reduction strategy that ignores the transient nature of poverty misses households that have a high probability of being poor and may instead devote scarce resources to households that are only transiently poor and could have found a way out of poverty without government assistance (Shewmake, 2008). Therefore, investigating the extent of vulnerability to poverty and understanding its correlates is important to formulate thriving social policy.

Vulnerability to climate change is defined as “*expected poverty*,” that is, the probability of falling below poverty line due to climate change. Here, the interest is to estimate household level vulnerability to both gradual climate change (change in temperature and precipitation from long run average) and frequency of climatic extremes such as drought and flood. But there is both

short-run and long-run adaptation to climate change and shocks which reduce vulnerability or change the way households are affected by the change.

Estimation of vulnerability at the household level should ideally be attempted with panel data of sufficient length and richness (Chaudhuri et al., 2002). However, such data are rare, particularly in poor, developing economies like Ethiopia. Instead, the best one can usually hope for are 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.

The main research question that this study is going to address is “*what is the extent of household vulnerability to adverse climate change and what determines it at a point in time?*” Of course; 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 (Kelly and Adger 2000; Deressa et al., 2008b). The environmental attributes 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 several studies conducted to investigate the vulnerability of Ethiopian farmers to poverty and climate change (Dercon, et al., 2005; Skoufias and Quisumbing, 2003; Dercon and Krishnan, 2000, Di Falco *et al.*, 2008 and Deressa et al., 2008a) and suggested policy options to reduce vulnerability. Many of these studies analyzed vulnerability of farmers to climatic extremes and non-climatic shocks. Of particular importance is a study by Deressa *et al.*, (2008a) which adopted an *ex ante* vulnerability assessment approach to assess the vulnerability of Ethiopian farmers to climate extremes. They analysed sensitivity of households to poverty lines due to climatic extremes and concluded that farmers in the kolla areas of the country are highly vulnerable to poverty. However, the study fails to address which types of households are vulnerable and why they are vulnerable in addition to overlooking the impact of gradual climate change. In another study Deressa *et al.*, (2008b) assessed the vulnerability of Ethiopian farmers to climate change using integrated vulnerability assessment approach that rely on constructing vulnerability indicators for seven agriculture-based regional states. Different socioeconomic and biophysical indicators are given arbitrary weights to construct the vulnerability indices. But this study will estimate vulnerability of farmers to climate change at household level and examine factors that are responsible for their vulnerability, including change in climatic elements such as average temperature and precipitation. Moreover, it takes adaptation by farmers as an explanatory variable.

### **1.3 Objectives of the Study**

The general objective of this study is to assess household vulnerability to climate change and outline factors that account for their vulnerability.

*The specific objectives are:-*

1. To analyse the extent of household vulnerability to climate change and extremes;
2. To identify and explain factors behind household vulnerability to climate change;
3. To investigate adaptation strategies of households and their role in reducing vulnerability to climate change.

### **1.4 Scope and Significance 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 Adama and Lume *Woreda* districts of East Shewa *Zone* that are dependent on agriculture as their main source of livelihood. It investigated the impact of climatic extremes and change on household vulnerability to fall below poverty line and the role of adaptation in reducing vulnerability. 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. In addition, such study provides a good basis for further research on the impact of climate change and extremes on total GDP and the general price level in the country, as well as in other countries that are reliant on agriculture.

## **1.5 Organization of the Thesis**

The rest of this thesis is organized as follows. Chapter two treats both theoretical and empirical literature reviews. The third chapter discusses conceptual framework and methodology of the study. Chapter four presents results and finding of the study whereas chapter five concludes and forward policy implications.

## CHAPTER TWO

### REVIEW OF LITERATURE

#### 2.1 Climate change and Agriculture

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 overall impacts of climate change on agriculture are expected to be negative, threatening global food security (IFPRI, 2009).

The impact of climate change on agriculture can be summarized as *direct* and *indirect* impacts. The *direct impacts* are the biological effects on crop yield that stems from rising temperature, change in the magnitude, intensity and spatial variation of rainfall and occurrence of extreme climatic events. The *indirect impacts* are impacts from climate change, such as increased rates of runoff and soil erosion and increased crop losses from insects, diseases, and weeds that could magnify production losses (IFPRI, 2009 and World Bank, 2009). In fact, increased flood and landslide risks from heavy storms and observations that higher temperatures are causing expansion of the over-winter range of some crop pathogens provide early evidence that climate

change is already intensifying these indirect effects (Padgham, 2009). Moreover, climate change will have a direct impact on water availability for irrigated crops. With climate change the water available for precipitation, called Internal Renewal Water (IRW), will be reduced. In addition to precipitation changes, climate change-induced higher temperatures increase the water requirements of crops.

Temperature rise induced by climate change affects crop yield in several ways. For instance, maximum daytime temperature accelerates crop maturity, resulting in reduced grain filling, while higher minimum nighttime temperatures increase respiration losses. In addition to mean temperature rise, episodic heat waves also have a strong negative impact on yields, particularly when they occur during sensitive phenologic stages, such as during reproductive growth causing increased sterility or during seedling emergence, which affects crop stand establishment (Padgham, 2009).

Higher temperature can also affect agriculture through impacts on agricultural water supplies. Even in the absence of reduced mean precipitation, increased water stress could occur where higher temperatures in warm regions increase moisture losses from evapotranspiration. Warming of the atmosphere, changes in rainfall abundance, and frequency and severity of extreme events will exert significant pressures on agricultural water use, with several regions currently experiencing water deficits likely to face further shortages. In dry land areas, marginal cropland could convert to rangeland, and some crop- and rangelands could no longer be suitable for food production (Padgham, 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 rice, wheat, maize, millet and sorghum by 11.9, 29.2, 10, 8.5 and 2.5 percent respectively under the CSIRO scenario. Under the NCAR scenario these figures are 13.6% for rice, 33.5% for wheat, 2.3% for maize, 7% for millet and 1.5% for sorghum. 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). World Bank also projects large negative yield impacts as high as 50% in areas that are highly dependent on agriculture.

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 (Fanzhai et al., 2009, World Bank, 2009). According to the recent global comprehensive estimate for over 100 countries by Cline (2007), global agricultural productivity will be reduced

by 15.9 percent by the 2080s, with developing countries experiencing a disproportionately large decline of 19.7 percent, should measures to abate global warming fail to be carried out.

## **2.2 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.

### **2.2.1 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.

#### **2.2.1.1 Vulnerability as Expected Poverty (VEP)**

In the expected poverty framework, vulnerability of a person is conceived as the prospect of that person becoming poor in the future if currently not poor or the prospect of that person continuing to be poor if currently poor (Deressa et al., 2008a). Thus, 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)<sup>1</sup>.

The merit of this vulnerability measure is that it can be estimated with a single cross section data. However, 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. Also, the measure is unlikely to reflect unexpected large negative shocks if we use the cross section data 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).

#### 2.2.1.2 Vulnerability as a Low Expected Utility (VEU)

Ligon and Schechter (2003) defined vulnerability 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. 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 takes the form:

$$V_i = U_i(Z_{CE}) - EU_i(C_i), \text{ Where } U_i \text{ is a (weakly) concave, strictly increasing function.}$$

---

<sup>1</sup> This method is discussed in detail in sections 3.2 and 3.4 below

However, measuring vulnerability as low expected utility requires specification of a particular utility function which will affect the magnitudes calculated. Moreover, 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  $V_h = 0.25$  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.

#### **2.2.1.3 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.

### 2.2.2 Indicator Method

The indicator method of quantifying vulnerability is based on selecting some indicators from the whole set of potential 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).

Two options are available for calculating the level of vulnerability using this method at any scale. The first is assuming that all indicators of vulnerability have equal importance and thus giving them equal weights (Deressa et al., 2008b). The second method is assigning different weights to avoid the uncertainty of equal weighting given the diversity of indicators used. In line with the second method, many methodological approaches have been suggested to make up for the weight differences of indicators. Even though there are attempts in giving weights, their appropriateness is still dubious; because there is no standard weighting method against which each method is tested for precision. 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.*

On the other hand, 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 above.

### **2.3 Empirical Literature**

Studies on impact of climate change on agriculture at household level are very scanty. Most of them focused on the effect of climatic extremes on farmers and the determinants of farmers' adaptation techniques. For instance 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. They have 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 by Deressa et al. (2008c) 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. 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, agroecological 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. However, this study does not tell us who are exposed to climate change and the extent of impact of climate change.

Deressa et al. (2008b) assessed the vulnerability of Ethiopian farmers to climate change based on integrated vulnerability assessment approach using vulnerability indicators constructed by principal component analysis. The vulnerability indicators consist of the different biophysical and socioeconomic attributes of seven agricultural based regional states. They found that the relatively least developed arid and semi arid regions of Afar and Somali are the most vulnerable to climate change. Tigray and Oromia regions are also vulnerable to climate change. Therefore, investing in the relatively least developed regions of Afar and Somali, in irrigation, early warning systems and production of drought tolerant varieties of crops and livestock can all reduce vulnerability of Ethiopian farmers to climate change. In construction of vulnerability indicator, the different socio economic and biophysical indicators of vulnerability of each region are classified according to IPCC's definition of vulnerability, which consists of adaptive capacity, sensitivity and exposure. But, arbitrary and subjective weights are attached to different indicators,

which threaten the reliability of the indices. Moreover, the scale of analysis was region which makes the indices too crude to launch policies that are useful to reduce vulnerability at local or household level.

A study by Sharon Shewmake (2008) uses farmers' responses to exogenous weather shocks in South Africa's Limpopo River Basin to gauge how farmers opt to respond to future climate change-induced shocks, in particular drought. Droughts are expected to increase in both frequency and intensity as a result of climate change. This study examined the costs of drought today and who it affects the most, in an effort to guide policy options in the future. The study used a combination of descriptive statistics and econometric analysis to approximate the potential impact of droughts on rural South African households. The study also estimated household vulnerability to climate change. After controlling for household heterogeneity using propensity score matching, he noted that there is no statistically significant impact of droughts on income, thus suggesting households have already adapted to living in a drought-prone environment. The types of households that were more vulnerable to climate shocks are analyzed using two measures of vulnerability: the probability of falling below income of 7,800 South African Rand (R), and the probability of income falling below 16,000 R. Residents of the Limpopo province were the least vulnerable under both metrics. Setswana and SeSwati households were more vulnerable than other ethnic groups. Households that do not own livestock and households that rely on rainfed agriculture were also more vulnerable than other households. In this study climate change is proxied by occurrence of drought, which hardly captures all components of climate change. Change in temperature, rainfall, wind and relative humidity are all components of climate change, therefore, ignoring them will lead to biased conclusions about impact of climate change on agricultural households.

A study by 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 2.5<sup>0</sup>C and 5<sup>0</sup>C; 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. In interpreting the result care must be taken as the Ricardian Approach is based on bold assumptions common with neoclassical economists such as constant returns to scale, perfect competition, etc.

Antle et al. (2003), developed economic measures of vulnerability to climate change with and without adaptation in the agricultural production systems of the Northern Plains Region of United States. They have implemented these measures using coupled, site specific ecosystem and economic simulation models. According to them this modeling approach has two key features

needed to study the response of agricultural production systems to climate change: it represents adaptation as an endogenous, non marginal response to climate change; and it provides the capability to represent the spatial variability in bio-physical and economic conditions that interact with adaptive responses. The result showed that the most adverse impact of climate change on net returns distribution are felt in the regions with poorest resource endowments and when mitigating effects of CO<sub>2</sub> fertilization and adaptation are absent. They also found that relative and absolute measures of vulnerability depend on complex interactions between climate change, CO<sub>2</sub> level, adaptation and economic conditions such as relative output prices. Vulnerability measured with respect to an absolute threshold is inversely related to resource endowments in all cases they investigated.

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.

Finally, they found that changes in rainfall patterns in both seasons increase the probability of adoption of yield-related adaptation strategies. And this adoption, in turn, is positively correlated with productivity. Extension services (both external and farmer to farmer) and access to credit affect adaptation positively and significantly. Farm households with larger access to social capital are more likely to adopt yield-related adaptation strategies. To them, this adoption seems also very important for risk management at the farm level. They found, indeed, that adopting adaptation strategies reduces crop variability and the risk of crop failure. But they did not show how climate change and adaptation affect household probability to fall in to poverty in the future.

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.

There are various studies conducted using vulnerability as expected poverty method. For example, using cross-sectional survey data in Pakistan, Jamal (2008) 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.

## 2.4 Summary of the Literature Review

Household vulnerability assessments have been approached in various ways in the literature. Most studies so far focused on the assessment of household vulnerability to poverty, instead of household vulnerability to climate change. Analysis of household susceptibility to *poverty line* remained central figure in most of them. As the threshold used for vulnerability assessment (usually poverty line) changes household vulnerability also changes. Similarly, vulnerability to climate change can be analyzed in similar ways to assessment of household vulnerability to poverty since climate change is one of the correlates of poverty. At a point in time there are factors that are responsible for a household to be in a given state. Like any other variables climate change is one of these correlates of poverty; and identifying the coefficient of climate change in vulnerability is important.

With regard to the methodologies that have been followed in the literature, they mostly relied on specification of one or more assumptions. In some of them we have to assume the data generating process of consumption; while in others it is a must to assume certain functional form for household utility. The reliability of these assumptions depends on the nature of the data and the environment in which the unit of analysis resides. Therefore, the final estimates that will be obtained can be best approximation of reality or not depending on the strength of these assumptions. Selection of particular estimation strategy should, therefore, be done with careful consideration of data and setting for which vulnerability is estimated.

The data used for vulnerability assessments are mostly cross sectional, mainly due to high cost related to panel data. The use of panel data is useful in identifying unobservable household characteristics that result in variation in consumption across households. With cross sectional data we can only observe variation in consumption at a point in time. This property of cross

sectional data is useful for this study, because it is assumed that climate change has significant effect on household consumption; differences in climatic condition and extremes (observable) across households is going to give us information on how households are affected by climatic elements and extremes. If the set of variables that are included as explanatory variables fail to explain variation in consumption, and then consumption of the household is uncontrollable, indicating the presence of risk. The estimate of vulnerability can further be made robust by including non climatic shocks as explanatory variables so that the error term can best reflect households' exposure to risks.

Estimation of vulnerability of households in VEP framework mainly depends on the disturbance term of household consumption function. Household consumption is a function of household characteristics and the structure of the economy captured by  $\beta$ . Other determinants of consumption of a household are shocks (both covariate and idiosyncratic) that cause consumption volatility and thus their inclusion in to the consumption function enable us to estimate vulnerability. The disturbance term is used as an indicator for the presence of risk. Large error term in household consumption function means there is considerable variation in household consumption that could not be attributed to certain household characteristics. As a result the household faces risk that will erode its welfare in the future.

The empirical literature on climate vulnerability is scanty and very recent. Although conclusions differ depending on the questions asked and methodologies used, some of the major findings of recent studies are summarized below.

- Both poor and relatively affluent households are vulnerable to aggregate and idiosyncratic shocks such as weather shock and illness respectively;

- The ability to cope with climate shocks is generally limited due to limited asset endowments, consumption insurance or risk sharing and credit constraints;
  - Adaptation capacity is likely to differ among households because of differences in assets, such as livestock, land etc. As a result, the poor (mostly asset poor) are more likely to be impacted by climate change;
  - Policy interventions that are based on poverty profile of households are less likely to be effective, because they ignore the current non-poor but which in the future become poor.
- So there is a case for more effective risk reducing, mitigating and coping interventions alongside income-augmenting policies.

**CHAPTER THREE**  
**CONCEPTUAL FRAMEWORK AND METHODOLOGY OF THE**  
**STUDY**

**3.1 Conceptual Framework**

The conceptual framework for this study depends on the IPCC’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 1 below.

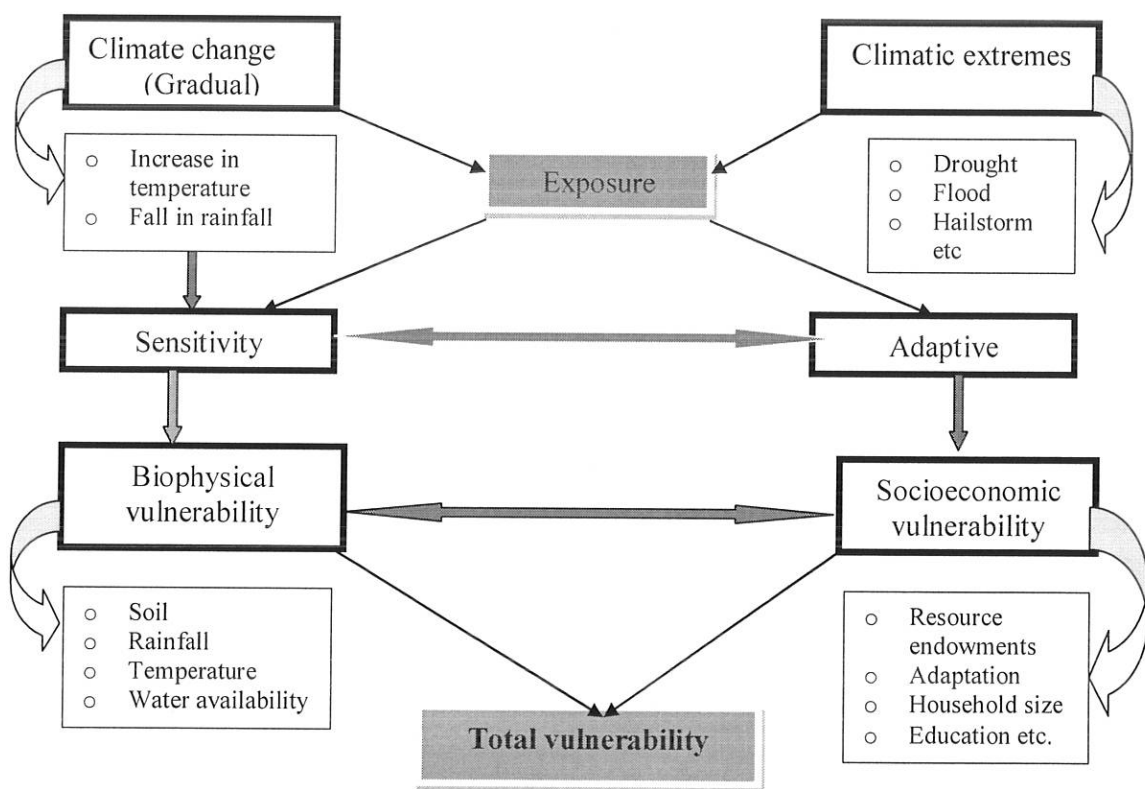


Figure 1 Conceptual Framework of Vulnerability Assessment

As Figure 1, (adapted from Deressa et al., 2008b) shows farmers are exposed to both gradual climate change (mainly changes in temperature and precipitation) and extreme climate conditions (mainly drought and flood). Exposure affects sensitivity, which means that exposure to higher frequencies and intensities of climatic risk highly affects outcome (e.g., yield, income, health). Exposure is also linked to adaptive capacity. For instance, higher adaptive capacity reduces the potential damage from higher exposure. Sensitivity and adaptive capacity are also linked: Given a fixed level of exposure, the adaptive capacity influences the level of sensitivity. Adaptive capacity reduces socioeconomic vulnerability, vulnerability that results from the socioeconomic and political status of an individual or household. Individuals in a community often vary in terms of education, gender, wealth, health status, access to credit, access to information, technology, social, environmental and physical capital; political power, and so on. These variations are responsible for the variations in vulnerability levels. On the other hand, sensitivity of a system to environmental stresses increases its vulnerability, 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 sensitivity of the system to the change and its adaptive capacity that are, in turn, a function of other biophysical, climatic and household characteristics.

### **3.2 Analytical Framework**

Vulnerability is defined within the framework of poverty eradication, as the *ex-ante* risk that a household will, if currently non-poor, fall below the poverty line, or if currently poor, will remain poor. Certainly this is not the only definition possible. In fact, in much of the recent work on the vulnerability of different segments within a population (see for instance, 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 we will see how climatic shocks and change, soil, environmental and household characteristics affect the probability of a household to become poor, or remain poor if it is already poor.

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  $t+1$ :

$$V_{ht} = Pr (C_{h,t+1} \leq Z) \dots\dots\dots (3.1)$$

Where  $C_{h,t+1}$  is the household's per-capita consumption level at time  $t+1$  and  $Z$  is the appropriate consumption poverty line. Note that the level of vulnerability at time  $t$  is defined in terms of the household's consumption prospects at time  $t+1$ .

Equation (3.1) is important because it reflects an important distinction between the notion of vulnerability and the concept of poverty. *Vulnerability* is a forward looking or *ex-ante* measure of a household's well-being, whereas *poverty* is an *ex-post* measure of a household's well-being (or lack thereof). This implies that while the poverty status of a household is concurrently observable i.e. with the right data we can make statements about whether or not a household is currently poor. But for the level of vulnerability this is not the case. We can estimate or make inferences about whether a household is currently vulnerable to future poverty, but we can never directly observe a household's current vulnerability level (Chaudhuri et al., 2003).

An assessment of vulnerability is, therefore, innately a more difficult task than assessing who is poor and who is not. To assess a household's vulnerability to poverty we need to make inferences about its future consumption prospects. And in order to do that, we need a framework for

thinking explicitly about both the inter-temporal aspects and cross-sectional determinants of consumption patterns at the household level.

Literature suggests that a household's consumption in any period will, in general, depend on a number of factors. Among them its wealth, its current income, its expectations of future income (i.e., lifetime prospects), and the uncertainty it faces regarding its future income and its ability to smooth consumption in the face of various income shocks. Each of these will in turn depend on a variety of household characteristics, those that are observable and possibly some that are not, as well as a number of features of the aggregate environment (macroeconomic and socio-political) in which the household finds itself. Chaudhuri et al. (2002), at a general conceptual level, suggested the following reduced form expression for consumption:

$$C_{ht} = C (X_h, \beta_t, \alpha_h, e_{ht}) \dots\dots\dots (3.2)$$

Where  $X_h$  represents a bundle of observable household characteristics,  $\beta_t$  is a vector of parameters describing the state of the economy at time  $t$ , and  $\alpha_h$  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. Substituting from (3.2) into (3.1) we can rewrite the expression for the vulnerability level of a household as:

$$V_{ht} = Pr (C_{h,t+1} = C (X_h, \beta_{t+1}, \alpha_h, e_{h,t+1}) \leq Z / X_h, \beta_t, \alpha_h, e_{ht}) \dots\dots\dots (3.3)$$

The expression above makes clear that a household's vulnerability level derives from the stochastic properties of the inter-temporal consumption stream it faces, and these in turn depend on a number of household characteristics and characteristics of the environment in which it

operates. According to Chaudhuri et al. (2002), at a conceptual level, the 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,  $\beta_t$ .

In practice, data constraints will usually not permit estimation of vulnerability at the level of generality embodied in expression (3.3). Nevertheless, the formulation is useful in providing a basis for thinking through the possible implications of the various restrictions that will need to be imposed in any attempt to estimate vulnerability with the sorts of data that are usually available.

As discussed by the IPCC (2001), systems with relatively poor endowments of capital (human, social, physical, natural) may be less able to adapt to climate change, and thus more vulnerable, than systems with relatively better endowments. This analytical framework can be used to investigate the following four specific hypotheses:

*Hypothesis 1: Adverse changes in consumption distributions are related to resource endowments and adaptation.* Using the statistical distribution of the consumption function it is possible to characterize the economic status of a household in an area. Farm income (consumption) of the resource poor producers should be lower than resource rich farmers. It would also be expected that these effects will be magnified when farmers do not adapt to climate change, because other things remaining constant, if there is adverse climate change, a household would suffer a substantial loss without adaptation.

*Hypothesis 2: Vulnerability is inversely related to adaptation to climate change.* The relationship between vulnerability and adaptation is a direct consequence of the definition of vulnerability presented above. A loss from an adverse climate change without adaptation will be greater than or equal to a loss with adaptation if the adaptation method/s is effective. Measuring vulnerability as expected poverty, adaptation will reduce a system's probability of falling below poverty line. But adaptation depends on resource endowments which affect the level of vulnerability as in hypothesis 1.

*Hypothesis 3: Adverse climate change (increase in temperature and decrease in precipitation) are directly related to vulnerability.* Specifically this means higher temperature increases the vulnerability of farmers and lower level of precipitation decreases vulnerability of farmers. This is based on the assumptions that increase in temperature and fall in precipitation adversely affect crop growth, which directly affect household welfare.

*Hypothesis 4: Occurrence of climatic extremes such as drought and flood are directly related to household vulnerability.* Too little precipitation and excessive rainfall are both damaging for agricultural production and therefore, they increase household vulnerability.

### 3.3 Empirical Model and Sources of Data

#### 3.3.1 Empirical Model

Among the above discussed approaches to measure vulnerability, the probability of a household to fall below a given consumption level due to climate change will be 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.

Following Chaudhuri et al. (2002) the stochastic process generating the consumption of a household  $h$  is given by:

$$\ln C_h = X_h \beta + e_h \quad (3.4)$$

Where  $C_h$  is per capita consumption expenditure,  $X_h$  represents a vector of observable household characteristics such as household size, location, educational attainment of the household head, land size, non farm income etc., climatic factors and shocks such as temperature, precipitation, drought, flood and adaptation strategies,  $\beta$  is a vector of parameters to be estimated and  $e_h$  is a mean zero disturbance term.

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. Cross section consumption variance is estimated from the error term as follows.

Assume that the variance of  $e_h$  is given by:

$$\sigma_{e,h} = X_h \theta \quad (3.5)$$

$\beta$  and  $\theta$  are parameter estimates from a three-step Feasible Generalized Least Squares (FGLS) procedure suggested by Amemiya (1977). First, equation (3.4) is estimated using an Ordinary Least Square (OLS) procedure. The residuals  $e_h$  from equation (3.4) are then regressed on  $X_h$  using OLS as follows:

$$e_{OLS,h}^2 = X_h \theta + \eta_h \quad (3.6)$$

The predicted values  $X_h \hat{\theta}$  from this auxiliary regression are then used to transform equation (3.6).

$$\frac{e_{OLS,h}^2}{X_h \hat{\theta}} = \left[ \frac{X_h}{X_h \hat{\theta}} \right] \theta + \frac{\eta_h}{X_h \hat{\theta}} \quad (3.7)$$

This transformed equation is estimated using OLS to obtain an asymptotically efficient FGLS estimate ( $\theta_{FGLS}$ ). It can be shown that ( $\theta_{FGLS}$ ) is a consistent estimate of  $\sigma_{e,h}^2$  which is the variance of the idiosyncratic component of the household consumption. Equation (3.4) is also transformed with the standard error of ( $\theta_{FGLS}$ ).

$$\hat{\sigma}_{e,h} = \sqrt{X_h \theta_{FGLS}} \quad (3.8)$$

$$\frac{\ln C_h}{\hat{\sigma}_{e,h}} = \left( \frac{X_h}{\hat{\sigma}_{e,h}} \right) \beta + \frac{e_h}{\hat{\sigma}_{e,h}} \quad (3.9)$$

OLS estimation of equation (3.9) yields a consistent and asymptotically efficient estimate of  $\beta$ . The estimated  $\beta_{FGLS}$  and  $\theta_{FGLS}$  symbolize expected log consumption and variance of log consumption respectively. The expected log of consumption and variance of log consumption for each household  $h$  are, respectively, estimated as:

$$\widehat{E}[\ln C_h / X_h] = X_h \widehat{\beta} \quad (3.10)$$

$$\widehat{V}[\ln C_h / X_h] = \widehat{\sigma}_{e,h}^2 = X_h \widehat{\theta} \quad (3.11)$$

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

$$\widehat{V}_h = \widehat{Pr}(\ln C_h < \ln Z / X_h) = \Phi \left( \frac{\ln Z - X_h \widehat{\beta}}{\sqrt{X_h \widehat{\theta}}} \right) \quad (3.12)$$

Where  $\ln Z$  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 as 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 (3.12) 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. (1999) 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.

Given that vulnerability of households is a bounded variable between 0 and 1, in order to use the OLS regression it needs to be transformed to a positive unbounded variable (Balint, 2003, Mahlet, 2007). Following Balint (2004) one transformation is to calculate the variable  $C$ , where

$$U = Vh / (1 - Vh)$$

The problem with this transformation is related to the fact that  $U$  is not normally distributed, since most of the values are concentrated between 0.9 and 1. In order to smooth this problem, instead the natural logarithm of  $U$  is used. The final formula for the dependant thus becomes;

$$\ln U = \ln \left[ \frac{Vh}{1 - Vh} \right]$$

Once dependent variable is defined like this, the explanatory variables are in levels, except the estimated value of assets other than land which in log form. Therefore, the interpretation of marginal effect of independent variables is in percentage form since the model is semi log.

In this study, international poverty line of USD 1 is used. Normally, national poverty line is important because it reflects local conditions and serves as a basis of development planning and policy making. However, the recent national poverty line of ETB 1075 per year per adult equivalent that was established in 2004/05 by MoFED cannot reflect the current market price of goods and services. Moreover, the study intends to estimate the impact of climate change on households' vulnerability, thus use of USD 1 as a threshold is not serious limitation.

Accordingly, international poverty line of USD1 is equivalent to ETB 4330.56 per year per adult equivalent using average exchange rate of 2009 (survey year).

### **3.3.2 Data Sources and Sampling Technique**

The data used in this study is obtained from household survey of production period 2009 in rural *Kebeles* of Adama and Lume *Woredas* in East Shewa zone. The sample *Kebeles* are purposely selected to include different attributes in the area. These attributes include average rainfall, rainfall variability, food aid dependent population due to droughts and rainfall fluctuation, irrigation activity, availability of meteorological data etc. the survey covers 10 *Kebeles* from two *Woredas*. By considering the socioeconomic and environmental conditions 8 *Kebeles* from Adama *Woreda* and 2 *Kebeles* from Lume *Woreda* were selected for this study. The detail of the *Kebeles* is provided in table 1.

Once the *Kebeles* are identified households are selected based on the total households in the *Kebele*. Sample households are selected using systematic sampling method by picking every N<sup>th</sup> household starting from a random start. For this purpose list of households obtained from respective *Kebele* administration or nearest DA office was used as sampling frame. A structured questionnaire was used to conduct the survey, and filled by trained enumerators and the researcher himself. The survey covers a total of 230 farming households out of which 222 are free of errors and omissions, thus used in the analysis. (The survey questionnaire is found in appendix II). Attempts are made to pick households proportionally from their respective *Kebeles*, but in *kebeles* like Kobo Luto and Jogo Gudedo households are not taken proportionally due to inaccessibility of households and time shortage to make replacement.

Table 1 Survey *Woredas* and *Kebeles*

<i>Woreda</i>	<i>Kebele</i>	Total household in the <i>Kebele</i>	Household covered	Nearest meteorological station	
				Name	Distance (km)
Adama	Geldaya G.	508	50	Welenchiti	15
	Kilinto	301	28	Adama	7
	Sole and sakakalo	141	16	Adama	5
	Kechema	481	17	Adama	7
	Kobo Luto	440	16	Koka	2
	Kuriftu	80	13	Adama	10
	Batu Dagaga	636	22	Sodere	4
	Wake	151	15	Sodere	4
Lume	Tadde	544	30	Modjo	5
	Jogo Gudedo	495	23	Modjo	11
<b>Total</b>			<b>230</b>		

The data set collected includes household characteristics, incidence of different climatic and other shocks, asset and livestock ownership, access to irrigation water and credit, non farm income, consumption expenditure, farm output, perception about climate change, adaptation options and social and physical capital. Consumption expenditure survey covers both food and non food expenditure. To reduce error, consumption items are classified as items more frequently purchased and less frequently purchased, so that respondents can easily remember them.

Secondary information and data used in the analysis are mean monthly maximum and minimum temperature and mean monthly rainfall values and type of soils. Data on rainfall and temperature was obtained from Adama meteorological branch office that has 139 meteorological stations

under it. Average monthly minimum and maximum temperature and rainfall data is available since 1978 for many of these stations and since 1988 for some of them. Mean monthly maximum and minimum temperature and monthly rainfall data of 5 stations that coincides with the above sample *Kebeles* was obtained. These are Adama, Sodere, Koka dam, Welenchiti and Modjo stations.

## CHAPTER FOUR

### RESULTS AND DISCUSSIONS

#### 4.1 The Study Area

This study has focused on Adama and Lume *Woredas* that are among the 13 administrative units in East Shewa Zone. Adama is found between 8°N and 38°E. The *Woreda* covers a total area of 960,020 hectares. The topography of the *Woreda* is characterized by undulating plains, of which 50% of the *Woreda* is plain, 35% is mountainous and 15% is gorgeous. The lowest altitude is 1450 meters above sea level and the highest is 2300 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 850mm, the maximum rainfall is 1050 and the minimum is 650mm. Average monthly temperature is 24°C and minimum and maximum annual temperature are 15°C and 33°C respectively (ZoFED, 2009).

On the other hand, 30% of Lume *Woreda* is highland, 45% is mid highland and 25% is low land. The altitude ranges between 1500 and 2300 meters above sea level. Mean annual rainfall falls between 500mm and 1200mm. Mean annual minimum and maximum temperature are 10°C and 20°C respectively. The topography of the *Woreda* is mostly plain (60%) followed by mountainous (33%) and gorgeous (7%). The total area of Lume *Woreda* is 75,220 hectares. These two *Woredas* together have total area of 171,240 hectares which accounts for 16 percent of the total area of East Shewa zone (WoFED, 2009).

## 4.2 Descriptive statistics

### 4.2.1 Characteristics of the sample population

The survey covers a total of 222 households that are engaged in crop production and rearing livestock as their primary activity. Female headed households comprise 15 percent (33) of the total sample. The average family size in the sample is 5.91 persons per household which is comparable with regional level figure of 5 persons per household and more particularly closer to East Shewa zone's figures of 5.13 persons per household. Adult equivalent<sup>2</sup> scale for average family size is 5.09. Dependency ratio is 0.85 for the households showing presence of small number of dependent members in the households. Most of the dependents are children less than 14 years of age. Average household head age in the sample is 43.88 years and an average year of schooling completed by household heads is 3.56 years.

The sample households mostly keep animals like oxen, cows, sheep, goat, donkey, poultry etc. Average livestock holding per head is 6.66 TLU<sup>3</sup>. Ox is a more important livestock held by many for draught power followed by donkey for transportation. Most households also keep poultry, sheep and goat for market 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 assets owned by households in the sample is ETB 19,351.68 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 1.83 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

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<sup>2</sup> Adult Equivalent is estimated as per scale given by Krishnan and Dercon (1985). (See appendix).

<sup>3</sup> 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).

and the average holding per household is, however, very small than the non irrigable land. About 12 percent of the households have access to irrigation water which lies along the Awash River. Irrigated land holding is 0.11 hectare per household. In the survey area crop production is conducted only during the main rainy season that runs from May to September/November. All the sampled population produces once in a year, except for those who have access to irrigation.

The major soil type in the study area is sandy loam which covers 50 percent of the *Woreda*, and more than 70 percent of the study area. Vertisols and Andosols also cover a significant portion of the land, 7 and 23 percent, respectively, of the study area. All these types of soil share common characteristics in that they have low moisture retaining capacity but highly productive when there are adequate moisture. The real threat to this is, however, the increasing soil degradation and erosion due to the looseness of the soils that allows them to easily taken away by erosion forces.

Differential access to resources and services is another aspect of the study area. Access to social utilities and infrastructure is relatively better in the study area. On average all households have to travel 8.34 km (two ways) on average to get all weather road and 12.29 km to get services of secondary schooling, banking, hospital daily input and output market. 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 less than a kilometer to get extension services. Variation in use of extension service is, however, observed across households. On average all households have made 7.55 extension contacts during the 2009 (2001/02 E.C) production season. The maximum contact is observed to be 52 times per season and the minimum is 0. In terms of input use farmers in the study area used 349.62kg of fertilizer (DAP and urea) and 1.61 liters of herbicide and pesticide per head.

Access to credit is another important aspect in rural livelihood improvement because it is an intermediate income that increases productivity and generates income. According to the survey during the 2009 production season 28.83 percent of the farmers have access to credit facility. Non-farm income is also important for rural livelihood both during crop failure and good harvest. In our case 35 percent of the households have one or more non-farm income that is at least ETB 1000 per year. The sources of their income are remittances, sale of tree, charcoal, self employment and petty trade among others. Most non-farm income earners derive their income from sale of charcoal (25%), land rental income (14.6%), petty trade (11%), self employment (10.4%), aid or donation (7.9%). For a comprehensive review, a summary of the major variables is provided in table 2 below.

Table 2 Descriptive Statistics for Dependent and Independent Variables

Variable	Mean	Standard .Dev	Description
<b>Vulnerability (VIPL1)</b>	<b>0.56</b>	<b>0.12</b>	<b>Estimated according to equation 3.12 (<i>dependent</i>)</b>
Education of head	3.56	4.14	Years of schooling completed by head
Age of household head	43.88	13.11	Age in years (proxy for experience)
Education of spouse	2.57	3.72	Years of schooling completed by spouse
Highest education	7.39	3.61	Highest years of education in the household
Family size	5.91	2.39	Number of household members
Dependency ratio	0.85	0.67	Number of dependents divided by independents
Gender of head	0.85	0.36	Dummy, 1 if male 0 if female
Land size	1.83	1.28	Size of arable land owned in hectare
Other asset value	19351.68	78,680	Estimated value of asset in Birr
Livestock size	6.66	6.39	Livestock owned by the household in TLU
Non-farm income	0.35	0.48	Dummy, 1 if the household has non-farm income above ETB 1000 per year, 0 otherwise.
Access to credit	0.29	0.45	Dummy, 1 if yes 0 otherwise
Irrigation size	0.11	0.34	irrigated land size owned by the household in hectare
Vertisols soil	0.07	0.27	Dummy, 1 if soil in their farm is vertisols, 0 otherwise
Rainfall change	-40.24	26.97	Change of rainfall from the baseline <sup>4</sup>
Max temperature	1.07	0.63	Change of max temperature from baseline
Min temperature	0.90	0.60	Change of min. temperature from baseline
Drought	3.09	0.70	Number of drought suffered during the last 20 years
Adaptation	0.58	0.49	Dummy, 1 if the household adapted, 0 otherwise
<i>Idder</i>	0.91	0.29	Dummy, 1 if the household is member of <i>Iddir</i> , 0 otherwise
<i>Ekkub</i>	0.20	0.40	Dummy, 1 if the household is member of <i>equb</i> , 0 otherwise
Relatives	25.07	26.42	Number of close relatives of the household in the kebele
Road	0.60	0.49	Dummy, 1 if the household is found in 0-4 km distance from all weather road, 0 otherwise
Extension contacts	7.56	9.37	Number of extension contacts during the last 12 months.
Fertilizer	349.62	260.32	Quantity of fertilizers (kg) used in the production
Herbicide	1.61	1.64	Quantity of herbicide and pesticide (liter) used
Input price rise	0.68	.47	Dummy, 1 if reported in input price rise, 0 otherwise
Death of head	0.07	0.25	Dummy, 1 if the household died, 0 otherwise

<sup>4</sup> The baseline is the long run average of temperature and rainfall values from 1978-2009.

Market dummy	0.41	0.49	Dummy, 1 if the household travels 0-4 km to get market facility, 0 otherwise
Status	0.15	0.36	Dummy, 1 if the household has position in the PA administration, 0 otherwise
Distance to input shop	13.55	18.74	Distance in km to input shop from the household home

The survey also covers whether a household suffers *non climatic* shocks or not, accordingly the most frequently reported shocks are input price rise beyond their expectation (68%), pest and disease (33%), output price fall (32%) and animal disease (31%). According to the survey these shocks have resulted in loss of household welfare. For instance, 65 percent of households that reported input price rise have claimed that it has affected the household very negatively, and 30 percent affected negatively while 5 percent of them are not affected by the shock at all.

Table 3 Major Non Climatic Shocks Suffered by Households

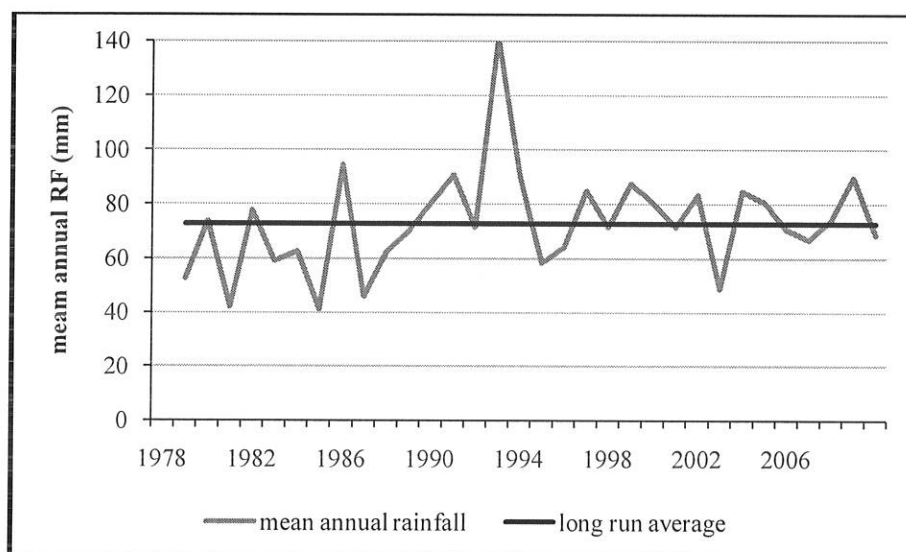
Shocks Name	Frequency	Percent
Death of household head	15	6.76
Illness of household head	25	14.97
Death of household member	15	8.98
Death of draught animal	59	26.58
Animal disease	51	30.54
Theft of livestock	15	8.98
Theft of other asset	8	4.79
Pest and disease	74	33.00
Output price fall	53	31.93
Input price rise	151	68.00
Fire outbreak	6	3.61
Contract dispute	2	1.20
Source: estimated from survey data		

### 4.3 Climate of the study Area

#### *Rainfall*

The study area is mostly Kolla (70%) and the rest (30%) is Woina Dega. The rainfall pattern of the study area shows high variability. Variance of Long run average annual rainfall is 365, indicating high variability from year to year. Figure 2 shows deviation of mean annual rainfall from the long run average. The long run average rainfall computed for the period 1978 to 2009 is 72.93mm. As it can be seen from figure 2 annual mean rainfall fluctuates around this value.

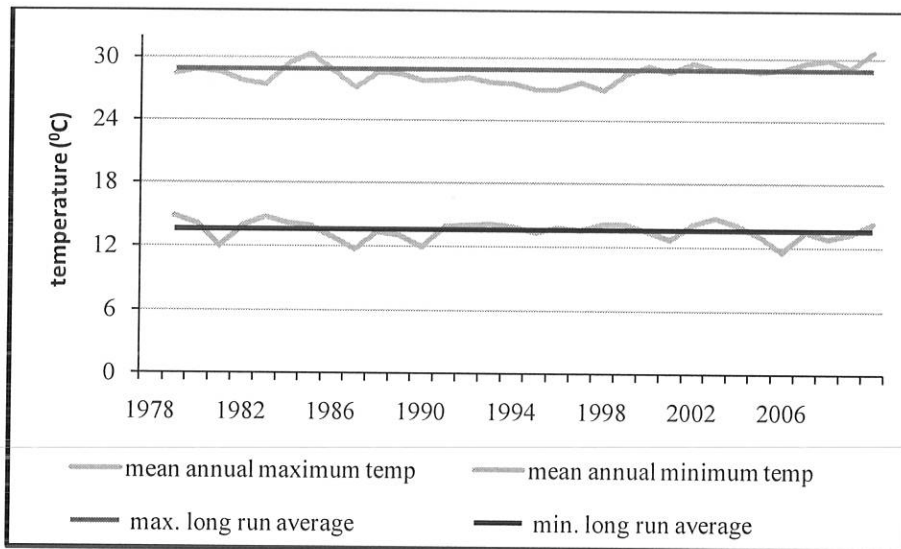
Figure 2 Mean Annual Rainfall Values for Selected Stations in Adama and Lume *Woreda*.



#### *Temperature*

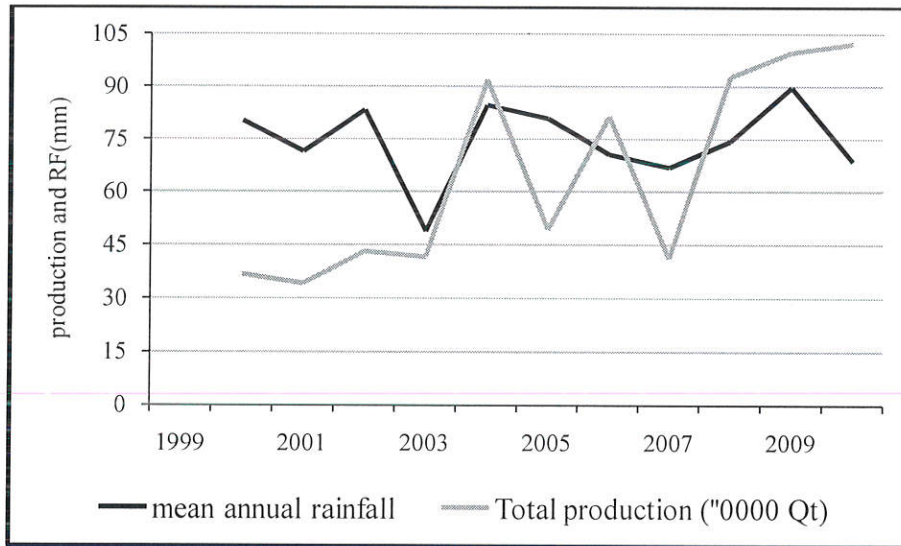
In the study area long run average maximum and minimum temperature are 28.86 and 13.59 degree Celsius, respectively. The variability of temperature is 0.935 and 0.726 degree Celsius, respectively. The deviation of maximum and minimum temperature from long run average is not as high as that of rainfall, but there is fluctuations around long run average that affect crop production. See figure 3 below.

Figure 3 Mean Maximum and Minimum Temperature and Long Run Average



It will be worthwhile to add here the pattern of relationship between total crop production and the mean annual rainfall in the study area. Figure 4 gives this relationship for the last decade in Adama *Woreda*. As hypothesized in this study, the relationship between rainfall and annual crop production in the area follow each other. When there is a fall in rainfall total crop production also falls. This could be a possible place to start analysis of relationship between household welfare and rainfall.

Figure 4 Relationships between Total Crop Produced and Rainfall for the Last Decade in Adama *woreda* (1999-2009)

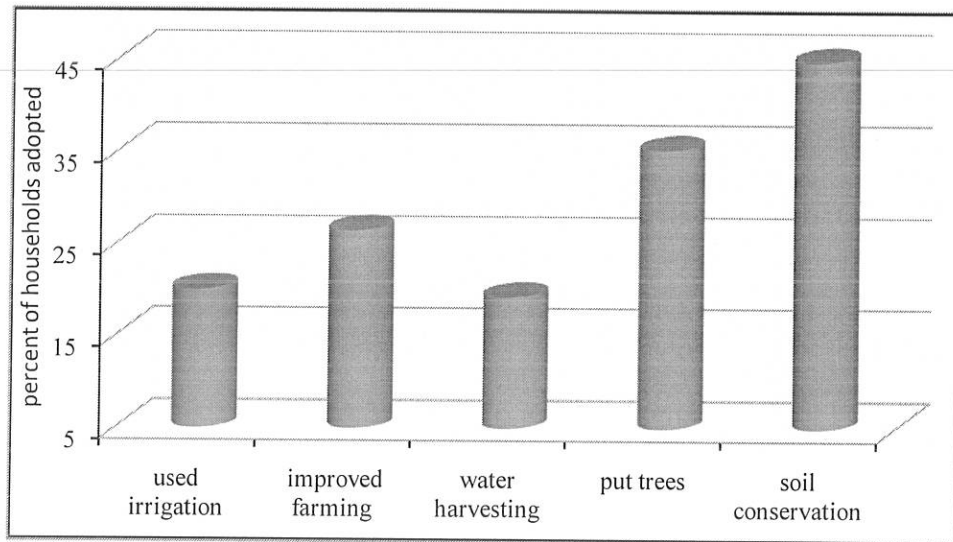


The survey instrument was also designed to track farmers' perception and understanding on climate change, their adaptation and coping mechanisms. They are asked whether they have observed changes in mean temperature, rainfall, frequency of droughts; flood etc. over the last 20 years. About 94%, 95% and 75% percent of them have indeed observed change in temperature, rainfall and frequency of droughts over the last 20 years. Moreover, about 87%, 89% and 75% of them reported, respectively temperature has increased, rainfall has decreased and frequency of drought has increased. These indicate that the farmers' perception is consistent with the meteorological stations data. The farmers also reported that these changes have affected their welfare negatively, through crop loss, livestock loss, health loss and other asset loss.

The adaptation techniques widely practiced by household to long term shifts in climatic elements are depicted in figure 5 below. Adoption of soil conservation techniques is the most widely practiced among the households, adopted by 45 percent of households followed by planting trees (35%) and adoption of improved farming techniques that include early or late planting and

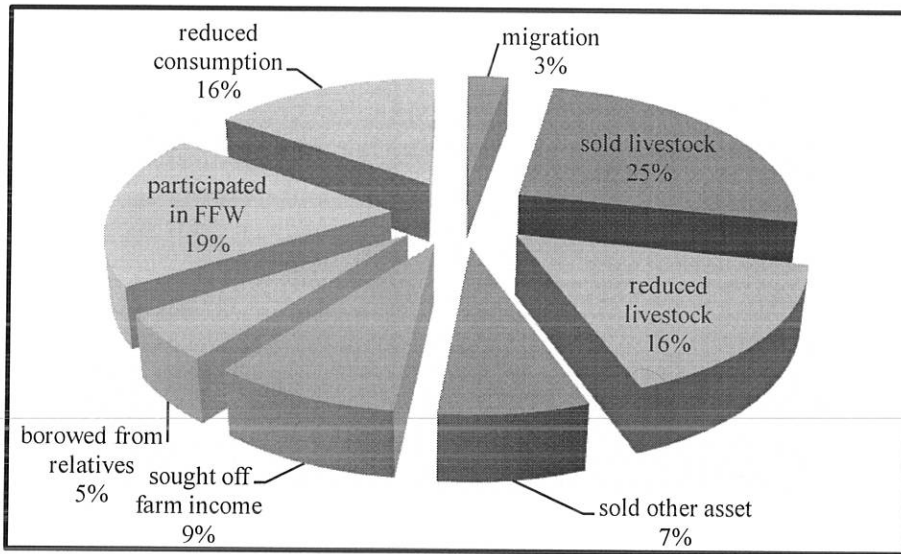
improved seed application. We should, however, note here that farmers practice soil conservation or plant trees because of government or NGO initiatives and profit motive not only for ameliorating impact of climate change. When faced with bad harvest due to rainfall shortage their main coping mechanism is selling of livestock and search for off farm income earning opportunities.

Figure 5 Adaptation Strategies and Practices of Households



Coping mechanism are more common during shortage of rainfall and drought. They are direct responses to climate change than adaptation. Selling livestock is the major coping mechanism among the households (35%), participation in food for work and searching non farm income are also widely practiced.

Figure 6 Coping Strategies Of Households.



#### 4.4 Consumption Expenditure and Estimates of Vulnerability

The survey indicates that the average consumption expenditure of households is ETB 19,843 per year<sup>5</sup>. This equals ETB 2981 per year per adult equivalent, which means \$0.6 per day per adult equivalent. Food and non food expenditure accounts for about 74 and 26 percent respectively, of the total expenditure. Increased (higher) proportion of non food expenditure indicates rising living standard of households. When disaggregated for kolla and Woina Dega agroecologies, consumption expenditure of households in Kolla areas have higher average expenditure (ETB 20,705) relative to farmers in Woina Dega areas (ETB 17,847). But consumption variance in kolla areas is higher than the consumption variance in Woina Dega areas indicating less variability of consumption in Woina Dega than in Kolla areas. However, the figures provided here should be interpreted with the possible bias in consumption measurement especially in such case where consumption data is based on single-visit interview. On the other hand, the share of

<sup>5</sup> This consumption expenditure is compared against with one of the most recent survey of consumption in neighbouring woreda of Adami Tullu by BDS-CDR; and the two figures are fairly comparable.

non-food expenditure in total expenditure is higher in Kolla (35%) than in Woina Dega agroecology (32%).

Table 4 Average Annual Household Consumption Expenditure (ETB) (2009 Price)

Agroecology	Food expenditure	Non food Expenditure	Total Expenditure	Share of non food expenditure	Standard deviation of consumption
Kolla	16,038	4667	20,706	34.90	10869.38
W. Dega	11,548	6300	17,848	32.18	10764.79
Total	14,683	5160	19,843	25.58	10851.77

#### 4.4.1 Incidence of Vulnerability and Poverty

The estimated head count vulnerability among the households shows 68.02 percent of them have 50 percent or more probability to become poor next year using USD1 per day per adult equivalent as poverty line<sup>6</sup>. On the other hand the incidence of poverty among the households is 62.16 percent using the same USD1 as a benchmark. These show there are households that are regarded as being non poor but have high probability to become poor next year. These estimates, however, are highly sensitive to poverty line, for instance if poverty line is fixed at USD0.6, households that are vulnerable to poverty become only 4 percent while those regarded as poor become 14 percent.

Vulnerability of farmers (as derived from variance of consumption) varies between Kolla and Woina Dega agroecologies. In Kolla the extent of vulnerability and poverty are 63.87 and 58.71 percent respectively, whereas in Woina Dega areas these figures are 77.61 and 70.15 percent respectively. Table 5 provides estimates of vulnerability and consumption poverty for

<sup>6</sup> One dollar poverty line is converted to ETB using daily average of 2009 inter-bank exchange rate of USD to ETB.

households. The vulnerability rate of 68.02 percent is more than the estimated head count poverty level of 62.16 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 1.09 (more than 1) for the total sample. Kolla and Woina Dega area ratios are 1.09 and 1.11 respectively.

Table 5 Estimates of Vulnerability to Poverty

<b>Estimates of Vulnerability to Poverty</b>			
<i>[households with vulnerability &gt;0.5]</i>			
Agroecology	Percentage of population		vulnerability poverty ratio
	vulnerable	poor	
Kolla	63.87	58.71	1.09
W. Dega	77.61	70.15	1.11
Total	68.02	62.16	1.09
Source: Estimated from survey data			

Relative vulnerability is also used as another measure of incidence of vulnerability among households. Relative vulnerability uses incidence of poverty among the households as the threshold above which household is regarded as vulnerable. Accordingly, 29.28 percent of the households have more than 62.16 percent (headcount poverty incidence) probability to become poor next year. As table 6 shows relative vulnerability is high in Woina Dega than in Kolla areas.

Table 6 Estimates of Relative Vulnerability to Poverty

<b>ESTIMATES OF VULNERABILITY TO POVERTY</b>			
<i>[population relatively vulnerable vul.&gt;0.6216]</i>			
	percentage of population		vulnerability poverty ratio
	vulnerable	poor	
Kolla	27.74	58.71	0.46
W. Dega	32.84	70.15	0.34
Total	29.28	62.16	0.42
source: estimated from survey data			

Table 7 gives a cross distribution of the percentage of vulnerable and poor households. It is evident from the table that a significant percentage of the non-poor are vulnerable to poverty next time. About 42 percent of the non-poor households are estimated as being vulnerable to poverty. Obviously a majority of the poor (84%) are also vulnerable to poverty. This suggests that programs that aim to reduce vulnerability should be designed and targeted differently from those aimed at poverty alleviation.

Table 7 Cross-Distribution of Vulnerability and Poverty

<b>CROSS-DISTRIBUTION OF VULNERABILITY AND POVERTY</b>			
Poverty status	vulnerability status		Total
	Vulnerable	Non- vulnerable	
Poor	84.06	15.94	62.16
Non poor	41.67	58.33	37.84
Total	68.02	31.98	100.00
Source: Estimated from survey data			

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.

Table 8 Sources of Vulnerability for the Households

	Overall	Non poor	Amon gst the Poor	Amongst the Non vulnerable	Amongst the Vulnerable	Amongst the high volatile Vul.	Low mean vulnerable
Mean percapita consumption	4276	6588	2869	6363	3470	5853	2745
Fraction poor	0.62	0.00	1.00	0.31	0.77	0.00	1.00
Mean vulnerability	0.56	0.48	0.60	0.42	0.62	0.59	0.63
Fraction vulnerable	0.68	0.42	0.84	0.00	1.00	0.42	1.00
Fraction high volatility vulnerable	0.16	0.42	0.00	0.00	0.16	1.00	0.00
Fraction low mean vulnerable	0.52		0.63	0.00	0.52	0.00	1.00

We estimated that households that are vulnerable due to high consumption volatility are only 16 percent whereas 52 percent are due to low mean consumption. So vulnerability is mainly due to

low consumption prospects and thus reduction in vulnerability should start from increasing household consumption.

Vulnerability profile by household characteristics is displayed in Table 9. The Table shows a positive association between vulnerability and household size. About 87 percent of households with family size greater than nine are vulnerable to poverty whereas only 51.85 percent of households with family size less than 6 are vulnerable.

Table 9 Vulnerability Estimates for Selected Household Characteristics

Vulnerability Estimates For Selected Household Characteristics		
<i>[percentage of vulnerable population]</i>		
<b>Overall vulnerable population</b>		<b>59.91</b>
Family size	1-5	51.4
	6-9	81.82
	more than 9	100
Age of household head	<30	80.36
	30-50	69.64
	50 plus	54.00
Schooling of head	illiterate	72.53
	1-4	73.08
	5-8	58.14
	9-12	56.00
	more than 12	72.73
Schooling of spouse	0	68.85
	1-4	70.21
	5-8	68.96
	>8	58.33
Livestock size (TLU)	0-4	68.35
	4-8	65.79
	8-12	70.45
	More than 12	67.84
Land size (ha)	0-1	56.25
	1-2	75.38
	2-4	71.11
	above 4	50.00
Fertilizer used (kg)	0-100	66.67
	101-200	69.09
	201-300	68.89
	More than 300	67.39
Extension contacts	0-10	72.84
	11-20	61.76
	21-30	42.86
	More than 30	60.00
Non-farm income	Yes	66.67
	No	68.75
<b>Source:</b> Estimated from survey data		

Vulnerability falls with increase in age of household head as shown in the table. Vulnerability is higher for household head age above 30. About 80 percent of household heads with age less than 34 and about only 54 percent of household age with age greater than 50 are vulnerable to poverty, respectively. Moreover, in these two age limits the incidence of poverty is 68 and 48 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 73 percent, but for households with head's education years greater than 5 the level of vulnerability decreases to less than 58 percent. Similarly, education of spouse has negative relationship with vulnerability. According to table 9 if education of spouse is more than 8, then vulnerability of household to poverty is 58 percent, but the vulnerability level rise to 69 percent if education of spouse is less than 8. 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 will 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 falls as household land size increases. This means households that have large land size are less vulnerable. Moreover, as land size increases the incidence of poverty become less. As it is evident from table 9 only 50 percent of households that have more than 4 hectares of land are vulnerable, but for households that have less than 4 hectares of land the extent of vulnerability is more than 70 percent.

Table 9 also shows that access to non-farm income is another variable that has implication for household vulnerability to poverty. According to this estimation vulnerability estimate of

households that have non-farm income is 66.67 percent whereas vulnerability level rises to 68.75 for households that have no non-farm income. Moreover, number of extension contacts made by farmers and quantities of fertilizer used in production have negative relationship with vulnerability.

Vulnerability of households with climatic and environmental characteristics is provided in table 10 below. Changes in rainfall from long run average, as shown, explains difference in household vulnerability. As it can be seen clearly from table 10, vulnerability in *Kebeles* where shortfall of season's rainfall is less than -60 (deviation increases) is 72 percent and it is higher than for *Kebeles* where the shortfall is more than -60 (deviation approaches decreases). However, as deviation decreases and approaches zero, the extent of vulnerability increases, which shows some form of non linearity between rainfall and household vulnerability. This is because higher rainfall is not always good. Similarly, increases in mean maximum temperature above long run average increases vulnerability. About 68 percent of households that are found in areas where production season's average is 1.5<sup>0</sup>C greater than long run average have vulnerability level of 76.60 percent, whereas vulnerability in *Kebeles* where season's maximum temperature 1.5<sup>0</sup>C less than long run average is only 65.79 percent. In addition, increase in season's minimum temperature above long run average also increases household susceptibility to poverty. As the result shows 81.25 percent of households that are found in areas where season mean minimum temperature exceeds long run average by more than 0.9<sup>0</sup>C are vulnerable to poverty.

Table 10 Vulnerability Estimates for Selected Environmental Characteristics

<i>[percentage of vulnerable population]</i>		
Overall vulnerable population		<b>68.02</b>
Rainfall change from long run average [ <i>production season average- long run average</i> ]	<-60	72
	-60 <RF< -5	63.64
	less than -5 mm	78.00
Minimum temperature increase above long run average	greater than 0.9 <sup>0</sup> C	81.25
	less than 0.9 <sup>0</sup> C	65.79
Maximum temperature increase above long run average	more than 1.5 <sup>0</sup> C	76.60
	less than 1.5 <sup>0</sup> C	65.71
Frequency of drought	1	66.67
	3	64.96
	4	78
soil characteristic	sandy loam	63.87
	Vertisol	74.42
	Andosols (Bole)	78.00
Adaptation	Some adaptation	63.57
	No adaptation	74.19

Vulnerability to climate change is a function of several factors, among which adaptation is one. According to table 10, households that use one or more adaptation methods have lesser likelihood to become poor. Households that adopt one or more adaptation methods has vulnerability estimate of 63.57 while those households that don not adopt any adaptation method have vulnerability level of 74.19. This suggests promotion of adaptation as one policy tool to reduce vulnerability to poverty.

## 4.5 Econometric Results

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 31 variables that are included in the model. Model information shows the model is suitable for the problem at hand. Adjusted *R squared* and over all F value are 0.71 and 18.61 respectively. 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 11 gives model information and the OLS estimates of coefficients of the model.

Table 11 gives estimates of the correlates of vulnerability. 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 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 2.00.

Table 11 Correlates of Estimated Vulnerability Level of Households

Estimated vulnerability Function- FGLS Estimates		
<i>[Dependent variable- vulnerability level of households: Equation 3.12]</i>		
Variables	Coefficients	t-statistics
<i>Intercept (Constant)</i>	-0.05006	-0.19
<b><i>Household Demography</i></b>		
Family Size	0.05832	4.00***
Dependency Ratio	-0.03966	0.93
Age of Head	-0.01478	-5.14***
Sex of Head	0.03087	0.41
<b><i>Household Education</i></b>		
Education of Head	-0.03163	-3.33***
Education of Spouse	-0.14866	-16.09***
Education of head squared	0.11351	10.07***
<b><i>Household Assets</i></b>		
Log of value of other assets value	-0.02811	-1.44
Livestock	-0.04008	-10.00**
Land Size	-0.20282	-9.03***
Irrigation Size	-0.27656	-3.87***
<b><i>Inputs and Facilities</i></b>		
Road	-0.01775	-4.71***
Market dummy	-0.01465	-3.27***
Extension Contacts	-0.01518	-4.99***
Credit	0.00219	1.28
Non Farm Income	-0.02674	-7.62***
<i>Idder</i>	-0.34926	-3.03***
<i>Ekkub</i>	-0.52342	-7.79***
Relatives	-0.00057	-1.70*
Status	0.05150	0.93
Fertilizer	-0.00067	-4.89***
Herbicide	0.20213	8.39***

Table 11 continued...

<b><i>Climate, Adaptation and Soil</i></b>		
Rain Fall Change	-0.25003	-4.56***
Minimum Temperature	0.47201	8.60***
Soil dummy	0.25477	2.18**
Drought	0.13632	8.94***
Adaptation	-0.09955	-1.96**
<b><i>Shocks</i></b>		
Input price rise	0.09475	1.66*
Death of Household Head	0.2784	7.74***
Crop pest and disease	-0.38159	-7.17**
<b><i>Summary Statistics</i></b>		
Adjusted R-Square	0.8395	
F-Value	37.96	
<b>Source:</b> Estimated From Survey Data		

\*\*\*, \*\*, \* indicates estimates are significant at 1%, 5% and 10% percent, respectively.

### ***Family composition***

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 a 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 5.83 percent and the estimate is significant at 1 percent significance level.

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 45.47 for the vulnerable group and 40.51 for the non-vulnerable group and the difference is statistically significant. Probably as a farmer gets older, he can acquire farming experience through his life that could have a positive contribution in raising his living standards. Similar pattern emerges from this study; as head age increases by one year household vulnerability to poverty decreases by 1.48 percent approximately.

### ***Household 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. Astonishingly the result of the study 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 3.17 whereas it is 4.38 for the non vulnerable and the difference is statistically significant at 5% level (Table 12). Household education is thus a significant factor that explains difference in household vulnerability levels. The econometric result also indicates that household head education and spouse education reduces household vulnerability to poverty. As head years of education and spouse years of education increases by 1 year, household vulnerability to poverty decreases by 3.16 and 14.86 percent respectively. However, as education of household head increases above sum threshold, household vulnerability to poverty also increases. This indicates that non linear relationship between vulnerability and education.

### ***Household Assets***

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 too 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 land size, livestock and non-land household assets are included as regressors. However, the result of the study shows that the estimated value of assets owned by the household other than land and livestock are found to be an insignificant determinant of vulnerability.

On the other hand, the amount of land size and livestock owned by households are found to be important determinants of vulnerability to poverty. 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. Similar pattern emerges from this study in that the amount of livestock reared by households has negative impact on household vulnerability level. The analysis indicates that as livestock holding increases by one unit, household vulnerability to poverty is reduced by 0.4 percent and the estimate is significant at 1 percent significance level. The result confirms the argument that livestock holding is a hedge against risks, because households with higher endowment of livestock are less vulnerable and their consumption volatility is less.

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 4.1 percent. More importantly, the size of irrigable land owned by the household is also found to be

negatively related with household vulnerability. According to the estimation as irrigable land size increases by one hectare, household vulnerability level decreases by 27.65 percent and the result is significant at 1 percent significance level. This reinforces the fact that irrigation is related with high consumption and it is important tool for both poverty and vulnerability reduction.

### *Non-farm income and input use*

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 15.47 percent less vulnerable than household with small or no non farm-income.

Use of agricultural inputs such as fertilizer and extension visit are other important variables that define household exposure to poverty. Using fertilizer increases productivity and thus reduces downward fluctuation of production that in turn reduces vulnerability to poverty. Extension visit, on the other hand, increases productivity of farmers by increasing their exposure to labor and land augmenting technologies. According to our estimation use of fertilizer and extension visit reduces household vulnerability to poverty by 0.06 and 1.5 percent respectively. However, the quantity of herbicide and pesticide used in production is found to be positively related with household vulnerability. This may be because in farming context herbicides and pesticides are used mostly either due to pest or weed infestation. Therefore, using herbicide or pesticide cannot increase or guarantee increased output; they at most maintain output that can be obtained

otherwise. Given that pest and weed infestation are not common problems across households, it is not odd to get positive relationship between amount of herbicide used and level of vulnerability.

### *Access to Services and Capital*

Proximity to infrastructures is important factor that affect household welfare. All weather roads, 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, all weather roads, input supply shop etc. (Chamberlin et al., 2006). In this study market access is measured as whether a household travels less than 16 km to market centers or more. 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 8km (less than 16 km for two ways distance) are 1.46 percent less vulnerable than households that travel more than 8km. Proximity to all weather roads has also similar impact on household vulnerability. Households that travel less than 4 km to get all weather roads are 1.77 percent less vulnerable than households that travel more than 4km. however, proximity to input shop is found to be insignificant determinant of household vulnerability.

Social institutions such as *Idder*, *Ekkub*, and number of relatives are other variables we have to look in to as far as vulnerability is concerned. Strong social capital guarantees better access to resources and serves as hedge against risks. Theoretically we expect households that have strong social capital are less vulnerable to poverty. The result of the study also agrees with this argument. Vulnerability estimate of households that are member of *Iddir* and *Ekkub* are 34.9 and 52.34 percents lower than households who are not members. This is not a coincidence as

membership to these institutions is indication of household social capital that enhances household resource potential useful to avoid vulnerability.

### *Rainfall, Temperature and Soil*

Variation in rainfall, temperature and soil are hypothesized to significantly explain household level of vulnerability. Since most of agriculture in the study area is rainfed, shortage of rain during production season reduces household production that increases their vulnerability to poverty. Similarly, increase in mean maximum and minimum temperature increase respiration loss of plants that increase water requirements of plants. Therefore, increase in temperature increases vulnerability of farmers to poverty line by reducing crop productivity, especially during rainfall shortage. Having this in mind change of production season rainfall from long run average (production season average rainfall less long run production season average) was included in the model. The result shows that increase in production season average rainfall above long run average reduces household vulnerability to poverty. As it can be seen from above table 11, one millimeter increase in season rainfall above long run average reduces household vulnerability by approximately 25 percent. On the other hand increase in season mean maximum and minimum temperature above long run average increases household vulnerability to poverty. For example, 1<sup>o</sup>C increase in minimum temperature above long run average increases household vulnerability to poverty by 47.20 percent<sup>7</sup>. The result indicates that relatively hotter areas are more vulnerable than areas with relatively cooler temperature.

Occurrence of drought is another climatic factor that affects household level vulnerability to poverty. Key informant interview has shown that there was at least 1 drought occurrence during

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<sup>7</sup> Mean maximum temperature and Andosols were excluded due to higher collinearity with minimum temperature and soil dummies

the last 20 years in the survey areas. Drought in this context is a situation where there is severe shortage of rainfall that resulted in complete loss of seasonal output. The analysis shows that households that experience more frequency of droughts are found to be highly vulnerable to poverty. As frequency of drought increases by one household vulnerability to poverty also increases by 31.23 percent and the estimate is statistically significant at 1 percent significance level.

There are certainly other factors affecting agricultural potential at the local level besides rainfall and temperature. Soil characteristics, in particular, are likely to be important at the community and farm levels (Chamberlin et al., 2006). The spatial variation in these characteristics is a major environmental factor that accelerates or reduces household vulnerability to poverty. Soils differ in their texture and capacity to retain moisture that is valuable in crop production. In the analysis three major types of soil were included; which are sandy loam, Vertisol and Andosols. These soil dummies show strong relationship with household extent of vulnerability. For example, households which are in areas of Vertisols are more vulnerable than households that are found in areas of sandy loam soil. This is because sandy loam soil has relatively better water retaining capacity than Vertisols and it can give yields with less moisture with the help of dew once the plants are grown to certain degree. But in case of Vertisols it has the property of cracking in time of rainfall shortage and it becomes major reason for crop failure in time of scanty rainfall. The results of the study show that households in areas of Vertisols are 25.47 percent more vulnerable to poverty than areas with sandy loam soil.

### *Non climatic Shocks*

Shocks that cause income or asset losses are also likely to reduce consumption if credit constraints are binding or if the shock reduces expected life-time earnings by destroying the

household's asset base (Tesliuc and Lindert, 2002). Household experiences of shocks have, thus, more things to do with household vulnerability to poverty. In the survey households reported different types of non climatic shocks that include input price rise, death and illness of household member, death of animal, crop pest and disease and output price fall etc. Experiencing one or more of these shocks results in reduction of household welfare, because they negatively affect household production potential. However, in this study the distribution of shocks between the vulnerable and non-vulnerable households is random for most of the shocks. But there is difference in vulnerability for households that encountered unexpected input price rise, death of head, death of animal and crop pest and disease. For instance 71 of the vulnerable households have reported input price rise whereas only 15 percent of the non-vulnerable households have encountered input price rise, and the difference is significant at 1 percent significance level. See ANOVA table annexed for details.

According to the econometric analysis death of household head and input price rise negatively affect household welfare. Households that face death of head and input price rise are 75.25 and 9.47 percent more vulnerable than households that do not face any of these shocks. However, crop pest and disease are found to be positively correlated with household welfare. This is because crop pest and disease suffered this year affect household welfare in the coming year. Other shocks such as output price fall, death of animal, illness of household member were not statistically significant.

## CHAPTER FIVE

### CONCLUSION AND POLICY IMPLICATIONS

Based on household survey data in Adama and Lume *Woredas*, this study analysed the probability of farmers falling below consumption poverty line due to climatic conditions and shocks namely mean seasonal rainfall, temperature and frequency of drought. In this analysis household consumption expenditure that consists both food and non food expenditure are 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 USD1 is estimated by using the Vulnerability as Expected Poverty approach.

Estimates show that about 62 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 68 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 percent of the households are vulnerable to poverty due to low consumption mean and about 16 percent of them are vulnerable due to high consumption volatility.

Moreover, the study has attempted to track the correlates of household vulnerability to poverty by assuming household vulnerability is linearly related with household and environmental characteristics. It was observed that household head age, education level, land size, livestock size, proximity to roads and market reduce household vulnerability to climate change, whereas family size and experiencing shocks tend to increase household vulnerability to climate change. Use of

inputs such as fertilizer and extension services, access to irrigation and non-farm income also reduces household vulnerability to poverty. Of particular importance to this study is that all climate and environment related factors are found to affect household vulnerability to poverty. For instance, increase in mean seasonal rainfall above long run average reduces household vulnerability to poverty, whereas increases in mean minimum temperature above long run average increases household exposure to poverty. On top of that the nature of soil is also related with vulnerability to poverty. Sandy loam soil was found to reduce household vulnerability to poverty but Vertisols tend to aggravate household vulnerability to poverty. On the other hand, use of one or more adaptation method was found to reduce the incidence of vulnerability of households.

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 volatility of consumption is also important. This means enabling farmers to meet the daily minimum requirement is not enough by itself, unless there are interventions that reduce volatility of consumption. This study proposes that expansion of irrigation use, off farm income opportunities, use of fertilizer and extension services are possible intervention areas to reduce household vulnerability.

In addition to policy interventions to increase consumption and reduce volatility of consumption promotion of adoption of different adaptation methods such as use of early maturing crops, soil conservation techniques and planting trees can reduce vulnerability. In case of occurrence of drought, coping mechanisms such as keeping livestock and creation of non-farm income opportunities reduce vulnerability.

Finally, strengthening the ability of households to reduce, mitigate or cope with the effects of both climatic and non climatic shocks is likely to reduce their vulnerability to poverty. However, these results should be interpreted and used with recognition of possible errors in consumption measurement and statistical problems that may arise with spatial variables.

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## APPENDIX I: SUPPLEMENTARY FIGURES AND TABLES

Table 12 Analysis of variance (ANOVA table)

Variable	Mean	Standard deviation	F statistics	P-value
Model			23.37	0.000
Age of head	43.88	13.11	37.86	0.000
Education of head	3.56	4.14	33.13	0.000
Education of spouse	2.57	3.72	2.15	0.144
Highest education	7.39	7.39	93.10	0.000
Gender of head	0.85	0.36	4.51	0.035
Dependency ratio	0.59	0.51	0.11	0.737
Family size	5.91	2.39	83.20	0.000
Land size	1.83	1.28	40.88	0.000
Irrigation size	0.11	0.35	7.61	0.006
Livestock size	6.66	6.39	2.71	0.102
Access to Credit	0.29	0.45	1.12	0.292
Fertilizer used	349.62	260.32	33.17	0.000
Member ship to <i>Ekkub</i>	0.20	0.40	18.67	0.000
Extension contacts	7.56	9.37	37.66	0.000
Herbicide used	1.61	1.64	109.86	0.000
Membership to <i>Idder</i>	0.91	0.29	8.55	0.004
Number of relatives	25.08	26.42	1.34	0.248
Log of asset value	8.39	1.62	1.33	0.062
Rainfall change	-40.24	26.97	3.53	0.000
Max temp. Change	1.07	0.63	23.01	0.975
Min. temp. Change	0.90	0.60	0.00	0.101
Adaptation	0.58	0.49	2.72	0.312
Rainfall variability	67.60	14.98	1.03	0.000
Distance to road	8.34	7.99	33.79	0.000
Non farm income	0.35	0.48	9.71	0.002
Vertisol soil type	0.70	0.27	0.82	0.367
Death of head	0.07	0.25	117.14	0.000
Death of animal	0.23	0.44	5.19	0.095
Distance to input shop	13.55	18.74	0.11	0.740
Pest and disease	0.33	0.48	1.08	0.340
Distance to market	16.62	8.98	10.84	0.001
Status	0.38	0.48	0.30	0.584

Table 13 Nutritional (Calorie) Based Adult Equivalence Scales

Years of age	Men	Women
0-1	0.33	0.33
1-2	0.46	0.46
2-3	0.54	0.54
3-5	0.62	0.62
5-7	0.74	0.70
7-10	0.84	0.72
10-12	0.88	0.78
12-14	0.96	0.84
14-16	1.06	0.86
16-18	1.14	0.86
18-30	1.04	0.80
30-60	1.00	0.82
60 and above	0.84	0.74

Source: adopted from MoFED as calculated by Dercon and Krishnan (1985).

Figure 7 Normal Probability Plot of Residuals from Linear Consumption Equation

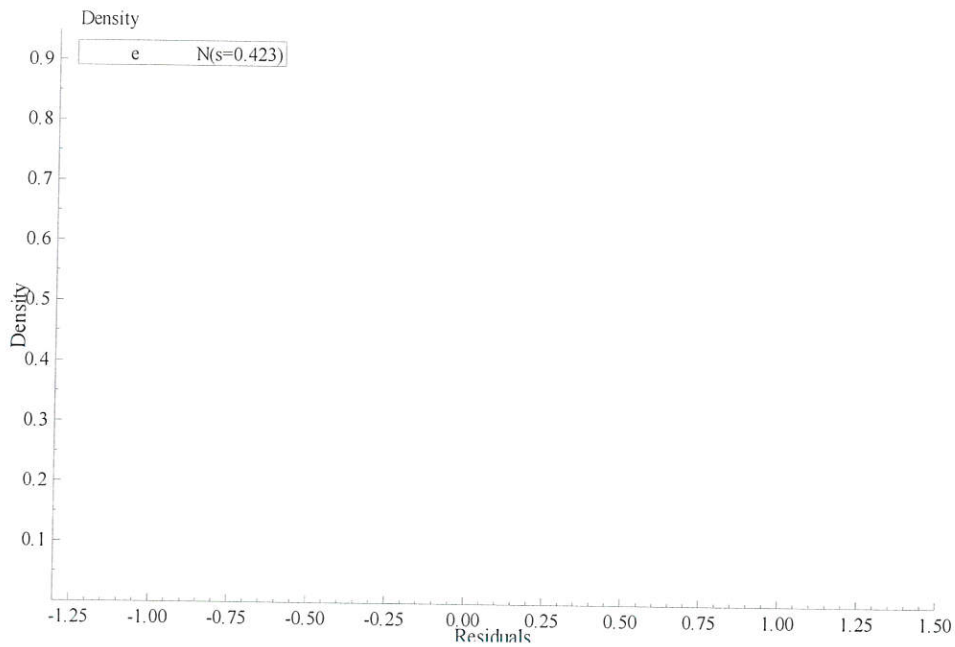
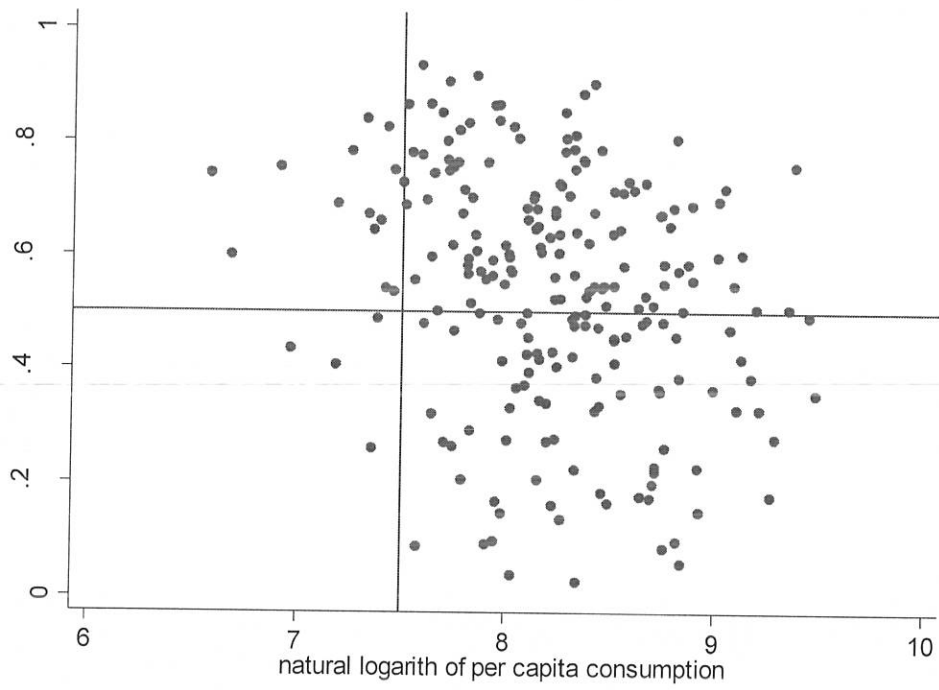


Figure 8 Plot of Vulnerability versus Per Capita Consumption



**ADDIS ABABA UNIVERSITY  
SCHOOL OF ECONOMICS  
HOUSEHOLD SURVEY QUESTIONNAIRE**

**Analyzing Household Vulnerability to Climate Change and their Adaptation  
Options**

**Bedaso Taye  
(Resource and Environmental Economics)**

**Advisor: Alemu Mekonnen (PhD)**

**Instructions**

The Following Information about the Household will be collected for the Production Season  
**January 2009- December 2009 (Tir 2001-Tahsass 2002 E.C)**

- *Household information*
- *Total crop production*
- *Total consumption Expenditure*
- *Livestock, Land Size and Other Asset Ownership*
- *Perception about Climate Change and Adaptation strategies*
- *Access to credit and Off Farm Income Sources*
- *Access to Social and Physical Capital*

Household Code \_\_\_\_\_

Kebele Code \_\_\_\_\_

Enumerator Name \_\_\_\_\_

Date of interview (dd/mm/yr) \_\_\_\_\_

**February 2010**



Section C. Crop production								
Season of 2001/2002	Plot number	What crop was planted on plot [#] during the [Belg/Meher] season?	Crop code	What was the area planted with [crop] on this plot during this season?	How much [crop] was harvested from this plot during this season in 2009 (Tir 2001 – Tahsas 2002)?		How does your harvest change in 2009 (Tir 2001 – Tahsas 2002) compared with 2008 production	If your answer to C6 is lower, what is the main reason for this change in production?
					Quantity	Quantity unit		
		Name For permanent crops, record all information in the Meher row, leaving the Belg row empty.	Crop code  [see codes]	Area  in hectare		1 Kilogram 2 Quintal 3 other (specify)	1 higher 2 same 3 lower	1 Rainfall shortage 2 lack of fertilizer 3 pest/disease infestation 4 Soil degradation 5 Others, specify
	C1	C2	C3	C4	C5q	C5u	C6	C7
Meher season May-Dec 2009 (Ginbot 2001- Tahsas 2002)								
Belg season (March-June 2009) OR (Megabit-Sene 2001)								

Crop codes		
grains		Vegetables
01	Teff	31 Cabbage
02	Barley (gebs)	32 Tomatoes
03	Wheat	33 chili (kana)
04	Maize	34 Red peppers (berbere)
05	Sorghum (mashita)	35 Lettuce (salata)
06	Millet (dagussa)	39 Other vegetables
07	oats (aqa)	39
08	Other grains	<b>Root crops</b>
	<b>Pulses</b>	21 Potato
11	bean (bakela)	22 Sweet potato
12	pea (ater)	23 Ginger (zingebet)
13	Harecot beans (bolike)	24 Carrot
12	Chickpeas (shimbira)	25 onion
14	Lentils (mose)	26 garlic
15	nigerseed (neug)	27 Fano/godete
13	linseed (tebat)	29 Other root crops
14	Sesame	<b>permanent crops</b>
19	Other pulses	51 Avocado
		54 Orange
		55 Papaya
		59 Other fruit
		61 Chat

Section C. Crop production								
Season of 2001/2002	Plot number	What crop was planted on plot [#] during the [Belg/Meher] season?	Crop code	What was the area planted with [crop] on this plot during this season?	How much [crop] was harvested from this plot during this season in 2009 (Tir 2001 – Tahsas 2002)?		How does your harvest change in 2009 (Tir 2001 – Tahsas 2002) compared with 2008 production	If your answer to C6 is lower, what is the main reason for this change in production?
	Name For permanent crops, record all information in the Meher row, leaving the Belg row empty.	Crop code [see codes]	Area in hectare	Quantity	Quantity unit	1 higher 2 same 3 lower		
	C1	C2	C3	C4	C5q	C5u	C6	C7
Meher season May-Dec 2009 (Ginbot 2001- Tahsas 2002)								
Belg season (March-June 2009) OR (Megabit-Sene 2001)								

Crop codes		
grains		Vegetables
01 Tef	31	Cabbage
02 Barley (gebs)	32	Tomatoes
03 Wheat	33	chilli (kana)
04 Maize	34	Red peppers (berbere)
05 Sorghum (mashita)	35	Lettuce (salata)
06 Millet (dagussa)	39	Other vegetables
07 oats (aja)	39	
08 Other grains		<b>Root crops</b>
		Potato
		<b>Pulses</b>
11 bean (baketa)	21	Sweet potato
12 pea (ater)	22	Ginger (zingebel)
13 Haricot beans (boloke)	23	Carrot
14 Chickpeas (shimbra)	24	
15 Lentils (msef)	25	onion
16 nigerseed (neug)	26	garlic
17 linseed (letba)	27	Taro/gociere
18	28	Other root crops
14 Sesame		<b>permanent crops</b>
19 Other pulses	51	Avocado
	54	Orange
	55	Papaya
	56	Other fruit
	61	Chat

**Section D consumption Expenditure** (here the person responsible for the purchase should be the main respondent)

consumption item	Item code	Food purchased for consumption				Food grown and consumed at home		
		During the last 12 months, has your household consumed any [...]?	If yes to D1 what is your frequency of purchase	For each purchase, what is the normal quantity of [...] purchased?		During the last 12 months, have you consumed any [...] from your own production?	What was the total quantity of [...] consumed from your own production during the last 12 months?	
				quantity	Unit		Quantity	Unit
		1 Yes 2 No	1. weekly 2. bimonthly 3. monthly 4. biannually 5. annually 6. other, specify		1.Kilogram 2 Quintal 3 other	1. Yes 2. No		
		D1	D2	D3q	D3u	D4	D5q	D5u
Teff	01							
Barley (gebs)	02							
Wheat	03							
Maize	04							
Sorghum (mashilla)	05							
Millet (dagussa)	06							
oats (aja)	07							
other grain products	09							
bean (bakela)	11							
pea (ater)	12							
Haricot beans (boloke)	13							
Chickpeas (shimbra)	12							
Lentils (misir)	14							
nigerseed (neug)	15							
linseed (telba)	13							
other pulses	19							
Potato	21							
Other root crops	29							
Cabbage	31							
Tomatoes	32							
Red peppers (berbere)	34							
other vegetables	25							
Beef	101							
mutton/goat meet	102							
Chicken	103							

section D1 and D2 should not include goods for resale, goods to be processed and sold, and raw materials

## Section D2 consumption Expenditure (frequently purchased food items)

consumption item	Item code	Food purchased for consumption				consumption out of own production		
		Does your household consumes any [...] during the last 7 days?	If yes to D21, how much quantity of [...] you consume in the last 7 days?	Unit	For each purchase, what was the normal value of [...] bought? [in Birr]	During the last 12 months, has your household consumed any [...] from your own production?	If yes to D25 what was the total quantity of [...] consumed from your own production during the last 12 months?	Unit
		1 Yes 2 No	Quantity	1.Kilogram 2 Quintal 3.liter 4. other (specify)		1. Yes 2. No	Quantity	1.Kilogram 2 Quintal 3.other
		D21	D22	D23	D24	D26	D27	D28
Avocado	51							
orange	52							
mango	53							
Other fruit	59							
chilli/ karia	101							
Ginger (zingebel)	23							
Carrot	24							
Milk/yoghourt	104							
Butter/cheese	105							
Eggs	106							
macaroni/pasta	107							
Cooking oil	108							
bread (dabo)	109							
sugar	111							
Salt	112							
Honey	113							
Soft drinks	114							
Araji /kathikala	115							
tella/tejj	116							
Coffee/tea	117							
Other beverages	120							
Restaurant/snacks	121							
Onion	122							
Other	129							
Other	129							

section D2 and D1 should not include goods for resale, goods to be processed and sold, and raw materials

**section D3 consumption Expenditure** (non food consumption expenditure)

Item name	Item code	During the past 2 weeks, has anyone in your household purchased or obtained any of the following items?	What is the value of [...] purchased or obtained in the past 2 weeks? [In Birr]
	code	1. Yes 2. No	
Soap and other cleaning supplies	11		
Razor, lotion, other personal care items	12		
Basket, bucket, other small household items	13		
Bus and taxi fare	14		
Other transport costs (bicycle, carts, etc)	15		
Mobile phone card, postage, phone calls	16		
lump/candle/matches	17		
Torch/battery	18		
kerosene, charcoal, firewood etc	19		
Chat	20		
Cigarettes and tobacco	21		
Repair, tailor and other services	22		
Barber	23		
Domestic worker (non agricultural workers)	24		
Other non food purchases	29		

Item code	During the past 12 months, has anyone in your household purchased or obtained any of the following items?	What is the value of [...] bought or obtained in the past 12 months?
code	Item name	1. Yes 2. No
31	Clothing/shoes for men	
32	Clothing/shoes for women	
33	Dishes, pots, pans, etc for kitchen	
34	Blankets, sheets, mattress, etc.	
35	School fees	
36	Excercise books, pens, pencils etc	
37	Health/medicine expenses	
38	Repairs and maintenance of house	
39	Water, electricity	
40	electricity and phone services	
41	Compensation and penalty	
42	contribution/ Donation to church	
43	Land tax and other taxes	
44	contribution to Idir	
45	contribution to Equb	
49	Other non asset purchases	

*Section D3 should not include purchases of assets, defined as household goods or equipment that will be used for production and last long.*

D31 Are members of your household consuming smaller or larger quantities of [food item] than 5 years ago?

1. Smaller quantities
2. About the same
3. Larger quantities

D32. If your answer is 'smaller quantities' what is the reason?

1. crop loss due to climate
2. livestock loss due to climate
3. theft/gangs
4. death of household income earner
5. inflation
6. other (specify)

D33. If your answer is 'greater quantitis what is the reason for change?

1. favourable climate
2. increase in input use
3. adoption of modern input
4. other specify

**Section E. Credit**

credit number.	Is there any credit giving institution in your kebele during the last 12 months?	If yes to E1 did you apply or ask for a loan?	If yes to E2 whom did you ask for a loan or credit?	Did your household receive a loan?	What was the amount borrowed ?	How long was the loan for?	What was the money used for?
	E1	E2	E3	E4	E5	E6	E7
	1 Yes 2 No	1. Yes 2. No	1 Relatives 2 Friends 3 Money lender 4 Cooperative 5 Bank 6 Credit Association 7 Others	1 Yes 2 No	Birr	Months	1 Ag inputs 2 Ag investment 3 household consumption 4.other (specify)
	E1	E2	E3	E4	E5	E6	E7
1							
2							
3							

**Section F. Other income**

Other income activity code	Other income activity	In the past 12 months, have members of your household received income from [activity]?	If yes to F1 what was the amount of income received from [activity] during the last 12 months?		How many months out of the past 12 months did members of this household receive income from	
code	Activity name	1. Yes 2. No	Birr/month	unit time (see time codes)	months	time codes
		F1	F2		F3	
11	Remittances					1. daily
12	sale of charcoal /firewood					2. biweekly
13	petty trade (net profit)					3. weekly
14	land rental income					4. bimonthly
15	sale of beverages					5. monthly
16	quarry/mining					6. biannually
17	Repair business					7. other (specify)
18	aid or donation					
19	self employment					
20	Pension					<b>unit code</b>
21	sale of handicraft					1. kg
22	Productive safety net program					2. liter
23	sale of tree/pole/grass					3. quintal
24	compensation received					4. big madaberia
29	other					5 small madaber
						6. other

Note: "Other" could include, interest income, or property rental income.

**G. Extension visit and input use**

service code	Type of services	Extension Visit		Input use				
		Does your household get extension services on [...] during the last 12 months?	How many times you have contacted extension agent during the last 12 months?	Input name	input code	During the last 12 months does your household use[input] in its	what was the quantity of the input used (specify units) [see unit code above)	
code	services	1. Yes 2. No	number of contacts	input		1.yes 2. No	Quantity	unit
11	Use of HYV			DAP	21			
12	climate change			UREA	22			
13	How to apply inputs			Pesticide	23			
14	Soil conservation			Herbicide	24			
15	Environmental conservation			HYV	25			
16	Early maturing crops			Compost	26			
19	Others			Water pump	27			
				Other(specify	29			

#### H. Climatic shocks and Perception about climate change and shocks

Climatic element	code	During the last 20 years have you observed change in [climatic element]?	If yes to H1 how is [climatic element] has changed?	what type of loss does your household suffer?
		1 Yes 2. No	1. Increasing, 2. decreasing 3. no change 4. Don't know	1. crop loss 2. human health 3. livestock loss 4. other asset loss 5. other (specify)
		H1	H2	H3
Temperature	01			
Precipitation/rainfall	02			
Drought (frequency)	03			
Erosion(frequency)	05			
Flood (frequency)	06			
Other(specify)	09			

#### I. Adaptation strategies

Measures taken	code	If the above changes affect your household negatively, have you taken measures to sustain your livelihood?	Have you observed its benefit?	If No to I1 what is the reason
		1. Yes 2. No	1. Yes 2. No	1. lack of information 2. lack of resource/tecknology 3. not available 4. no adequate land to apply 5. other(specify)
		I1	I2	I3
Migrated to other place	11			
Used irrigation	12			
Sold livestock	13			
Reduced livestock	14			
Adopt improved farming techniques	15			
adopt water harvesting techniques	16			
Put trees for shading	17			
Adopt soil conserving techniques	18			
sold asset	19			
sought off farm income	20			
borrowed from relatives	21			
participated in Food For Work	22			
Reduced consumption	23			
Did nothing	24			
Other (specify)	29			

#### J. Non climatic shocks

Please ask the respondent whether the household has suffered any of the following shocks during the last 12 months?

Type of shock	code	Have your household suffered [shocks] during the last 12 months?	how many times that [shock] Occur during the last 2 years?	How did the shock affect your household's consumption?
		1. Yes 2. No		1. very negatively 2. negatively 3. not at all
Death of household breadwinner	31			
Illness of household breadwinner	32			
Death of household member	33			
Death of draft animal	34			
Animal disease	35			
Theft (loss) of livestock	36			
Theft of any asset	37			
Crop pest and disease	38			
Output price fall	39			
Input price rise	40			
Fire outbreak	41			
Other(specify)	43			

**K. Information on Access to capital**

physical capital		social capital					
Type of facility	code	How much you have to travel to get [ services] from your home?		Name of social institution	code	Is your household member of [.....]?	Have you collected mone from [...] during the last 12 months?
		in km	in minute				
All weather road	01			Iddir	11		
Schooling (primary)	02			Baltina	12		
Schooling (secondary)	03			Ekub	13		
Hospital/clinic	04			Mahber	14		
Banking/insurance	05			Cooperatives	15		
Electricity	06			Other (NGO...etc)			
Extension advisor	07						
Daily market	08						
periodic maket (weekly)	09						
Input shop	10						

**L. Social Capital**

L1. How many close relatives that your household has in this locality?

 L1

L2. Do any of your household members or close relative has position in the kebele/peasant administration?

1. Yes 2. No  L2

L3. If yes to L2 what is his/her role in the kebele adminstration?

1. Kebele administrator
  2. Secretary
  3. member
  4. other (specify)
- 
- L3

*Thank you very much for  
your cooperation!!!*

## Declaration

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

The examiners' comments have been dully incorporated.

Declared by:

Name: Bedaso Taye Walegnu

Signature: 

Date: 25/06/10

Confirmed by Advisor:

Name: Alemu Mekonnen

Signature: 

Date: 25/6/10