Welfare Implications of Credit Constraints and Climate Change Adaptation Strategies on Ethiopian Farm Households

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This is to certify that the dissertation prepared by Hailu Elias entitled: "Welfare Implications of Credit Constraints and Climate Change Adaptation Strategies on Ethiopian Farm Households" and submitted in partial fulfillment of the requirements for the Degree of Doctor of Philosophy (Economics) complies with the regulations of the University and meets the accepted standards with respect to originality and quality.

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ABSTRACT

Agriculture remains a key source of growth to Ethiopia's economy, but it continues to be highly vulnerable to climatic constraints, particularly to rainfall variability and drought shocks. Building a climate resilient agricultural sector requires understanding the adaptation strategies of farm households and the institutional constraints that condition the choice of these strategies. Accordingly, the focus of this PhD dissertation is assessing the role of one such institutional factor-credit access- on the adaptation patterns of farm households and the welfare implications of the same. The dissertation contains eight chapters divided into three sub themes. The first theme consists of background to the dissertation work presented in the first three chapters. These include introduction to the dissertation, research methodology, and review of the literature pertinent to the thesis. The second theme presents four independent but inter-related articles that try to link adaptation to climate change with provision of finance to Ethiopian farm households. Each of the articles correspond to chapters four to seven. The third theme concludes the dissertation and it is presented in chapter eight. All the thesis work is based on two waves of survey data collected from four zones of the Amhara region in northern Ethiopia, linked with monthly rainfall and temperature data of 30 years with the household survey data using the thin plate spline interpolation technique. As the four articles are central to the thesis work, a summary of those is presented in the paragraphs below.

The first article identifies the nature and extent of credit constraints and borrowing behavior of farm households by applying the Generalized Linear Latent and mixed model (gllamm). The key findings indicate that the likelihood of borrowing from the formal credit market is negatively impacted by borrowers' perceived probability of rejection due to strict lending policies and institutional rigidities; the transaction cost of borrowing; and risk aversion behavior of farmers.

The second article quantifies the linkage between different forms of credit constraints and choice of climate adaptation strategies using a pseudo fixed effects regression model. A robustness test is also conducted using the Multivariate Probit (MVP) and the seemingly unrelated simultaneous equation (SURE) models. The quantitative analysis points to the fact that the type of credit constraint indeed matters for the choice of adaptation strategies of households.

Discouraged borrowers found to have lower probability of participating in off-farm employment and crop diversification. Relatively better credit access seems to have encouraged irrigation, while adaptive capacity of risk rationed farmers has significantly decreased. Similarly, significance of the interaction terms between rainfall variability and credit constraint categories in the choice of adaptation strategies indicates the importance of credit, especially with greater effect of climatic factors. By contrast, soil conservation and tree planting are the least responsive to credit access and this indicates that the severity of credit constraints depends both on the nature of the credit constraint and on the type of adaptation investment. Hence, given the links between credit constraints and climatic factors, increasing awareness about how the credit market works and provision of climate information can help farmers better adapt to climate change.

The third article gives empirical evidence on the effect of climatic factors and adaptation strategies on asset holdings under different credit constraint conditions. Using an instrumental variable-fixed effects (IV-FE) regression technique, the results indicate that drought shock and rainfall variability have significant negative effects on household asset holdings in the study area. Compared to unconstrained borrowers, farmers who are discouraged and quantity constrained are found to have significantly lower value of assets in real terms. This figure is even lower when climatic shocks are coupled with credit constraints.

The fourth article investigates the effect of different credit constraint conditions on agricultural productivity among smallholder farmers in the study area using the propensity score matching (PSM) method. The results provide evidence for the adverse effects of credit constraints on improving agricultural productivity. As the result suggests, adoption of productivity-enhancing technologies is hampered by credit constraints and this is found to have a direct negative effect on agricultural productivity. The impact estimates indicated that relaxing credit constraints has significant positive impact on agricultural productivity, while higher transaction costs and discouraging credit market policies found to reduce it significantly. These findings suggest the need to work on more innovative lending approaches by giving attention to context-specific factors to build demand-driven, climate-smart, and inclusive rural credit market.

Key words: *Credit Constraint, borrowing behavior, climate change; Adaptation strategy, rural credit market, household asset, productivity.*

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Hailu Elias
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To: my beloved wife Yenenesh Habte

&

My children Eyobed, Ephraim, and Yohana

May this PhD dissertation inspire you to seek wisdom and live a purpose-driven life to serve your generation.

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ACRONYMS AND ABBREVATIONS

AEMFI	Association of Ethiopian Microfinance Institutions
BoFED	Bureau of Finance and Economic Development
CBE	Commercial Bank of Ethiopia
CSA	Central Statistics Authority
EEA	Ethiopian Economics Association
FDRE	Federal Democratic Republic of Ethiopia
EPIICA	Ethiopian Project on Interlinking Insurance with Credit in Agriculture
GDP	Gross Domestic Product
HH	Household
MFI	Microfinance Institution
Masl	Meters above sea level
MoARD	Ministry of Agriculture and Rural Development
MoFED	Ministry of Finance and Economic Development
NBE	National Bank of Ethiopia
NGO	Non- governmental organizations
PAs	Peasant Associations
PSM	Propensity Score Matching
PSNP	Productive Safety Net Program
SNNPR	southern Nations Nationalities and Peoples Region
SLM	Sustainable Land Management Practice
SWC	Soil and Water Conservation
TLU	Tropical Livestock Unit
WFP	World Food Program

CHAPTER 1

INTRODUCTION

1.1 Background

Accelerating climate change coupled with weak financial markets pose a serious threat to the development of poor African countries. Climate models project that climate change during the first half of the 21st century will make the Sub Saharan Africa (SSA) a center of food crises of the world (Scholes and Biggs, 2004). The median temperature in these countries is expected to increase between 3 and 4^{o}C by the end of the 21st century, that is roughly 1.5 times higher than the global mean response (Bryan et al., 2013). Estimates by FAO (2008) also show that by 2100, climate change alone would cause a decline in the gross domestic product (GDP) of the Sub Saharan Africa by about 2 to 7 percent. Although, the rural poor of the SSA who depend on natural resources and subsistence agriculture contribute very little to this change, they are the first victims of the adverse effects of global warming, given their limited adaptive capacity and lack of access to institutional credit facilities (World Bank, 2005; FAO, 2008; Hammill et al., 2008).

Despite the recent fast growth performance[1], Ethiopia remains to be one of the least developed Sub Saharan African countries highly vulnerable to climatic shocks. Rain-fed subsistence agriculture is the primary source of food and income for more than 80 percent of the country's population who live in rural areas. The sector is dominated by smallholder farmers who produce more than 90 percent of crop output and cultivate more than 95 percent of the crop land. Agriculture accounts for about 40 percent of the gross domestic product (GDP) of the country and 85 percent of total employment (MoFED, 2013; UNDP, 2014). Although Agriculture remains a key source of growth to Ethiopia's economy, it continues to be highly vulnerable to

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[1] *Ethiopia's real GDP grew by 10.3 percent in 2013/14, showing growth acceleration compared to 9.7 in 2012/13 and 8.8 percent in 2011/12. In 2013/14 the shares of services, agriculture and industry stood at 46 percent, 40 percent and 14 percent, respectively (UNDP, 2014).*

rainfall variability and drought shocks, that are the major causes of famine and food insecurity in the country.

The climatic condition is expected to be harsh in the coming years and based on global circulation models, the mean temperature in Ethiopia is predicted to increase from 0.9 to 1.1^{o}C by 2030, 1.7 to 2.1^{o}C by 2050 and 2.7 to 3.4^{o}C by 2080 (Belliethathan et al., 2009). Long-term climate change in Ethiopia is associated with negative changes in precipitation patterns, rainfall variability, and temperature, that could increase the country's frequency of droughts and floods (Tadege, 2007). You and Ringler (2010) also reported that Ethiopia is highly susceptible to frequent climate extremes such as frequent droughts and floods. The country experienced 12 extreme droughts between 1900 and 2009 that killed over 402,000 people, adversely affected the livelihoods of more than 54 million people causing damages of about US $93 million. Again, during the same period, 47 major floods occurred in Ethiopia that killed 1,957 people, affected 2.2 million Ethiopians and damaged about US$ 16.5 million worth property (EM-DAT, 2009).

The change in the climatic condition is expected to cause even more severe adverse effects on the country's economy and society. Rainfall variability has particularly contributed towards a great many of the food shortages and crop crises that Ethiopian farmers constantly face (Birhanu and Zeller, 2011; Bezabith et al., 2014). Dercon (2009) also showed that about half of all rural households in Ethiopia experienced at least one major drought in the five years preceding 2004, suggesting that climatic shocks are the major causes of transient poverty and welfare loss.

Adaptation, in relation to climate change, is an adjustment in natural or human systems in response to actual or expected shock factors or their effects, in order to moderate harm or exploit beneficial opportunities[2]. Adaptive capacity on the other hand, is ability of a system or society to modify its characteristics or behavior so as to cope better with changes brought about by external conditions such as climate change (IPCC, 2007). Most of the traditional risk sharing or mitigating strategies adopted by Ethiopian farmers, particularly those associated with a wider range of shocks, provide only a partial insurance mechanism (Mogues, 2011), have a high opportunity cost, tend to be very localized, and are limited in scope (Dercon, 2009). Thus, it is

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[2] *Section 3.4 presents a more detailed review of the literature on different adaptation strategies to climate change.*

crucial to improve the adaptive capacity of farmers to sustain their livelihoods and reduce their vulnerability to climate change (Mendelsohn, 2012).

Against this background, availability and accessibility of a reliable and well-functioning financial market is expected to improve the adaptive capacity of farm households. Financial resources such as remittances (e.g. Yang and Choi, 2007), savings (e.g. Fafchamps et al., 1998) and credit (e.g. Jacoby and Skofias, 1997), are shown to act as insurance against income shocks. Increased access to credit can help farmers to invest in better agricultural technologies such as high yielding variety (HYV) seeds, small-scale irrigation, fertilizers, and pesticides that can enhance output per hectare. When farmers get access to rural credit services, they enhance their asset building capacity and it can also help them to improve their adaptive capacity to sustain their livelihoods and reduce their vulnerability to climate change.

As the life-cycle hypothesis (Friedman, 1957; Modigliani, 1986) suggests, existence of a perfect and complete credit market allows households to borrow the amount of credit they want when they face liquidity problems and repay it in a period of high income. Micro-level evidence also attests to the view that financial resources can help the poor to harness capabilities needed to be resilient against shocks and improve their welfare (Swift, 1989; Moser, 1998; Ellis, 2000). Furthermore, the rural credit market can provide complementary services such as skills training on agricultural practices, better ways of allocating household resources, and methods of improving household health and educational status (Hammill et al., 2008).

However, in low-income countries, access to credit is limited due to imperfections in the credit market, and this may force households to resort to adopting inefficient adaptation strategies that have long term negative consequences on their future welfare. Crop failure due to rainfall variability, for example, can force farmers to sell their assets to smooth out consumption. In some cases, the value of assets could also drop if shocks persist for a relatively longer period and this may lead to irreversible loss of productive assets and may put households at risk of future poverty. Credit constraints coupled with exposure to climatic shocks may also compel farmers to shift away from high income and high risk economic activities to low risk and low income activities, leaving them in unsustainable livelihoods and the vicious circle of poverty (Humphreys et al, 2004; Charles, 2011). The macro level literature on the relationship between credit access and climatic shocks also shows that the effect of climatic shocks on economic growth will be amplified when credit constraints are binding (e.g. Aghion et al., 2005).

1.2 The Research Problem

Financial resources can potentially form one of the key strategies to both expanding and strengthening risk mitigating instruments, particularly with increasing threat of climate change. However, the direct role of access to credit in withstanding against climatic shocks, and the nature of credit constraints and their differing impacts on specific climate change adaptation strategies is not fully understood. First, evidence on the specific links between credit constraints, choice of adaptation strategies, and welfare implications are largely mixed. Binswanger (1991), for instance, argues that access to rural credit (relaxing credit constraints) tends to increase the demand for land, leading to a more rapid expansion of crop farmland and pasture that may damage the environment. Pfaff (1999) using number of bank branches as a proxy for credit supply finds that there is positive correlation between access to credit and deforestation, and Hargrave and Kis-Katos (2010) also find similar results. Assunção et al., (2013), using data from Brazil, argue that credit constraints reduce deforestation by reducing the probability of clearing forest areas to convert them into agricultural land.

On the contrary, other studies show that credit constraints significantly increase environmental pollution (Andersen, 2012); reduce farm investment (Carter and Olinto, 2003), agricultural output (Petrick, 2005), and efficiency of intra-household resource allocation (Fletschner, 2008). It also reduces farm profit (Foltz, 2004), and technical and financial efficiency in agriculture (Hamda and Öhlmer, 2006; Fletschner *et al.*, 2010). Islam and Lopez (2011), argue that reducing credit market imperfections will reduce environmental degradation by reducing credit constraints. Tamazian and Rao (2010) also highlight that financial sector development has an important positive effect on choosing sustainable adaptation strategies and environmental protection efforts. Further, Dasgupta *et al.,* (2006), using data from low and middle income countries, found that a well-performing financial market reduces environmental pollution by discouraging environmentally damaging production activities.

Second, an in depth analysis of the role of credit constraints to adaptation and household welfare in the context of climate change is missing in prior studies. This is despite the growing literature on the links between climate change and agricultural performance, as well as the impacts of alternative climate adaptation strategies in the African context (for example, see: Adger et al., 2003; IPCC, 2007; Seo and Mendelsohn, 2008; Hassan and Nhemachena, 2008; Di Falco and Bulte, 2011; Di Falco et al., 2011; Bezabih and Di Falco, 2012; Palmer and Di Falco, 2012). However, there has been little exploration of the impact of credit constraints on the choice of adaption strategies[3]. Specifically, the choice of adaptation strategies and their likely differing responsiveness to financial constraints has been significantly under-researched, especially within a panel framework.

Third, in the context of Ethiopia, there are reasons to expect that the adaptive capacity and welfare of farm households to be limited due to credit constraints (EEA, 2011). The lion's share of bank loan in Ethiopia goes to finance public enterprises and sectors given top priority by the government (IMF, 2012:12); and Ethiopia ranks 104th while, neighboring Kenya stood 12th out of 185 countries in terms of ‘access to credit’ (World Bank, 2013). Banks in Ethiopia are not willing to lend to smallholder farmers due to the inherent risk in agricultural production and lack of collateral, and hence, smallholder farmers are excluded from the formal banking market. Micro financing institutions and rural credit cooperatives try to fill the credit demand and supply gap by providing alternative formal credit services to farm households (see Amha and Peck, 2010 for details). However, despite the rapid growth of these institutions in recent years, they reach only less than 20 percent of farm households and only less than 3 percent of the rural and urban households (AEMFI, 2011).

Fourth, over the years, it was assumed that if there is supply of credit, then demand follows automatically. But, this assumption has been challenged in many instances where high dropout and low participation rate of farm households in the rural credit market is observed. Despite the increasing number of micro credit programs in the rural areas of developing countries, many farm households rely on informal lenders (Diagne and Zeller, 2001). This

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[3] *Section 3.4 presents a more detailed review of the literature on the links between credit access and adaptation to climate change, focusing on the responsiveness of key adaptation strategies (relevant to the setting of the study and empirical analysis) to credit constraints, highlighting the gaps in the existing literature.*

implies that availability of the rural credit market doesn't guarantee participation in this market unless the institutional design of lending institutions take in to account the conditions under which farm households operate. Prior studies also show that there is high client dropout rate of 25 to 60 percent per year in East African rural credit markets (Wright, 2001). In the Ethiopian context, many ‘eligible’ households in northern Ethiopia, are not happy to participate in the rural credit market (Woldehanna and Oskam, 2002; Berhane and Gardebroek, 2011).

In light of these practical problems and the identified gaps in the literature, the focus of the current dissertation is on assessing the nature and extent of credit constraints and the link between different forms of credit constraints and choice of adaptation strategies. The major premise of the study is that improving household access to finance and integrating climate change adaptation strategies into poverty reduction strategies is an important step in making vulnerable households more resilient to climate change. This premise is based on the testable hypothesis that degree and nature of credit constraints is a critical factor in the choice of adaptation strategies, asset holdings, agricultural productivity, and household welfare.

It is also crucial to investigate both supply- and demand-side factors that impede farm households' access to and participation in the rural credit market in a panel data framework and, to the author’s knowledge, no study tried to address these empirical issues in the context of the study area. Further, understanding the effect of climatic factors coupled with credit constraints on farm households' production and asset accumulation decisions is of great interest for formulating pro-poor growth policy. Thus, findings of the current study may give insight for designing targeted policy packages that can induce poor households to build assets, adopt productivity-enhancing agricultural technologies and sustainable adaptation strategies to become less vulnerable to climatic shocks. It is also expected to have important implications for promoting demand-driven, climate-smart, and inclusive rural credit market in a low-income country setting.

1.3 Objectives of the Dissertation

Credit constraints can have direct contribution to potential welfare loss of farm households by reducing agricultural productivity, capacity to build productive assets, and increasing vulnerability to the adverse effects of climate change.

In addressing these issues, the general objective of the current dissertation is to explore the nature and extent of credit constraints, farm households' choice of various climate change adaptation strategies and the implications for agricultural productivity and household welfare.

The specific objectives deduced from the general objective are to:

i) explore the nature and extent of multiple credit constraints and borrowing behavior of farm households;
ii) examine the effect of credit constraints and climatic factors on farm households' choice of adaptation strategies;
iii) investigate the impact of climatic shocks and adaptation strategies on household asset holdings under different credit constraint conditions; and
iv) evaluate the impact of multiple credit constraints on Agricultural productivity under changing climatic condition;

1.4 Justification and Significance of the Study

The adverse effects of climate change are already in play in poor, natural resource-dependent developing countries such as Ethiopia. Agriculture remains a key source of growth to Ethiopia's economy but it continues to be highly vulnerable to rainfall variability and drought shocks. Climate change is one of the major challenges to the effective implementation of Ethiopia's Growth and Transformation Plan (GTP) and the country's ambition to attain the sustainable development Goals (SDGs).

Ethiopian farm households, in particular, bear a disproportionate burden of the adverse effects of climate change given their limited adaptive capacity coupled with credit constraints. In this regard, a research that explores the impact of climate change and credit constraints on key household priorities such as increasing agricultural productivity, building productive assets and improving adaptive capacity is crucial. This involves investigating the existence, nature and extent of credit constraints; exploring the impacts of climate change; identifying indigenous adaptation strategies adopted in different agro-ecological zones under various credit constraint conditions; and the implications for household welfare.

Such studies can generate the required empirical evidence to inspire policies, strategies and programs aiming at improving the quality of life of the poor and bring about rural transformation. However, to the knowledge of the author, there are no such detailed household level studies that demonstrate the link between credit constraints, choice of adaptation strategies and various welfare outcomes. The current dissertation tries to bridge these identified gaps, and it is hoped that it will contribute to the existing knowledge by providing important information in designing and fine-tuning climate-resilient growth policies and in promoting climate-smart and inclusive credit market in a low-income developing country setting.

1.5 Summary and Outline of the Dissertation

The current dissertation consists of eight chapters including the introductory chapter. Chapters four to seven were prepared as self-contained articles to be published in reputable journals. Chapter four is already published as a conference proceeding and is also expected to appear as a journal article after incorporating reviewers' comments. Chapters five to seven have already been submitted to different journals and discussion paper series, and they are expected to be published following the review process. Thus, the reader may face some repetitions here and there, especially overlaps in the data descriptions.

The second chapter provides background information regarding the regional economy, socio-economic conditions of the study area, data sources and how the study was conducted. Chapter three extends the discussion in chapter two and it gives survey of the literature on the rural credit market and discusses some of the imperfections that create credit constraints on farm households. Chapter four identifies the nature of credit constraints and borrowing behavior of households in the context of rural Ethiopia. This is crucial both from empirical and policy perspectives, since it is a central welfare and development issue. Empirical evidence on this topic is rare in the context of rural areas in sub Saharan Africa in general, and particularly in rural Ethiopia and chapter four tries to fill this gap.

Chapter five focuses on assessing the link between different forms of credit constraints and the choice of adaptation strategies. The major premise of this chapter is that improving household access to finance and integrating climate change adaptation strategies into poverty reduction strategies is an important step in making the most vulnerable households more resilient to climate change. This chapter shows that credit constraints are significant determinants of participation in different adaptation strategies. However, the severity of credit constraints depends on the type of adaptation investment. This highlights the need to recognize the complex relationships between financial provision and climate change policies, and the implications for situation–specific policy design regarding adaptation to climate change.

Chapter six gives empirical evidence on the effect of climatic factors and adaptation strategies on household asset holdings under different credit constraint conditions. To the knowledge of the author, no study tried to address this issue in the Ethiopian context in general, and particularly in the context of the study sites. Hence, this chapter contributes to the limited literature in this area by: (i) providing new evidence on the impact of objectively measured, exogenous climatic shocks on household asset holdings; and (ii) investigating the effect of different credit constraint conditions on managing climatic shocks and in building assets. Understanding the effect of climatic shocks and credit constraints on household asset holdings is expected to provide insight for designing targeted policy packages that can help poor households to improve their adaptive capacity and become less vulnerable to climatic shocks.

Chapter seven investigates the effect of different types of credit constraints on agricultural productivity under changing climatic condition. Specifically, that chapter looks into the effect of being credit constrained on farm households' agricultural productivity in a panel data framework. The results provide strong evidence for the adverse effects of being credit constrained (falling in discouraged or quantity constrained borrower group) in improving agricultural productivity in the study area. It is a rational decision to invest in fertilizers, improved seeds, and drought-resistant crops that can increase productivity in the face of changing climatic conditions. However, adoption of such technologies is hampered by credit constraints and this has a direct negative effect on agricultural productivity in the study area, as shown in this chapter. The chapter generates policy-relevant information to enhance agricultural productivity by improving performance of the rural credit market.

Finally, chapter eight concludes the dissertation by pointing out issues to be considered in future research and in designing and fine-tuning policies that enhance and strengthen institutional support to improve the adaptation capacity of farm households.

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CHAPTER 2

RESEARCH METHODOLOGY

2.1 Introduction

This chapter provides an overview of the regional economy and describes the underlying socio-economic and biophysical contexts in which the sampled farm households are operating. The chapter is organized as follows. Section 2.2 provides brief background information about Amhara region from which four zones were selected for the current study. In addition to the specific data descriptions given in each chapter, a general discussion about the study zones and data used in this dissertation is presented in sections 2.2.2 and 2.2.3. Section 2.2.4 discusses the change in the climatic condition in the study area during the last three decades. Finally, section 2.3 describes the methodology adopted in this study.

2.2 Background to the Economy of the Amhara Region and the Sampled Zones

Ethiopia has 11 regions, with each region divided into zones and each zone into woredas (districts). Woredas are further subdivided into kebeles[4] or peasant associations (PAs), which are composed of households. The Amhara National Regional State (ANRS) is situated between 9°–13°45'N latitude and 36°–40°30'E longitude in the north-western part of Ethiopia with a total land area of 157,126.85 km, that is about 15 percent of the country's land area and with an altitude ranging from 600 meters above sea level (asl) at Metema area to 4520 meter asl at Ras Dashen mountain located in north Gonder (Amhara Regional State Report, 2003). The region is bounded by Afar, Benishangul Gumz, Oromia and Tigray regional states in the east, south-west,

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[4] *Kebele is the lowest administrative unit in the Ethiopian governance structure.*

south and north, respectively, and by the Sudan in the west. In the region, there are only three major towns that have a population of above 150,000 ([5]Amhara, BoFED, 2009).

The regional economy is highly dependent on agricultural production, that is mainly under smallholder's production system with the majority practicing traditional methods of farming. Agriculture is the backbone of the regional economy with a total cultivated area of 4.40 million hectares (about 34 percent of the cultivated area of the country) and total production of 76 million quintals (32 percent of the country's production). Cereals, pulses, oil seeds, fibers, cotton and root crops are the major crops grown in the region. The region also has a huge potential in terms of livestock populations as it comprise about 25 percent Tropical Livestock Unit (TLU) of the country (BoFED, 2011). The major source of livelihood for the population of the region is agriculture (that comprises about 56 percent), while service sector and industry account for 21 and 17 percent respectively. The regional economy has grown at an average rate of 8.7 percent for six consecutive years (2005-2011) and the growth rate for each of the sectors shows that agriculture grows annually by 9.17 percent, the service sector by 9.0 and industry by 6.7 percent (BoFED, 2012).

2.2.1 Agro-ecological Zones of the Study Area

Based on its altitude, the region can be divided into three broad agro-ecological zones: *Kola* (hot zone) - below 1500 masl that covers 31 percent of the region; *Woyina Dega* (warm zone) - between 1500 - 2500 masl covering 44 percent and *Dega* (cold zone) - between 2500 - 4620 masl and it covers 25 percent of the region. The mean annual temperature of the region is between 15ºc and 21ºc. But in valleys and marginal areas, it exceeds 27ºc. (Taye and Zewdu, 2012). The region experiences bi-modal type of rainfall distribution where there is large coverage during the rainy season "*Meher*" that encompasses all areas of the region and the short rainy season "*Belg*" covers Eastern parts of the region.

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[5] *Amhara Bureau of Finance and Economic Development (BoFED) (2009/10). Regional Growth and Transformation Plan 2010/11–2014/15.*

On the other hand, the region has about 12 dominant soil types with a distribution that is very much influenced by the physiographic and geology of the region (MOA, 2000). The mountainous and degraded landscapes are covered with shallow and stony soils; the undulating and gently rolling areas are characterized by dark red- to brown-coloured deep soils; depressions and flat plains are characterized by black clay soils; while the foot hills consist of alluvial soils (ibid). This can be considered as an important resource as far as agricultural production and rural livelihoods are concerned.

2.2.2 Description of the data set

2.2.2.1. Data source and type

The empirical data used for this study was drawn from two waves of panel survey by the Ethiopian Project on Interlinking Insurance and Credit in Agriculture (EPIICA) designed and implemented jointly by the Ethiopian Economics Association, University of California San Diego, University of Athens, Greece, Dashen Bank and Nyala Insurance Company. While the first survey was conducted in 2011, the second round was conducted after two years later in 2013. This study is based on these two surveys conducted in 2011 and 2013 respectively.

The data were collected from four zones (north Shewa, south Wollo, north Wollo and west Gojjam) of the Amhara National Regional State located in the northern and Central Highlands of Ethiopia (Figure 2A.1). Households within the selected kebeles were randomly selected to participate in the study. About 33 percent of the 1,200 sampled households reside in north Shewa zone, 31 percent in west Gojjam, 23 percent in south Wollo, and the remaining 13 percent reside in north Wollo zone.

This unique panel data contains quantitative information on agricultural production, agricultural input use, access to credit, consumption expenditure and household's socio-economic characteristics. The Household socio-economic characteristics contain demographic information (age, education, marital status etc), household borrowing and lending behaviour, food consumption items, consumption and non consumption expenditure, income from different sources, risk, food security, and asset holdings of farm households. The agricultural production section contains detailed information on crop production, cultivated land area, the types of inputs used, types of crops produced, amount of crops produced, amount of crops sold, and Livestock production and marketing of farm households.

2.2.2.2. Constructing the Panel data set and linking it with climate data

Even though the measurement for most of the variables used in the analysis is straight forward, the data cleaning process required explanation for some of the variables. Farmers reported their cultivated land by using different local units of measurement thus, plots cultivated by households measured by local units were converted into standard measure, hectare, using standard conversion units from EPIICA conversion factors that was collected during the survey period. Then, the plot level information was aggregated into household level. On the other hand, quantity of crop produced was also converted in to standard units (kg) using local unit conversion factors prepared during the data collection. The quantity of production (cereal crops and root crops or fruits) was converted into value in ETB. The nominal value of production was converted into real values using CSA's production price data and 2011 was used as a base year.

Livestock ownership in tropical livestock units (TLUs) was calculated using Janke (1982) approach. In this study, consumption is defined as the sum of values of all food items, including purchased meals, and non-food items. The food and non food expenditure was converted into real expenditure using CSA's consumer price index. After this, the data was aggregated at household level in order to get total real value of expenditure at household level. Finally, a balanced panel of 1,189 households consisting of 2,378 observations over two rounds was created.

Monthly rainfall data were obtained from the National Meteorological Agency of Ethiopia, from eight stations close to the study districts (woredas) for the years between 1983 and 2013. The rainfall measure was constructed by taking the sum of monthly rainfall for each year and averaging it over 30 years. The temperature average was also calculated as the monthly temperature average, further averaged over 30 years. Then, we calculated the coefficient of variation (CV) for rainfall, measured as the standard deviation divided by the mean for the respective periods. We linked these climate variables with the household survey data using the thin plate spline interpolation technique. This technique uses latitude, longitude, altitude and other relevant geographic information in linking the climate data with the household survey data (Wahba, 1990; Gu, 2002; Wood, 2003).

2.2.3 Selected Demographic and Socio-economic Indicators of the Study Zones

The total estimated population of the region is 20,219,999 that is about 24 per cent of the country's population, with an annual growth rate of 2.4 percent and average household size of 4.3 (CSA, 2013).[6] The distribution of the regional population by residence shows that 3,782,997 are urban residents, 16,437,002 are rural residents with 9,619,672 male and 9,600,327 female. North Gondar administrative zone has the highest population size while, west Gojjam administrative zone has the highest population density. On the other hand, according to the report by the regional BoFED (2012), majority of the population is mainly of young age group; 40.51 percent of the population is below the age of 14 years; those between 15-64 years of age group are 55.23 percent and above 65 years are 4.26 percent.

Vulnerability and adaptive capacity of farm households to climate change-induced hazards is expected to vary with demographic and socio-economic conditions. Hence, in this section, we discuss demographic characteristics such as gender (male or female headship), age, education and family size of respondent households, and also socio-economic conditions including ownership of productive assets, agricultural production and access to markets (for example, access to the rural credit market).

Table 2A.1 exhibits some basic demographic and socio-economic characteristics of the sampled households. Most household heads in the sample are above 25 years of age and the majority of them are in the 45 to 60 years of age category. The number of female headed households has increased from about 9 percent in 2011 to 12 percent in 2013. Family size, in this study, is defined as the number of permanent members of a household who share the same hut, kitchen and resources for food and other basic needs. The average household size in the study area is about 5 persons, while it is a bit higher in some zones such as west Gojjam. A plausible explanation for this trend may be the fact that children are considered as assets in rural areas of most developing countries including Ethiopia. However, in the context of the study area, the

[6] *Central Statistical Agency (CSA). 2013. Population Projection for Ethiopia 2007–2037. Addis Ababa: CSA.*

larger family size is expected to have serious food security constraint in the light of declining crop and livestock production and diminutive land holdings. The survey instrument also gathered information about years of schooling and on average, 22 percent of the heads have 5 years of formal education and 27 percent have attended some informal education[7].

Land holding is an important productive asset that determines the social and economic status of farmers in the community. The data reveals that the mean land holding was about 1.07 hectares (ha) in 2011 and it declined to about 0.73 in 2013 (Figure 2.1). A major reason for this may be the fast population growth in the Country in general, and that of the region in particular. As population grows, the demand for farm land increases while, the land size is fixed. From among the farming communities, farmers in west Gojjam owned relatively larger size of land in 2011 followed by north Shewa and south Wollo. Since estimates indicate that an average household with 5 members would require about one hectare of land for subsistence production (Alemneh, 1992), the decline in land holdings observed in the study area remain a major cause of concern in terms of feeding the ever increasing population given the low level of productivity.

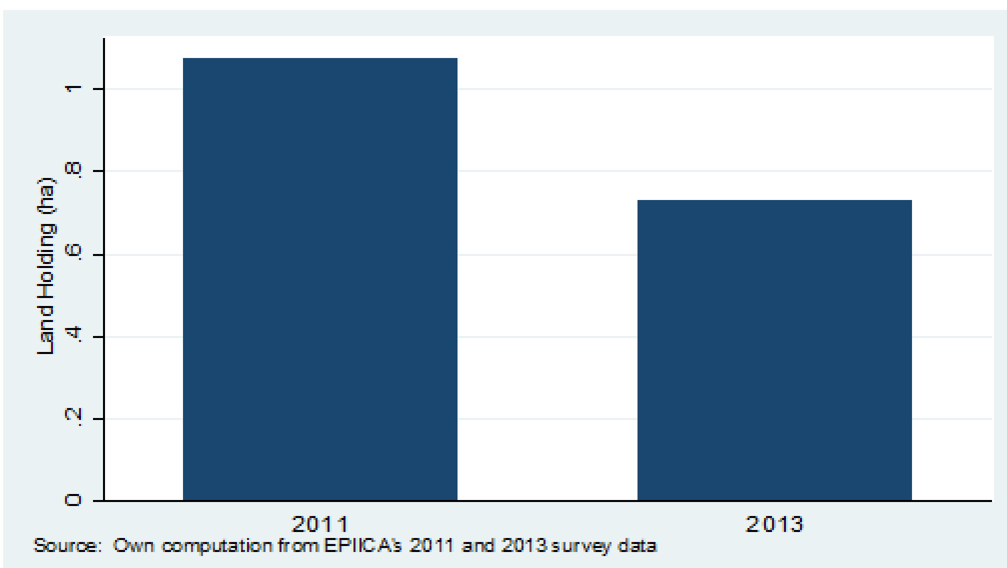
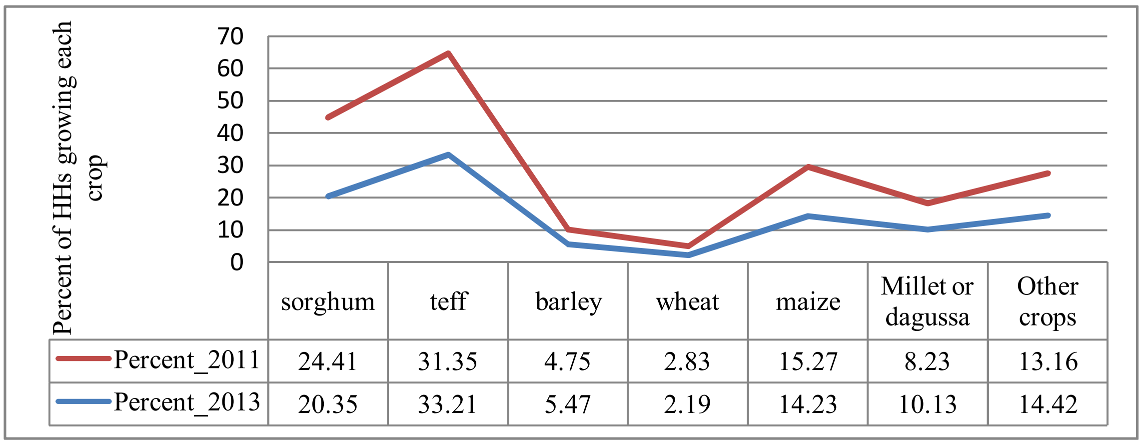


Figure 2.1. Land holding (ha) by year

[7] *Further discussion on the relationship between socio-economic characteristics, credit constraint status, and choice of adaptation strategies is given in sections 3.4 and 5.2 below.*

Agricultural production in the study area is dominated by 6 major cereals that account for about 86 percent of the total crop production of the study area (Figure 2.2). Among the cereals, Teff, Sorghum, and maize are the three major crops grown in the study area and they account for 31, 24, and 15 percents in the year 2011, in that order. The last column in Figure 2.2 shows that the production of other crops such as oil seeds, pulses, perennials, and fruits and vegetables accounts only for less than 15 percent over the years. Moreover, there is a general declining trend in crop production in the study area.



	sorghum	teff	barley	wheat	maize	Millet or dagussa	Other crops
Percent_2011	24.41	31.35	4.75	2.83	15.27	8.23	13.16
Percent_2013	20.35	33.21	5.47	2.19	14.23	10.13	14.42

Figure 2.2 Major crops grown in the study area by year

Agricultural productivity of the study area also remained very low over the years. Although, there was a slight increase in productivity in north Shewa and north Wollo zones, the overall real value of output per hectare has been below ETB 1,500 in the study area during the study period (Figure 2.3). As the case in Ethiopia, in general, climatic shocks, deforestation and land degradation have been among the major causes for the lower agricultural productivity in the study sites.

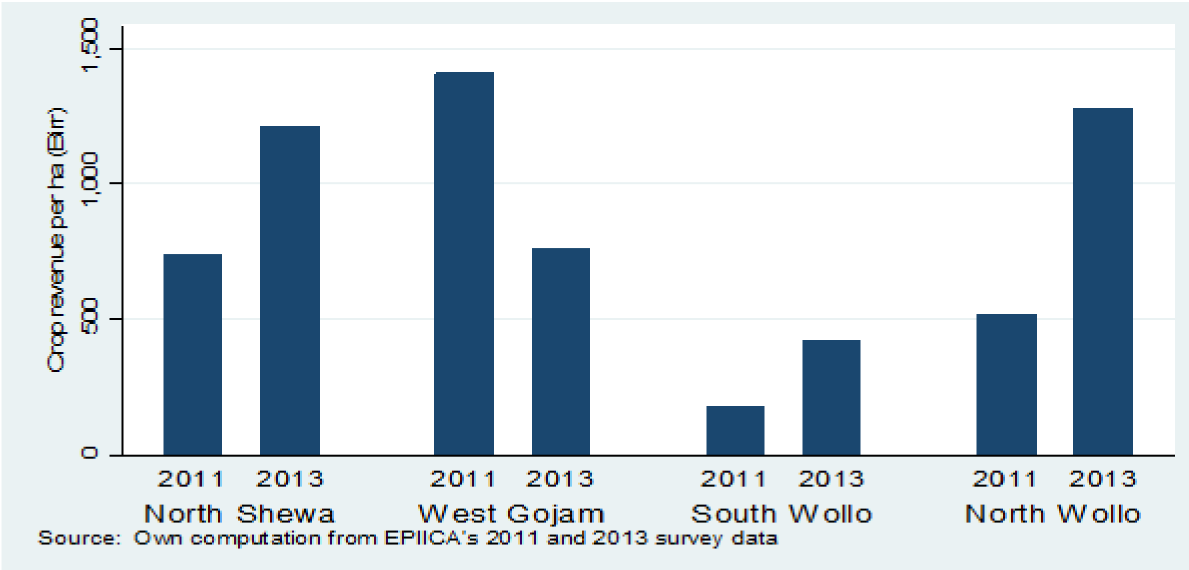


Figure 2.3. Average real crop revenue per hectare (Productivity)

Future climate Predictions using General Circulation Models (GCM) also show that the mean maximum temperature will increase by 2.3 °c in north Shewa, south Wollo and north Wollo zones in 2080s while, it will rise by 1.8 °c in west Gojjam zone. On the other hand, rainfall is expected to decrease by 27.2 percent in the first three zones while, it will reduce by 12.2 percent in west Gojjam zone (Ayalew et al., 2012). This indicates that climate change will continue to be a major threat for the study area as it may lead to increased exposure to rainfall variability, recurrent droughts and shortage of water. This is expected to further reduce agricultural productivity of the study sites in the future.

Land expansion to increase agricultural production is no more a feasible option because of the high population pressure and scarcity of suitable farm lands. Hence, improving agricultural productivity is the way out and it requires more investment on sustainable adaptation strategies, improved farming systems and adoption of agricultural technologies such as high-yielding, drought resistant varieties, chemical fertilizers, and soil conservation measures (Kassie *et al.*, 2011). Nevertheless, adaptation efforts are very weak and technology adoption also remains very low in the Amhara region due to reasons such as: (i) lack of information and know-how about different agricultural technologies, (ii) weak integration of research with agricultural extension to learn from the day-to-day problems of farmers and to incorporate them in designing better agricultural technology policies; and (iii) weak access to innovative and reliable credit facilities to purchase recommended agricultural technologies that can improve productivity (BoFED, 2013: p. 35). (Section 7.3.2 provides further discussion on this).

2.2.4 Climatic Condition of the Study Area: Evidence from Time Series Data

In this section, we analyze and discuss the time series climate data obtained from the National Meteorological agency to explore whether there is a change in the climatic condition in the study area. As discussed in section 2.2.2 above, we linked the climate data with the survey data using the thin plate spline interpolation technique that uses latitude, longitude, altitude and other relevant geographic information to link the climate data with the household level data. Figure 2.4 shows the interpolated rainfall stations used in this study. Among the stations, Gudoberet and Haik represent two major climate zones or patterns in the study area. Haik station represents the more arid and drought prone zones including south Wollo and north Wollo, while Gudoberet has comparable rainfall pattern as in west Gojjam zone, which gets relatively higher total annual rainfall. Hence, we discuss the rainfall and temperature patterns in these two stations as follows[8].

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[8] *Although we analyzed the climate data from all the nearest stations of the study area, the discussion in this section focuses only on two of the stations for two reasons: (i) these stations give the general picture of the climatic condition in the study area, and (ii) to keep the document more compact. The full set of tables and graphs are available on request for interested readers.*

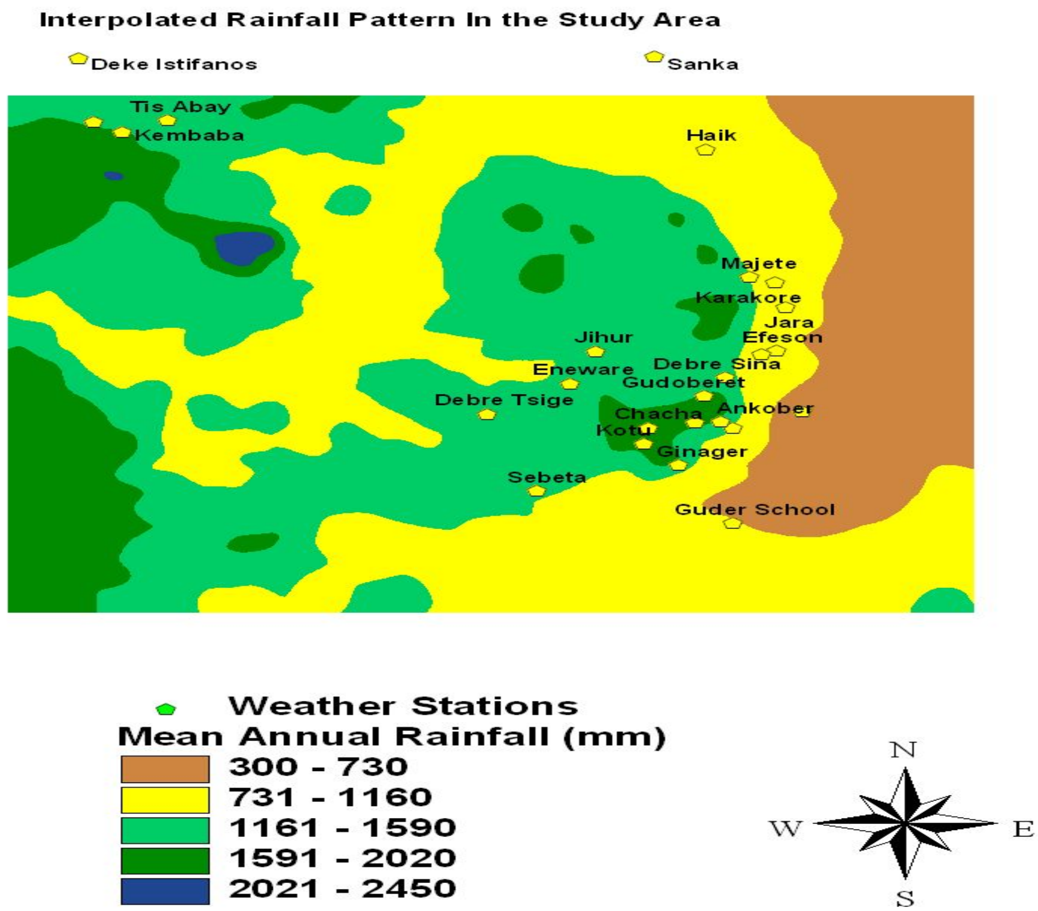

Figure 2.4: Interpolated rainfall pattern in the study area

2.2.4.1. Climate Data for Basona Worena District, north Shewa Zone

The rainfall and temperature data collected from Gudoberet station in Basona Worena Woreda of north Shewa zone shows that there is an increasing but highly fluctuating trend in the rainfall. Even if there is an increase in the mean annual rainfall (by about 30 mm per year), figure 2.5 shows that the rainfall was more or less constant during the period 1994 to 2004. In the remaining years, specially, before 1994 and after 2004, there is high fluctuation (anomaly) from the mean annual rainfall in the area. Such high variability may adversely affect agricultural activities in general, and particularly, crop production in the study area.

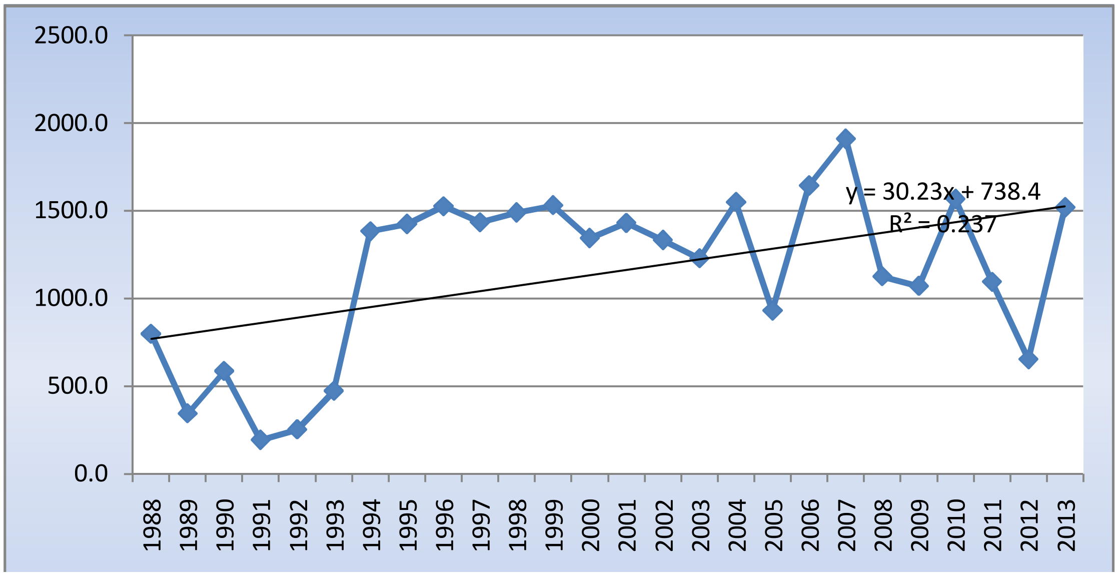

Figure 2.5: Trend of total annual rainfall (mm) in gudoberet station

We also analyzed the long run seasonal distribution and variability of rainfall as it has important implications for farm households whose crop production directly depend on rainfall. Figure 2.6 shows that this woreda has two rainfall seasons. The first season starts in November and goes to February with a peak rainfall in February. The other season begins in May and ends in September, with the highest rainfall in June. This distribution of the mean monthly rainfall in the area shows that the woreda remains dry during many of the months except some rain in July and December. It implies that the area seems to be more suitable only for crops like wheat, which grow in short rainfall seasons. This may have serious adverse effect on agricultural production and welfare of farmers (see chapters 6 and 7 for further details on the impact of such changes on household welfare).

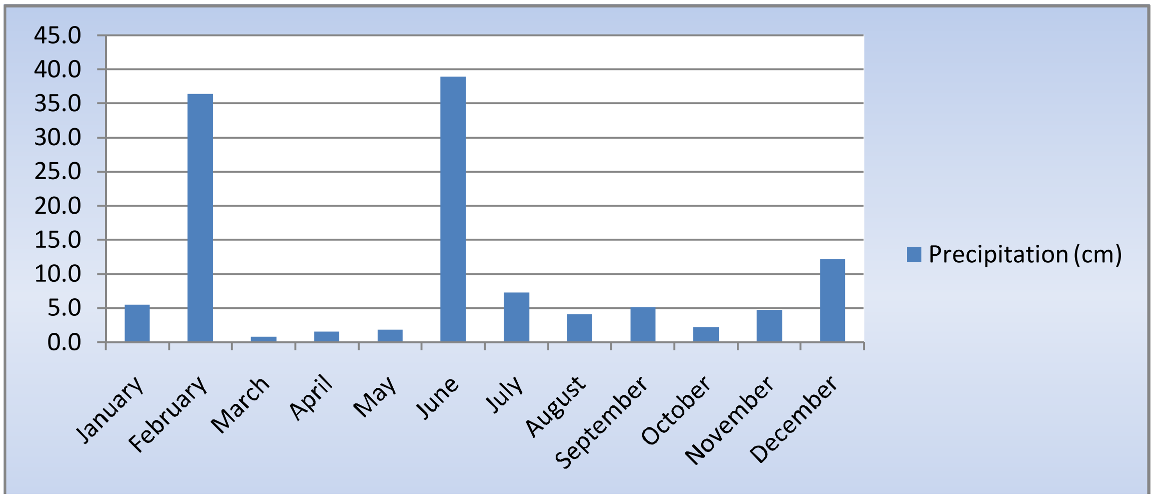

Figure 2.6: long-term pattern of monthly rainfall in Gudoberet site

Figure 2.7 shows that the mean annual maximum temperature in this site has been slightly increasing over the last three decades. The regression model for the mean maximum temperature tells that the annual temperature is increasing by 0.023 ^{o}C per year while, the mean minimum temperature is declining by 0.04 ^{o}C per annum. This suggests that days are becoming hotter while nights are becoming cooler over the years.

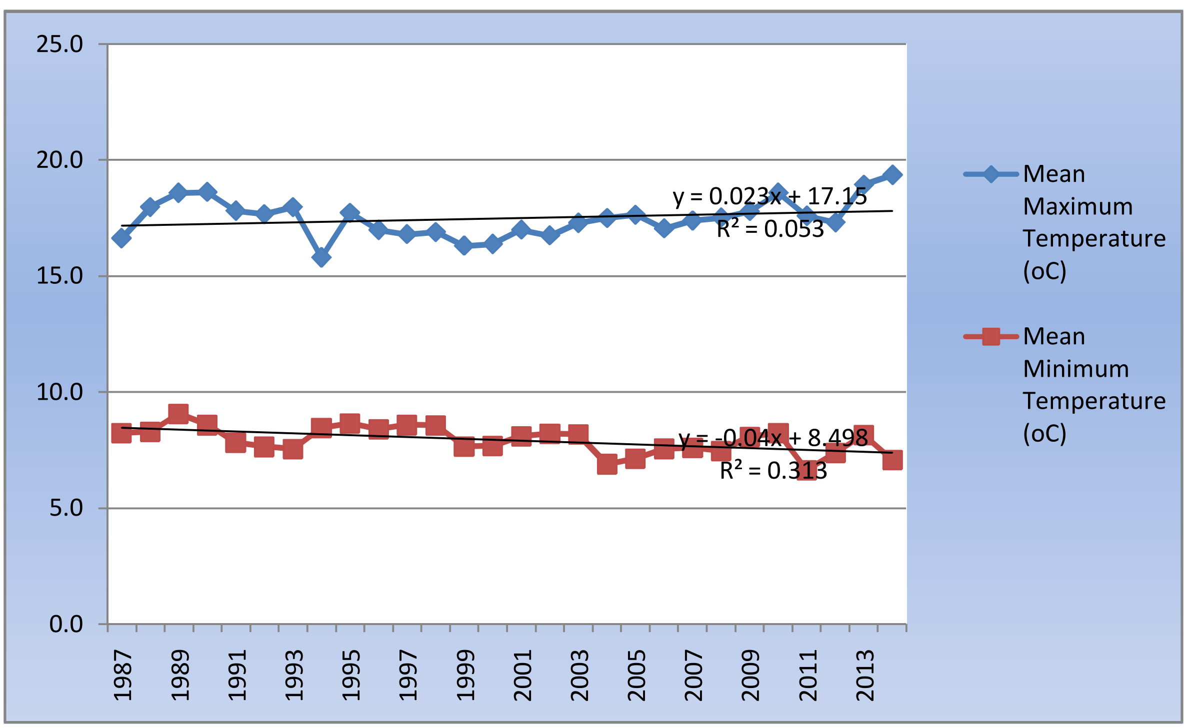

Figure 2.7: Mean Annual Minimum and Maximum Temperature Trend in Gudoberet Station

Variation of the mean maximum temperature from its mean value was 0.5 °C in 1995 and this has increased by 1.5°C in 2013, showing an enormous change in the atmospheric temperature in this woreda within a decade (Figure 2.8). This agrees with the general global warming phenomenon. Global climate models predict that a higher upward variation of the temperature is a disaster both for plants and animals (Brooks, 2006; Moorhead, 2009). Plants, for example, are very sensitive to high temperatures during their decisive flowering and seed development stages, while livestock die due to reduced feed, lack of water, and incidence of animal diseases.

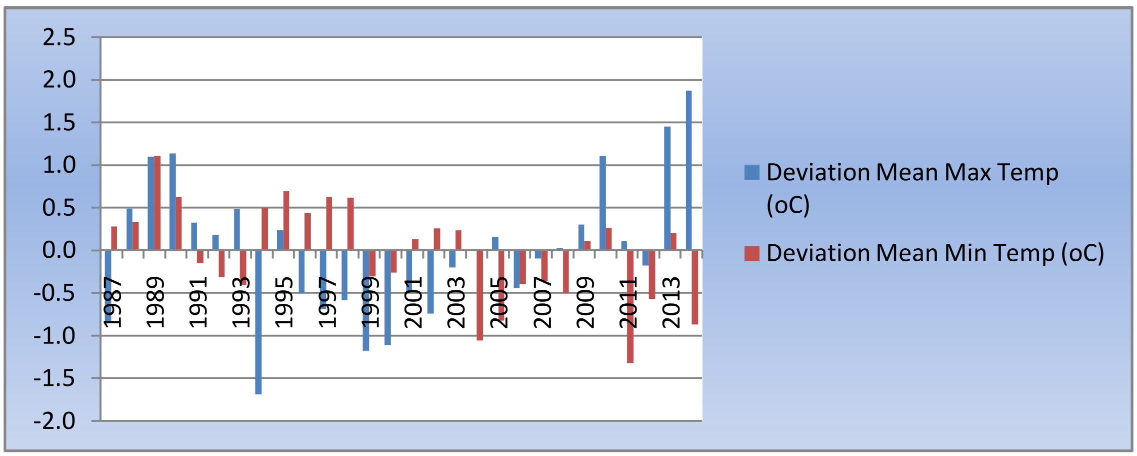

Figure 2.8: Anomaly from Mean of the Annual Minimum and Maximum Temperatures (°C) in Gudoberet Station

2.2.4.2. Climate Data for Guba Lafto District, north Wollo Zone

The long run rainfall trend in Haik station (in Guba Lafto district of north Wollo zone) is presented in Figure 2.9. It shows that this site gets much lower amount of total annual rainfall with a very high variability, compared to that of the Gudoberet station. The long term pattern of the rainfall (Figure 2.10) also confirms that, on average, the area gets a rainfall amount of less than 135 mm in most months of the year. The district gets a relatively higher amount of rainfall only in February and June, with the highest being 290 mm in February. In recent years (since 2010), the rainfall in north and south Wollo zones has shown a drastically decreasing trend (Figure 2.9), which also agrees with the predictions of global climate models.

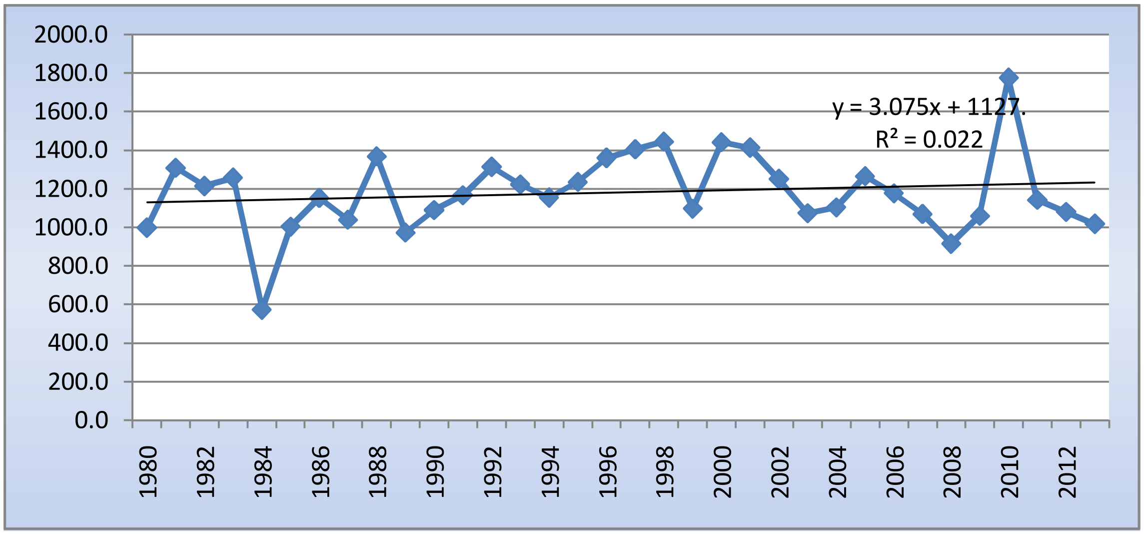

Figure 2.9: Trend of Total Annual Rainfall (mm) in Haik Station (north Wollo)

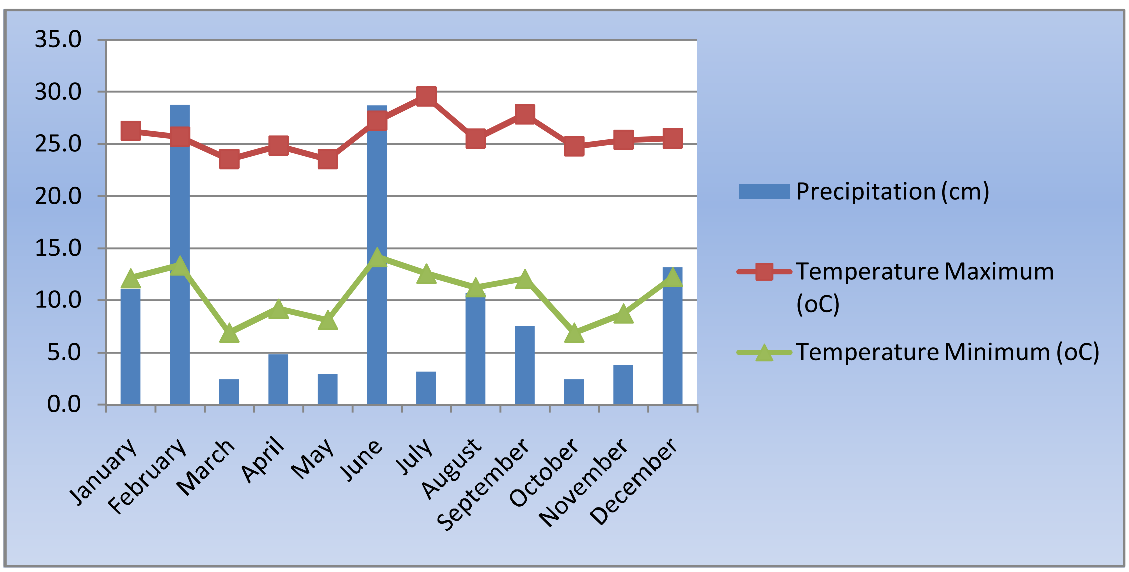

Figure 2.10: Long-term Pattern of Monthly Rainfall and Temperature in Haik station

The mean annual maximum temperature in Haik station has been increasing by 0.03 ^oC per year over the last three decades, while the mean annual minimum temperature has been steadily declining by about 0.013 ^oC per annum (Figure, 2.11). This is a similar trend as the case in Gudoberet but the days are hotter in Haik, while the nights are less colder.

In summary, these findings show that there is strong evidence for climate change in the study area with decreasing rainfall trend and increasing day time maximum temperatures. The total amount of the annual and seasonal rainfall has been declining and becoming highly unpredictable while, the day time temperature has been steadily increasing over the last three decades. Such change in the climatic condition is expected to have serious adverse effect on agricultural production and livelihoods of farm households as discussed in the subsequent chapters of this study (see chapters 5 to 7).

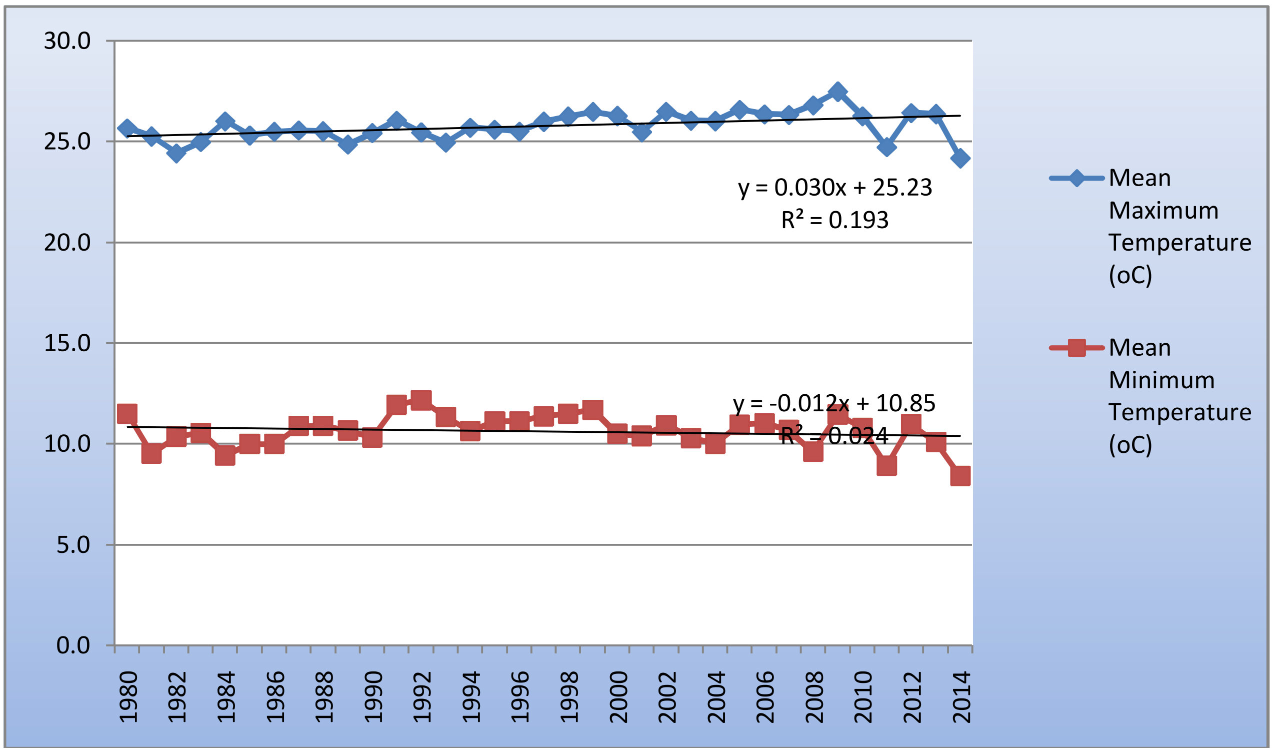

Figure 2.11: Mean Annual Minimum and Maximum Temperatures Trend in Haik Station

2.3 Research Methodology

To meet the specific objectives listed in this dissertation, we used a variety of research methods. The primary goal of adapting to climate change is to reduce vulnerabilities of farm households to disruptive climatic shocks and to protect and enhance their livelihoods. This in turn, requires understanding how their livelihoods are comprised, conducted and interact with climatic conditions. Thus, first, we conceptualize the natural and socio-economic context in which the households live, and composition of the livelihood assets they own. This is important, because, it is expected that households' vulnerability to climate change, their choice of adaptation strategies and their participation in the rural credit market largely depend on the natural and socio-economic context in which they live. Hence, based on the literature on rural livelihoods (Swift, 1989; Frankenberger and McCaston, 1998, Carney, 1998; Ellis, 2000; 2003a; 2004) and context of the study area, the dissertation is conceptualized using Figure 2.12 below.

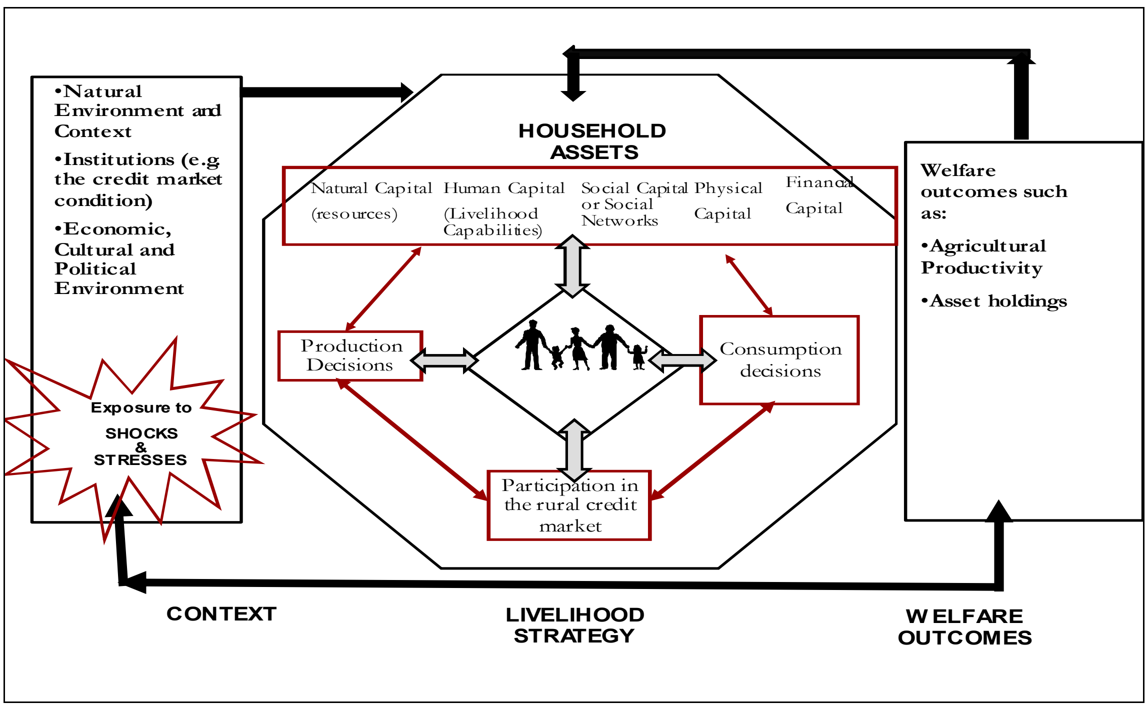

Figure 2.12: Diagrammatic conceptualization of the study

Household assets mainly comprise "the means of production available to an individual, a household or a group that can be used in the livelihood activities" (Ellis, 2000; Adem, 2011). The questionnaire captured the status of the livelihood assets or capitals owned by the sampled households during the study period. We classified them in to five major asset groups, viz. natural, physical, human, social, and financial capital using the sustainable livelihood framework (SLF) as depicted in figure 2.12 above. Indicators of natural assets included in the questionnaire were: ownership of farm land, access to irrigation water, access to drinking water and firewood, while, physical assets consisted of livestock in TLU terms, ownership of production tools[9], consumer durables[10], and number of trees planted. Household size, age, gender, and education of the head were used as indicators of human capital whereas, Neighborhood ties, benefits from kinship, membership in local associations such as solidarity groups, primary multi-purpose cooperatives, Iddir[11], Iqqub[12] or rotating savings and credit association (ROSCA), kebele council etc. were used as indicators of social capital. Finally, financial capital was captured using ownership of bank account, amount of savings, access to credit facilities from formal lending institutions (such as banks, MFIs, credit cooperatives etc.), and access to remittances through the banking system. Table 5A.1 provides descriptive evidence on the average amount of some of these assets owned by sampled households across the four zones during the study period.

These assets are expected to determine households' agricultural production decisions, consumption levels, and credit constraint condition. However, on the reverse, the credit market

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[9] *production tools listed in the questionnaire are: Plough, Yoke, plough beam, Shovel/spade, Sickle, Grain mill, Weaving equipment, Axe, Hoe, Irrigation or pedal pump, Water storage tank, Water harvesting well, Tractor, Truck, Beehives, Other (bellows, mill, hammer, pick, wheelbarrow, saw, knife). We took the mean total of the number of these assets owned by each household as an indicator for production tools.*

[10] *Consumer durables listed in the questionnaire are: Radio, Cassette player, TV set, Dish antenna/decoder, Cell phone, Sewing machine, Chairs, Sofas, Tables, Beds, Electric gas/stove, Other stove (Kerosene, charcoal, etc.), Water heater, Watch, Motor vehicle, Motor cycle, Bicycle, and Lantern (masho). We took the mean total of the number of these assets owned by each household as an indicator for consumer durables.*

[11] ***Iddir** is a traditional insurance system where a member of the Iddir who faces a shock is entitled to the collection of the weekly or monthly pool free of charge.*

[12] *In the literature, **Iqqub** is conceived as a form of traditional savings and credit institution. For example, Levine, (1972); and Aredo (1993) described it as a form of saving association in which weekly or monthly payments of a fixed sum are exchanged for the privilege of receiving a large sum at some point in the life of the group. With the exception of the last recipient, all others borrow from each other for a varying period of time but borrow at zero interest rate (a negative interest rate if there is inflation). This implies that a household facing climatic shock can borrow from the Iqqub to build asset and pay back the money at the end of the period with zero interest, demonstrating the mutual benefit from such social interactions.*

condition may also determine the households' asset ownership and production decisions. Thus, an endogeneity problem stemming from a reverse causality is suspected in Figure 2.12, and the study carefully addressed this issue in the estimation procedure to minimize bias.

Moreover, the questionnaire captured socio-economic conditions of the households, impacts of climatic factors, and the existing local coping strategies and adaptation mechanisms. This survey data set is matched with longitudinal rainfall data collected by the Ethiopian Meteorological Agency from corresponding meteorological stations. We used the climate data set to understand changes/trends in the climatic condition in the study area over the last 30 years. However, there are missing data points for few years and thus, we used available stations in close proximity to the study sites in each *Woreda (district).* We reviewed in detail, and documented the mainstream literature on credit constraints, climate change and its impact on African and Ethiopian agriculture, choice of various adaptation strategies and their welfare implications.

To meet the first specific objective of the dissertation, five credit constraint categories were identified using the direct elicitation technique. Such detailed categorization is expected to provide clear understanding about both the demand and supply side causes of credit constraints in the rural credit market. Then, a Generalized Linear Latent and mixed model (gllamm) was estimated and this found to have an added advantage of providing more efficient and unbiased results (see chapter 4 for more details).

The second objective focuses on assessing the link between different forms of credit constraints and choice of adaptation strategies. A pseudo-fixed effects model which involves explicitly modeling the relationship between time varying regressors and the unobservable effects in an auxiliary regression is employed to meet this objective (Mundlak, 1978). A robustness test is also conducted using the Multivariate Probit (MVP) and the seemingly unrelated simultaneous equation (SURE) models. (see chapter 5 for more details).

The third objective aims at providing empirical evidence on the effect of climatic shocks and adaptation strategies on household asset holding under different credit constraint conditions. This effect was estimated using a fixed effects instrumental variable (FE-IV) technique to account for the potential endogeneity problem and to identify the causal relationship between credit constraints and the welfare outcome. Previous period credit constraint and membership in a solidarity group were used as valid instruments that are highly correlated with the probability of getting access to credit, but not correlated with the welfare outcome variable directly. The FE-IV model was estimated after conducting appropriate robustness tests of the instrumental variables (see chapter 6 for more details).

The fourth objective of the study was to evaluate the impact of different types of credit constraints on agricultural productivity under changing climatic condition. However, in relation to credit constraint status, farmers are not randomly assigned into different credit constraint categories. The probability of a given farmer to fall in a constrained or unconstrained category depends, among others, on the personal characteristic of that individual. Thus, in estimating the impact of credit constraints on agricultural productivity, it is crucial to take care of this potential selectivity bias. Hence, we used the propensity score matching (PSM) method to reduce this bias by making productivity comparisons between farmers who are constrained (the treatment group) and those who are unconstrained (the control group). After estimating the propensity scores, the average treatment effect for the treated (ATT) group is also estimated (see chapter 7 for more details).

Appendix 2A: Tables and Figures

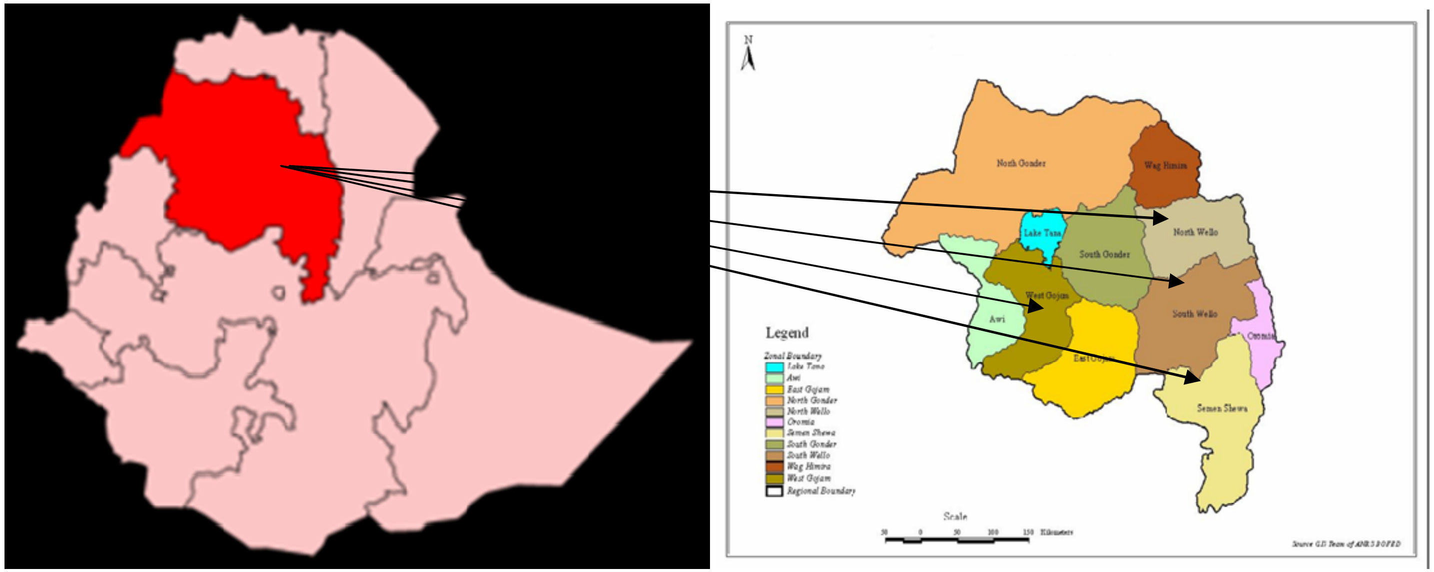

Figure 2A.1 Location map of the study area, Ethiopia

Table 2A.1 Socio-economic information of the Households (HHs)

Socio-economic Info.	All		north Shewa		west Gojam		south Wello		north Wello	
	2011	2013	2011	2013	2011	2013	2011	2013	2011	2013
Number of HHs surveyed	1189(50)	1189(50)	395(33.2)	395(33.2)	370(31.1)	370(31.1)	275(23.1)	275(23.1)	149(12.5)	149(12.5)
Average age of HH head (years)	48.9	50.5	50.8	52.6	46	47.9	49.1	49.6	50.8	52.7
Female headed HHs (%)	111(9.3)	139(12)	40(10)	55(14)	25(6.7)	25(6.8)	29(10.7)	36(13.1)	17(12)	23(15.4)
Average HH size	5.3	5.1	5.47	5.07	5.74	5.63	4.65	4.52	4.92	4.9
average years of formal education of head	4.8	5.2	4.9	4.8	4.5	4.6	5.2	6.1	3.9	5
HH heads who attended informal educ.	317(26.7)	290(24.4)	140(34.7)	130(32.9)	76(20.4)	71(19.2)	74(27.2)	49(17.8)	27(19)	40(27)
Households whose house roof is made of Iron sheets	854(72)	932(78)	287(71.2)	298(75.4)	338(91)	344(93)	169(62)	214(78)	60(42.3)	76(51)
Average monthly income from a Microenterprise(ETB)	528.84	926.23	504	1075.1	577.3	718.9	714	1047	317.8	733.2
Households who benefited from PSNP	146(12.3)	136(11.4)	20(5)	0	0	0	60(22)	57(21)	65(45.8)	79(53)
Households who have Bank account	164(14)	267(22.5)	60(15)	118(30)	50(13.5)	44(12)	25(9.2)	61(22.3)	29(21.2)	44(30)

Source: Own calculation from EPIICA's 2011 and 2013 survey

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CHAPTER 3 THE LINK BETWEEN CREDIT CONSTRAINTS, ADAPTATION TO CLIMATE CHANGE AND HOUSEHOLD WELFARE: REVIEW OF RELATED LITERATURE

3.1 Introduction

As this dissertation aims at linking credit constraints with key rural development components such as adaptation to climate change, rural poverty and welfare, it is relevant to look into theoretical foundations of credit constraints in relation to key economic theories to put the study in to a broader perspective. Thus, section 3.2 presents a brief summary of these theoretical foundations and section 3.3 documents the literature on credit demand depression. Section 3.4 discusses the link between credit constraints and adaptation to climate change, while section 3.5 dwells on the welfare implications of credit constraints in a rural setting. Section 3.6 concludes the chapter by summarizing the existing literature on the development of the rural credit market in Ethiopia over the past five decades with an emphasis on market imperfections which left farm households in a credit constraint condition.

3.2 Imperfections in the Rural Credit Market and Causes of Credit Constraints: Overview of the Literature

The issue of imperfections in the credit market has been a research agenda since 1950's. However, more influential papers were published in the 1970s and 1980s. The most cited theoretical papers include: Jaffee and Russell (1976); and stiglitz and Weiss (1981). Jaffee and Russell (1976) tried to develop a model of credit rationing in an imperfect credit market context where borrowers know better about the likelihood of loan default than lenders. They tried to show that in competitive markets, equilibrium with a single set of terms (or a single contract equilibrium) will tend to occur at the point of rationing. Later on, based on this framework, Stiglitz and Weiss (1981) showed why such equilibrium occurs.

Among the imperfections in the credit market, it is documented in the literature that adverse selection and incentive compatibility problems are the two major imperfections which cause credit constraints in developing countries (Bardhan and Udry, 1999; Karlan and Zinman, 2009). The problem of adverse selection occurs when lenders cannot separately identify risky borrowers from safe borrowers due to lack of information about riskiness of the borrower's projects. Stiglitz and Weiss (1981) tried to model this problem and later on, many others developed the concept further. It is a challenge both for bigger commercial banks and rural formal lenders such as Micro financing institutions (MFIs) and credit cooperatives. The bigger commercial banks tackle the problem by asking for collateral and thus, smallholder poor farmers who lack acceptable and adequate collateral are automatically excluded from having access to loans from commercial banks.

The micro credit revolution introduced a new innovation of "group lending" scheme in the rural credit market since 1970s. This approach provided lenders with essential strategies such as: (i) peer selection (screening), (ii) joint liability, (iii) peer monitoring, and (iv) regular public repayment system. These strategies of group lending scheme have attracted economic research during the last three decades (see Armendiaz and Morduch, 2010 for a list of related studies). This lending technology has done much in helping the poor to have access to credit and hence, it rapidly spread in most developing countries including Ethiopia, due to its attractive contractual structure. This new approach tried to solve three main problems of the formal banking sector. First, it allowed the supply of smaller loans to the poor; second, it changed the collateral structure from 'assets' to 'groups of people' as a guarantee for the loan; and third, lenders charge their clients lower interest rate compared to the smaller loan amount granted to large number of borrowers and hence the higher administrative (intermediation) cost.

However, group lending strategy also fails to solve the problem of adverse selection at least for three reasons. First, when some lenders can discriminate between safe and risky borrowers while others cannot do so, bad borrowers will be adversely selected. Bose (1998) describes this case as follows:

> *"If lender 'A' can effectively discriminate between safe and risky borrowers while lender 'B' cannot do so, an increase in the supply of credit by lender 'A' will make the composition of the pool of borrowers of lender 'B' to be more of the risky borrowers. This is because, now the more risky borrowers who are filtered-out by lender 'A' will go*

to lender 'B' as an alternative source of credit. This in turn will worsen the terms of credit on some safe borrowers".

Second, the group formation process itself is normally a 'self-selection' process and hence there is a high probability that all or most members of the group are risky borrowers or have risky projects. This may also lead to a bad loan portfolio to the lender (Demont, 2010). Third, in rural areas, it is common to observe multiple loans taken from both formal and informal lenders (e.g. see Conning and Udry, 2005; and Guirkinger, 2008). This may lead to the problem of a ponzi game where some risky members of the group borrow from the informal credit market to repay the formal loan to continue being a client to the lender as a good borrower. Such behavior of borrowers is common in the rural credit market of developing countries including Ethiopia (EEA, 2011) and hence taking loan from a given formal lender many times (a 'repeated loan', in a micro credit terminology) may not mean that the client is a good borrower. In this case, a bad borrower may get loan being adversely selected while good borrowers are marginalized. The key implication of the adverse selection problem is that poor, but, genuine farm households who seek out loan are still credit constrained even though the number of rural credit service providers is rapidly increasing in recent years in rural areas of developing countries as the case in Ethiopia. In chapter 4 this problem is discussed in depth using a theoretical model to show how the adverse selection problem creates credit constraints on farm households.

The incentive compatibility problem, on the other hand, is basically a post-contract issue (Milgrom and Roberts, 1992; Stiglitz, 1994; Long, 1994) which occurs due to incomplete information. It means that the borrower may have an incentive to change his actions after concluding the loan contract in any one or a combination of the following three ways. First, the borrower may divert the loan to another purpose than the agreed one; second, the borrower may invest it on a more risky project than the original one; and third, the borrower may not exert the maximum effort to make the project successful. It is, thus, another form of imperfection in the rural credit market that forces lenders to require collateral and it creates a constraint on farm households who lack the required collateral asset.

3.3 Credit Constraints from the Demand Side: Credit Demand Depression

The pioneering work of Stiglitz and Weiss (1981) on the theory of credit constraints states that credit constraint is a long-term equilibrium in the credit market because of the problems of information asymmetry and adverse selection. Later on, other studies also came up with similar findings but most of them focus on the supply side of the credit market. However, as much as the supply side, the demand side of the market is also very important in the analysis of credit constraints. For instance, issues related to transaction cost, risk aversion, and behavioral bias are some of the demand side factors which need to be critically analyzed to understand the nature of credit constraints in the rural credit market. Zhang (2005) indicated that lack of access to formal credit usually discourages rural households and it has a negative effect on people's expectation and their choice behavior of credit providers. Once the loan applications are rejected, rural households become discouraged, change their expectations and attitudes toward formal lenders. This in turn may change their preferences and choice of credit service providers. In many developing countries, formal lenders are not the first choice of rural households because they expect that their loan application will be rejected automatically or the loan application process is lengthy and complicated.

Kon and Storey (2003) also argue that the imperfect credit screening mechanisms used by lenders send biased signal and discourage potential borrowers from applying for credit due to the wrong feeling that their application will not be considered. This can further lead to credit constraint from the demand side (or what the literature calls "Demand depression"). Risk aversion and humiliation of borrowing are some of the other reasons for farm households not to borrow from formal credit service providers (Wang, 2004). Credit cooperatives, which are the alternative source of credit for farm households, may also have some internal problems including rent seeking behavior of credit officers based on the applicant's personal relationship, official position, and personal identity. In addition to that, the loan amount, the loan term, the loan repayment schedule, and collateral requirements usually do not match with farmers' production and consumption needs. Due to such inconveniences in the formal credit market, farm households usually shy away from formal lenders whose loan interest rate is low compared to that of the informal ones. The households prefer paying the high interest rate charged by informal lenders because of the simplicity and convenience of the services provided by informal lenders. This can be taken as another form of credit constraint that leads to exploitation of the rural poor by informal lenders. It can further increase income inequality in the society because the relatively richer households, who have the collateral, can borrow from formal lenders at lower interest rate while the poorer ones borrow from informal lenders at higher interest rate and this can perpetuate rural poverty. The problem of the rural credit market has got less consideration in development policies, may be because the issue is not well studied and brought to the attention of policy makers of developing countries.

3.4 Credit constraints and adaptation to climate change: Summary of the literature

In this section, we review the key climate adaptation tools as per previous literature and that are also relevant in the context of the empirical setting in this study. We also assess how each of them is potentially linked to credit constraints. The essence of choosing credit as a determinant of adaptation strategy stems from the fact that investment decisions and agricultural productivity are shown to be greatly impacted by credit market imperfections as shown conceptually (Stiglitz and Weiss 1981, Esweran and Kotwal 1986, Carter 1988) and empirically (Fedder et al., 1990: Diagne and Zeller, 2001: Malawi; Foltz, 2004: Guirkinger and Boucher, 2008: Ali and Deininger, 2012). However, the specific role of credit constraint with respect to climate adaptation has not been widely explored[13].

Our choice of the adaptation strategies for this study is based on Deressa et al. (2009) and Difalco et al. (2011) who assessed responses of farmers who were asked what measures they have taken in response to perceived changes in temperature and precipitation. Accordingly, we

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[13] *As many adaptation strategies could be considered as investment/disinvestment strategies, the key role of credit in shaping agricultural investment decisions is what makes it a pivotal potential instrument in the choice of adaptation strategies. However, credit/borrowing from formal and informal sources is in some instances seen as a coping strategy by itself (Feder et al. 1985).*

consider the following key strategies as climate adaptation tools: soil conservation[14] and tree planting, crop diversification, off-farm employment, asset depletion, and irrigation.[15]

The first strategy, the adoption of soil conservation technology has long been understood as a pivotal tool for enhancing food security for smallholder farmers in Sub-Saharan Africa and increasingly more so as a way of shielding against climate risk (Difalco and Veronesi, 2014; Teklewold et al., 2015). Particular to developing countries, the adoption of soil and water conservation measures is found to be one of the major responses to perceived long-term changes in temperature and rainfall (Deressa et al. 2009; and Difalco and Bulte, 2012).

Notwithstanding their importance in both food security and climate risk mitigation (Kassie et al., 2012), the adoption of soil conservation technologies remains too low (Holden et al., 1998; Holden and Shiferaw, 2001). Among the many factors that act as barriers to soil conservation investment, credit market imperfections, resulting in short term planning horizons are argued to be strong contributors to making investment in soil conservation unattractive (Holden et al., 1998). In this study, the soil conservation and tree planting variable is defined as a dummy variable representing the presence of a soil conservation structure or tree(s) on the farmstead.

The second strategy is crop diversification and the adoption of seed technology. The strategy has significant contribution to withstand the effects of climatic factors by increasing overall productivity of agricultural systems in the face of varying climatic factors (Difalco et al., 2010; Difalco and Chavas, 2009). In addition, diversification reduces the risk of crop loss associated with climatic variability (through spreading out the growing and harvesting of

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[14] Land related investment in general and soil conservation investment in particular are considered as major adaptation strategies specific to the agricultural sector (Wossen et al, 2014;Meinzen-Dick et al., 2012; Deressa et al. , 2009; Difalco and Bulte, 2012; Difalco and Vernossi, 2014).

[15] It should be noted that asset depletion was also reported as a risk mitigation strategy in the survey we use in the analysis, but not in the two studies we discussed above, thus, we included it as one of the adaptation strategies. The strategies that we have identified below as adaptation strategies could be understood to be risk mitigation strategies. Further, these adaptation strategies could also be thought of as ex-ante and ex-post risk management strategies with Crop diversification, irrigation, soil conservation and participation in the off-farm employment falling into the first and asset depletion falling into the second category.

different crops over the course of the year) (Kar et al., 2004). In some cases, particular seed technologies are also shown to play an effective role of buffering against rainfall variability (e.g. Bezu et al., 2014).

While diversification could be considered a capital-saving strategy, certain crop varieties could require access to capital. In their study of the responsiveness of household crop patterns to changing prices and credit availability, Komarek (2010) finds that significant changes in household cropping patterns could occur with improved access to credit. Similarly, Cavatassi et al. (2012) show the negative impact of credit constraints on the ability to diversify. Credit access also has the tendency to increase farm level diversity by increasing access to different seed materials, and in a resource poor system, even modern varieties appear to contribute to rather than threaten diversity (Benin et al. 2004). We define farm level diversification in two ways: count diversity and cash vs staple crop. Count diversity is defined as the number of crops grown by the household in a given year. The second diversification variable is defined as a dummy variable with one representing cash crop and zero otherwise.

The third strategy considered in this study, off farm employment, is also known to act as a buffer against climate change (Deressa et al. (2009) Difalco et al. (2011), Meze-Hausken (2012), Mortimore and Adams, (1999), Lambin et al., (2001), Eakin, (2005) and Davies et al. (2008). However, off-farm income tends to be more effective as a climate coping strategy since climate shocks are idiosyncratic rather than covariate due to the possible correlation with climate-dependent agricultural incomes (Jayachandran 2006; World Bank 2008b). Participation in off-farm activities tends to be constrained by capital needs as credit constraints may prevent households from taking up non-agricultural activities (Mcnamara and Weiss 2005, Ito and Kurosaki 2009). In this chapter, participation in off farm activities is defined as a dummy variable including activities such as trading agricultural products, wholesale/retail trade/shop and being employed in non-farm activities for a certain wage.

The fourth adaptation strategy considered in this study is irrigation. The reduction in water availability as a result of climate change (both in terms of quantity as well as reliability) increases the need for an efficient water management system for agriculture, such as irrigation, particularly in Africa (Vörösmarty et al., 2010). The responsiveness of irrigated and rainfed farms to climatic factors are shown to be significantly different in Africa (Kurukulasuriya and

Mendelsohn, 2007; Deressa et al., 2006), south America (Seo and Mendelsohn, 2008, and the U.S. (Wanga et al., 2014). It should be noted, however, that irrigation's ability to mitigate water scarcity is also limited by the overall reduction in water availability, globally (Eliotta et al., 2014).

Just like the other strategies, there is evidence of significant links between credit constraints and irrigation. Using data on irrigation wells in India, Fafchamps and Pender (1996) show that the availability of credit can dramatically increase investment in irrigation and that interest-rate subsidization has little impact. A study on the determinants of private investment in irrigation in Colombia shows that credit policies promote investment in irrigation (Dinar and Keck, 1997). In their assessment of the determinants of irrigation adoption in the Tigray region of Ethiopia, Gebregziabher et al. (2009) find that access to extension service as opposed to credit has a significant impact.

Overall, the literature indicates the relevance of the strategies discussed above as climate adaptation tools. However, the degrees of adaptation effectiveness could be dependent on the adaptation options available to a given set of households, which calls for analyzing the responsiveness of adaptation strategies to climatic factors. In addition, the stringency of credit constraints could differ depending on the credit demands of a given adaptation strategy. These observations indicate the need to empirically investigate the relationships between the adaptation strategies and credit constraints.

3.5 Welfare implications of credit constraints: Review of the literature from the transactions cost theory perspective

Rural financing involves higher transaction costs than in urban areas mainly because of poor infrastructure development (Honohan and Beck, 2007). It can be costly for formal credit institutions to have branches and staff in remote areas, handling small transactions given the distances, lower population densities, bad roads, erratic electricity provision, and lack of communications systems. Thus, farm households can be constrained from participation in the credit market as a result of such higher transaction costs of borrowing.

Financial institutions also face high creditworthiness assessment costs that might exceed the profits they can make with these relatively small loans. If farmers evolve from smallholders to more specialized farmers, the lender must analyze the borrower in all its details (e.g., ability and character, the prospects for the product, cash flow forecasts, etc.) in order to understand the risks involved. To cover such costs, loans must be significantly larger, reaching a size that substantially exceeds the absorption capacity for capital of the smallholder- hence the financing gap. Farming is also very heterogeneous, and deep sector information is often not readily available. Farming households in particular often have a wide range of crops and activities that can make the assessment of creditworthiness more complex and costly and this in turn lead to credit constraints (Honohan and Beck, 2007).

New institutional economists also presented an argument that account for institutional characteristics of credit markets (Lin and Nugent, 1995). Hoff and Stiglitz (1990) argue that with imperfect information, interest rates have sorting and incentive effects. For example, while high interest rates adversely sort good credit risks from bad credit risks, high interest rates may induce borrowers to invest in riskier projects and not exercise due diligence in reducing risks. It should also be highlighted that the supply of loanable funds is an increasing function of expected profits. Thus, unlike in the classical economic analysis where excess demand at a given interest rate is choked off by a rise of interest rates, the adverse selection and moral hazard literature proposes that there is no tendency for interest rate to rise in order to choke off excess demand, as credit may be rationed through non price mechanisms (Lin and Nugent, 1995) that may lead to credit constraints.

Credit constraints created due to the above reasons may have significant negative consequences on income and welfare, especially on low income households and firms (Stiglitz, 1981). For example, credit constraints prevent firms from undertaking desired activities and from realizing profit maximizing investment levels. Thus, entrepreneurially talented but poor households are prevented from starting up their own businesses (Boucher, 2006). The impact is that credit constraint can potentially affect the income level of poor households and become an obstacle in their effort to start new businesses and secure a more diversified livelihood and economic activity.

In another argument, access to credit is also one of the main determinants of economic activity and pro-poor growth in developing countries (Levine and Zervos, 1998). For example, by accessing credit, the poor may acquire productive capital to improve their capacity to generate income, savings and investment for better welfare (Beck and Demirguc-Kunt, 2005). In fact, credit is required to finance working capital and investment in fixed capital, particularly among households too poor to accumulate much saving (Ghosh, Mookherjee and Ray, 1999). In this regard, some argue that the poor people are active economic agents that could change their fortune if given the right support, and hence the credit market can be used as a tool for improving the quality of life of the poor (Nkamnebe, 2005).

3.6 The Rural Credit Market and Credit Constraints in Ethiopia: An Overview

Though there has been a rural credit market in Ethiopia since 1940s following the establishment of the Ministry of Agriculture in 1943 and the then Agricultural Bank of Ethiopia in 1945 (Admassie, 1987), the problem of credit constraints also has a long history. The objective of the Agricultural Bank was to assist small landholders whose farms had devastated during the Italian occupation by providing loans to purchase seeds, livestock, and implements; and to repair or reconstruct their homes and farm buildings. A more detailed plan of action to assist farm households was outlined in the pre-five years development plan (1945 – 1951) and in the three consecutive five years development plans[16] of the Imperial regime. However, both the

[16] The first five years plan was from 1957 to 1961; the second was from 1962 to 1967; and the third was from 1968 to 1973.

pre-five years development plan and the three consecutive five years development plans failed to relax credit constraints of smallholder farmers. The main reasons for this failure included: the very high collateral requirement (as high as 200 percent of the loan), lack of land ownership right of farmers, loan diversion for non-agricultural uses, and the very poor loan repayment performance due to a very weak loan collection effort of lenders. The credit was also going to wrong groups of the society such as "absentee landlords", merchants, and government officials and it did not reach to poor farmers. Smallholder farmers received only 7.5 percent of the total loan disbursed by the development bank of Ethiopia during the period 1951 – 1969 (Admassie, 1987). This clearly shows the nature of imperfections in the rural credit market and extent of credit constraints of smallholders during the Imperial era, that was overthrown by a military-cum-socialist regime-called the Derg in 1973.

The Derg regime in turn, set the financial sector to serve socialized sectors such as public enterprises, state farms and cooperatives (NBE, 1976; Gebrehiwot, 1997) and more than 89 percent of banks' agricultural credit went to state farms (Admassie *et al.*, 2005). The World Bank (1991) report also indicated that only 4.7 percent of domestic credit went to the private sector during the period from 1986 to 1991 and this created credit constraints on farm households. Following the downfall of the Derg regime in 1991, the new government (The Ethiopian People Revolutionary Democratic Front) came up with major reforms in the Ethiopian financial sector, some of which being: (a) shifting away from a controlled to a market friendly financial system that allows market-based credit allocation; (b) expanding credit and saving facilities; (c) opening the sector for domestic private investors which led to the emergence of private banks and insurance companies; and (d) adopting prudent monetary and banking policies. These and related reform measures contributed a lot to the development of the sector and currently, formal, semi-formal and informal financial service providers are operating in the country. However, in view of international standards, the Ethiopian formal financial sector still lags behind in many respects. For instance, the sector is not yet ready for international competition and entry of foreign banks is not yet allowed. In terms of services and product development, many modern financial products such as certificates of deposit, repurchase agreements, commercial papers, futures, options etc. are missing in the Ethiopian financial sector (see EEA, 2011).

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CHAPTER 4 MULTIPLE CREDIT CONSTRAINTS AND BORROWING BEHAVIOR OF FARM HOUSEHOLDS: PANEL DATA EVIDENCE FROM RURAL ETHIOPIA[‡]

Abstract

Promoting an inclusive rural credit market in developing countries is a re-emerging and pressing development agenda given its importance in the poverty reduction and economic growth process. Existing literature mainly focuses on the supply side of the market with little or no attention given to demand aspects. This chapter analyzes both the demand and supply side factors affecting credit constraints and borrowing behavior of farmers. In doing so, two waves of survey data were used, that included about 1200 randomly selected households from four zones of the Amhara region in northern Ethiopia. The Generalized Linear Latent and mixed model (gllamm) was employed to account for unobserved heterogeneity and potential correlations across credit constraint categories. The results show that exposure to climatic shocks, age and lack of education increase the probability of being constrained while female, and married heads are relatively less constrained. The results further indicate that borrower's perceived probability of rejection due to strict lending policies and institutional rigidities; the transaction cost of borrowing; and risk aversion behavior of farmers highly reduce the probability of borrowing from the formal credit market. Compared to north Shewa, farmers living in south Wollo zone are found to be discouraged and hence do not prefer borrowing from the formal sector and this signifies zonal variation in credit constraints and borrowing behavior. These findings suggest the need to work on more innovative lending approaches by giving attention to context-specific factors to build demand-driven, climate-smart, and inclusive rural credit market.

Key words: *Credit Constraint, borrowing behavior, rural credit market, inclusive finance, gllamm, Ethiopia.*

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4.1 Introduction

In developing countries where agriculture takes the lion's share of the GDP, the rural credit market plays crucial role in enhancing agricultural growth and transformation. For farm households, access to rural credit facilities is more than having access to other inputs of production. This is because, it is easier to acquire recommended agricultural technologies, and farming tools to improve productivity and produce marketable surpluses once financial resources are available. It also helps farm households to build assets and smooth out consumption in the face of fluctuating agricultural income due to climatic shocks.

However, farm households in many developing countries are credit constrained. It is estimated that only five percent of farmers in Africa and about fifteen percent in Asia and Latin America have access to formal credit. On average, 80 percent of this credit goes only to 5 percent of the borrowers in many developing countries (Bali Swain, 2001; Antwi and Antwi, 2010). Studies confirm that such constraints have significant adverse impacts on farm investment (Carter and Olinto, 2003), agricultural output (Petrick, 2005), and efficiency of intra-household resource allocation (Fletschner, 2008). It also reduces farm profit (Foltz, 2004), and technical and financial efficiency in agriculture (Hamda and Öhlmer, 2006; Fletschner *et al.*, 2010). Credit constraints coupled with exposure to climatic shocks may also force farmers to shift away from high income and high risk economic activities to low risk and low income activities, leaving them in unsustainable livelihoods and the vicious circle of poverty (Humphreys *et al*, 2004; Charles, 2011). The credit constraint condition is not much different in rural Ethiopia. For example, during the period 1951 – 1969, smallholder farmers received only 7.5 percent of the total loan disbursed by the development bank of Ethiopia. The rest was going to wrong groups of the society such as "absentee landlords", merchants, and government officials and it did not reach poor farmers (Admassie, 1987). Only 4.7 percent of domestic credit went to the private sector during the period from 1986 to 1991 (World Bank, 1991) and more than 89 percent of banks' agricultural credit went to state farms during that period (Admassie *et al.*, 2005). This created serious credit constraints on farm households over the decades.

Promoting an inclusive credit market and ensuring farm households' access to financial services in developing countries is, thus, became a re-emerging and pressing development agenda and the recent policy emphasis has shifted to "Finance for All" (Lamberte *et al.*, 2006;

World Bank; 2007; 2008b). In line with this policy shift, Ethiopia has done much in reforming its financial sector as discussed in section 3.6 above. Although there is an improvement in access to credit following these reforms, smallholder farmers still face credit constraints. Commercial Banks in Ethiopia, hesitate to lend to farmers due to the inherent risk in agricultural production and lack of the required loan collateral, and hence, farm households are excluded from the formal banking market. Microfinance institutions and financial cooperatives are the alternative credit providers to these households. However, despite the rapid growth of these institutions in recent years, they reach only about 20 percent of the households (AEMFI, 2011; EEA, 2011), implying the existence of credit constraints.

Hence, identifying the nature of credit constraints and borrowing behavior of households is crucial both from empirical and policy perspectives, since it is a central welfare and development issue. But, empirical evidence on this topic is rare in the context of rural areas in the sub Saharan Africa in general, and particularly in rural Ethiopia. In filling this gap, this study is set out to: (1) identify the types of households who are credit constrained; (2) investigate the demand and supply side factors affecting credit constraint status; and (3) examine how such constraints affect borrowing behavior of farm households. This chapter contributes to the existing literature in three ways. First, there are only few studies on credit constraints and borrowing behavior in rural Ethiopia and to the knowledge of the author of this dissertation, there is no rigorous prior work on this topic in the context of the study area. Further, the existing few studies categorize households into two regimes as either credit constrained or unconstrained[17]. This is a crude measure and does not provide adequate information about the real causes and multiple manifestations of credit constraints. Guirkinger and Boucher (2008), and Reyes and Lensink (2011) argue that existence of the credit market may not guarantee participation of households in the credit market; or getting some amount of loan may not automatically solve the credit constraint problems of farmers. Hence, the binary categorization is now extended to five classes using the direct elicitation approach. These are: (i) Unconstrained non-borrowers; (ii) unconstrained borrowers; (iii) quantity constrained borrowers; (iv) transaction cost constrained borrowers; and (v) risk-rationed borrowers. Such detailed

[17]See e.g. Hamda and Öhlmer (2006); and Kedir and Ibrahim (2011) for recent studies. Though these studies recognize that using a dummy does not entangle between borrowing status and credit constraint condition, they classify the households only into two categories in their final econometric analysis.

categorization is expected to provide clear understanding about both the demand and supply side causes of credit constraints in the rural credit market. (Section 4.4.2 provides further details about the classification strategy).

Second, prior comparable studies mentioned above, rely on cross-sectional data that show only a one period picture of the credit constraint situation and may not provide precise estimates due to omitted variables. This study is based on a unique panel data collected from randomly selected rural households and this is expected to show possible changes in credit constraint status of farm households over time. Moreover, a multinomial logit model with random effects was estimated to control for unobserved heterogeneity and this has an added advantage of providing more efficient and unbiased results. Third, using zone dummies, this study also shows to what extent the rural credit market is segmented and how credit constraints vary across the study sites.

The rest of the chapter is organized as follows. Section 4.2 discusses the theoretical and empirical literature related to credit constraints and borrowing behavior of farm households. It is followed by a description of the data and methods in Section 4.3 and a theoretical discussion on how we categorized farm households into different credit constraint categories in section 4.4. In Section 4.5, we present the econometric model, and in section 4.6, we discuss results of the study. Section 4.7 concludes the chapter with highlights of the key findings and policy implications.

4.2 Credit Constraints and Borrowing Behavior: Theory and Empirical Evidence

The concept of credit constraints and borrowing behavior of households is linked with the permanent income hypothesis (Friedman, 1957). This hypothesis states that households try to maximize their utility by smoothing the marginal utility over the life cycle. It assumes existence of a perfect and complete capital market where households can borrow the amount of credit they want when they face liquidity problems and repay it in a period of high income. Thus, with standard convex preferences, and in the absence of borrowing constraints, transitory income shocks will not affect consumption, since it depends only on permanent income.

However, the credit market literature provides three competing theories about structure of the rural credit market in developing countries, namely: the monopoly market theory, the perfectly competitive market theory, and the imperfect information theory (Stiglitz and Weiss, 1981; Hoff and Stiglitz, 1996; Bardhan and Udry, 1999; and Ho, 2004). The monopoly market theory argues that informal credit dominates in the rural credit market where village money lenders have a monopoly power and can charge the maximum possible interest rate to maximize their profits. This market is highly complicated because money lenders use various strategies to control their clients. This theory, however, does not capture the full image of the rural credit market in developing countries. It does not explain why formal and informal lenders co-exist despite the fact that formal loan interest rates are much lower than that charged by informal lenders. The perfectly competitive market theory, on the other hand, predicts that the rural credit market clears with a market-clearing single equilibrium where the lending interest rate serves as the main screening device. It means that lenders increase the interest rate when the loan applicant is a high-risk borrower and they reduce the interest rate for low-risk borrowers. But, this theory is based on unrealistic assumptions and it fails to describe the real world condition, where pervasive credit-rationing is observed in the rural credit market even when there is equilibrium in the market. Compared to the above two theories, the imperfect information theory provides a more advanced and realistic explanation about the nature of rural credit markets in developing countries. According to this theory, the rural credit market is characterized by market imperfections such as: uncertainty; the problems of incentive compatibility and information asymmetry, that lead to the problems of adverse selection, moral hazard, higher transaction cost and higher risk in borrowing and lending transactions. This in turn, may leave many households credit constrained (See chapter 3 for more discussion on this).

Prior empirical studies also confirm that most households in developing countries are credit constrained due to market imperfections (See for e.g., Kochar, 1997; Foltz, 2004; Khandker, 2005; Chen and Chivakul, 2008). However, in Sub-Saharan Africa, and particularly in rural Ethiopia, quantitative evidence on causes of credit constraints and borrowing behavior of households is thin (Hamda and Öhlmer, 2006; Aterido *et al.*, 2011; and Ayalew and Deininger, 2014).

This calls for further studies aiming at explicitly addressing the demand and supply side causes of credit constraints and borrowing behavior of households in the context of imperfect credit markets.

4.3 Methodology

4.3.1 Description of Data and Variables Used in the Analysis

The analysis in this chapter is based on a balanced panel data collected from 1,189 households in two rounds in the years 2011and 2013.The two surveys provided information on livestock and crop production, marketing, farm and non-farm income, household consumption expenditure, ownership of assets, participation in non-agricultural enterprises, exposure to various climatic shocks and coping strategies, attitude towards risk, demand for crop insurance and credit constraints (See the discussion in section 2.2.2 for details about the study area and data used in the dissertation).

Dependent variables of this study are: the probability that a household will fall in one of the credit constraint categories, and the probability of participating or getting credit from formal, semi-formal, or informal sources. Formal sources of credit include commercial banks and Micro financing Institutions (MFIs), while semi-formal credit providers are basically the financial cooperatives (SACCOs). Informal lenders include social networks such as Iddir, Iqqub, relatives, friends, private money lenders, and trade partners (see Aredo, 1993; Bose, 1998; Diagne and Zeller, 2001; Conning and Udry, 2005; Barslund and Tarp, 2008; Guirkinger, 2008; Demont, 2010; Amha and Peck, 2010 for details). Unlike prior studies, which mainly focus on supply-side factors, both demand and supply-side causes of credit constraints and borrowing behavior of households were considered in this study. From the supply side, prior studies suggest that potential borrowers may be constrained due to liquidity constraints of lending institutions. When lenders face shortage of loanable fund, they may ration credit, leading to quantity constraints. Creditworthiness factors such as household's socio-economic characteristics, endowment of livelihood assets, and institutional constraints may also create credit constraints. From the demand side, farm households may shy away from formal lenders due to such factors including: (i) high transaction cost of borrowing; (ii) high risk costs of loan contracts; and (iii) cognitive and behavioral biases created due to previous borrowing experiences (Kon and Storey, 2003; Mpuga, 2008; Cheng, 2009; Reyes and Lensink, 2011). The theory of discouraged borrowers (Kon and Storey, 2003) also suggests that the imperfect credit screening mechanisms used by lenders usually force potential borrowers not to apply for credit. Thus, the demand-side factors can be conceived as households' rational reaction to institutional rigidities of lending institutions.

However, these factors which create barrier on credit market participation and hinder investment on profitable activities, have not been studied thoroughly in the context of sub-Saharan Africa. Top-down credit market policies that focus on simply increasing credit supply without giving due attention to demand-side factors, may not result in an inclusive credit market and sustainable rural development. Thus, this study is set out to investigate the types of households that are discouraged, rejected, systematically excluded from the rural credit market in the context of rural Ethiopia.

4.3.1.1 Explanatory Variables and Hypothesis

The choice of the explanatory variables is guided by the review of related literature, and context of the study area. After a brief account of each variable, their expected effect on credit constraints and borrowing behavior of farm households is hypothesized.

Age: of the household head is used in this study as a proxy for maturity and the potential for careful handling of bank loans and repayment capability of the borrower. It is expected that lenders discourage individuals whose age is above 40 years given the health risks and shorter life expectancy in developing countries as in the Sub Saharan Africa (SSA).

Gender: Access to credit and adaptive capacity is expected to be affected by the gender of the household head. Female-headed households are among the most vulnerable segments of the rural poor, and according to the literature on the gender equity gap, male- and female-headed households have unequal opportunities in access to credit. Some studies show that female-headed households are more credit constrained than the male-headed ones (For example, see Baiyegunhi, 2008; Chiu, et al., 2014).

This may be because, gender inequalities are significant in most developing countries in terms of ownership and use rights over resources including land and livestock; in capacity to capture beneficial environmental services; in political empowerment; in their access to information, agricultural advisory services, and adoption of agricultural technologies (Quisumbing, Haddad & Pena, 2001; Deere & Leon, 2002; Deere & Doss, 2006; CGIAR, 2012).

Education: Household heads were classified as having no education, some informal education, and some formal education. It is expected that those who have some level of education have the potential to earn higher incomes and more likely to have assets that can serve as collateral. Therefore, it is expected that educated farmers are less constrained.

Marital status: Married heads are more likely to be stable, trustworthy and abide by rules and regulations compared to the unmarried or separated heads and financial institutions view them as more reliable and may allow them to have better access to credit (Mpuga, 2008). Thus, married heads are expected to be less constrained.

Household size: A positive relation between larger household size and household's access to rural credit is expected because each member may contribute to the household's asset accumulation either directly as a labor input in the agricultural production process or through remittances.

Farm size and ownership of livestock: In this study, farm size (measured in hectares) and ownership of livestock are used as indicators of natural and physical assets, respectively. These assets are expected to ease credit constraints in two ways. First, households who own these assets are expected to have more potential for equity financing and thus may not even go for credit. Second, if internal finance falls short of the total required amount of cash, then those who own land and livestock have higher probability of obtaining credit because of the positive influence of these assets on lenders' valuation of the applicant as creditworthy.

Membership in a primary credit cooperative: is expected to have positive effect on access to credit. Plausible reason for this is that the cooperatives are expected to serve as channels through which members can have access to credit from micro financing institutions; sources of product and credit market information, and in some cases, the cooperatives may also provide input loan from their own internal fund.

Location and exposure to climatic shocks: It is presumed that exposure to climatic shocks such as drought, and spatial location matters in the credit constraint status and borrowing behavior of households. Households residing in drought prone areas are expected to be more constrained since lenders are not willing to take uninsured risk of default in the case of crop failure due to climatic shocks.

Risk aversion: In this study, it is hypothesized that risk averse[18] farmers do not want to participate in the rural credit market because they perceive loans as risky and they do not want to put their land or other productive assets at risk in case they fail to repay the debt.

Discouraged households: Farmers who want to get credit but are discouraged due to high transaction costs of borrowing and various institutional rigidities, may not want to apply for formal credit and hence may remain constrained (see for example: Guirkinger and Boucher, 2008; Mpuga, 2008; Cheng, 2009; Reyes and Lensink, 2011).

Quantity constrained borrowers: are those who applied for credit and received some amount that is less than their request due to the available contract terms. These households face a binding credit limit, may be because, they lack the required collateral to obtain larger amounts and hence, they look for other sources than formal lenders (Diagne and Zeller, 2001; Barslund and Tarp, 2008; Guirkinger, 2008).

4.4. Theoretical Model

4.4.1. Identifying Multiple Credit Constraint Categories: A Theoretical Model

Following Kon and Storey (2003) and Cheng (2009), a theoretical discussion is presented in this sub section to explain how supply and demand side factors discourage poor farmers not to participate in the rural formal credit market. It also discusses the borrowing behavior of farmers under credit market imperfections. The purpose of this discussion is to show, theoretically, the main drivers of borrowing behavior and credit constraint status of farm households.

It is assumed that a farm household looks for external sources of fund when its production and consumption needs exceed the available internal fund.

Let the total asset available to a farm household be:

$$TA = A_m + A_n \qquad [4.1]$$

where the total household asset (TA) is composed of: assets which can serve as collateral for credit (mortgage-able asset, A_m) and other assets which are useful for the production process but

[18] *In this study, farmers are categorized as risk averse (in relation to credit market transactions), based on the criteria listed in Table 4.1.*

cannot serve as a collateral (non-mortgage-able asset, A_n). This implies that the amount of money a household can borrow (B) is a function of mortgage-able asset ($B = f(A_m)$).

The costs of credit include the interest payment on the amount borrowed (r^L*B), costs of applying for credit such as cost of preparing the application materials, travelling cost and time, cost of informal payments for credit officers or managers, cost of psychological discomfort etc. (denote these costs by D). Thus the total cost of borrowing (C_b) is given by:

$$C_b = (1+r^L)*B + D \quad [4.2]$$

A smallholder's agricultural output (Q) in a developing country context normally depends on: the available production assets (TA), household labor input (H_L) and a vector of household characteristics (θ):

$$Q = f(TA, H_L; \theta) \quad [4.3]$$

If the farm household borrows money to expand its agricultural production by using better technology such as high yielding variety (HYV) seeds, fertilizers, and pesticides, then the new agricultural output (Q^β) will be:

$$Q^\beta = f(T_m, A_m, H_L, \theta) \quad [4.4]$$

where T_m represents the minimum amount of capital required to purchase technological inputs to expand production. But, in rural settings, rain-fed agriculture is a risky activity which is prone to various climatic shocks and plant diseases. Denoting the probability of a farmer to harvest a Q^β amount of output by ϕ and hence, $(1-\phi)$ is the probability of failure in which case, the farmer will get only Q^f amount of output where $Q^\beta > Q > Q^f$. If the farmer gets only Q^f amount of output, then it becomes very difficult for the household to repay the loan and hence will default and lose the loan collateral asset (A_m).

Therefore, a rational farmer will borrow if and only if the following two conditions are met:

$$\phi.Q^B + (1-\phi)(Q^f - A_m) > Q + (1+r^L)B + D \quad [4.5]$$

and

$$B(A_m) \geq T_m - A_c \quad [4.6]$$

Equation (4.5) says that the benefit from the loan should be greater than its cost and equation (4.6) states that a household will borrow if and only if the available current assets (A_c) can not cover the minimum required amount of capital to expand agricultural production (T_m).

Let the reservation cost of a rural household be denoted by δ_0 and specified by equation (4.7)

$$\delta_0 = Q + \left(1 + r^L\right).B + D \qquad [4.7]$$

But, from equation (4.5), it is clear that the cost of borrowing has two parts: the interest and principal cost ((1+r^L).B) and the application or transaction cost (D). A farmer who is willing to pay the interest cost (r^L.B) may not be willing to apply for credit if the application cost (D) is higher than the reservation cost (i.e. D > δ_o). Such borrowers are classified as "transaction-cost constrained (TCC)" borrowers. In addition to transaction costs, the behavior of borrowers is also affected by institutional inefficiencies of credit providers. In some cases, applicants who are willing to incur the transaction cost of borrowing apply for credit and lenders may adversely select wrong applicants due to information asymmetry or due to some special relationship with the lending institution or just because they are members of some social or political group. Such wrong decisions may marginalize genuine applicants and leave them credit constrained. If the probability of being rejected due to institutional mistakes is captured by λ, then the probability of getting the credit will be (1-λ). Further, denote the expected benefit from borrowing by E(Q_o) then:

$$E(Q_0) = \phi.Q^B + (1-\phi)\left(Q^f - A_m\right) \qquad [4.8]$$

Using this notation, it is possible to re-write equation (4.5) as:

$$(1-\lambda)\left[E\left(Q_o\right) - \left(1 + r^L\right)B\left(A_m\right) - D\right] + \lambda(Q - D) > Q \qquad [4.9]$$

and after some rearrangement,[19] equation [4.9] can be transformed into:

$$E\left(Q_o\right) > Q + \left(1 + r^L\right)B\left(A_m\right) + \frac{D}{1-\lambda} \qquad [4.10]$$

This implies that institutional mistakes made by lenders in selecting applicants (i.e. an adverse selection problem) in addition to the transaction cost, will create an extra cost of borrowing (say, δ_1) which is given by:

[19] *See appendix B for the mathematical derivation*

$$\delta_1 = Q + (1 + r^L)B + \frac{D}{1-\lambda} \qquad [4.11]$$

If a farm household cannot afford additional cost of borrowing given by equation [4.11] above, then it will not apply for credit. Such households are called credit constrained due to institutional mistakes or adverse selection.

A third category of households are those who want some compensation (say, ω) for taking the risk of borrowing money from a lender. These are risk-averse borrowers who usually do not want to lose their collateral in case they fail to repay the loan. Adding ω to equation [4.9] gives:

$$(1-\lambda)\left[E(Q_o) - (1 + r^L)B(A_m) - D\right] + \lambda(Q - D) - \omega > Q \qquad [4.12]$$

Again, after some calculus, equation [4.12] becomes:

$$E(Q_o) > Q + (1 + r^L)B(A_m) + \frac{D+\omega}{1-\lambda} \qquad [4.13]$$

This shows that cost of borrowing further increases by an amount of $\left(\frac{D+\omega}{1-\lambda}\right)$ for risk averse applicants and they are classified as households who are credit-constrained due to risk-aversion.

In general, the above discussion shows that there are at least three categories of farm households who are credit constrained from the demand side: (i) those who are constrained due to the high transaction cost of borrowing (δ_0); (ii) those who are constrained due to adverse selection (δ_1); and (iii) those who are constrained due to risk aversion (ω).

4.4.2. Identifying Credit Constraint Categories Using the Direct Elicitation Strategy

Identifying constrained households is an empirical challenge since credit rationing cannot be observed directly. However, two identification strategies are documented in the literature (Boucher *et al*, 2009; Cheng, 2009; Reyes and Lensink, 2011; Ayalew and Deininger, 2014). These are: The direct and the indirect approaches. The later is based on the life-cycle or the permanent income hypothesis[20]. Using the direct elicitation strategy, five credit constraint categories are identified as shown in Table 4.1. First, the unconstrained borrowers are those who are willing to participate in the credit market and have full access to credit facilities from a given lending institution. The credit limit set by lenders to overcome the information asymmetry problem will not be a constraint for such borrowers. Second, the unconstrained non-borrowers are those who do not borrow from credit institutions because they do not have an urgent need for external finance or they do not have a profitable project that would require a loan. The production and consumption (resource allocation) decisions of such households is not affected by the prevailing credit market imperfections.

Table 4.1: Criteria used to classify households into different credit constraint categories

Classification Criteria based on the responses of HHs	Credit Constraint Category
I prefer working with my own funds	Discouraged HH (risk-rationed)
I do not want to put my land and other assets at risk	Discouraged HH (risk-rationed)
I do not want to be worried; I am afraid	Discouraged HH (risk-rationed)
Group loan is risky	Discouraged HH (risk-rationed)
My religion doesn't allow me to borrow	Discouraged HH (risk-rationed)
Formal lenders do not offer refinancing	Discouraged HH (risk-rationed)
Collateral asked is too high	Quantity constrained borrowers
I received loan from formal lenders but not the desired amount	Quantity constrained borrowers
Formal lenders are too strict, and inflexible	Discouraged HH (tran cost-rationed)
The bank branch is too far away	Discouraged HH (tran cost-rationed)
Too time consuming to deal with commercial or other banks	Discouraged HH (tran cost-rationed)
I received the desired loan amount from formal lenders	Unconstrained borrowers
My productive activities do not give me enough to repay debt	Unconstrained non borrowers
Interest rate is too high	Unconstrained non borrowers
I do not need a loan	Unconstrained non borrowers

Source: Own classification based on EPIICA's 2011 and 2013 questionnaire

[20] *Further discussion about the strength and weaknesses of this strategy is given in Diagne et al. (2000).*

Third, borrowers who have an excess effective demand for credit but face a credit limit due to supply-side limitations were classified as "quantity constrained" households. These households stated that they applied for credit and received some loan, but the loan amount is less than their effective demand given the available contract terms. Fourth, from the demand side, there are 'transaction-cost rationed' households who have positive effective demand but do not apply for credit. These households reported that they do not want to incur the additional costs associated with the loan application process, including the extra paper work and the time they waste dealing with lenders. Further, from their past experience or from their knowledge about lenders' credit procedures, they are sure that their application will be rejected. Such households may have profitable agricultural projects but they do not participate in the credit market because their projects become unprofitable once these costs are accounted for. Fifth, lenders normally want borrowers to bear certain amount of risk to overcome the moral hazard problem in borrowers' effort or choice of investment project. One mechanism to do so is to ask for collateral. However, risk-averse households found to prefer working with their own funds, not to put their land and other assets at risk. These farmers do not want to incur debt even if they qualify for the loan and have a profitable project after accounting for transaction costs.

4.5. Econometric Model

4.5.1. Introduction

One alternative to estimate a set of coefficients corresponding to each outcome of a categorical data is to use a multinomial logit model without random effects (Long and Freese, 2006); and Greene, 2012: pp.763–766)). However, a unique feature of a longitudinal categorical data is the existence of unobserved heterogeneity among the repeated observations for a single individual (Train, 2009; Haan and Uhlendorff, 2006; Hole, 2007; Reyes and Lensink, 2011). This heterogeneity may occur because each household can make several choices that may not be independent and hence the probabilities of each category for the same household will share the same unobservable random effects (Reyes and Lensink, 2011). The parameter estimates will be biased if these unobservables are not accounted for. This calls for a more advanced estimation strategy beyond the traditional pooled multinomial model without the random effects. Hence, we employed the generalized linear latent and mixed model (gllamm) to fit a multinomial logit model with correlated random intercepts which accounts for any spurious dependence between individuals or categories.

4.5.2. The Generalized Linear Latent and Mixed Model (Gllamm)

Consider an individual i who is faced with J different alternatives at time t. The probability that this individual falls in a specific category j conditional on observed characteristics χ_{it} which vary between individuals and over time; and also conditional on unobserved individual effects, α_i that are time constant, can be specified as:

$$prob(j \mid \chi_{it}, \alpha_i) = \frac{\exp(\chi'_{it}\beta_j + \alpha_{ij})}{\sum_{k=1}^{J}\exp(\chi'_{it}\beta_k + \alpha_{ik})} \qquad [4.14]$$

We follow the standard assumption that α is identically and independently distributed over individuals and it follows a multivariate normal distribution with mean μ and variance-covariance matrix (Ω), i.e. $\alpha \sim iid(\mu, \Omega)$ (Train, 2009; Haan and uhlendorff, 2006; Hole, 2007).

The likelihood function for equation (4.14) can be specified as:

$$L = \prod_{i=1}^{N}\int_{-\infty}^{\infty}\prod_{t=1}^{T}\prod_{j=1}^{J}\left(\frac{\exp\left(\chi'_{it}\beta_j + \alpha_j\right)}{\sum_{k=1}^{J}\exp\left(\chi'_{it}\beta_k + \alpha_k\right)}\right)^{d_{ijt}} f(\alpha)\,d\alpha \qquad [4.15]$$

This is so, because the choice probabilities given in equation (4.14) are conditioned on α_i and hence we must integrate over the distribution of α to get the sample likelihood for the multinomial Logit with the random intercepts. This model will be identified if the coefficient vector(β) and the unobserved heterogeneity term (α) of one category are set to zero. Hence, $d_{ijt} = 1$ when individual i falls in category j at time t and zero otherwise.

The key problem in solving equation (4.15) is that we cannot obtain an analytical solution for the integral part of the model. This is because the random effects are assumed to have a multivariate normal distribution and the marginal distribution can be found only after integrating out these random effects. This calls for some form of numerical integration. The literature suggests various simulation and quadrature techniques including: the Adaptive Gaussian Quadrature (AGQ), Monte Carlo Simulation, Laplace Approximation, Taylor series approximation, and Gauss Hermite quadrature to solve this problem (Hartzel *et al.*, 2001; Rabe-Hesketh *et al.*, 2004; Haan and Uhlendorff, 2006; Train, 2009; Cameron and Trivedi, 2009). Among these simulation and quadrature techniques, the AGQ approach is preferred for a longitudinal categorical data because it is computationally more efficient than the ordinary quadrature in performing the numerical integration of equation (4.17) above. Another advantage of using the AGQ is that the number of quadrature points required to approximate the integral are much lower than that of the ordinary quadrature and prior studies used this technique to evaluate similar integrals (examples include: Hartzel *et al.*, (2001); Rabe-Hesketh *et al.*, (2004); and Haynes *et al.*, (2006)).

Inclusion of the AGQ technique is a recent development in statistical software. For instance, STATA software has a procedure called the generalized linear, latent and mixed model (gllamm) that is designed to model categorical dependent variables with repeated observations (Rabe-Hesketh *et al.*, 2004; Haan and Uhlendorff, 2006). It is an extension of the generalized linear model because it incorporates both the fixed and random effects and hence the response distribution is defined conditionally on the random effects. This model takes care of individual unobservable heterogeneity by capturing them through the alternative-specific random intercepts or coefficients (ASC) and it accounts for the possible correlation of choices made by individuals.

4.6. Results and Discussion

4.6.1. Credit Constraints and Borrowing Behavior: An Econometric Assessment

We estimated a conventional, robust, panel data multinomial logit (MNL) model without random effects on the determinants of credit constraints and borrowing behavior of farm households in the study area (Tables 4A.3 and 4A.4 in appendix 4A). However, given the type of problem at hand and the panel nature of the data we have, we suspect an unobserved heterogeneity to exist between individuals and across different constraint categories. Therefore, we also estimated an MNL model with random effects using the generalized linear latent and mixed model (gllamm) (Tables 4.2 and 4.3). To select one of these two sets of specifications, we conducted various tests including: the Likelihood ratio (LR) test, the Bayesian Information Criterion (BIC) and Akaike's Information Criterion (AIC). The test results support the gllamm than the MNL model without random effects. Therefore, the discussion that follows is based on the results given in Tables 4.2 and 4.3. The unexplained variance in the first two categories and the correlation between all the three categories is captured by the random effects at the individual level (Table 4.2). These values statistically differ from zero and it implies that the individual effect captured by the MNL model with random effects explains a considerable portion of the total heterogeneity.

The null hypothesis of the Wald test that all coefficients except the intercept term are equal to zero is rejected at a one percent level of statistical significance and this confirms the theoretical predictions of the above model. Variables explaining credit constraint and borrowing behavior are categorized into: (i) household demographic characteristics; (ii) ownership of livelihood assets; (iii) risk preference behavior; (iv) institutional constraints; and (v) location and exposure to climatic shocks. A descriptive Statistics of the variables used in the analysis is given in Table 4A.2 in the appendix.

Exposure to drought shock found to increase the probability of being quantity constrained by 46 percent (Table 4.2). In a rain-fed smallholder agriculture (as the case in the study area), good harvest is possible only if it rains, and other idiosyncratic shocks do not occur. According to World Bank (2004), 45 percent of the south Wollo zone is exposed to drought and Malaria, and we found households living in this zone to be highly discouraged and quantity constrained, relative to households residing in the other three zones of the study area. This seems logical, since access to external sources of finance is very difficult in such a fragile environment, because lenders are not willing to take uninsured risk of default in the case of crop failure due to climatic shocks. Households residing in west Gojjam zone, however, found to have relatively better access to formal credit and this may be because, west Gojjam is relatively more fertile region known for its Teff production (a staple food "INJERA" in Ethiopia).

We found a significant negative effect of risk aversion on the probability of borrowing from formal and informal sources of credit (Table 4.3). This can be explained by the fact that lenders require their clients to bear some amount of risk in the form of collateral. However, risk averse farmers do not want to put their assets at risk and hence prefer working with their own funds (Table 4.1). It implies that these farmers choose less risky but low value crops or projects which require no credit. Choosing such less risky but low value crops in turn means that these farmers are less efficient in agricultural production and generating lower income for their household. Thus, following Boucher *et al.* (2009), it is possible to note that credit constraint can occur even when there is excess supply of credit and this arises when the effective demand for credit is lower than the supply due to risk aversion.

Table (4.1) presents institutional constraints in the credit market of the study area and these include: (a) long and strict credit procedures such as collateral requirements or group formation, fixed repayment schedules which do not fit with harvest seasons; (b) high transaction costs of borrowing associated with the loan application process, paper works, distance, and the number of times an applicant should visit lender's office to secure the loan; (c) cost of negotiation with lenders; and (d) institutional mistakes made in selecting applicants. As expected, we found a significant negative effect of these constraints on the demand for credit. Household heads, who are discouraged due to these constraints, do not prefer borrowing from formal lenders. This can be explained by the fact that lenders usually make their credit procedures to be very strict to solve the screening, monitoring, and moral hazard problems which are very common in the credit market of developing countries (Stiglitz and Weiss, 1981; Hoff *et al.*, 1996; Antwi and Antwi, 2010). However, these strict and lengthy credit procedures make the transaction cost of borrowing to be very high and hence discourage genuine applicants who want to have access to rural finance.

We used the year dummy as a control variable to capture the change in credit constraints and borrowing behavior of farm households between 2011 and 2013. The result shows that demand for credit both from formal and informal sources has increased by 56 percent and 38 percent, respectively (Table 4.3). However, the probability of being quantity constrained has also increased by 61 percent which implies that farm households do not get the amount of credit they applied for. Possible reasons for this gap between the demand for- and supply of rural credit include: lack of adequate loanable fund in the hands of lenders; strict refinancing policy of lenders; lack of loan collateral in the hands of borrowers; and lack of loan track record or long term relationships between borrowers and lenders.

Table 4.2 Determinants of credit constraint categories – gllamm model

Variable	Unconstrained non-borrowers	Constrained - Quantity rationed borrowers	Discouraged - Tran. cost and risk-rationed borrowers
Age	.0231***	.0127*	.0276***
	(0.007)	(0.007)	(0.007)
Female	-1.4***	-0.553	-1.08**
	(0.454)	(0.44)	(0.461)
Married	-.745*	-0.424	-.735*
	(0.422)	(0.423)	(0.431)
Household size	-0.077	-0.0245	-0.055
	(0.05)	(0.048)	(0.051)
No educ.	.459**	-0.2	.497**
	(0.228)	(0.213)	(0.237)
Formal educ.	-0.106	0.107	0.178
	(0.239)	(0.223)	(0.247)
Land hect.	.466***	0.001	0.134
	(0.12)	(0.123)	(0.125)
Own livestk(tlu)	-1.28**	-0.795	-1.11*
	(0.568)	(0.574)	(0.579)
Coop member	0.0732	0.137	-0.11
	(0.302)	(0.308)	(0.307)
Year dummy	-0.148	.613***	0.159
	(0.183)	(0.189)	(0.19)
Ln(food exp)	0.191	0.035	.274**
	(0.121)	(0.119)	(0.126)
Drought shock	0.18	.459**	0.279
	(0.187)	(0.181)	(0.192)
west Gojjam	-1.65***	-0.136	-1.32***
	(0.228)	(0.209)	(0.229)
south Wollo	1.56***	1.63***	1.38***
	(0.279)	(0.288)	(0.284)
north Wollo	-.493*	.93***	-.909***
	(0.297)	(0.271)	(0.314)
Constant	0.944	-0.22	-0.283
	(0.95)	(0.947)	(0.982)

Variance - Covariance Matrix of the Random Effects			
	UCNB	QCB	DISC
UCNB	1		
QCB	0.567***(0.206)	1	
DISC	1.36***(0.164)	-0.314(0.200)	1
Statistics			
Log likelihood	-2794.11		
Obs.	2294		
AIC	5696		
BIC	6081		

Note: * p < .1; ** p < 0.05; *** p < 0.01
BIC and AIC are Bayesian Information Criteria and Akaike's Information criteria, respectively.
UCNB, QCB and DISC stand for unconstrained non borrower, quantity constrained borrower, and discouraged borrower.

Among the socio-economic variables, age of the household head found to have a positive and statistically significant effect on the probability of being discouraged (Table 4.2). This is as expected, since the average age of the heads in the study area was 49 in 2011 and 51 years in 2013. Lenders usually discourage individuals whose age is above 40 years given the health risks and shorter life expectancy in poor developing countries like Ethiopia. Moreover, the result in Table 4.3 reveals that older individuals do not want to borrow both from formal and informal lenders. This is so, probably, because they are already discouraged by lenders or because they do not want to take the risk related to borrowing. These results are consistent with findings by Crook (2001) and Mpuga (2008) that the demand for credit becomes negative for individuals whose age is above 50 years.

Gender of the household head is captured in the model as a dummy variable with a value of one for female and zero for male. Contrary to our theoretical expectation, the result shows that gender has a negative and significant effect on the probability of being credit constrained (Table 4.2) and they prefer borrowing from the formal sector (Table 4.3). This implies that, female headed households have higher probability of access to rural credit, compared to their male counterparts. This may be due to the recent micro credit revolution which focuses more on empowering women. It agrees with the actual case in rural Ethiopia where 54 percent of the clients of Micro Finance institutions are female (EEA, 2011). Ashraf *et al.*, (2003) showed that credit schemes that favor female-headed households has gained popularity in recent years and has become successful. Hansen and Rand (2011), using micro level data from eight Sub-Saharan African countries also found that there is female favoritism rather than discrimination in the African credit markets since women are considered as more loyal and have better repayment performance. Aterido *et al.* (2011) also reached to similar conclusion.

Table 4.3 Determinants of farm HHs' choice of lenders compared to non-borrowers - Generalized linear latent and mixed model (gllamm)

Variable	HHs who prefer formal lenders	HHs who prefer informal lenders	HHs who prefer semi-formal lenders
Risk averse[¥]	-2.01***	-1.02***	.655*
	(0.224)	(0.226)	0.339
Discouraged borrower[¥]	-1.83***	.652*	-0.212
	(0.449)	(0.379)	(0.575)
Quantity constrained bor[¥]	-.287*	-0.0258	0.025
	(0.174)	(0.192)	(0.329)
Age	-.0154***	-.0192***	0.005
	(0.006)	(0.006)	(0.01)
Female	.698*	0.0463	0.06
	(0.383)	(0.391)	(0.6)
Married	0.191	-0.176	-0.42
	(0.36)	(0.359)	(0.544)
Household size	.0771*	0.017	-0.04
	(0.041)	(0.05)	(0.071)
No educ.	-.316*	-0.128	-.529*
	(0.19)	(0.199)	(0.319)
Formal educ.	0.08	-0.01	-.81**
	(0.201)	(0.221)	(0.365)
Land hectare	-.215**	-0.19	0.099
	(0.102)	(0.117)	(0.196)
Own livestock (tlu)	1.11**	0.322	-0.169
	(0.508)	(0.438)	(0.61)
Coop member	-0.0416	0.165	-0.111
	(0.26)	(0.298)	(0.415)
Year dummy	.56***	.377**	-0.22***
	(0.166)	(0.185)	(0.38)
ln(food exp.)	-0.169	-0.1	-0.101
	(0.103)	(0.116)	(0.177)
Drought shock	-0.215	0.008	0.239
	(0.163)	(0.18)	(0.3)
west Gojjam	0.07***	-.729***	-0.228
	(0.177)	(0.204)	(0.317)
south Wollo	-0.47***	-0.234	-0.06***
	(0.239)	(0.228)	(0.653)
north Wollo	-0.123	0.371	.629*
	(0.25)	(0.263)	(0.354)

constant	-0.867	-0.691	-0.653
	(0.818)	(0.822)	(1.24)
Variance- Covariance Matrix of the Random Effects of HH Lender choice			
	formal	informal	Semi-formal
Formal	1		
Informal	0.219(0.201)	1	
Semi-formal	0.459***(0.384)	-0.966(0.73)	1
Statistics			
Log likelihood	-2002.87		
N	2294		
AIC	4132		
BIC	4580		

<u>Note:</u> * p < .1; ** p < 0.05; *** p < 0.01; ¥ = predicted values
BIC and AIC are Bayesian Information Criteria and Akaike's Information criteria, respectively.

Married individuals found to have higher probability of access to rural credit as revealed by the negative and statistically significant coefficient on the probability of being discouraged (Table 4.2) and this is in line with the prior expectation discussed in the foregoing section.

The findings also confirm that households having larger number of members have higher probability to demand credit from formal lenders. In developing countries where the rural labor market is usually imperfect or missing, family labor is an important source of agricultural labor supply. Hence, it is possible to argue that larger household size may mean more labor supply in agriculture which can lead to higher agricultural production, higher household income, better capacity to accumulate productive assets and repay loans. Some members of the household may also migrate to nearby towns or bigger cities for off farm employment and may send remittances back to their families. This in turn, may help farm households to build assets which can serve as loan collateral.

The literature on rural livelihoods argues that household income and participation in the credit market is determined by the portfolio of assets owned (Ellis, 2000). In relation to this, we used size of land owned, ownership of livestock asset in tropical livestock units (tlu), level of education, and membership in a primary multi-purpose cooperative as indicators for natural, physical, human, and social capital of households, in that order. As presented in Table 4.2, ownership of farm land has a significant positive effect on the probability of being unconstrained non borrower. This is in line with the hypothesis that households who own relatively larger size of land asset are expected to have more potential for equity financing and thus, they may not even go for credit. Mpuga (2008) also finds that households having larger size of land do not have demand for credit in rural Uganda. Ownership of more number of livestock asset (tlu) also found to have a significant negative effect on the probability of being discouraged (Table 4.2) and farmers who own more number of livestock prefer borrowing from formal lenders (Table 4.3). This goes with the expectation that such farmers have higher probability of obtaining credit from formal sources because of the positive influence of these assets on lenders' valuation of the loan applicant, since livestock can easily be converted into cash in cases of default.

Compared to those who have some level of education, uneducated heads are highly discouraged and hence do not want to borrow from the rural credit market. This finding is consistent with the results of Gropp *et al.*, (1997) who showed the positive effect of education on access to credit. This suggests the importance of education in access and participation in the rural credit market. Some level of education is expected to increase technical knowledge, know-how and farming skills, better credit information and familiarity with credit procedures of lending institutions. It is also expected that educated individuals will be engaged in non-farm business activities and are more likely to use the loans wisely than the uneducated ones.

4.7. Conclusion and Implications

Using household level panel data from four zones of the Amhara region in Ethiopia, we examined the constraints to farmers' access to rural credit. We attempted to explore the extent to which credit constraints stem from demand or supply-side factors. We also made an in depth analysis on key variables explaining the probability of a household to fall in one of the four different credit constraint categories and their respective borrowing behavior. We estimated a generalized linear latent and mixed model (gllamm) and the result showed that credit constraint status and borrowing behavior are significantly affected by: (i) borrower's perceived probability of rejection due to institutional rigidities; (ii) location, borrower's exposure to climatic shocks and risk preference behavior; (iii) availability of mortgage-able livelihood assets; (iv) the transaction cost of borrowing; and (v) Household demographic characteristics such as: gender, age, education, family size, and marital status.

Understanding household socio-economic conditions is essential in designing credit market policies. For instance, gender-credit constraint gap is of central policy importance as many micro credit institutions in Sub-Saharan Africa target female-headed households to enhance their asset building capacity and to pull them out of abject poverty. This story is found to be largely supported by the data as evidenced by the result that the probability of being credit constrained decreases for female-headed households (Table 4.2).

The result also shows that education is an important determinant of credit constraint status of farm households and it also affects the demand for credit in rural areas. Mobilizing and sensitizing literate people about the need for and importance of credit would be easier, and this suggests that more investment on education in rural areas would reduce credit constraints and improve participation of farm households in the rural credit market. In addition, the demand for credit is higher for households who own more livestock and they are also less discouraged in the credit market. It is therefore, important to devise policies that aim at increasing household incomes and asset holdings so as to promote their participation in the credit market.

In Ethiopia, in contrast with Reyes and Lensink's (2011) findings for Chile, demand side factors such as risk aversion behavior of farm households play important role in access to rural credit as confirmed by the results given in Table 4.3. The key lesson from this result is that increasing the supply of credit alone is not the solution for the credit constraint problems of farm households. It is crucial to understand farmers' attitude towards risk and to design a bottom-up credit policy that encourages farm households to take risk. In Ethiopia, the credit market is basically supply-driven in the sense that borrowers take only what the lender offers and do not ask too many questions. The type of loan products, prices (interest rate), quality and reliability of the services are determined by the supplier, and innovative loan products are not very common in this market. This implies that institutional issues of the credit market need more attention of the macro, meso and micro level policy makers and practitioners to make the market demand-driven, inclusive and more competitive.

As discussed above, lenders require their borrowers to bear some amount of risk in the form of collateral. However, risk averse farmers are not willing to take such risk and this necessitates designing innovative collateral-substitutes such as contract farming, using supply contracts as collateral, reputation-based lending, directly monitoring borrowers, lending according to crop cycle, and providing group loans. The sign and significance on the location and drought shock dummies also call for credit market policies which consider location-specific key variables and not simply making blanket recommendations to be applied across the board. For instance, farm households in south Wollo are vulnerable to drought shock and they are found to be highly discouraged in the credit market. Although it requires further study to identify its benefits and drawbacks, interlinking credit with insurance may also be suggested as a solution to the credit constraint problem stemming from risk aversion.

Information asymmetry is another important source of credit constraint in the study area as discussed above, and credit reference bureaus can help lenders to have credit information of loan applicants. Hence, we suggest strengthening such credit reference bureaus to solve the information asymmetry problem to reduce credit constraints. As the sign and statistical significance of the year dummy reveals, there is an increased demand for formal credit and yet a serious quantity constraint over the years 2011 and 2013. This is consistent with the general situation in access to credit in Ethiopia as discussed in section 3.6 above. For instance, EEA (2011) and AEMFI (2011) showed that micro financing institutions, which are the major formal credit providers to rural farm households, reach only about 20 percent of farm households. A possible cause of this supply side constraint is lack of loanable funds in the hands of the rural credit service providers. As Kristen (2006) argues, compared to the bigger commercial banks which have excess liquidity, the rural credit service providers possess better information and enforcement mechanisms and are typically more flexible and innovative. However, these institutions are constrained by shortage of resources and infrastructure to reach more number of clients. Hence, collaboration between commercial banks and the rural credit institutions would lead to a win-win situation to both parties. This can increase the supply of credit and improvement in the operating environment of the rural credit institutions, so that farm households will have better access to credit.

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Appendix 4A: Tables and Figures

Table 4A.1: Credit constraint status of HHs in the study area (percent)

Credit Constraint Category	2011	2013	Full sample
Unconstrained			
Borrowers	263(22.1)	205(17.2)	468(19.7)
Non-Borrowers	508(42.7)	389(32.7)	897(37.7)
Total unconstrained households	771(64.8)	594(49.9)	1365(57.4)
Constrained Households			
Quantity Constrained borrowers	152(12.8)	269(22.6)	421(17.7)
Discouraged borrowers[1]	266(22.4)	326(27.4)	592(25)
Total constrained households	418(35.2)	595(50.1)	1013(42.7)

source: own calculation from EIIPICA's 2011 and 2013 survey data

[1]*Discouraged borrowers category includes risk rationed and transaction cost rationed borrowers.*

Table 4A.2. Descriptive Statistics of variables used in the data analysis

Variable name	Variable definition and Unit of measurement	N	mean	St. dev.	min	max
Dependent Variables:						
Constraint cat.	Credit constraint category of the household (1= ucb, 2 = ucnb, 3=qcb, 4=disc)	2,378	2.478	1.068	1	4
Sector choice	Households' Choice of loan sector (1=formal, 2=informal 3= semi-formal sector)	2378	1.54	0.73	1	3
Explanatory variables:						
Age	age of the household head (years)	2377	49.725	14.118	18	100
Female	gender of the HH head (dummy = 1 if female, 0 for male)	2378	0.105	0.307	0	1
Married	marital status of the HH head (dummy = 1 if married, 0 otherwise)	2378	0.866	0.341	0	1
Household size	household size (number of members of the household)	2298	5.209	1.913	1	11
No education	level of education of the HH head (dummy = 1 if uneducated, 0 otherwise)	2378	0.531	0.499	0	1
Informal education	level of education of the HH head (dummy = 1 if attended informal educ., 0 otherwise)	2378	0.255	0.436	0	1
Formal education	level of education of the HH head (dummy = 1 if attended formal educ., 0 otherwise)	2378	0.21	0.407	0	1
Land hectares	area of land owned by the HH (ha)	2378	0.902	0.697	0	5.25
Own livestock	Livestock herd size (Tropical Livestock units; TLU)	2376	9.10	9.89	0	34.34
Coop. member	membership in a cooperative association (dummy = 1 if member, 0 otherwise)	2378	0.925	0.264	0	1
Food expenditure	amount of money spent on HH consumption items	2377	309.766	225.346	0	4000
Drought shock	exposure to drought shock (dummy = 1 if the HH experienced drought shock, 0 otherwise)	2378	0.391	0.488	0	1
Location dummies (north shewa is the reference zone)						
north Shewa	zone in which the HH resides (dummy = 1 if the HH resides in north Shewa, 0 otherwise)	2378	0.336	0.472	0	1
west Gojjam	zone in which the HH resides (dummy = 1 if the HH resides in west Gojjam, 0 otherwise)	2378	0.312	0.463	0	1
south Wollo	zone in which the HH resides (dummy = 1 if the HH resides in south Wollo, 0 otherwise)	2378	0.23	0.421	0	1
north Wollo	zone in which the HH resides (dummy = 1 if the HH resides in north Wollo, 0 otherwise)	2378	0.122	0.328	0	1

Table 4A.3 Determinants of Credit constraint status of farm HHs compared with unconstrained borrowers

Variable	Unconstrained non-borrowers	Constrained quantity rationed borrowers	Discouraged Tran. cost and risk-rationed borrowers
Age	.0167***	.0101*	.0215***
	(0.005)	(0.006)	(0.006)
Female	-1.21***	-0.445	-.897**
	(0.35)	(0.391)	(0.379)
Married	-.684**	-0.394	-.674*
	(0.335)	(0.363)	(0.361)
Household size	-0.065	-0.017	-0.043
	(0.04)	(0.04)	(0.04)
No educ.	.346*	-0.198	.391**
	(0.177)	(0.196)	(0.198)
Formal educ.	-0.125	0.124	0.157
	(0.19)	(0.201)	(0.207)
Land hectares	.417***	-0.002	0.088
	(0.104)	(0.126)	(0.111)
Own livestk(tlu)	-1.08**	-0.747	-.92*
	(0.486)	(0.529)	(0.505)
Coop member	0.006	0.088	-0.172
	(0.257)	(0.29)	(0.273)
Year dummy	-0.068	.611***	0.238
	(0.147)	(0.182)	(0.159)
Ln(food exp.)	.158*	0.049	.246**
	(0.09)	(0.108)	(0.101)
Drought shock	0.13	.425**	0.236
	(0.16)	(0.18)	(0.17)

west Gojjam	-1.26***	-0.062	-.947***
	(0.166)	(0.191)	(0.177)
south Wollo	1.38***	1.54***	1.22***
	(0.252)	(0.278)	(0.248)
north Wollo	-0.271	.911***	-.682**
	(0.251)	(0.259)	(0.275)
Constant	0.818	-0.477	-0.452
	(0.75)	(0.81)	(0.801)
Statistics			
Wald $chi^2(45)$	367		
Prob > chi^2	0.000		
Number of obs	2289		
AIC	5746		
BIC	6022		

Note: robust standard errors in brackets; * p < .1; ** p < 0.05; *** p < 0.01; The Wald test clearly shows the joint significance of all regressors. The variables are estimated using robust standard errors based on the White's hetroskedasticity consistent estimators of variance. The AIC and BIC stand for the Akaike's information criteria and the Bayesian information criteria, respectively which are used to choose the appropriate model. The gllamm model (Table 4.2) is found to be more appropriate based on the values of BIC and AIC.

Table 4A.4 Determinants of farm HHs' choice of lenders compared to non-borrowers - Multi-nomial logit model with standard errors adjusted for cluster effects (Robust model)

Variable	HHs who prefer formal lenders	HHs who prefer informal lenders	HHs who prefer semi-formal lenders
Risk_averse[¥]	-1.85***	-.979***	-.555*
	-0.194	-0.229	-0.289
Discouraged bor[¥]	-1.68***	-0.612	-0.117
	-0.438	-0.386	-0.468
Quantity const[¥]	-0.227	-0.013	0.043
	-0.151	-0.199	-0.274
Age	-.0128***	-.019***	0.004
	-0.005	-0.006	-0.008
Female	.651*	0.0347	0.014
	-0.336	-0.368	-0.397
Married	0.207	-0.172	-0.375
	-0.317	-0.348	-0.367
Household size	.0721**	0.0136	-0.039
	-0.034	-0.045	-0.066
No educ.	-.281*	-0.118	-.459*
	-0.167	-0.193	-0.264
Formal educ.	0.0782	-0.0013	-.674**
	-0.175	-0.216	-0.301
Land hect.	-.198**	-0.188	0.11
	-0.0945	-0.125	-0.149
Own livestock(tlu)	1.04*	0.308	-0.172
	-0.534	-0.413	-0.445
Coop mem.	-0.018	0.16	-0.054
	-0.24	-0.291	-0.358
Year dummy	.497***	.361*	-0.2***
	-0.136	-0.191	-0.334
Ln(food exp.)	-.17**	-0.102	-0.106
	-0.084	-0.124	-0.144
Drought shock	-0.194	0.015	0.217
	-0.14	-0.18	-0.271
west Gojjam	.937***	.694***	-0.197
	-0.147	-0.195	-0.268
south Wollo	-0.33***	-0.208	-0.8***
	-0.218	-0.229	-0.614
north Wollo	-0.097	0.377	.589*
	-0.225	-0.258	-0.305
Constant	-0.76	-0.689	-0.225
	-0.755	-0.769	-0.923

Statistics	
Wald $chi^2(54)$	455
Prob > chi^2	0
Number of obs.	2289
AIC	4138
BIC	4465

¥ = *predicted values*

Appendix 4B: Mathematical derivation

Given equation (4.9) as: $(1-\gamma)\left[E\left(Q_o\right)-r.B\left(A_m\right)-D\right]+\gamma\left(Q-D\right)>Q$

Dividing both sides by $(1-\gamma)$ and re-arranging, will give:

$$E\left(Q_o\right)>Q/_{1-\lambda}+r^L.B(A_m)+D-\lambda\left(Q-D\right)/_{1-\lambda} \qquad [4.9.1]$$

$$E\left(Q_o\right)>r^L.B(A_m)+D+\left[Q/_{1-\lambda}-\lambda\left(Q-D\right)/_{1-\lambda}\right] \qquad [4.9.2]$$

But $\left[Q/_{1-\lambda}\right]-\left[\lambda\left(Q-D\right)/_{1-\lambda}\right] becomes Q+\left[\lambda D/_{1-\lambda}\right]$. Hence, equation (4.9.2) becomes:

$$E\left(Q_o\right)>r^L.B(A_m)+\left[D+\left[\lambda D/_{1-\lambda}\right]\right]+q \qquad [4.9.3]$$

Again, $D+\left[\lambda D/_{1-\lambda}\right] becomes \left[D/_{1-\lambda}\right]$ Thus equation (4.15.3) becomes:

$E\left(Q_o\right)>r^L.B\left(A_m\right)+Q+\left[D/_{1-\lambda}\right]$ that is same as equation (4.10) above.

CHAPTER 5. THE IMPACT OF CREDIT CONSTRAINTS AND CLIMATIC FACTORS ON CHOICE OF ADAPTATION STRATEGIES: EVIDENCE FROM RURAL ETHIOPIA[‡]

Abstract

Climate adaptation actions, like any other investment, require financial resources which are likely to be in short supply in the rural sector in developing countries. This chapter assesses the role of credit constraints in the choice of adaptation strategies in settings with severe financial market imperfections. Household level panel data from selected zones in the highland region of Ethiopia, combined with climate information from the adjacent meteorological stations, is employed in the analysis. We quantify the linkage between different forms of credit constraints and choice of climate adaptation strategies using a pseudo fixed effects regression model. The results show that being a discouraged or risk rationed borrower reduces the probability of participation in off-farm self-employment and diversifying crops. As a robustness check, we also run a Multivariate Probit (MVP) and a seemingly unrelated simultaneous equation (SURE) models that allow for correlation among the unobserved disturbances. The results from these later regressions also show that better credit access, represented by being unconstrained borrower, encourages irrigation while, soil conservation and tree planting are the least responsive to credit access. This suggests that credit constraints are significant determinants of participation in adaptation strategies. However, the severity of credit constraints depends both on the nature of the credit constraint and on the type of adaptation investment, which highlights the need to recognize the complex relationships between financial provision and climate change adaptation policies.

Key Words: *credit constraints; climatic factors; Adaptation strategies, Pseudo-fixed Effects; Multivariate Probit; seemingly unrelated simultaneous equation model; Ethiopia*

JEL Codes: *C23, G29, Q54, Q12*

[‡] *This chapter is co-authored with Mintewab Bezabih and Tadele Ferede, and is under a peer review process to be published in the EfD discussion paper series and also in a reputable Journal.*

5.1 Introduction

Agrarian economies in low-income developing countries, characterized by an uncertain production environment, are inherently risk-prone (Dercon, 2002; Yesuf and Bluffstone, 2009). The riskiness of the sector is likely to be exacerbated by the threats of climate change (Dinar, et al, 2008; IPCC, 2007; Kurukulasuriya *et al.,* 2006). Identifying the opportunities and constraints associated with effective adaptation strategies are, thus critical for the performance of the sector and the economy as a whole (Maddison, 2007; Bryan *et al.,* 2013).

Most of the traditional risk sharing or mitigating strategies, particularly those associated with a wider range of shocks, provide only a partial insurance mechanism (Mogues, 2011), have a high opportunity cost, tend to be very localized, and are limited in scope (Dercon, 2009). In such settings, credit access tends to act as insurance against income shocks[21] (e.g. Yang and Choi, 2007). This implies that financial resources can potentially form one of the key strategies to both expanding and strengthening risk mitigating instruments, particularly with increasing threat of climate change.

Farm households in developing countries, have complex and changing livelihood strategies with small and uncertain incomes. They try to increase and stabilize their incomes, that are determined by their portfolio of assets: social, human, financial, natural and physical assets (Ellis, 2000; 2004). The lion's share of their income goes for the purchase of food items and agricultural inputs. However, poor farm households often face cash shortage to make purchases of these items and other small expenditures such as purchase of cooking fuel, kitchen tools etc. (Sinha and Lipton, 1999). Therefore, rural households are more exposed to variations in their income and are therefore dependent of financial services compared to other groups. They have three options to meet their need for 'Lump sums' of money (see Levy, 1993; Berry and Levy, 1994; Kariuki, 1995; Rutherford *et al*., 2002; Green *et al.,* 2005). One option is to sell the assets they hold or expect to hold (for example, next season's crops). The second option is to mortgage or pawing their assets. However, both are not feasible options for many farm households in developing countries including Ethiopia, since these households normally have few or no assets

[21] Other financial resources that serve similar purposes include remittances and savings (e.g. Fafchamps et al., 1998). However, the analysis in this chapter focuses only on access to credit.

and asset disposal as an option is not a sustainable solution for survival. The third option is to convert the small savings (from their daily activities) in to 'lump-sums'. Again, this can be done in three ways: saving up, saving down and saving through. These are the core services that the rural financial market is expected to accomplish.

'Saving-up' is basically building up small savings over time (daily, weekly, etc.) and finally withdrawing a 'lump-sum'. This is a good approach (if possible), because it does not involve debt. 'Saving down' on the other hand, involves acquiring a lump sum of loan first and then using micro-savings to repay the loan over time. In this case, the main problem for poor farm households is lack of access to such "saving down" services from financial institutions due to various reasons which will be discussed in detail in chapter three. The third option is the 'saving through' approach that involves making a continuous flow of savings that are converted into a 'lump sum' at an intermediate time. Sometimes, the person becomes a 'net saver' and at another time 'net borrower'. This is a user-friendly approach that allows the person to meet the need for planned expenditure (such as purchase of agricultural inputs) or unplanned expenditures due to various shocks (such as medical expenses or funerals). Again, the problem here is the lack of access to such financial services, and hence the rural households are forced to face the undesirable outcomes of market imperfections (Rutherford *et al.*, 2002).

Thus, the policy interest on the rural credit market over the last four decades was to create access for the rural poor to credit and saving services and hence use it as a tool to improve adaptive capacity and alleviate poverty. The literature highlights many channels through which access to rural credit can improve the lives of farm households. First, it eases the problem of capital constraint and hence reduces the opportunity cost of capital intensive assets and encourages labor saving technology that in turn raises labor productivity (Petrick, 2005). Second, when farm households have better access to credit, they tend to take risk and focus on high risk and yet high return agricultural activities. This means that it also changes the risk management strategies of households (Kochar, 1997; Diagne *et al.*, 2000; Barslund and Tarp, 2008). Third, when there is no credit constraint, the production and consumption decisions of farm households will be separate[22] and this will make household resource allocation to be optimal (Feder *et al.*, 1990; Foltz, 2004; Reyes and Lensink, 2011).

In light of this background, the current chapter argues that improving household access to finance and integrating climate change adaptation strategies into poverty reduction strategies is an important step in improving livelihoods and adaptive capacity of farm households. The rest of the chapter is organized as follows. Description of the data is provided in section 5.2 and the methodological approach consisting of the econometric strategy is discussed in section 5.3, while section 5.4 discusses the empirical findings. Section 5.5 concludes the chapter.

5.2. Data and Variables

Data used in this study was collected using two waves of rural household surveys conducted in 2011and 2013. The survey sites include households from four zones (north Shewa, south Wollo, north Wollo and west Gojjam) of the Amhara National Regional State, located in the northern and Central Highlands of Ethiopia (see the discussion in sections 2.2 and 2.3 for details about the study area and the data set).

5.2.1. Dependent Variable: Choice of Different Adaptation Strategies

Our choice of the adaptation strategies for this study is based on Deressa et al. (2009) and Difalco et al. (2011) who assessed responses of farmers who were asked what measures they have taken in response to perceived changes in temperature and precipitation. Accordingly, we consider the following key strategies as climate adaptation tools: soil conservation and tree planting, crop diversification, off-farm employment, asset depletion, and irrigation. (See section 3.4 in chapter 3 for detailed review of the literature on each adaptation strategy).

In 2013, approximately 53 percent of the sampled households opted for crop diversification while 33 percent invested in soil conservation measures, including tree planting.

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[22] See Squire, and Strauss (1986) and Sadoulet and de Janvry, 1995) for details about separable and non-separable household models

Investing in small-scale irrigation, off-farm income generating activities, dis-saving, and depleting productive assets were the other adaptation strategies practiced by about 13, 12, 27 and 25 percent of the sample households, respectively in 2013 (Table 6.3).

The stringency of credit constraints could differ depending on the credit demands of a given adaptation strategy and this implies the need to empirically investigate the relationships between the adaptation strategies and credit constraints. Hence, in this chapter we analyze the responsiveness of each adaptation strategy to climatic factors.

5.2.2. Explanatory Variables

We categorized variables explaining farmer's choice of adaptation strategies into measures of climate variability; indicators of credit constraint status; household demographic characteristics; ownership of physical assets, and social capital. Table 5A.1 presents the descriptive statistics of these variables.

5.2.2.1. Credit Constraint Categories

As discussed in chapter 4 above, three categories of credit constraints were generated based on the direct elicitation (survey-based) method (Kon and Storey, 2003; Guirkinger, 2008): quantity constrained borrowers, those who are discouraged due to high transaction costs, and risk rationed borrowers (see section 4.4.2 for further details about each constraint category and the classification strategy adopted).Table 4A.1 shows categorization of credit constraint status of farm households and their willingness/ability to participate in the rural credit market in the study area. The percentage of households who are quantity constrained has increased from 13 to 23 percent, while the percentage of discouraged households has increased from 22 percent in 2011 to 27 percent in 2013. This shows that, more number of farm households in the study area are credit constrained during the period spanning our analysis.

5.2.2.2. A Measure for Climatic Factors

Climatic factors, in this dissertation, comprise of temperature and rainfall average, rainfall variability and the incidence of drought. Monthly rainfall data were obtained from the National Meteorological Agency of Ethiopia, from eight stations close to the study districts (woredas) for the years between 1983 and 2013(see section 2.2.4 for details). The rainfall measure was constructed by taking the sum of monthly rainfall for each year and averaging it over 30 years. The temperature average was also calculated as the monthly temperature average, further averaged over 30 years. Then, we calculated the coefficient of variation (CV) for rainfall, measured as the standard deviation divided by the mean for the respective periods. We linked these climate variables with the household survey data using the thin plate spline interpolation technique. This technique uses latitude, longitude, altitude and other relevant geographic information in linking the climate data with the household survey data (Wahba, 1990; Gu, 2002; Wood, 2003). The major advantage of the CV is that it is scale invariant and as such provides a comparable measure of variation for households that may have different wealth levels (Alem and Colmer, 2013). We also included a dummy variable representing the households' experience of drought shocks. Figure 5.2 shows the coefficient of variation of rainfall across the study zones over time. As would be expected, the increasing variability of rainfall over the years in the study area concurs with the pattern of the national level of rainfall variability (see figure 5.1).

5.2.2.3. Ownership of Physical Assets and Social Capital

In this study, we included land holding as an important explanatory variable since it is a productive asset that determines the social and economic status of farmers (See section 2.2 in chapter 2 for more details on land holding in the study area). The social capital variables included in the analysis are membership in a primary farmer's cooperative association, participation in a kebele council, membership in a non-cooperative peasant association and membership in a rotating saving and credit association (ROSCA) as explanatory variables. Membership in these groups is represented by a dummy variable with a value of 1 if respondents belong to these groups and 0 otherwise. These are important social assets enjoyed for their own sake, used for material gain, and called upon in times of shocks or crises (Woolcock and

Narayan, 2000). On average, 10 percent of the total households interviewed indicated membership in a kebele association, while 23 percent indicated membership in a ROSCA (Table 5A.1).

5.2.2.4. Socio-economic characteristics

Household socio-economic characteristics such as age, gender, marital status, and level of education of the head were included in the analysis as control variables. The average age of household heads in the sampled zones is about 50 years with heads in west Gojjam zone being relatively younger than those in the other three zones (Table 2A.1). The average household size was approximately five. About nine percent of the households in the study sites were headed by female in 2011, with this figure having increased to twelve percent in 2013. About 22 percent of the household heads have around 5 years of formal education, whereas 27 percent have attended some informal education in 2011 and 24 percent in 2013.

5.3. Estimation Procedure

Our analytical approach extends the model by Rahm and Huffman (1984) and Adesina and Zinnah (1993) that links farmers' utility to the choice of a given agricultural technology (in our case, adaptation strategy) by adding credit constraints and environmental risk representing climate change. Accordingly, the farm household's utility function $U(\mu_{ij}, \tau_{ij}, \gamma_{ij})$ is the basis of ranking the preference of the i^{th} farmer for a given adaptation strategy j, where μ_{ij} represent a vector of socioeconomic characteristics of the farm household; τ_{ij} represent a vector of credit constraint variables, and γ_{ij} represents a vector of control variables. Formally,

$$U_{ij} = \mu_j F_i(\mu_{ij}, \tau_{ij}, \gamma_{ij}) + e_{ij} \qquad [5.1]$$

where $i = 1, 2, \ldots, n$; $j = 1, 2, \ldots, m$; and e_{ij} $is\ the\ disturbance\ term$

The choice of adaptation strategy 1 over strategy 2 would be based on the utility derived from the two strategies such that $U_{i1} > U_{i2}$. The unobservable utility function can be expressed in terms of the observable components in the latent variable model, given in equation (5.2):

$$P_i^* = \alpha Z_i + \varepsilon_i \quad with\ P_i = \begin{cases} 1\ if P_i^* > 0 \\ 0\ otherwise \end{cases} \quad [5.2]$$

where P is a dummy variable with $P = 1$ if the adaptation strategy is adopted and zero otherwise. α is a vector of parameters to be estimated; Z is a vector that represents the socioeconomic, credit and climate-related variables; and ε is the random error term. Since the current analysis is based on panel data, the estimable equation is extended to incorporate time features, represented by equation (5.3).

$$P_{it} = \beta X_{it} + c_i + \varepsilon_{it} \quad [5.3]$$

For farmer i, at time *t,* P is a dummy variable with $P = 1$ if the adaptation strategy is adopted and $P = 0$ otherwise. β is a vector of parameters to be estimated; X_{it} is a vector of explanatory variables representing socioeconomic, credit and climatic factors; c_i is the unobserved individual effect which is assumed to be independent of X_{it}; and ϵ_{it} is a random error term,

$\varepsilon_{it} \sim I.I.D.N(0,\sigma_\alpha^2)$, and $c_i \mid X_i \sim N(0,\sigma_\alpha^2)$,

The likelihood function of the random effects (RE) probit model relies on the probabilities:

$$pr(y_{it} = 1 \mid x_{it}, c_i) = \Phi(x_{it}\beta + c_i) \quad [5.4]$$

where $\Phi(.)$ is either the standard normal CDF (probit) or the logistic CDF (logit).

The random effects model is associated with the strong assumption of no correlation between the unobserved individual effect c_i and the regressors/observed covariates (Baltagi, 2005). However, this is, unlikely because some of the time-invariant characteristics, such as farmer's motivation or ability may be correlated with some of the regressors in the model. The fixed effects estimator, on the other hand, relies on a transformation to remove this individual specific constant term, along with time invariant observed covariates (Wooldrige, 2003).

Therefore, it is necessary to adopt a method that allows for correlation between c_i and x_{it}. Our estimation procedure involves the pseudo-fixed effects estimation (Mundlak's) approach (Wooldridge, 2003) which involves explicitly modeling the relationship between time varying regressors and the unobservable effect in an auxiliary regression (Mundlak, 1978). In particular, c_i can be approximated by a linear function:

$$c_i = \omega \overline{s}_{im} + \xi_{im} \quad [5.5]$$

where $\overline{s}_{im}$ represents a vector of time variant explanatory variables, ω is a vector of parameters to be estimated. Averaging over *t* for a given *i* and substituting the resulting expression into (5.2) gives:

$$P_{it}^* = x_{it}\beta + \omega \overline{s}_{it} + \xi_{it} \quad [5.6]$$

where P_{it}^* is the choice of a given adaptation strategy by household *i* in year t.

In addition to this, we managed the possible selection bias in credit constraint status of farm households as follows. As the gllamm estimation (discussed in section 4.5.2 of chapter four) is supposed to serve the purpose of correcting for selection bias, we include two variables as instruments in the first stage regression. The first variable is the lag of credit access- a dummy variable capturing past information regarding whether the household has accessed any credit during the past year. The second is membership in a solidarity group, again a dummy variable representing whether the household belongs in a social network. After regressing this model (equation 4.15), we impute the Mills ratios and thereafter we include these ratios as a regressor in our outcome model to correct for the selection bias. This approach has been employed by among others: Millet, (2001); Okten *et al*., (2004); Bushway et al., (2007) and Teklewold et al, (2013). The intuition behind this approach is that by including the inverse mills ratio from the first stage model as a regressor in the second stage panel probit model, we obtain estimators that are free from the bias caused by sample selection (Wooldridge, 2002; Gujarati, 2004 and Greene (2004). Using this, we estimated five separate adoption models for five different adaptation strategies.

However, a farmer may adopt two or more strategies simultaneously or the adoption of one strategy may be conditioned on the adoption of another strategy, either because they are substitutes or complements. This means that a single equation estimation approach may cause bias and inefficiency in the parameters if an interdependence is observed and/or if unobserved heterogeneity is correlated among these strategies (Greene, 2008). Thus, as a robustness check, following Teklewold et al. (2013); and Kassie et al. (2013), we estimated a

Multivariate Probit model (MVP) which is a non-linear seemingly unrelated simultaneous equation model, and also a linear seemingly unrelated simultaneous equation model (SURE[23]) that allow correlation among the unobserved disturbances. We also tested interdependence of technologies in the adoption decisions by checking the sign and significance of the off-diagonal elements of the variance-covariance matrix of the Multivariate Probit (MVP) model. A positive sign is interpreted as a complementary relationship among the adaptation strategies, while a negative correlation is interpreted as being substitutes.

5.4. Discussion of Results

As discussed in Section 5.2, the adaptation strategies considered in the empirical analysis include crop diversification, soil conservation, participation in off farm self-employment, depletion of household assets, and investment in small-scale irrigation. Below, we discuss the quantitative relationship between these adaptation strategies and credit constraints, with climate related variables as key conditioning factors.

5.4.1. Credit Constraints and Participation in Off-farm Self-employment Activities

Table 5A.2 presents determinants of the probability of participating in off-farm income generating activities for different credit constraint categories. The three columns report the results for unconstrained, discouraged and risk rationed borrowers, respectively. Being unconstrained borrower increases the probability of off-farm employment participation by approximately 33 percent, while being discouraged borrower decreases this probability by approximately 28 percent. These results demonstrate that credit constraints adversely affect the probability of participation in off-farm self-employment since such activities require startup capital and institutional support, including access to credit.

The coefficient of variation (CV) of rainfall is found to have a significant positive effect in choosing off-farm income generating activities (Table 5A.2). The robustness check results in table 5A.10 also show that an increase in the mean temperature increases the probability of farmers to participate in off-farm self-employment activities, while better rainfall encourages

[23] *We used the SURE model as a robustness test for the second definition of the crop diversification count variable since MVP works only for binary dependent variable.*

farmers to stay on their farms. This shows that off farm employment could be regarded as an alternative adaptation strategy to compensate for the shortfalls in household income that arise from rainfall variability. This is in agreement with Bezabih *et al.,* (2010) who found that the coefficient of variation of rainfall has a positive and significant effect on off-farm participation.

The interaction between credit constraint categories and coefficient of variation of rainfall is significant for the risk rationed group in both tables 5A.2 and 5A.10. The result in Table 5A.2 shows that the probability of participating in off-farm job creation declines by 69 percent when the coefficient of variation increases by one percent, for households belonging to this particular credit constraint group. This suggests that when coupled with credit constraints, the adverse effects of climate variability are intensified. On the contrary, being an unconstrained borrower encourages off-farm job creation.

As an additional robustness check, the incidence of drought was interacted with each of the three credit constraint categories[24]. The results indicate that participation in off farm employment reduces with drought for both discouraged and risk rationed households. The results also hold when other controls, such as physical and social capital variables, household socioeconomic characteristics and location dummies are included in the model. Ownership of a radio (a proxy for access to information), social capital variables such as membership in a Kebele[25] council and membership in a rotating saving and credit association or Iqqub appear to have statistically significant positive impact on off-farm self-employment.

These results are also in line with previous studies. Narayan and Prichett (1999) found that households who have better social networks are more likely to participate in activities that improve their personal income and they also enjoy better public services. Better social networks reduce transaction costs of doing business and hence, improve profitability of such businesses (Fafchamps and Minten, 2002). Carter and Castillo (2005) also established that households who have higher social capital quickly recover from negative shocks.

[24]The regression results from the interaction between drought and rainfall variability are placed in Appendix 5A.6 to 5A.9.

[25] Kebele is the lowest administrative unit in the Ethiopian governance structure.

Size of land owned reduces the likelihood of participating in off-farm income generating activities and this finding agrees with Mishra and Goodwin (1998) and Harris *et al.,* (2010) who argue that the larger the farm size, the lower the probability that farmers work off their farm. Moreover, older farmers hesitate to work off-farm and as Mishra and Goodwin (1998) noted, this may suggest differences in attitudes regarding work that are correlated with age.

Gender of the head does not appear to have a significant impact on off-farm employment participation as evidenced by its insignificant coefficient. Married heads of households are also less likely to be employed off-farm. This is likely due to stronger family obligations to stay on farm, for married household heads. Household size and level of education appear to have no impact on off-farm employment participation.

5.4.2. Credit Constraints and Crop Diversification

Tables 5A.3, 5A.11 and 5A.16 present the effect of credit constraints and climatic factors on crop diversification. As discussed in section 3.4, we define farm level diversification in two ways: count diversity and cash vs staple crop. Count diversity is defined as the number of crops grown by the household and we used the seemingly unrelated simultaneous equation (SURE) model for this definition (see Table 5A.16 for results). The second diversification variable is defined as a dummy variable with one representing cash crop and zero otherwise.

From the results, we note that unconstrained households tend to diversify more (Table 5A.3), while discouraged households have lower probability of doing so (Table 5A.11). This could be explained by the fact that planting different types of crops, especially cash crops, is risky and requires substantial cash outlays to purchase inputs like seeds and fertilizers. Prior studies also confirm that access to credit is one of the critical factors in the crop diversification decisions of farm households (for example, see Aghion and Bolton, 1997; Paul, 2005).

In order to assess the impact of credit constraints conditional on climatic factors, we interact these two sets of variables. We find that the interaction between rainfall variability and credit constraint has a negative and statistically significant impact, for the discouraged and risk rationed groups of borrowers (Tables 5A.3, and 5A.11). Hence, rainfall variability, coupled with credit constraints, found to reduce the tendency of farm households to diversify.

Table 5A.7 presents the results from the interaction between credit constraint dummies and the incidence of drought. The results are comparable to those of the credit-rainfall interactions. Farmers who are illiterate and those who are married and having larger household size, tend to mono crop than diversify. This may suggest their strategy to avoid the risk of hunger in the face of climate variability and credit constraints. These results are in line with Lamb (2002) who showed that in the presence of credit market imperfections, only wealthier households choose crops with higher average profits, as well as higher profit variance, because these households have greater ability for smoothing consumption ex post.

5.4.3. Credit Constraints, Tree Planting and Soil Conservation

As per the results in Tables 5A.4 and 5A.12, credit constraints have no significant effect on land conservation activities except for discouraged borrowers. The interaction between the coefficient of variation of rainfall and credit constraints is also not significant, indicating that soil conservation practices may not be responsive to credit availability/constraints. A plausible explanation for this insignificant coefficient is that soil conservation and afforestation measures are highly subsidized by the government. Mekonnen and Damte (2011) also found similar results where credit constraints had no significant effect on the likelihood of investing on soil conservation and tree planting in Ethiopia.

As can be seen in Table 5A.8, the interaction between drought and credit constraint categories is also weak. The exception, the reduction in the propensity to invest in soil conservation for discouraged category of borrowers, is negative and significant when interacted with drought shock. This indicates some evidence of the potency of credit constraints in hampering conservation activities in the incidence of drought shock. The results indicate that exposure to rainfall variability and drought shock are the main drivers of soil conservation in the study sites and this culture has been growing over the years spanning our study, as the positive and significant year dummy confirms. One reason for this improvement may be the priority given by the government for massive community-based land conservation measures in recent years to tackle with the adverse effects of climate change and to promote green growth (MoFED, 2010; 2013).

Indicators of capital such as radio ownership, membership in kebele council and ROSCA (Iqqub) are not significant in any of the regressions. Being older head of household, being a female headed household, household size, and education are not likely to be significantly associated with soil conservation activities.

5.4.4. Credit Constraints and Household Assets Depletion

The results in Table 5A.5 show that the tendency of asset depletion is negatively and significantly associated with being unconstrained borrower. Contrary to this, being in the discouraged borrower's category significantly increases the likelihood of asset depletion. The probability of selling assets significantly increases when rainfall variability is interacted with risk rationing and the results in Table 5A.13 also substantiate these findings. It also agrees with the findings of carter et al., (2007) who found that poor farmers in Honduras sell their assets when they face drought shock. Santos et al., (2011) also showed that poorer farmers in Bangladesh deplete their assets to cope with climatic shocks. As per Table 5A.9, unconstrained borrowers are less likely to engage in asset depletion while the discouraged and risk rationed borrower households are significantly more likely to do so.

5.4.5. Credit Constraints and investment in small-scale irrigation

The results in Table 5A.14 indicate that investment in small-scale irrigation in the study area is the least responsive activity to credit constraints except for few variables. However, farmers living in north Wollo and south wollo found to invest more on irrigation compared to the other two zones. One reason for this improvement may be the priority given by the government to small-scale irrigation projects in recent years, in order to increase agricultural productivity and tackle the adverse effects of climate change to promote green growth (MoFED 2014). Among the socio-economic variables, education found to have a significant positive effect on investing in irrigation projects, implying the role of education in improving adaptive capacity of farm households.

5.5. Conclusions and Implications

This chapter empirically investigated the links between alternative adaptation strategies and different forms of credit constraints in selected areas of the Amhara Regional State of Ethiopia using household level panel data. Key determinants of the choice of adaptation strategies include: credit constraint status (being a quantity constrained, risk rationed, discouraged, or unconstrained borrower); exposure to climatic factors; household demographic characteristics; ownership of livelihood assets; and other control variables such as location. The quantitative analysis points to the fact that the type of credit constraint matters for the choice of adaptation strategies of households.

The findings of the study can be summarized in four major ways. First, the existence of a significant proportion of discouraged and risk rationed borrowers indicates that the rural credit market in Ethiopia is not yet inclusive; we found that this reduces the adaptive capacity of farm households. For instance, discouraging credit policies and procedures reduce the probability of participation in off-farm employment. This can be explained by the fact that lenders usually make their credit procedures very stringent to solve the screening, monitoring, and moral hazard problems that are very common in the credit market of developing countries (Stiglitz and Weiss 1981; Antwi and Antwi 2010). Further, the adaptive capacity of risk rationed farmers has significantly decreased. This can be explained by the fact that lenders require borrowers to bear some amount of risk in the form of collateral. Second, relatively better credit access seems to have encouraged irrigation, while credit constraint seems to have discouraged participation in off-farm employment and diversification. This largely significant impact of the different credit constraint categories on participation in alternative adaptation strategies confirms the critical role credit availability has in adaptation investment. Similarly, the importance of the interaction terms between rainfall variability and credit constraint categories in the choice of adaptation strategies indicates the importance of credit, especially with greater effect of climatic factors.

The role of credit in the uptake of the different adaptation strategies underlines the need to understand the links between credit institutions and the other institutions directly linked with the different adaptation strategies, such as seed delivery mechanisms (in relation to diversification), land tenure arrangements (in relation to tree planting and soil conservation), and general agricultural extension systems (in relation to irrigation activities). Further, given the links between credit constraints and climatic factors noted in this study, increasing awareness about how the credit market works and provision of climate information can help farmers better adapt to climate change. Administrative zones such as south and north Wollo, which are more vulnerable to climate variability, need special assistance so that they may have better access to the rural credit market and build their adaptive capacity.

The policy implications of this chapter go beyond the role of credit in adaptation to climate change. Policies that enhance and strengthen institutional support may also be valuable in enhancing the adaptation capacity of households. Hence, in future research, it is worth investigating the role of similar institutions in the context of climate change adaptation.

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Table 5A.1. Definition and summary Statistics of variables used in the data analysis

Variables	Description	mean	Std. dev.
Dependent variable:	**Choice of Adaptation strategies**		
Soil_conserv	Soil conservation (1= yes; 0 = otherwise)	0.41	0.49
Crop_divers	crop diversification (1= yes; 0 = otherwise)	0.21	0.41
Off_farm	off-farm employment (1= yes; 0 = otherwise)	0.12	0.32
irrigation	Irrigation (1= yes; 0 = otherwise)	0.13	0.34
Dis_sav	Asset depletion (1= yes; 0 = otherwise	0.30	0.46
Explanatory variables			
Household characteristics			
age	age of the HH head (years)	49.72	14.12
female	1 = household head is female	0.11	0.31
marr	1 = head is married	0.87	0.34
hh_size	household size (number of members of the HH)	5.21	1.91
no_educ	1 = head is uneducated	0.53	0.50
infrml_educ	1 = head attended some informal education	0.26	0.44
frml_educ	1 = head attended some formal education	0.21	0.41
Resource constraints			
lnd_hect	Farm size, ha	0.90	0.70
TLU	Livestock herd size (Tropical Livestock units; TLU)	9.10	9.89
Asset_value	total value of household asset, Birr*	1175.92	2261.27
own_radio	1 = head owns radio	0.25	0.43
Climatic shocks			
rain_cv	Coeff. of variation (CV) of rainfall	0.36	0.11
Mean_rainfall	Annual mean rainfall	104.9	18.3
Mean_temp	Annual mean temperature	32.07	2.8
drought	1 = Household faced drought shock (self-reported)	0.39	0.49
Credit constraint status			
IMR1	Inverse mill's ratio for unconstrained borrowers (from first stage reg)	0.43	0.34
IMR2	Inverse mill's ratio for unconstrained non borrowers (from first stage reg)	0.35	0.28
IMR3	Inverse mill's ratio for quantity constrained borrowers (from first stage reg)	0.45	0.34
IMR4	Inverse mill's ratio for discouraged borrowers (from first stage reg)	0.49	0.37
IMR5	Inverse mill's ratio for risk rationed borrowers (from first stage reg)	0.44	0.34
prvs_cnst	1 = HH faced credit constraint in the previous period (used as IV in the first stage reg.)	0.16	0.37

Social capital (networks)			
Solidarity_group	1 = head is member in a solidarity group (used as IV in the first stage reg.)	0.23	0.42
cp_mem	1 = head is member in a primary farmer's cooperative association	0.92	0.26
Kebele_asso	1 = head is member of peasant association	0.098	0.28
Ekub_mem	1 = head is member in Ekub (ROSCA)	0.23	0.42
Location dummies			
nshoa	1 = north Shewa zone	0.34	0.47
wgoj	1 = west Gojjam zone	0.31	0.46
swolo	1 = south Wollo zone	0.23	0.42
nwolo	1 = north Wollo zone	0.12	0.33

Source: Own calculation based on EPIICA's survey
Note: * ETB = Ethiopian Birr, 1 USD = 18.5 ETB as of March 2013.

Table 5A.2: Effect of climate variability (rainfall variability) on off-farm self-emplyment under different credit constraint conditions: A Hetroskedasticity Robust Pseudo Fixed Effects Model

	Model I		Model II		Model III	
Dependent variable: Participation in Off farm self-employment (IGA)						
VARIABLES	coefficient	s.e.	coefficient	s.e.	coefficient	s.e.
Credit constraint categories						
Unconst. Borr. (IMR)	0.332*	(0.189)				
Discouraged Borrower (IMR)			-0.277*	(0.146)		
Risk rationed Borrower (IMR)					-0.187	(0.135)
Interaction terms						
Unconst. Borr. *rain_CV	0.122	(0.249)				
Discouraged * rain_CV			0.351	(0.343)		
Risk rationed * rain_CV					-0.689*	(0.359)
Climate variables						
Rainfall variability	0.362*	(0.212)	0.367*	(0.214)	0.494**	(0.223)
Year Effect	-0.059	(0.116)	-0.055	(0.115)	-0.084	(0.116)
Physical and Social capital variables						
Land owned (hectare)	-0.400***	(0.153)	-0.270**	(0.13)	-0.280**	(0.132)
Own radio (proxy for info.)	0.370***	(0.122)	0.367***	(0.124)	0.378***	(0.125)
Head is member in kebele council	0.188*	(0.113)	0.230**	(0.115)	0.223*	(0.116)
Head is member in a ROSCA (Ekub)	0.121	(0.177)	0.128	(0.177)	0.119	(0.178)
Household Characteristics						
Age of head	-0.025***	(0.007)	-0.017***	(0.005)	-0.017***	(0.005)
Dummy for female head of the household	0.501	(0.385)	-0.010	(0.281)	-0.018	(0.283)
Dummy for a married head	-0.136	(0.304)	-0.502**	(0.254)	-0.518**	(0.256)
Household size	0.014	(0.037)	-0.013	(0.035)	-0.011	(0.035)
Head has no education	0.021	(0.239)	0.212	(0.218)	0.242	(0.218)
Head attended some formal education	-0.226	(0.282)	-0.211	(0.286)	-0.187	(0.285)

Time Average (Mundlak)						
Land owned (time avg.)	0.026	(0.172)	0.048	(0.176)	0.061	(0.178)
Head is member in a ROSCA (time avg.)	0.744***	(0.252)	0.694***	(0.256)	0.699***	(0.258)
Head has no education (time avg.)	-0.235	(0.281)	-0.239	(0.287)	-0.271	(0.288)
Head attended some formal educ. (time avg.)	0.461	(0.344)	0.524	(0.35)	0.51	(0.351)
Location factors						
Dummy for west Gojjam	-0.16	(0.356)	-0.739***	(0.196)	-0.756***	(0.199)
Dummy for south Wollo	-0.584*	(0.354)	-0.066	(0.168)	-0.059	(0.169)
Dummy for north Wollo	0.003	(0.207)	-0.149	(0.205)	-0.121	(0.204)
Constant	-0.895**	(0.428)	-0.569	(0.411)	-0.56	(0.414)
Statistics						
Observations	2,289		2,296		2,296	
Number of quest_id	1,189		1,189		1,189	
Wald chi2(21)	74.5		72.72		72.66	
Log likelihood	-699.5		-704.1		-702.5	
Prob > Chi2	0		0		0	
sigma_u	1.065		1.111		1.124	
Rho	0.531		0.552		0.558	
Likelihood ratio test of rho = 0:						
chibar2(01)	52.65		57.56		58.43	
Prob >= chibar2	0		0		0	

Robust standard errors in parentheses *** p < 0.01, ** p < 0.05, * p < 0.1

Rainfall variability is measured using coeff. of variation (CV) of rainfall from the long term average

Table 5A.3: Effect of climate variability (rainfall variability) on crop diversification under different credit constraint conditions: A Hetroskedast. Robust Pseudo Fixed Effects Model

	Model I		Model II		Model III	
Dependent variable: crop diversification						
VARIABLES	coefficient	s.e.	coefficient	s.e.	coefficient	s.e.
Credit constraint categories						
Unconst. Borr. (IMR)	0.643***	(0.163)				
Discouraged Borrower (IMR)			-0.141	(0.176)		
Risk rationed Borrower (predicted value)					0.115	(0.103)
Interaction terms						
Unconst. Borr. *rain_CV	-0.092	(0.23)				
Discouraged * rain_CV			-0.226**	(0.090)		
Risk rationed * rain_CV					-0.458*	(0.262)
Climate variables						
Rainfall variability	-0.514***	(0.165)	-0.119	(0.184)	-0.561***	(0.165)
Year Effect	0.033	(0.081)	0.103	(0.094)	0.078	(0.082)
Physical and Social capital variables						
Land owned (hectare)	-0.286**	(0.116)	-0.003	(0.109)	-0.027	(0.094)
Own radio (proxy for info.)	0.031	(0.107)	0.03	(0.109)	0.032	(0.108)
Head is member in kebele council	0.004	(0.10)	-0.01	(0.099)	0.011	(0.098)
Head is member in a ROSCA (Ekub)	-0.101	(0.168)	-0.11	(0.167)	-0.097	(0.167)
Household Characteristics						
Age of head	-0.01	(0.006)	0.012***	(0.004)	0.008**	(0.004)
dummy for female head of the household	1.547***	(0.337)	0.472*	(0.255)	0.624**	(0.243)
Dummy for a married head	0.206	(0.256)	-0.487**	(0.219)	-0.376*	(0.214)
Household size	-0.028	(0.031)	-0.09***	(0.029)	-0.08***	(0.03)
Head has no education	-0.714***	(0.201)	-0.29	(0.18)	-0.346*	(0.177)
Head attended some formal education	-0.01	(0.23)	0.02	(0.232)	0.052	(0.232)

Time Average (Mundlak)						
Land owned (time avg.)	-0.553***	(0.155)	-0.504***	(0.165)	-0.504***	(0.157)
Head is member in a ROSCA (time avg.)	-0.157	(0.231)	-0.187	(0.235)	-0.228	(0.234)
Head has no education (time avg.)	0.276	(0.236)	0.228	(0.24)	0.263	(0.239)
Head attended some formal educ. (time avg.)	0.201	(0.294)	0.267	(0.299)	0.241	(0.297)
Location factors						
Dummy for west Gojjam	-0.073	(0.3)	-0.984***	(0.173)	-1.106***	(0.164)
Dummy for south Wollo	-1.305***	(0.326)	-4E-05	(0.275)	-0.239	(0.18)
Dummy for north Wollo	-0.043	(0.191)	-0.420**	(0.177)	-0.234	(0.19)
Constant	-0.329	(0.365)	-0.02	(0.355)	0.123	(0.353)
Statistics						
Observations		2,296		2,296		2,296
Number of quest_id		1,189		1,189		1,189
Wald $chi^2(21)$		130.7		117.5		123
Log likelihood		-986		-995.5		-998.9
Prob > Chi^2		0		0		0
sigma_u		1.035		1.09		1.073
Rho		0.517		0.543		0.535
Likelihoo ratio test of rho = 0: $chibar^2(01)$		76.58		87.38		85.23
Prob >= $chibar^2$		0		0	0	0

Robust standard errors in parentheses *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table 5A.4: Effect of climate variability (rainfall variability) on soil conservation under different credit constraint conditions: A Hetroskedasticity Robust Pseudo Fixed Effects Model

	Model I		Model II		Model III	
Dependent variable: soil conservation						
VARIABLES	coefficient	s.e.	coefficient	s.e.	coefficient	s.e.
Credit constraint categories						
Unconst. Borr. (IMR)	0.014	(0.099)				
Discouraged Borrower (IMR)			-0.11	(0.129)		
Risk rationed Borrower (IMR)					-0.025	(0.099)
Interaction terms						
Unconst. Borr. *rain_CV	0.234	(0.183)				
Discouraged * rain_CV			0.172	(0.221)		
Risk rationed * rain_CV					-0.056	(0.152)
Climate variables						
Rainfall variability[1]	0.332***	(0.125)	0.367***	(0.121)	0.358***	(0.124)
Year Effect	-0.07	(0.065)	0.076	(0.065)	0.077	(0.065)
Physical and Social capital variables						
Land owned (hectare)	-0.151**	(0.064)	-0.157**	(0.064)	-0.149**	(0.065)
Own radio (proxy for info.)	-0.02	(0.079)	-0.024	(0.079)	-0.025	(0.079)
Head is member in kebele council	-0.06	(0.074)	-0.055	(0.075)	-0.055	(0.074)
Head is member in a ROSCA (Ekub)	0.016	(0.123)	0.045	(0.12)	0.045	(0.12)
Household Characteristics						
Age of head	0.004	(0.001)	0.004	(0.003)	0.004	(0.003)
dummy for female head of the household	0.066	(0.19)	0.068	(0.19)	0.067	(0.19)
Dummy for a married head	-0.362**	(0.17)	-0.363**	(0.17)	-0.361**	(0.17)
Household size	-0.029	(0.021)	-0.029	(0.021)	-0.029	(0.021)
Head has no education	-0.08	(0.137)	-0.074	(0.137)	-0.077	(0.137)

Head attended some formal education	0.102	(0.186)	0.113	(0.185)	0.106	(0.185)
Time Average (Mundlak)						
Land owned (time avg.)	0.307***	(0.101)	0.306***	(0.101)	0.303***	(0.101)
Head is member in a ROSCA (time avg.)	-0.159	(0.164)	-0.153	(0.164)	-0.161	(0.164)
Head has no education (time avg.)	0.193	(0.176)	0.189	(0.176)	0.191	(0.176)
Head attended some formal educ. (time avg.)	0.103	(0.227)	0.089	(0.227)	0.097	(0.226)
Location factors						
Dummy for west Gojjam	0.514***	(0.11)	0.513***	(0.11)	0.503***	(0.11)
Dummy for south Wollo	-0.695***	(0.13)	-0.723***	(0.13)	-0.720***	(0.129)
Dummy for north Wollo	0.206	(0.133)	0.206	(0.134)	0.201	(0.134)
Constant	-0.379	(0.262)	-0.448*	(0.266)	-0.438	(0.267)
Statistics						
Observations		2,296		2,296		2,296
Number of quest_id		1,189		1,189		1,189
Wald $chi^2(21)$		100.1		99.24		98.96
Log likelihood		-1459		-1460		-1460
Prob > Chi^2		0		0		0
sigma_u		0.718		0.716		0.715
Rho		0.34		0.339		0.338
Likelihood ratio test of rho = 0: $chibar^2(01)$		48.98		48.75		48.45
Prob >= $chibar^2$		0		0		0

Robust standard errors in parenthesis *** p < 0.01, ** p < 0.05, * p < 0.1

Table 5A.5: Effect of climate variability (rainfall variability) on Depleting household assets under different credit constraint conditions: A Hetroskedasticity Robust Pseudo Fixed Effects Model

	Model I		Model II		Model III	
Dependent variable: asset depletion						
VARIABLES	coefficient	s.e.	coefficient	s.e.	coefficient	s.e.
Credit constraint categories						
Unconst. Borr. (IMR)	-0.935***	(0.147)				
Discouraged Borrower (IMR)			0.203*	(0.123)		
Risk rationed Borrower (IMR)					-0.06	(0.08)
Interaction terms						
Unconst. Borr. *rain_CV	0.027	(0.144)				
Discouraged * rain_CV			0.204	(0.364)		
Risk rationed * rain_CV					0.365***	(0.138)
Climate variables						
Rainfall variability[1]	0.226*	(0.135)	0.235*	(0.135)	0.332**	(0.139)
Year Effect	-0.174**	(0.074)	-0.187**	(0.074)	-0.204***	(0.074)
Physical and Social capital variables						
Land owned (hectare)	0.655***	(0.103)	0.234***	(0.077)	0.233***	(0.077)
Own radio (proxy for info.)	-0.001	(0.075)	0.008	(0.074)	0.006	(0.074)
Head is member in kebele council	0.073	(0.069)	0.06	(0.069)	0.079	(0.069)
Head is member in a ROSCA (Ekub)	0.071	(0.127)	0.057	(0.125)	0.048	(0.126)
Household Characteristics						
Age of head	0.024***	(0.004)	0.002	(0.003)	0.002	(0.003)
dummy for female head of the household	-1.358***	(0.278)	-0.015	(0.176)	-0.003	(0.177)
Dummy for a married head	-0.539***	(0.203)	0.286*	(0.159)	0.291*	(0.16)
Household size	-0.076***	(0.021)	-0.014	(0.02)	-0.011	(0.019)
Head has no education	0.365**	(0.16)	-0.152	(0.139)	-0.165	(0.139)
Head attended some formal education	0.132	(0.193)	0.072	(0.193)	0.07	(0.192)
Time Average (Mundlak)						
Land owned (time avg.)	-0.084	(0.1)	-0.109	(0.101)	-0.109	(0.101)
Head is member in a ROSCA (time avg.)	0.006	(0.16)	0.039	(0.16)	0.07	(0.161)
Head has no education (time avg.)	-0.099	(0.168)	-0.091	(0.169)	-0.063	(0.169)

Head attended some formal educ. (time avg.)	-0.02	(0.222)	-0.079	(0.222)	-0.068	(0.222)
Location factors						
Dummy for west Gojjam	-1.946***	(0.262)	-0.434***	(0.106	-0.459***	(0.107)
Dummy for south Wollo	1.520***	(0.261)	-0.04	(0.088)	0.028	(0.092)
Dummy for north Wollo	0.239**	(0.111)	0.513***	(0.104)	0.589***	(0.105)
Constant	-0.12	(0.254)	-0.782***	(0.238)	-0.817***	(0.241)
Statistics						
Observations		2,019		2,025		2,025
Number of quest_id		1,160		1,161		1,161
Wald $chi^2(21)$		140.3		113.2		115.5
Log likelihood		-1148		-1172		-1171
Prob > Chi^2		0		0		0
sigma_u		0.252		0.298		0.298
Rho		0.0598		0.0814		0.0814
Likelihoo ratio test of rho = 0: $chibar^2(01)$		0.977		1.872		1.879
Prob >= $chibar^2$		0		0		0

Robust standard errors in parenthesis *** p < 0.01, ** p < 0.05, * p < 0.1

Table 5A.6: Effect of climate variability (drought) on off-farm job creation under different credit constraint conditions: A Hetrosked. Robust Pseudo Fixed Effects Model

	Model I		Model II		Model III	
Dependent variable: Participation in Off_farm self-employment (IGA)						
VARIABLES	coefficient	s.e.	coefficient	s.e.	coefficient	s.e.
Credit constraint categories						
Unconst. Borr. (IMR)	0.385**	(0.196)				
Discouraged Borrower (IMR)			-0.03	(0.154)		
Risk rationed Borrower (IMR)					-0.149	(0.135)
Interaction terms						
Unconst. Borr. * drought	0.330*	(0.192)				
Discouraged * drought			-0.552**	(0.257)		
Risk rationed * drought					-0.54**	(0.227)
Climate variables						
Household experienced drought shock	-0.171	(0.127)	0.002	(0.124)	0.003	(0.124)
Year Effect	0.09	(0.11)	0.083	(0.11)	0.074	(0.11)
Statistics						
Observations	2,289		2,296		2,296	
Number of quest_id	1,189		1,189		1,189	
Wald chi2(21)	74.06		72.33		72.47	
Log likelihood	-699		-703.6		-703	
Prob > Chi2	0		0		0	
sigma_u	1.073		1.11		1.113	
Rho	0.535		0.552		0.553	
Likelihood ratio test of rho = 0: chibar2(01)	53.01		57.33		57.39	
Prob >= chibar2	0		0		0	

Robust standard errors in parentheses *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Control factors such as physical and social capital variables, socioeconomic characteristics and location factors are included in the regressions but are not reported as they have similar results as the corresponding regressions in Tables 5A.2 to 5A.5

Table 5A.7: Effect of climate variability (drought) on crop diversification under different credit constraint conditions: A Hetroskedasticity Robust Pseudo Fixed Effects Model

	Model I		Model II		Model III	
Dependent variable: crop diversification						
VARIABLES	coefficient	s.e.	coefficient	s.e.	coefficient	s.e.
Credit constraint categories						
Unconst. Borr. (IMR)	0.674***	(0.156)				
Discouraged Borrower (IMR)			-0.114	(0.174)		
Risk rationed Borrower (IMR)					0.148	(0.104)
Interaction terms						
Unconst. Borr. * drought	-0.369	(0.252				
Discouraged * drought			-0.297*	(0.163)		
Risk rationed * drought					-0.353**	(0.166)
Climate variables						
Household experienced drought shock	-0.735***	(0.106)	-0.069	(0.11)	-0.071	(0.11)
Year Effect	0.271***	(0.085)	0.105	(0.094)	0.118	(0.095)
Statistics						
Observations	2,289		2,296		2,296	
Number of quest_id	1,189		1,189		1,189	
Wald chi2(21)	175.3		120.3		122.4	
Log likelihood	-960.7		-1004		-1003	
Prob > Chi2	0		0		0	
sigma_u	0.875		1.067		1.057	
Rho	0.434		0.532		0.528	
Likelihood ratio test of rho = 0: $chibar^2(01)$	46.77		80.38		79.26	
Prob >= $chibar^2$	0		0		0	

Robust standard errors in parenthesis *** p < 0.01, ** p < 0.05, * p < 0.1

Table 5A.8: Effect of climate variability (drought) on soil conservation under different credit constraint conditions: A Hetroskedasticity Robust Pseudo Fixed Effects Model

	Model I		Model II		Model III	
Dependent variable: soil conservation						
VARIABLES	coefficient	s.e.	coefficient	s.e.	coefficient	s.e.
Credit constraint categories						
Unconst. Borr. (IMR)	0.021	(0.133)				
Discouraged Borrower (IMR)			0.043	(0.133)		
Risk rationed Borrower (IMR)					-0.014	(0.08)
Interaction terms						
Unconst. Borr. * drought	-0.146	(0.133)				
Discouraged * drought			-0.075*	(0.039)		
Risk rationed * drought					0.018	(0.118)
Climate variables						
Household experienced drought shock	0.159*	(0.088)	0.178**	(0.088)	0.156*	(0.089)
Year Effect	0.141*	(0.079)	0.12	(0.079)	0.155**	(0.078)
Statistics						
Observations	2,289		2,296		2,296	
Number of quest_id	1,189		1,189		1,189	
Wald $chi^2(21)$	92.73		95.52		92.78	
Log likelihood	-1459		-1458		-1463	
Prob > Chi^2	0		0		0	
sigma_u	0.725		0.716		0.732	
rho	0.344		0.339		0.349	
Likelihood ratio test of rho = 0: $chibar^2(01)$	49.42		47.44		51.69	
Prob >= $chibar^2$	0		0		0	

Robust standard errors in parenthesis *** p < 0.01, ** p < 0.05, * p < 0.1

Table 5A.9: Effect of climate variability (drought) on Depleting household assets under different credit constraint conditions: A Hetroskedasticity Robust Pseudo Fixed Effects Model

	Model I		Model II		Model III	
Dependent variable: asset depletion						
VARIABLES	coefficient	s.e.	coefficient	s.e.	coefficient	s.e.
Credit constraint categories						
Unconst. Borr. (IMR)	-0.947***	(0.157)				
Discouraged Borrower (IMR)			0.240**	(0.116)		
Risk rationed Borrower (IMR)					0.277**	(0.114)
Interaction terms						
Unconst. Borr. * drought	0.119	(0.126)				
Discouraged * drought			-0.048	(0.118)		
Risk rationed * drought					-0.369**	(0.148)
Climate variables						
Household experienced drought shock	0.006	(0.079)	-0.118	(0.078)	-0.123	(0.076)
Year Effect	-0.123*	(0.073)	-0.079	(0.07)	-0.04	(0.072)
Statistics						
Observations		2,019		2,025		2,025
Number of quest_id		1,160		1,161		1,161
Wald $chi^2(21)$		138.2		110.8		116
Log likelihood		-1149		-1172		-1170
Prob > Chi^2		0		0		0
sigma_u		0.251		0.318		0.299
rho		0.0592		0.0917		0.082
Likelihood ratio test of rho = 0: $chibar^2(01)$		0.955		2.376		1.901
Prob >= $chibar^2$		0		0		0

Robust standard errors in parenthesis *** p < 0.01, ** p < 0.05, * p < 0.1

Appendix 5A: Additional Regression Results for Robustness Test

Table 5A.10. Effect of Credit constraints and climatic factors on Off_farm self-employment: A Multivariate Probit model with Mean Rainfall, Mean Temperature and Mundlak effects

Dependent variable: Off_farm self-employment		
VARIABLES	coefficient	std.err.
Credit constraint categories		
Unconst.non Borrower (IMR)	0.130	0.149
Quantity constrained Borrower (IMR)	0.266*	0.176
Discouraged Borrower (IMR)	0.073	0.213
Risk rationed Borrower (IMR)	-0.101	0.146
Climate variables		
Mean Rainfall	-0.053***	0.014
Mean Temperature	0.261*	0.176
Mean Temperature sqr	-0.006*	0.004
Household faced drought shock (self-reported)	0.114	0.133
Interaction terms		
Qnty_const * rain_CV	-0.882**	0.345
risk_rashned * rain_CV	-0.759**	0.326
Discouraged * rain_CV	-0.414	0.607
Physical asset and plot characteristics		
Land owned (hectare)	-0.237*	0.159
Tropical Livestock Units (TLU)	0.041	0.175
Own radio (proxy for info.)	0.164	0.202
Household Characteristics		
Age of head	-0.011***	0.004
dummy for female head of the household	0.323	0.284
Dummy for a married head	-0.100	0.263
Household size	-0.150	0.145
Head has no education	-0.227	0.244
Head attended some formal education	-0.410	0.327
Time Average (Mundlak)		
Land owned (time_avg)	0.109	0.194
Head has no education (time_avg)	0.320	0.306
Head attended some formal educ. (time_avg)	0.898**	0.376
Own radio (proxy for info.) (time_avg)	-0.045	0.267
Tropical Livestock Units (TLU) (time_avg)	-0.041	0.176
Household size (time_avg)	0.197	0.147
year dummy	0.449*	0.269
Location factors		
Dummy for west Gojjam	1.895***	0.644
Dummy for south Wollo	-0.0285	0.181
Dummy for north Wollo	-0.403**	0.208
constant	1.611	1.953
Statistics		
Observations	1140	
Wald chi-square	522.1	
Prob > chi^2 =	0	
Log likelihood =	-2632.18	

*** p < 0.01, ** p < 0.05, * p < 0.1

Table 5A.11. Effect of Credit constraints and climatic factors on crop diversification decision: A Multivariate Probit model with Mean Rainfall, Mean Temperature and Mundlak effects

Dependent variable: crop diversification		
VARIABLES	coefficient	std.err.
Credit constraint categories		
Unconst.non Borrower (IMR)	-0.509	0.557
Quantity constrained Borrower (IMR)	4.214*	2.394
Discouraged Borrower (IMR)	-7.670**	2.932
Risk rationed Borrower (IMR)	0.153	0.790
Climate variables		
Mean Rainfall	-0.005	0.013
Mean Temperature	0.165	0.140
Mean Temperature sqr	-0.003	0.003
Household faced drought shock (self-reported)	-0.250*	0.157
Interaction terms		
Qnty_const * rain_CV	0.314	0.308
risk_rashned * rain_CV	-0.032	0.180
Discouraged * rain_CV	-0.333***	0.103
Physical asset and plot characteristics		
plot has flat slope (base cat. = steepy slope)	0.319	0.230
plot has gentle slope	0.367*	0.240
distance_to_plot	0.001	0.002
Land owned (hectare)	-0.061	0.141
Tropical Livestock Units (TLU)	0.163	0.147
Own radio (proxy for info.)	0.029	0.175
Household Characteristics		
Age of head	0.014***	0.005
dummy for female head of the household	0.534**	0.278
Dummy for a married head	-0.256	0.226
Household size	0.015	0.120
Head has no education	-0.340*	0.217
Head attended some formal education	0.122	0.283
Time Average (Mundlak)		
Land owned (time_avg)	-0.374**	0.175
Head has no education (time_avg)	0.361	0.248
Head attended some formal educ. (time_avg)	0.039	0.324
Own radio (proxy for info.) (time_avg)	-0.147	0.230
Tropical Livestock Units (TLU) (time_avg)	-0.167	0.148
Household size (time_avg)	-0.007	0.122
year dummy		
Location factors		
Dummy for west Gojjam	-0.660	0.592
Dummy for south Wollo	0.187	0.305
Dummy for north Wollo	-0.284	0.273
constant	0.354	3.440
Statistics		
Observations	1140	
Wald chi-square	522.1	
Prob > chi^2 =	0	
Log likelihood =	-2632.177	

*** p < 0.01, ** p < 0.05, * p < 0.1

Table 5A.12. Effect of Credit constraints and climatic factors on Soil Conservation and Planting Trees: A Multivariate Probit model with Mean Rainfall, Mean Temperature and Mundlak effects

Dependent variable: Soil Conservation and Planting Trees		
VARIABLES	coefficient	std.err.
Credit constraint categories		
Unconst.non Borrower (IMR)	-0.447	0.468
Quantity constrained Borrower (IMR)	-1.152	2.004
Discouraged Borrower (IMR)	-6.033**	2.741
Risk rationed Borrower (IMR)	-0.494	0.692
Climate variables		
Mean Rainfall	0.017*	0.012
Mean Temperature	0.210*	0.128
Mean Temperature sqr	-0.004*	0.003
Household faced drought shock (self-reported)	-0.068	0.139
Interaction terms		
Qnty_const * rain_CV	-0.262	0.280
risk_rashned * rain_CV	-0.081	0.156
Discouraged * rain_CV	-0.038	0.128
Physical asset and plot characteristics		
plot has flat slope (base cat. = steepy slope)	0.323*	0.188
plot has gentle slope	0.483**	0.200
distance_to_plot	0.003**	0.002
Land owned (hectare)	0.110	0.116
Tropical Livestock Units (TLU)	-0.060	0.129
Own radio (proxy for info.)	0.128	0.154
Household Characteristics		
Age of head	0.006*	0.004
dummy for female head of the household	0.148	0.250
Dummy for a married head	-0.083	0.207
Household size	0.293***	0.106
Head has no education	-0.092	0.189
Head attended some formal education	0.324	0.251
Time Average (Mundlak)		
Land owned (time_avg)	-0.001	0.141
Head has no education (time_avg)	0.333*	0.216
Head attended some formal educ. (time_avg)	-0.181	0.286
Own radio (proxy for info.) (time_avg)	-0.386*	0.203
Tropical Livestock Units (TLU) (time_avg)	0.056	0.130
Household size (time_avg)	-0.247**	0.108
year dummy	0.280*	0.215
Location factors		
Dummy for west Gojjam	-0.577	0.522
Dummy for south Wollo	-0.788***	0.150
Dummy for north Wollo	-0.068	0.229
constant	0.862	2.861
Statistics		
Observations	1140	
Wald chi-square	522.1	
Prob > chi^2 =	0	
Log likelihood =	-2632.177	

Table 5A.13. Effect of Credit constraints and climatic factors on Depleting Productive Assets: A Multivariate Probit model with Mean Rainfall, Mean Temperature and Mundlak effects

Dependent variable: Depleting Productive Assets		
VARIABLES	coefficient	std.err.
Credit constraint categories		
Unconst.non Borrower (IMR)	1.556***	0.490
Quantity constrained Borrower (IMR)	1.898	1.871
Discouraged Borrower (IMR)	2.189	2.407
Risk rationed Borrower (IMR)	1.034	0.716
Climate variables		
Mean Rainfall	0.027**	0.014
Mean Temperature	-0.071	0.140
Mean Temperature sqr	0.003	0.003
Household faced drought shock (self-reported)	-0.127	0.110
Interaction terms		
Qnty_const * rain_CV	0.565**	0.277
risk_rashned * rain_CV	0.467***	0.159
Discouraged * rain_CV	0.871*	0.475
Physical asset and plot characteristics		
plot has flat slope (base cat. = steepy slope)	-0.004	0.183
plot has gentle slope	-0.272	0.197
distance_to_plot	-0.002*	0.002
Land owned (hectare)	0.233**	0.116
Tropical Livestock Units (TLU)	0.276**	0.133
Own radio (proxy for info.)	0.082	0.158
Household Characteristics		
Age of head	0.002	0.004
dummy for female head of the household	0.078	0.259
Dummy for a married head	0.317	0.217
Household size	-0.143	0.107
Head has no education	0.180	0.190
Head attended some formal education	0.333	0.257
Time Average (Mundlak)		
Land owned (time_avg)	0.087	0.143
Head has no education (time_avg)	-0.223	0.221
Head attended some formal educ. (time_avg)	-0.166	0.291
Own radio (proxy for info.) (time_avg)	-0.190	0.207
Tropical Livestock Units (TLU) (time_avg)	-0.281**	0.134
Household size (time_avg)	0.180*	0.109
year dummy		
Location factors		
Dummy for west Gojjam	-1.735***	0.619
Dummy for south Wollo	-0.015	0.155
Dummy for north Wollo	0.779***	0.219
constant	-8.501***	2.614
Statistics		
Observations	1140	
Wald chi-square	522.1	
Prob > chi^2 =	0	
Log likelihood =	-2632.177	

Table 5A.14. Effect of Credit constraints and climatic factors on Investing in Small-scale Irrigation: A Multivariate Probit model with Mean Rainfall, Mean Temperature and Mundlak effects

Dependent variable: Investing in Small-scale Irrigation		
VARIABLES	coefficient	std.err.
Credit constraint categories		
Unconst.non Borrower (IMR)	0.313**	0.156
Quantity constrained Borrower (IMR)	0.574	0.504
Discouraged Borrower (IMR)	0.701***	0.239
Risk rationed Borrower (IMR)	0.069	0.158
Climate variables		
Mean Rainfall	-0.016	0.014
Mean Temperature	0.052	0.141
Mean Temperature sqr	-0.001	0.003
Household faced drought shock (self-reported)	-0.302	0.246
Interaction terms		
Qnty_const * rain_CV	-0.447	1.109
risk_rashned * rain_CV	0.123	0.281
Discouraged * rain_CV	-4.581	283.391
Physical asset and plot characteristics		
plot has flat slope (base cat. = steepy slope)	0.663***	0.284
plot has gentle slope	0.368	0.298
distance_to_plot	-0.001	0.002
Land owned (hectare)	-0.093	0.133
Tropical Livestock Units (TLU)	-0.357**	0.166
Own radio (proxy for info.)	-0.083	0.189
Household Characteristics		
Age of head	-0.006*	0.004
dummy for female head of the household	-0.306	0.267
Dummy for a married head	-0.282	0.234
Household size	0.120	0.112
Head has no education	0.103	0.217
Head attended some formal education	0.526*	0.315
Time Average (Mundlak)		
Land owned (time_avg)	0.143	0.171
Head has no education (time_avg)	0.161	0.267
Head attended some formal educ. (time_avg)	-0.360	0.357
Own radio (proxy for info.) (time_avg)	0.227	0.245
Tropical Livestock Units (TLU) (time_avg)	0.352**	0.167
Household size (time_avg)	-0.139	0.115
year dummy	-0.070	0.226
Location factors		
Dummy for west Gojjam	-0.065	0.634
Dummy for south Wollo	0.724***	0.175
Dummy for north Wollo	0.601***	0.193
constant	-0.459	1.686
Statistics		
Observations	1140	
Wald chi-square	522.1	
Prob > chi^2 =	0	
Log likelihood =	-2632.177	

Table 5A.15. Estimated Covariance Matrix of the Multivariate Probit Model(MVP) Regression between Different Adaptation Strategies

	ρ_C	ρ_E	ρ_T	ρ_D	ρ_I
ρ_C	1				
ρ_E	0.34 (0.068)***	1			
ρ_T	0.27 (0.053)***	0.099(0.066)*	1		
ρ_D	-0.066 (0.059)	-0.18(0.069)***	0.028(0.052)	1	
ρ_I	0.035 (0.068)	-0.002(0.080)	0.047(0.065)	0.015(0.065)	1

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

$\chi^2(10) = 58.95$

Prob> $\chi^2 = 0.00$

*,** and *** indicate statistical significance at 10, 5 and 1%, respectively; numbers in parentheses are the standard errors.

C,E, T, D, and I stand for: Crop Diversification, Off-farm Employment, Tree planting and soil conservation, Depleting assets or Dis-saving, and Irrigation respectively.

Table 5A.16. Effect of Credit constraints and climatic factors on crop diversification decision (Number of crops): Seemingly unrelated regression (XTSUR) model with Mean Rainfall, Temperature and Mundlak effects

Dependent variable: crop diversification		
VARIABLES	coefficient	std.err.
Credit constraint categories		
Unconst. Borrower (IMR)	-1.092	1.343
Quantity constrained Borrower (IMR)	-3.485	2.749
Discouraged Borrower (IMR)	6.196**	2.838
Risk rationed Borrower (IMR)	-2.624**	1.115
Climate variables		
Mean rainfall	0.035***	0.013
Mean Temperature	0.002	0.026
Household faced drought shock (self-reported)	0.329**	0.151
Physical asset and Social capital		
Land owned (hectare)	0.19	0.174
Distance to Plot	0.003	0.002
Own radio (proxy for info.)	0.091	0.151
Household Characteristics		
Age of head	-0.016***	0.006
dummy for female head of the household	-0.108	0.441
Dummy for a married head	-0.101	0.392
Household size	0.197***	0.039
Head has no education	0.043	0.26
Head attended some formal education	0.284	0.389
Time Average (Mundlak)		
Land owned (time_avg)	-0.172	0.2
Head is member in a ROSCA (time_avg)	-0.376	0.352
Head has no education (time_avg)	0.033	0.336
Head attended some formal educ. (time_avg)	-0.188	0.453
year dummy	0.688***	0.243
Location factors		
Dummy for west Gojjam	0.01	0.45
Dummy for south Wollo	-0.049	0.215
Dummy for north Wollo	0.950***	0.358
Statistics		
Observations[26]		534

*** p < 0.01, ** p < 0.05, * p < 0.1

[26] *To keep the document concise, we did not report the remaining XTSUR regression results. Interested readers can get them from the author.*

CHAPTER 6 IMPACT OF CREDITCONSTRAINTS AND ADAPTATION STRATEGIES ON ASSET HOLDINGS OF FARM HOUSEHOLDS: PANEL DATA EVIDENCE FROM RURAL ETHIOPIA[‡]

Abstract

Exposure to extreme weather events intertwined with credit constraints can reduce farm households' asset holdings in low-income developing countries. This chapter assesses the effect of climate variability and adaptation actions on household asset holdings over time in a small-scale farming setting with severe credit market imperfections. A household level panel data set collected from 1200 households in 2011 and 2013 along with the corresponding climate data is employed in the analysis. Using an instrumental variables-fixed effect (IV-FE) regression technique, we found that experiencing drought shock and rainfall variability have significant negative effects on household asset holdings in the study area. Compared to unconstrained borrowers, farmers who are discouraged and quantity constrained are found to have significantly lower amounts of asset holdings, and this amount is even lower when climatic shocks are coupled with credit constraints. However, having strong social networks, investing in off-farm self-employment, soil conservation and tree planting, participating in productive safety net programs (PSNP), all found to have significant positive effects on real asset values. These findings suggest that encouraging social networks and investment in rural off-farm entrepreneurship by creating better performing rural credit markets can serve as a risk-diversification and asset-building mechanism.

Key words: *credit constraints, asset, Panel data, instrumental variable, climate change, Ethiopia.*

[‡]*This chapter is under a peer review process to be published as an article in a reputable Journal.*

6.1 Introduction

Climatic shocks are the major adverse events, among others, which reduce welfare of farm households in developing countries. Drought, floods, erratic rainfall patterns, landslides and high temperature are among the key climatic shocks indicating the increasing trend of climate change. These shocks can have both direct and indirect effects on agricultural production and household asset holdings (e.g. Carter *et al.*, 2007; Kuijpers *et al.*, 2013). The direct and immediate impact is reduction of agricultural production and destruction of some types of assets. An earlier study estimated that a 10 percent decrease in seasonal rainfall from its long run average reduces Ethiopia's food production by a 4.4 percent (Von Braun, 1991). Mulat *et al.*, (2004) also showed that the amount and temporal distribution of rainfall is the most important determinant of inter-annual fluctuations in Ethiopia's national crop production levels. McDonald and Simon (2011) reported that Ethiopian farmers living in semi-arid and arid lowlands are highly vulnerable to climatic shocks because they are heavily reliant on rain-fed subsistence agriculture and have less diversified assets. The indirect effect is basically through the costs of coping with these shocks. This could happen when households use adaptation strategies that have higher future costs such as depleting available productive assets, or keeping children from going to school (which may result in reduced human capital formation in the long run). It may also widen the income disparity between the rich and the poor by forcing the poor to be poorer while making the rich to be richer. Little *et al.*, (2002) argues that poor households sell their assets when they face shocks and the rich ones buy these assets at highly devalued prices which further increases income inequality in rural areas. The inability of households to maintain their asset base in the presence of climatic shocks may also force them to end up with little capacity to recover their asset base as they exit from these shocks with few asset holdings (Fuente, 2008). This implies that, drawing down productive assets to smooth current consumption may lead to irreversible loss of assets which may put households at risk of future poverty. Hence, climatic shocks can predispose farm households to current and future depletion of assets and can keep them in poverty traps.

Although, there is sizable literature on the impacts of shocks on household asset holdings (see e.g. Mogues, 2011; Carter*et al.*, 2007; Quisumbing and Baulch, 2009; Wainwright and Newman, 2011; Santos *et al.*, 2011; Quisumbing *et al.*, 2011; Naschold, 2012; Barrett and Carter

2012; Giesbert and Schindler, 2012; Kuijpers *et al.*, 2013), evidence on the effect of climatic shocks on household welfare under different credit constraint conditions is missing. Previous studies did not address this issue in the Ethiopian context in general, and particularly in the context of the study sites. Hence, this study contributes to the limited literature in this area by: (i) providing new evidence on the impact of exogenous climatic shocks and various adaptation strategies on household asset holdings; and (ii) investigating the effect of different credit constraint conditions on managing climatic shocks and in building assets. Understanding the effect of climatic shocks and credit constraints on household asset holdings may give insight for designing targeted policy packages that can induce poor households to build assets and become less vulnerable to climatic shocks.

The rest of the chapter is organized as follows. Section 6.2 briefly discusses relevant literature on the impact of climatic shocks on household asset holdings in the context of developing countries, and section 6.3 presents description of the data and methods used in the study, while discussion of the results is given in section 6.4. Finally, section 6.5 concludes the chapter with highlights of the key findings and some implications for policy.

6.2 Climatic Shocks and Asset Holdings: Review of Related Literature

Climatic shocks may have long term adverse impacts on household asset holdings in developing countries. For instance, children affected by drought shock in the late 1970s and early 1980s in rural Zimbabwe suffered a loss of about 14 percent of lifetime income, implying the long term welfare effects of shocks (Alderman *et al.*, 2004). Quisumbing and Baulch (2009), using data from Bangladesh, showed that covariate and idiosyncratic shocks have significant negative effects on the accumulation of assets over time. Quisumbing *et al.* (2011) also analyzed the impact of shocks on assets using panel data from Uganda and Bangladesh and found that jointly held assets and wives' assets in Uganda were adversely affected by shocks. Giesbert and Schindler (2012) examined the impact of drought shock on household asset accumulation in Mozambique. They found that when faced with drought, relatively asset wealthy households sell their assets in order to maintain their consumption levels while, poorer households reduce both assets and consumption simultaneously.

Wainwright and Newman (2011) examined the consequences of risk on households' ex-post behavior in Vietnam for the period 2006 and 2010 using panel data. They consider both the consumption and asset depletion responses of households to the incidence of adverse income shocks. Their results suggested that the ability of households in rural Vietnam to cope when faced with adverse income shocks is highly correlated with their level of total liquid assets and their levels of income and wealth. Particularly, their finding implies that households deplete their total stock of liquid assets in response to exogenous economic and idiosyncratic shocks. Financial savings, particularly cash and gold held at home, act as important buffers in the face of spatially covariant natural shocks as well as idiosyncratic shocks though its extent is lesser for the latter one. Santos *et al.* (2011) examined the nature of shocks experienced and the type of coping mechanisms that were adopted by households in Bangladesh. According to their findings, the poor are less able to cope with shocks compared with the non-poor and the poor are more likely to use coping mechanisms that could have negative welfare implications in the longer term where depletion of asset is one of them.

Farm households in Ethiopia also use various strategies to adapt with changing climatic conditions. Mogues (2011) found that well-endowed households engage in consumption smoothing by drawing down on their herd in times of food shortages. However, asset-poor households sacrificed their consumption so as to protect their few livestock holdings; if they have reason to fear that reacquisition of even these low levels of animal capital will be slow and/or very costly. Carter *et al.*, (2007) assess the adaptation or coping strategies of households in Ethiopia and in Honduras focusing on drought and hurricane, respectively. In Ethiopia, the study finds that during periods of drought, low wealth households try to hold on their few assets in the face of declining income and consumption. In Honduras, however, relatively wealthy households seem to be able to protect their assets while poorer households use asset depletion as a coping mechanism.

In summary, these studies show the welfare implications of climatic shocks and adaptation strategies adopted by farm households in developing countries including Ethiopia. However, they fail to discuss the role of the rural credit market in managing climatic shocks and in building assets. Hence, we contribute to this literature by conducting an asset-based analysis to understand the impact of shocks and adaptation strategies on household wellbeing under different credit constraint conditions.

6.3 Methodology

6.3.1 Description of Data and Variables used in the Analysis

Data used in this study were collected from four zones of the Amhara National Regional State located in the northern and Central Highlands of Ethiopia (see the discussion in sections 2.2 and 2.3 for details about the study area and the data set).

6.3.2 Identification Strategy and Estimation Procedure

There are some methodological challenges in estimating the impact of climate variability on household asset holdings under different credit constraint conditions. We suspect an endogeneity problem stemming from selection bias and/or reverse causality. The latter being a possible scenario because credit constraint status can be considered as a pre-determined factor that affects households' ability to build assets or the real asset values in turn, may determine access to credit. Further, participation of farm households in the rural credit market is likely to be non-random. For example, households with more collateral resources, or those who possess better individual skills, ability, motivation and social network can have better access to credit, while households with fewer resources and weak networks are more likely to be credit constrained. Second, the geographic location of residence may also create selection bias because farmers who are far distant from a bank or microfinance branch office may face high transaction cost and may be discouraged. From the supply side, lenders may also hesitate to provide credit to households residing in risk-prone zones. This section describes the estimation strategy and how the above issues are addressed in this chapter.

The effect of climate variability and credit constraints on household asset holdings can be specified as:

$$Y_{it} = \beta_0 + \beta_1 X_{it} + \beta_2 S_{it} + \beta_3 C_{it} + \beta_4 (S_{it} * C_{it}) + \beta_5 T + \lambda_i + \mu_{it}\,;\; i = 1,2,...,N; t = 0,1 \qquad [6.1]$$

where Y_{it} is the welfare outcome variable of interest (real asset value) for household i in year t; S_{it} and C_{it} are indicators of climate variability and credit constraint status of each household in each year, in that order. X_{it} represents a vector of observable explanatory variables; the year dummy(T=1 if year of survey is 2013) is included to allow for time effects; λ_i is a measure of unobservable variables associated with the welfare outcome and μ_{it} is an error term. The β_s are parameters to be estimated while the main coefficients of interest are β_2, β_3 and β_4, the differential impact of climate variability under different credit constraint conditions.

The panel nature of the data allows to estimate standard fixed effects regression model under the assumption of strict exogeneity of covariates, X_{it} conditional on the unobserved effect (Wooldridge, 2003). A fixed effects model provides consistent estimates of the credit constraint parameter through the within transformation or first differencing given that all the unobservable λ_i are time-invariant. Thus, we employed a fixed effects instrumental variable (FE-IV) technique to account for the potential endogeneity problem discussed above and to identify the causal relationship between the credit constraint variable and the welfare outcome.

However, getting appropriate instruments, correlated with the endogenous variable but uncorrelated with the error term, is usually difficult. Even so, we managed to obtain two instruments for the endogenous credit constraint variable and conducted robustness test of the instrumental variable regression. Previous period credit constraint and membership in a solidarity group are the instruments which are highly correlated with the probability of getting access to credit, but are not correlated with the welfare outcome variable directly. Using these instruments, we re-specified equation (6.1) as:

$$Y_{it} = \beta_0 + \beta_1 X_{it} + \beta_2 S_{it} + \beta_3 (C_{it} = IV_{it}) + \beta_4 (S_{it} * C_{it}) + \beta_5 T + \lambda_i + \mu_{it}; i = 1,2,...,N; t = 0,1 \qquad [6.2]$$

where X_{it} is a vector of overlapping variables that affect the welfare outcome variable Y_{it}; while IV_{it} include non-overlapping variables which are correlated with the credit constraint condition directly but not with the outcome variable. Equation (6.2) is estimated using fixed effects instrumental variable (FE-IV) method with STATA's 'xtivreg2' command, after conducting various robustness tests of the above model.

6.4 Results and Discussion

6.4.1 Credit Constraints, Climate Variability and Household Asset Holdings: Descriptive Evidence

As discussed in section 6.1 above, the objective of this chapter is to examine the effect of climatic shocks and adaptation strategies on the value of household assets[27] under different credit constraint conditions. However, taking the nominal value of assets may not tell the accurate story due to inflationary pressure and hence, we converted it to the real value of assets and used it as a dependent variable. In this section, we provide descriptive evidence on the effect of climatic shocks, credit constraints, social capital, choice of adaptation strategies, and household socio-economic conditions on the real value of assets (See sections 2.2 and 2.3 for the list of assets used in this study).

In a setting where rain-fed agriculture is the main source of income for households, it is expected that rainfall variability to be the major climatic shock which determines changes in household income and asset holdings. We employed annual rainfall data collected from the National Meteorological Agency of Ethiopia for each district and generated the coefficient of variation (CV) of rainfall (measured as the standard deviation divided by the mean for the respective periods). The major advantage of using the CV is that it is scale invariant, providing a comparable measure of variation for households having different wealth levels. Figure 6.1 below, shows that in most parts of Ethiopia, the coefficient of rainfall variability is greater than 30 percent and this is generally considered in the literature as a major climatic shock for farmers who depend on rain-fed agriculture (CSA, 2011). This is also true for the study area and there is also an increasing trend in the CV over the years (Figure 6.2) and thus, we consider rainfall variability as a major shock to the sample farm households.

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[27] *In the context of the current study, household assets include livestock (cattle, sheep and goats, poultry and equines owned), ploughing equipments, water pumps, beehives, cart, household cooking materials, and consumer durables such as house, bed, telephone, radio, bicycle etc. (Tadele, 2008).*

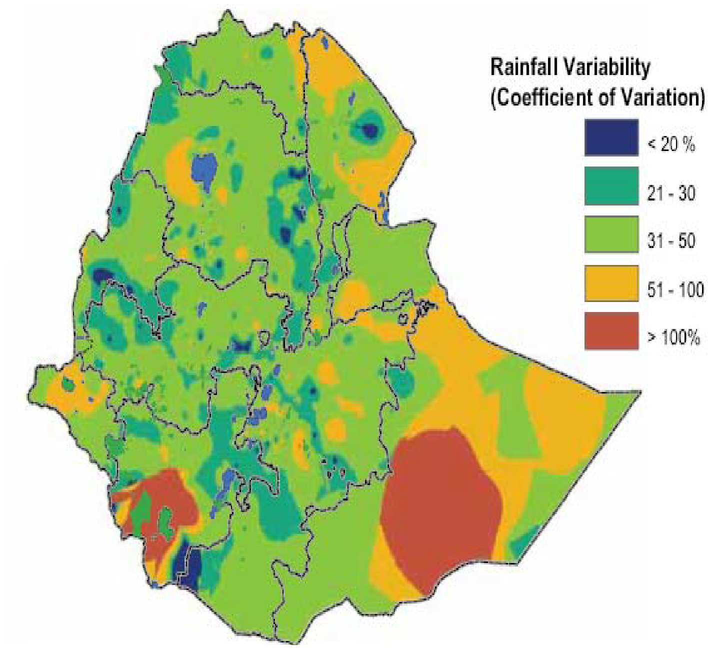
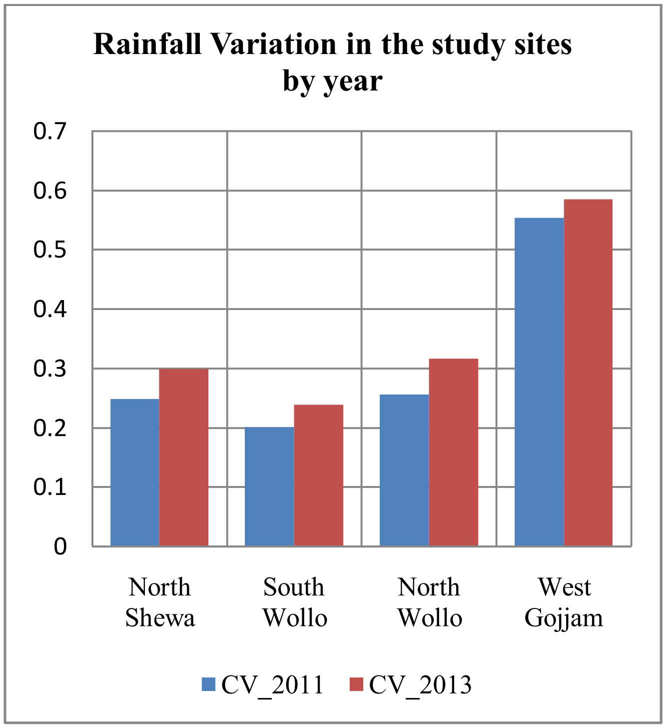


Figure 6.1: Rainfall variability in Ethiopia

Source: National Meteorological Agency of Ethiopia



Source: Own computation from EPIICA survey data

Figure 6.2: Rainfall variability in the study sites

In addition to rainfall variability, the sampled households were asked to consider other shocks and indicate whether they have been adversely affected by these shocks. The households reported that drought, heavy rainfall, major harvest loss due to wild animals, and loss of livestock due to illness or death, as some of the major shocks affecting their welfare in 2011 and 2013. About 21 percent of the households reported that they experienced drought shock in 2011 and this figure has increased to 63 percent in year 2013, implying a significant increase in vulnerability of the households to drought over the years (Table 6.1). The second most serious shock reported was a heavy and untimely rainfall that caused flooding and destroyed crops of about 40 percent of the households in 2011. However, only 14 percent of the households reported experiencing this shock in 2013 given the higher exposure to drought risk during this period.

Table 6.1. Farm Households' exposure to various shocks in the study area

	2011	2013
Most serious shock	Percent[a]	Percent
Drought	20.8	63.21
Heavy rainfall, flooding, untimely rains etc.	40.02	13.64
Major harvest losses due to wild animals	4.65	7.77
Idiosyncratic shocks[b]	6.4	7.23
Loss of livestock (death, illness; not sale)	3.7	2.44
Market shocks[c]	15.5	4.5
Frost	4.02	12.04

Source*:* Own computation from EPIICA's 2011 and 2013 survey data.

a) percentage of households having been affected by the specific shock

b) Idiosyncratic shocks include: illness, death, disability, theft of household assets, fire and loss of land

c) market shocks include: unexpected decline in crop prices, major increases in prices of inputs and consumer goods

Farmers also reported intensity of the effects of these shocks on their welfare as shown in table 6.2 below. For instance, about 41 percent of the households lost 25 to 50 percent of their harvest while 31 percent of the sampled farmers lost 50 to 75 percent of their crop due to these shocks. Moreover, about 72 percent of the households faced emotional breakdown due to the most serious shocks, implying the devastating effects of uninsured natural calamities in the study area.

Table 6.2. Effect of the most serious shock on harvest (Intensity of shocks)

Harvest loss (percent)	Fraction of affected households (percent)
75-100	17.44
50-75	30.63
25-50	40.52
<25	11.42
Other non-material consequences of the most serious shock	
Social disruption	14.08
Family breakdown	8.45
Emotional breakdown	71.83
Educational breakdown	4.23

Source: Computed from EPIICA 2011 and 2013 survey data

As discussed in chapter four, using the survey-based (the direct elicitation) strategy (Kon and Storey, 2003; Guirkinger, 2008), we identified two groups of unconstrained and three groups of constrained households. The unconstrained category includes unconstrained borrowers and unconstrained non-borrowers, while the constrained category consists of quantity constrained borrowers; households who are discouraged due to high transaction costs of borrowing and institutional bottlenecks; and those who are constrained due to risk of borrowing (risk-rationed borrowers).

The unconstrained households are those who have identified themselves as having full access to credit facilities from a given lending institution. The credit limit set by lenders to overcome the information asymmetry problem will not be a constraint for such borrowers. The unconstrained non-borrowers are those who have stated that they do not borrow from credit institutions because they do not have an urgent need for external finance or they do not have a profitable project that would require a loan. The production and consumption (resource allocation) decisions of such households are not affected by the prevailing credit market imperfections.

Credit-constrained households are further classified into supply-side constrained or quantity-rationed households; and demand-side constrained households. Quantity-rationed borrowers have an excess effective demand for credit and they face a credit limit due to supply-side problems. It means that these households applied for credit and received the loan, but the loan amount is less than their effective demand given the available contract terms. From the demand side, transaction-cost rationed households have a positive effective demand but do not apply for credit because, they do not want the extra paper work; the additional costs associated with the loan application process; or from their past experience or from their knowledge about the lenders' credit procedures, they are sure that their application will be rejected. Such households do not participate in the credit market because of these high transaction costs. Some households do not want to risk their assets, or do not want to incur debt or they are not willing to provide the necessary loan collateral, and we categorized these group of households as 'risk-rationed' borrowers (see section 4.4.2 for further details on the classification strategy adopted).

In resource poor rural areas, farmers who face climatic shocks try to smooth out their consumption by investing in alternative income generating schemes. Kochar (1997), using data from India, showed that when farmers face a crop income shock, they prefer off-farm employment as a coping strategy rather than dis-saving or depleting their assets. About 12 percent of the households in the study area preferred off-farm self-employment as a strategy to manage climatic shocks in 2013 (Table 6.3). Off-farm self-employment is expected to have positive effect on asset holdings and our data also confirms that households who participated in off-farm self-employment opportunities to have higher real value of assets (Figure 6.3).

Table 6.3 Adaptation strategies used by households to deal with climatic shocks

Type of Strategy	2011 (percent)	2013 (percent)
Land conservation (e.g. afforestation)	24.91	33.14
Irrigating the farm land	5.6	13.37
Changing crop mix	26.73	53.41
Selling productive assets such as livestock	41.72	25.23
Using cash savings (dis-saving)	26.58	26.75
Participation in a safety net program	13.2	11.44
Receive assistance from the government or NGO	12.28	12.03
Participation in off-farm self-employment	10.6	11.94

Source: Computed from EPIICA's 2011 and 2013 survey data

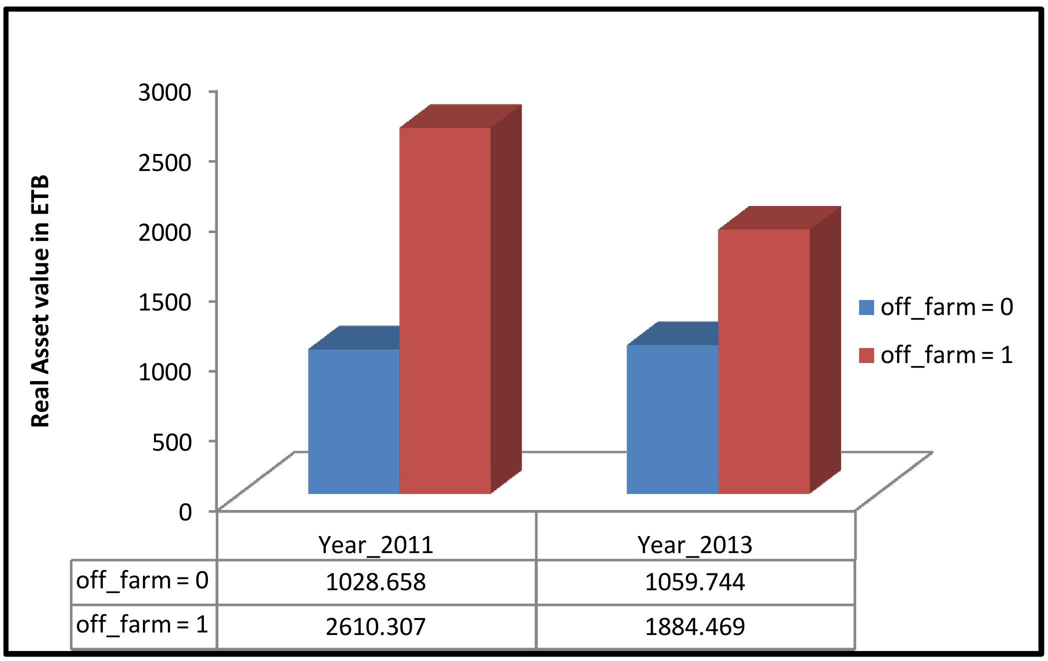


Figure 6.3: Real asset value by off-farm employment category

Source: Computed from EPIICA's 2011 and 2013 survey data

Social capital is expected to help households to protect their assets in the face of shocks. Mogues (2011), for example, found that both local social relationships as well as 'bridging' social capital are found to have a positive effect on asset holdings directly, as well as indirectly by mitigating the impact of income shocks on livestock capital. We consider membership in Iqqub or a rotating saving and credit association (ROSCA), and putting trust on primary cooperatives as important social capital variables and Figure 6.4 shows that these variables indeed have positive effects on household asset holdings over the years.

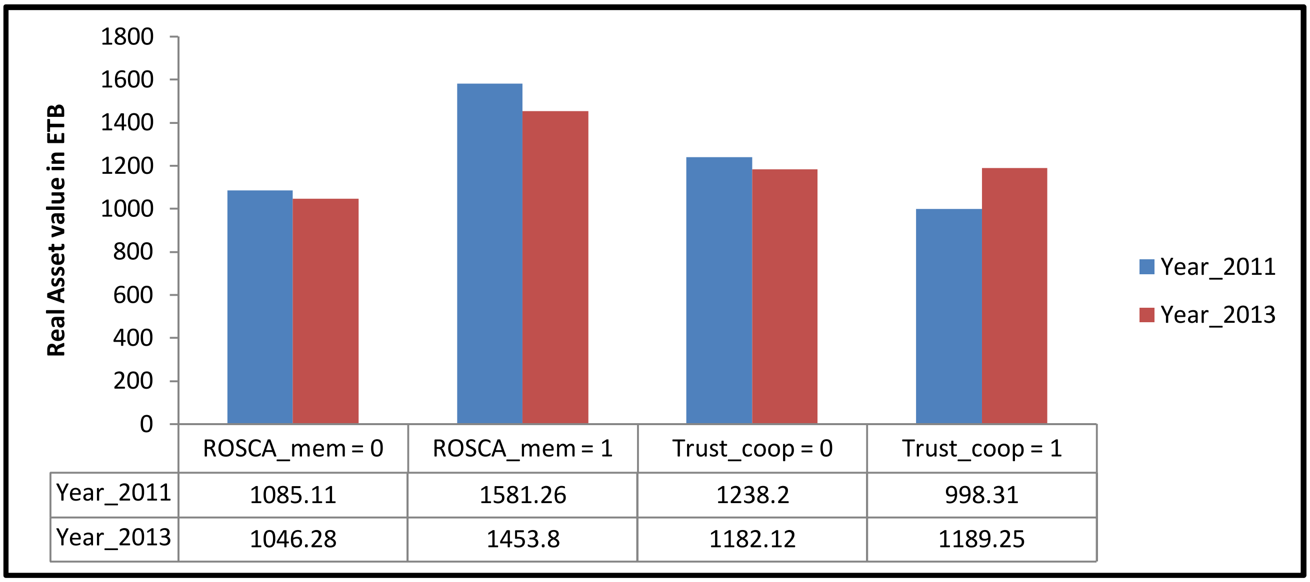


Figure 6.4: Effect of social capital on real asset value

Source: Computed from EPIICA 2011 and 2013 survey data

6.4.2 Effect of Credit Constraints and Climate Variability on Household Asset Holdings: Econometric Evidence

Before reporting the regression results, we conducted four important robustness tests for each credit constraint category: under-identification, weak-identification, and over-identification tests; and endogeneity test (Table 6A.2). The first three tests were conducted to test quality of the instruments employed, while the fourth test is used to check validity of using the instrumental variable technique. The null hypothesis of under-identification is rejected based on the Kleibergen-Paap rk LM test result indicating that the excluded instruments are correlated with the endogenous regressor and the model is identified. The model is estimated using the 'xtivreg2' command with the 'robust' option to take care of a possible heteroskedasticity and STATA reports the robust Kleibergen-Paap Wald rk F test statistic. Stock and Yogo (2005) have compiled critical values for various estimators as reported in Table 6A.2 and the robust

Kleibergen-Paap Wald rk F test statistic is well above these critical values, suggesting that the null hypothesis of weak-identification and weak instruments can safely be rejected. The Pseudo-F version of Sargan's statistic also suggests that the estimation does not suffer from the over-identification problem and hence combination of the instruments we used is optimal. Finally, we tested whether the credit constraint variable is indeed endogenous. Based on the Durbin-Wu-Hausman chi-square (χ^2) test result, the null hypothesis of exogeneity is rejected, suggesting the validity of using the instrumental variable technique.

After conducting the robustness tests, we reported the first stage regression results in Table 6A.1. We found that facing credit constraint in the previous period strongly discourage participation of farm households in the credit market and create quantity constraints while members in a solidarity group are unconstrained. The first stage regression results (Table 6A.1) show that households who experienced climatic shocks are quantity constrained. The probable reason for this is the fact that lenders are not willing to take the risk of default if crops fail and farmers lack income to repay the loan. We also found that farmers in the study area are more discouraged and quantity constrained over the years spanning this study, as evidenced by the significant coefficient of the year dummy. One reason for the quantity constraint may be lack of enough loanable funds in the hands of lenders, while lack of collateral in the hands of farmers is the probable reason for being discouraged.

Table 6.4 reports the coefficient estimates of the fixed effects-instrumental variable (FE-IV) model[28] on the effect of credit constraints and climate variability on household asset holdings in the study area. The regression results show that experiencing drought shock, crop damage due to wild animals, death of livestock, and exposure to various idiosyncratic shocks all have significant negative effects on household asset holdings in the study area.

To explore the effect of rainfall variability on the real value of household assets, we mapped district-level rainfall data for each household and calculated the coefficient of variation (CV) of rainfall from its long term average as discussed in earlier sections. After controlling for

[28] As additional robustness test, we also estimated the model using the First Difference (FD) estimator and found similar results. This agrees with the literature since both fixed effects and first difference give similar results for a two-period panel data set (Wooldridge, 2003).

other factors, we found a causal negative relationship between the coefficient of variation of rainfall and real value of assets, implying that farm households in the study sites are losing their assets due to climatic shocks. These results agree with previous studies (for example: Mogues, 2011 for highlands of Ethiopia; and Ifejika, 2011 for Kenya).When farm households face such shocks they may sell their assets as a strategy to smooth-out their consumption (e.g. Skoufias and Quisumbing, 2003; Dercon, 2009). The other more serious effect of a high variation in rainfall and drought is that these shocks cause illness and death of livestock due to lack of water and fodder.

After controlling for household socio-economic characteristics, the real value of assets has declined for discouraged and quantity constrained households while it has increased over the years for unconstrained borrowers. This implies that relaxing credit constraints and creating better access to credit can help farmers invest in productive assets and cope with climatic shocks more effectively. This agrees with the descriptive evidence provided above and also with previous literature. Islam and Maitra (2012) using household level panel data from Bangladesh, also found that households having access to credit are less likely to sell their productive assets in response to shocks.

In rural areas of developing countries, where the credit and insurance markets usually fail, farm households use social capital as important insurance mechanism in dealing with climatic shocks and building assets. We found that the real asset value of farmers who trust their primary cooperatives, and those who are members of a rotating saving and credit association (ROSCA), has increased by 16 and 21 percents, respectively. This shows that trusting people and building local social networks play positive roles in coping with climatic shocks and in building assets in the context of rural Ethiopia. Such social networks play an imperative role in serving as alternative sources of credit to finance household consumption or to purchase productive assets. In the context of rural Ethiopia, ROSCAs provide interest free credit to its members to be repaid on regular (e.g. weekly, or monthly) installments. This mutual assistance facility helps farmers to engage in small-scale businesses, house construction, and acquisition of productive assets such as livestock and farm implements. Aredo (1993) also showed that a ROSCA member who faces a shock (e.g. death of draft oxen) is entitled to the collection of the weekly pool free of charge, and the person uses the money to purchase productive assets. This suggests the value of social capital in the face of climatic shocks and credit constraints. Other studies also show that social capital plays important positive role in managing climatic shocks and in building assets (Thorp *et al.*, 2005; Islam and Maitra, 2012; Ngigi and Birner, 2013). Thorp *et al.* (2005) found that social networks protect assets of farm households from becoming eroded by shocks while, Ngigi and Birner (2013) found that membership in a Community Based Organization (CBO) helps households to better manage climatic shocks and build livestock assets in Kenya.

The productive safety net program (PSNP) was initiated by the Ethiopian government in collaboration with a group of development partners in 2004 with the objective of gradual shift away from a system dominated by emergency humanitarian aid to a productive safety net system (GOE, 2004). The chronically food-insecure households receive support for several months of the year for up to five years and this is expected to bridge the annual household food consumption gap and also help to build assets. The study also found that the real asset value of participants of the PSNP in the study sites has increased by 23 percent during the period between 2011 and 2013. This shows the positive effect of the program on asset holdings and adaptive capacity of farm households. Béné *et al.* (2012) also found similar results that Ethiopia's PSNP helped farmers build assets; avoid running down savings, and acquiring new skills.

Deforestation and land degradation have been severe problems in Ethiopia for so many years. The forest coverage of the country has reduced from about 40 percent a century back to only about 3 percent (Berry, 2003). This led to accelerated soil erosion which washed away the fertile top-soils and many parts of the Ethiopian highlands (including the sites of this study) are left with infertile and shallow soils. This had a serious negative effect both on farm households and the macro economy. At the household level, the severe land degradation resulted in a loss of livestock asset equivalent to 1.1 million tropical livestock units (TLUs). At macro level, Ethiopia lost about 17 percent of the potential agricultural GDP because of physical and biological soil degradation (Birhanu, 2014).Large scale afforestation and reforestation schemes are expected to restore the disturbed rural ecology and to protect the soil from erosion. With this understanding, Ethiopia has been heavily investing in tree planting and afforestation in recent years (MoARD and World Bank, 2007). Farm households in the study area also have been investing in tree planting and soil conservation as a strategy to cope with the changing climatic conditions. The regression results also show that the real asset value of farmers who invested in these activities has increased by 10 percent during the period 2011 to2013.

Table 6.4. A Heteroskedasticity Robust Fixed Effects-IV Model (Two Instruments second stage regression results)

	Model (1)		Model (2)		Model (3)	
VARIABLES	coefficient	s.e.	coefficient	s.e.	coefficient	s.e.
Credit Constraint Categories						
Discouraged borrower	-0.724*	(0.387)				
Quantity constrained borrower					-0.896*	(0.458)
Unconstrained borrower			0.682*	(0.412)		
Climatic and other shocks						
Rainfall variability (CV)	-0.755***	(0.250)	-0.505**	(0.230)	-0.54***	(0.189)
Rain CV Interacted with discouraged borr.	0.515	(0.328)	0.087	(0.130)	-0.261**	(0.129)
Rain CV Interacted with qty. constr. borr.	0.113	(0.133)			-0.164**	(0.463)
HH experienced drought shock	-0.096	(0.066)	-0.028	(0.063)	-0.113*	(0.066)
Drought Interacted with discouraged borr.					-0.191	(0.148)
Drought Interacted with risk rationed borr.			0.116	(0.103)	0.193	(0.16)
Crop damage due to wild animals	-0.323***	(0.108)	-0.283***	(0.105)	-0.326***	(0.116)
Market-related shocks	-0.078	(0.095)	-0.035	(0.09)	-0.04	(0.09)
Idiosyncratic shocks	-0.191*	(0.116)	-0.109	(0.114)	-0.240*	(0.128)
Livestock death	-0.301*	(0.168)	-0.214	(0.168)	-0.23	(0.161)
Year Effect	0.095	(0.064)	0.054	(0.062)	0.085	(0.061)
Household investment decisions						
HH invested in off-farm business (IGA)	0.29***	(0.102)	0.301***	(0.106)	0.272***	(0.105)
HH invested on soil conservation	0.099*	(0.057)	0.077	(0.055)	0.103*	(0.05)
HH changes crop mix	-0.002	(0.083)	0.006	(0.08)	-0.044	(0.078)
Participation in Productive Safety net prg. (PSNP)	0.234*	(0.134)	0.228*	(0.130)	0.26**	(0.115)
Social capital variables						
Trust primary farmers' cooperative	0.161***	(0.059)	0.15**	(0.061)	0.164***	(0.059)
Head is member in a ROSCA (Ekub)	0.135*	(0.08)	0.011	(0.132)	0.207***	(0.072)
Household Characteristics						
Age of head	0.001	(0.012)	-0.002	(0.011)	0.001	(0.012)

Dummy for female head of the household	0.314	(0.375)	0.200	(0.305)	0.226	(0.33)
Dummy for a married head	0.210	(0.208)	0.252	(0.195)	0.198	(0.199)
Household size	0.049	(0.04)	0.045	(0.039)	0.041	(0.038)
Head has no education	-0.188**	(0.0920)	-0.139*	(0.0831)	-0.147*	(0.083)
Head attended some formal education	-0.0337	(0.103)	-0.0321	(0.107)	-0.0226	(0.106)
Location factors						
Dummy for west Gojjam	0.405	(0.312)	-0.0389	(0.592)	0.456	(0.303)
Dummy for south Wollo	0.436	(0.289)	0.745*	(0.392)	0.818**	(0.383)
Dummy for north Shewa	-0.609	(0.399)	-0.499	(0.410)	-0.583	(0.419)
Diagnostic tests						
Number of observations	2090		2090		2090	
Number of groups	1045		1045		1045	
F(25, 1020)	3.6		2.24		2.86	
Prob > F	0.000		0.000		0.000	

Robust standard errors in parentheses *** p < 0.01, ** p < 0.05, * p < 0.1

a) Rainfall variability is measured using coeff. Of variation (CV) of rainfall from the long term average

b) Income generating activities (IGA) include: trading agricultural products, wholesale/retail trade/shop etc.

c) E.g. tree planting and soil conservation measures

6.5 Conclusion and Implications

This chapter tried to show the effect of climatic shocks and credit constraints on household asset accumulation using a panel data set from rural Ethiopia. We used fixed effects instrumental variable (FE-IV) technique to control for a potential bias in the estimates stemming from endogeneity of the credit constraint status. The regression results show that rainfall variability, experiencing drought shock, crop damage due to wild animals, death of livestock and exposure to various idiosyncratic shocks all have significant negative effects on household asset holdings in the study area. Compared to unconstrained borrowers, farmers who are discouraged and quantity constrained found to have significantly lower amount of asset holdings and the amount reduces further, when climatic shocks are coupled with credit constraints. This demonstrates the devastating effect of climatic shocks intertwined with credit constraints.

The analysis also shows that trusting farmer's primary cooperatives and membership in a rotating savings and credit association (ROSCA) both to have significant positive effects on real asset values, suggesting the role of social networks in building assets and managing climatic shocks. Thus, public policy should aim at strengthening community-based approaches to adapt to climate change to help in improving farmers' adaptive and asset building capacity.

We further conclude that investing in off-farm self-employment to have positive effect on asset holdings in the face of climatic shocks and credit constraint conditions. Agriculture being rain-fed and subsistence in rural Ethiopia, the findings suggest that public policies that encourage investment in rural non-farm sector by creating better performing rural credit markets, can serve as a risk-diversification and asset-building mechanism. It may also facilitate employment creation, household income growth, poverty reduction, and rural development in general.

Participating in productive safety net programs (PSNP) also found to have a significant positive effect on the real value of household assets, suggesting the positive role of the PSNP in the gradual shift of participants from high vulnerability and dependence on humanitarian food aid to less vulnerability and better adaptive capacity. We also conclude that investing in soil conservation and tree planting increase household asset holdings in the studied zones. This could be through improved productivity and increased agricultural income due to better soil conservation practices of farmers.

This illustrates the positive role of adaptive measures in improving household asset building capacity and hence, calls for scaling up and sustaining existing efforts to cope with the ever increasing climate variability. The study further demonstrated that climatic shocks have serious adverse effect on asset accumulation trajectories of uneducated rural households who face credit constraints. This calls for more investment in education in rural Ethiopia in general, and especially in the study sites.

Ethiopian farm households live in varied agro-ecological and socio-economic conditions. This implies that their exposure to various shocks, their coping strategies and their level of production and asset accumulation differ across different zones. A generic "*one-size-fits-all*" type of policy package and blanket recommendation may not help them to enhance their adaptive capacity. Hence, understanding the types of shocks which significantly affect household's asset holdings in a particular socio-economic context is important in designing public policies to help farmers in building assets and becoming more resilient to climatic shocks.

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Appendix 6A. Supplementary Tables

Table 6A.1 A Hetroskedasticity Robust Fixed Effects-IV Model

	Model (1)		Model (2)		Model (3)	
VARIABLES	coefficient	s.e.	coefficient	s.e.	coefficient	s.e.
Dependent variables:	Discouraged borr.		Unconstrained borr.		Qty. constr. borr.	
Climatic and other shocks						
Rainfall variability (CV)	-0.207	(0.13)	-0.19	(0.16)	.075*	(0.04)
HH experienced drought shock	0.022	(0.03)	-0.02	(0.03)	.010	(0.03)
Crop damage due to wild animals	-0.068	(0.05)	0.092**	(0.04)	-.059	(0.04)
Market-related shocks	-0.060	(0.04)	0.043	(0.04)	-.007	(0.03)
Idiosyncratic shocks	-0.061	0.04	0.015	(0.05)	-.102***	(0.04)
Livestock death	-0.176*	(0.06)	0.125**	(0.06)	-.060	(0.05)
Year Effect	0.072***	(0.02)	-0.049**	(0.02)	.051***	(0.02)
Household investment decisions						
HH invested in off-farm business (IGA)	0.004	(0.04)	0.010	(0.04)	-.019	(0.03)
HH invested on soil conservation	0.007	(0.03)	0.005	(0.02)	.011	(0.02)
HH changes crop mix	0.028	(0.04)	-0.047*	(0.03)	-.025	(0.02)
Participation in Productive Safety net prg (PSNP)	-0.024	(0.07)	0.058	(0.05)	.018	(0.01)
Social capital variables						
Trust primary farmers' cooperative	0.004	(0.03)	0.006	(0.03)	.011	(0.02)
Head is member in a ROSCA (Ekub)	-0.102***	(0.03)	0.274***	(0.04)	-.005	(0.03)
Household Characteristics						
Age of head	0.000	(0.00)	0.004	(0.00)	.0008	(0.00)
Dummy for female head of the household	0.174	(0.18)	0.012	(0.17)	.040	(0.07)
Dummy for a married head	-0.098	(0.09)	0.059	(0.07)	-.086	(0.07)
Household size	0.014	(0.02)	-0.010	(0.01)	-.0003**	(0.01)
Head has no education	-0.071	(0.04)	-0.001	(0.03)	-.013	(0.02)
Head attended some formal education	-0.031	(0.05)	0.034	(0.05)	-.007	(0.04)
Location factors						
Dummy for west Gojjam	0.022	(0.07)	0.389	(0.29)	.081	(0.05)
Dummy for south Wollo	-0.576*	(0.33)	0.107**	(0.05)	-0.058**	(0.03)
Dummy for north Shewa	-0.020	(0.11)	-0.137**	(0.06)	0.025	(0.04)

excluded instruments: prvs_cnst, solidarty_grp						
HH faced credit constraint last year	0.09	(0.05)	0.35*	(0.28)	0.68	(0.41)
head is member in a solidarity group	0.23***	(0.212)	-0.36***	(0.214)	-0.95***	(0.27)
Diagnostic tests						
number of observations	2090		2090		2090	
number of groups	1045		1045		1045	
F(26, 1019)	29.64		6.57		1688.65	
Prob > F	0.000		0.000		0.000	
Centered R^2	0.3		.16		0.51	
Uncentered R^2	0.3		0.16		0.51	
Partial R-squared of excluded instruments	0.03		0.03		0.03	
Test of excluded instruments:						
F(2, 1019)	10.65		14.51		15.63	
Prob > F	0.000		0.000		0.000	

Table 6A.2. Robustness Tests for Two Instruments

Robustness Test	Model (1)	Model (2)	Model (3)
Under identification test (Kleibergen-Paap rk LM statistic)	21.12***	27.3***	21.16***
Weak identification test (Kleibergen-Paap rk Wald F statistic):	12.03	16.55	14.51
Hansen J statistic (over identification test of all instruments):	2.8	1.71	2.69
Chi-sqr (2) p-val	0.11	0.19	0.10
Endogeneity test of endogenous regressors:	5.64**	5.93**	3.86*
Chi-sqr (2) p-val	0.01	0.01	0.05

Included instruments: climate variables, HH investment decision variables, social capital, HH characteristics, location factors and year dummy

Excluded instruments: *prvs_cnst, solidarty_grp*

CHAPTER 7: IMPACT OF CREDIT CONSTRAINTS AND CLIMATE VARIABILTY ON AGRICULTURAL PRODUCTIVITY: PANEL DATA EVIDENCE FROM RURAL ETHIOPIA

Abstract

Increasing agricultural productivity is a major step in transforming the rural economy and ensuring food security. In this chapter, we used a unique household level panel data linked with a spatial climate data to examine the impact of different credit constraint conditions on agricultural productivity under changing climatic conditions. A propensity score matching (PSM) method was employed to provide unbiased estimates of the production impacts of credit constraints on crop productivity. After controlling for potential selection bias, we found that relaxing credit constraints increases agricultural productivity by Ethiopian Birr 169 per hectare, while the real crop revenue for discouraged and quantity constrained farmers has declined by Ethiopian Birr 443 and 275 per hectare, in that order. These results suggest that relaxing credit constraints by improving performance of the rural credit market could significantly increase agricultural productivity in rural Ethiopia.

Key words: *Credit constraints, agricultural productivity, PSM, public policy, Ethiopia.*

7.1. Introduction

African agriculture is characterized by low productivity and harsh weather conditions such as erratic rainfall and high average temperature (Difalco and Veronesi, 2011). Among African countries, Ethiopia is the most vulnerable country to climate change with the least adaptive capacity (Thornton *et al.,* 2008). This is mainly because rain-fed subsistence agriculture is the primary source of food and income for more than 80 percent of Ethiopians. Therefore, climatic factors present a great risk to agricultural productivity and food security. This calls for adopting effective climate adaptation strategies and agricultural technologies to improve productivity and achieve food security. Agricultural production involves a time lag between planting and harvesting, which leads to an uneven timing of agricultural income and expenditure and access to an affordable source of credit is expected to relax the liquidity constraints of farmers.

However, performance of the rural credit market in developing countries is very poor due to imperfections such as weak contract enforcement, underdeveloped information systems, imperfect property rights, and unstable political institutions, among others (Andersen, 2012). Contracting challenges and problems related with information asymmetries about the borrower type and behaviour leave poor households in a credit constraint condition (Jack, 2011). This is because, lenders often use collateral as a strategy to offset problems related to asymmetric information and moral hazard. Farmers, however, lack the required loan collateral and hence, face credit constraints during crucial periods such as peak planting seasons. Thus, farmers are forced to use much less amount of productivity-enhancing technologies, leading to lower yield (Morduch, 1995).

In countries where the credit market is weak, the impact of natural disasters on the aggregate output will also be more severe (Noy, 2009). Raddatz (2007) showed that climatic shocks have long term negative effects on the GDP in poor countries where the credit market is fragile. Thus, governments of some developing countries give due attention to the performance of the rural credit market given its role in improving productivity, household food security and reducing vulnerability to climate change. In Brazil, for instance, the official rural credit portfolio covers about a third of the annual financial needs of the agricultural sector (MAPA, 2003).

Micro level studies from different countries also show that household welfare is significantly reduced when credit constraints are intertwined with climatic shocks. For instance, Rosenzweig and Wolpin (1993) and Jacoby and Skoufias (1997) found that credit constraints that are caused by imperfections in the credit market have long term welfare effects when shocks hit households. This effect is severe on poorer households because such shocks can destroy their lifetime wealth directly and also reduce their current and future agricultural income. It may also reduce their earning potential through the forced dis-saving of productive assets. Tol and Leek (1999) showed that the welfare effect of a natural disaster depends to a large extent on the condition of the market at the time of the adverse event.

Despite the immense literature on the links between climate change and choice of different adaptation strategies in the African context (for example, see: Kurukulasuriya and Mendelsohn, 2008; Hassan and Nhemachena, 2008; Deressa et al, 2008; Di Falco *et al.,* 2011; Bezabih and Di Falco, 2012), the effect of different credit constraint conditions on agricultural productivity under changing climatic conditions has not been studied in depth, especially within a panel framework. Previous studies did not assess this link in the context of rural Ethiopia in general, and using household level panel data particularly from the study area.

In filling this gap, the current study looks into the effect of different forms of credit constraints on agricultural productivity under changing climatic conditions. Particularly, we estimated the productivity differentials between constrained and unconstrained farmers. This is expected to generate policy-relevant information on approaches to enhance productivity by improving performance of the rural credit market.

The rest of the chapter is organized as follows. Section 7.2 provides background information on the effect of climate change and credit constraints on agricultural productivity in Ethiopia, while section 7.3 describes the data and variables used in the analysis. The methodological approach consisting of a theoretical model on the productivity effects of credit constraints and the econometric strategy is presented in section 7.4. Discussion of the results is provided in section 7.5, and section 7.6 concludes the chapter with some remarks and policy implications.

7.2. Productivity Effects of Credit Constraints and Climatic Factors in Rural Ethiopia: An Overview

Economic theory suggests that ex-ante credit constraints have important implications for the economic growth of developing countries. When farmers face credit constraints, they fail to purchase recommended agricultural technologies and farming tools which could improve productivity. Ex-post credit constraints also prevent farmers from borrowing after investment decisions have been made and thus, farmers fail to smooth-out consumption when income flows are risky (Eswaran and Kotwal, 1990; Boucher *et al.,* 2009). Moreover, credit constraints can affect the level and distribution of income in the economy (Aghion and Bolton, 1997). It discourages development of rural enterprises that create job opportunities for the rural poor and thus, hamper the agricultural growth and transformation process of poor developing countries. Generally, imperfections in the rural credit market intertwined with climatic shocks can reduce agricultural productivity and food security and leave farm households in the vicious circle of poverty.

Ethiopia's Agriculture is highly vulnerable to frequent climate extremes such as frequent droughts and floods, which have caused significant adverse effects on the country's economy and society, and are expected to become more pronounced in the future under climate change (You and Ringler, 2010). Such changes in climatic conditions can seriously reduce agricultural productivity through changes in the moisture and fertility of the soil, length of the growing season of crops etc. Among the climatic shocks, rainfall variability has particularly contributed towards a great deal of the food shortages and crop crises that farmers constantly face (Birhanu and Zeller, 2011; Bezabih, Di Falco, and Mekonnen, 2014).

Further discussion about the constraints for Agricultural productivity in the study area is provided in section 2.2 of this dissertation. The specific focus of this chapter is on estimating the impact of climatic factors and credit constraints on agricultural productivity in the study area.

7.3. Data and Variables

7.3.1. Data Source and Description of the Study Area

Data used in this study were collected in two waves of a rural household survey conducted in 2011and 2013. The analysis in this chapter is based on a balanced panel data for 1,189 households in the two rounds of the survey[29]. See the discussion in section 2.2 for details about the study area and the data set.

7.3.2. Dependent Variable: Agricultural Productivity

The outcome variable of interest in this study is real crop revenue per hectare, since crop production is the major agricultural activity in the study area with the largest share. Various annual crops (cereals, pulses, oil seeds, fibers, cotton and root crops) and Perennials are grown in different parts of the Amhara region based on the suitability of the agro-ecological condition. Because farmers in the study area are engaged in the production of several different types of crops, monetary values were used instead of quantities to measure productivity to make it comparable across households. Productivity was measured as real crop revenue per hectare that accounts for inflation (See section 2.2 for more details).

7.3.3. Explanatory Variables and Hypothesis

We categorized variables explaining agricultural productivity into measures of climate variability; indicators of credit constraint status; household demographic characteristics; ownership of physical assets, and social capital.

7.3.3.1. Credit Constraint Categories

In this chapter, we classify farm households into constrained and unconstrained categories based on their responses to the specific questions raised in relation to their willingness to participate in the rural credit market.

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[29]The initial number of observations was 1200.

The unconstrained borrowers are those who applied for credit and received the amount requested and did not want to borrow more. Three sub categories of credit constrained households were identified using the direct (survey-based) elicitation strategy, and these are: quantity constrained, risk rationed and discouraged borrowers. Quantity-constrained borrowers are characterized by an excess effective demand for credit and they face a credit limit due to supply-side problems. It means that these households have applied for additional funds, but given the available contract terms, their request is partially or fully rejected. The Risk-rationed sub category includes those who do not want to participate in the credit market even if the market is available because they do not want to risk their assets and hence are not willing to provide the necessary collateral, or they do not want to incur debt. As discussed in section 4.4.2, the discouraged households are those who do not want to borrow because of the high transaction cost of borrowing. These costs include, among others, the cost of preparing the loan application, evaluating viability of the project and value of the loan collateral, and monitoring the periodic loan repayment. These costs are independent of the loan amount and hence farmers who apply for smaller amount of loan are highly discouraged (Kon and Storey, 2003; Guirkinger, 2008; Ayalew and Deininger, 2014). See section 4.4.2 for further details about each constraint category and the classification strategy adopted.

7.3.3.2. A Measure for Climatic Factors

Climatic factors are captured using rainfall variability and the incidence of drought. Monthly rainfall data were obtained from the National Meteorological Agency of Ethiopia, from eight stations close to the study districts (*Woredas*) for the years between 1983 and 2013 (see section 5.2.2.2 for the discussion on how the rainfall measure was constructed). About 39 percent of the households in the sample reported to have faced drought shock during the two survey years.

7.3.3.3. Ownership of Physical Assets and Social Capital

The social capital variables included in the analysis as explanatory variables are trust and participation in farmers' primary cooperatives, and membership in a rotating saving and credit association (ROSCA). These are important social assets enjoyed for their own sake, used for material gain, and called upon in times of shocks or crises (Woolcock and Narayan, 2000). Trust in cooperatives is represented by a dummy variable with a value of 1 if respondents trust their cooperatives and 0 otherwise. We considered ownership of land as an indicator for physical capital, and the data show that the average size of land holding in the study area is about 0.9 hectares.

7.3.3.4. Socio-economic Characteristics

Sampled households were interviewed on issues related to livestock and crop production, marketing, farm and non-farm income, household consumption expenditure, ownership of assets, participation in non-agricultural enterprises, exposure to various climatic shocks and choice of various adaptation strategies, attitude towards risk, demand for crop insurance and credit constraint conditions. (See section 2.2 and Table 2A.1 for the descriptive statistics).

7.4. Methodology

7.4.1. Quantifying Productivity Effects of Credit Constraints and Climatic Factors: A Theoretical Framework

To increase crop production and to cope with the changing climatic conditions, rural farm households use both modern and traditional technologies including multiple cropping on one field, mixed farming of crops and livestock, using improved seeds (e.g. drought resistant crop varieties), irrigation, selling valuable assets, reducing household consumption, and other related mechanisms (Teklewold *et al.*, 2013). However, credit constraints could have adverse impact on the adoption of these strategies to deal with a multitude of agricultural production constraints. This implies that useful information can be obtained by analyzing the link between financial constraints and agricultural productivity, both theoretically and empirically.

7.4.1.1. The Set Up

To conceptualize the impact of credit constraints on agricultural productivity under changing climatic conditions, we draw from the theoretical literature on producer-consumer model (e.g. Singh *et al.,* 1986; Sadoulet and De Janvry, 1995; Petrick, 2004; and Briggeman *et al.,* 2009).

Assume a farm household who maximizes its utility by consuming c_0 and c_1 amounts of goods and services in periods 0 and 1, given a set of household characteristics z^h. We assume that the utility function is inter-temporally additive, twice differentiable and quasi-concave such that:

$$u = (c_0, c_1; z^h) \qquad [7.1]$$

Agricultural production in period 0 requires purchase of variable inputs (x) such as seeds and fertilizer at a given price p and harvest occurs in period 1. These inputs can be purchased either with own resources (w) or with a borrowed capital (k) that will be repaid back with k(1 + r) in period 1 where r is the loan interest rate.

Let the agricultural production follow a twice differentiable and concave function:

$$y = f(x, z^y) \qquad [7.2]$$

where z^y represents fixed and exogenous production inputs such as land and major farm tools.

Under this setup, a farm household tries to maximize the following utility function:

$\max u(c_0, c_1; z^h)$ subject to:

$$w + k - c_0 - px = 0 \qquad [7.3]$$

$$f(x, z^y) - c_1 - (1+r)k = 0 \qquad [7.4]$$

$$\bar{k}(z^h, z^y) - k \geq 0 \qquad [7.5]$$

Where equations (7.3) and (7.4) state the household budget constraints in periods 0 and 1, while equation (7.5) describes the credit[30] constraint condition in period 0 where $\bar{k}(z^h, z^y)$ denotes the upper bound of credit that the household can obtain. In the rural areas of developing countries

[30] We took the Kuhn-Tucker conditions for equation (7.5) because it is an inequality constraint.

like Ethiopia, this constraint is compulsory due to reasons such as: (1) the problem of adverse selection, moral hazard, and costly state verification due to information asymmetries as discussed in Stiglitz and Weiss (1981); (2) Screening, monitoring, and enforcement problems in under developed rural credit markets (Hoff and Stiglitz, 1993; and (3) the problem of lack of collateral. Lenders usually consider collateral as an important means of reducing default risk and hesitate to grant credit to the poor who lack the required collateral. This makes credit constraints to be binding for the poor (Ghosh *et al.,* 2001).

To solve the above utility maximization problem, we set the Lagrangian as:

$$L = u(c_0, c_1; z^h) + \psi(w + k - c_0 - px) + \zeta[f(x; z^y) - c_1 - (1+r)k] + \gamma[\bar{k}(z^h, z^y) - k] \quad [7.6]$$

The first order conditions (FOCs) of the optimal solution can be expressed as:

$$\frac{\delta L}{\delta c_0} = \frac{\delta u(.)}{\delta c_0} - \psi = 0 \quad [7.7]$$

$$\frac{\delta L}{\delta c_1} = \frac{\delta u(.)}{\delta c_1} - \zeta = 0 \quad [7.8]$$

$$\frac{\delta L}{\delta x} = -\psi p + \zeta \frac{\delta f(.)}{\delta x} = 0 \quad [7.9]$$

$$\frac{\delta L}{\delta k} = \psi - \zeta(1+r) - \gamma = 0 \quad [7.10]$$

$$\frac{\delta L}{\delta \gamma} = \bar{k}(z^h, z^y) - k \geq 0, \gamma \geq 0, \gamma \frac{\delta L}{\delta \gamma} = 0 \quad [7.11]$$

where equation (7.9) represents optimal production, while equations (7.7) and (7.8) represent optimal consumption. Equations (7.3), (7.4) and (7.11), on the other hand, are conditions which must be satisfied by an optimal solution, while $\psi, \zeta \, and \gamma$ are the lagrangian multipliers.

In the subsequent section, we discuss how credit constraints affect household's production decisions under changing climatic conditions. We begin by finding an optimal production decision when credit constraints are not binding[31]. Inserting equation (7.10) in to (7.9) given that γ =0 yields[32]:

$$\frac{\delta f(.)}{\delta x} = p(1+r) \qquad [7.12]$$

This shows that the household production function does not depend on the utility function or on none of the household characteristics and this implies that household production and consumption decisions are now, separable. Hence, removing credit constraints by allowing farm households to have access to credit can ensure separability of production decisions from consumption decisions and hence standard recursive household models can work. This in turn means that household resource allocation decisions will be efficient as standard neo-classical household models predict (e.g. Singh *et al.,* 1986; Sadoulet and De Janvry, 1995).

Equation (7.12) is similar to the standard resource allocation rule. However, we assumed that household production and input purchase decisions are made in period zero, while income is earned in period one and hence input prices are inflated by the interest rate (r).

On the other hand, when credit constraints are binding, equation (7.5) will hold with equality and hence $\gamma > 0$ in equation (7.11) above. To show the effect of this constraint on input use, we rewrite equation (7.10) as:

$(1+r) = \frac{\psi - \gamma}{\zeta}$. Solving for ψ and substituting this expression in equation (7.9) yields:

$$\frac{\delta f(.)}{\delta x} = [(1+r) + \frac{\gamma}{\zeta}]p \qquad [7.13]$$

If we denote the optimal input and agricultural technology demand which can be derived from equation (7.12) for credit unconstrained (cuc) households by x^*_{cuc} and the optimal input and agricultural technology demand for credit constrained (cc) households (which can be derived from equation (7.13)) by x^*_{cc}, then it is possible to note that the opportunity cost of the optimal

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[31] In the above setting, we say that credit constraints are not binding when gamma (γ) = 0

[32] Given that γ = 0 in equation (7.10) means that $\psi = \zeta(1+r)$ and inserting it in equation (7.9) gives equation (7.12).

input for the credit-constrained household (x^*_{cc}) is greater than the opportunity cost for the credit-unconstrained household (x^*_{cuc}) because it is inflated by $(\frac{\gamma}{\zeta})p$ amount for credit-constrained households (see equation 7.13). This implies that credit-constrained households will lower the purchase of production inputs and agricultural technology (x) to increase the value of the marginal product. Therefore, the above theoretical analysis shows that total agricultural production and productivity of a credit-constrained household will be lower than that of a noncredit-constrained household because of credit constraints.

This chapter tries to show the effect of this constraint on agricultural productivity under changing climatic conditions. The next section will focus on an econometric strategy to test the above theoretical model empirically.

7.4.2. The Econometric Model

We employed a two period panel data to analyze the effect of different types of credit constraints on agricultural productivity under changing climatic conditions. In relation to credit constraint conditions, farmers are not randomly assigned into different credit constraint categories. The probability of a given farmer to fall in a constrained (treatment) or unconstrained (control) category depends, among others, on the personal characteristic of that individual. Thus, in estimating the impact of credit constraints on agricultural productivity, it is crucial to take care of this potential selectivity bias.

Prior studies used different methods to control for such selection bias. Petrick (2004), for instance, used the Heckman estimator to show the effect of credit constraints on agricultural output while, Foltz (2004) used the switching regression technique to estimate the effect of credit constraints on agricultural investment. In another study, Briggeman et al., (2009) used the propensity score matching (PSM) method to control for a potential selection bias in estimating the impact of credit constraints on the value of the production for farm and non-farm sole proprietorships. This method was first suggested by Rosenbaum and Rubin (1983), and now a days, it became a common impact evaluation tool, specially, in a panel data framework. Using the PSM method can reduce the potential bias by making productivity comparisons between farmers who are credit constrained and those who are unconstrained. The main purpose of using the PSM method is to find a group of non-treated (unconstrained) farmers similar to the treated (constrained) groups in all relevant observable characteristics with the only difference being one group is constrained and the other group is unconstrained.

In this chapter, we used the PSM method to control for the possible selectivity bias in estimating the effect of credit constraints on agricultural productivity in rural Ethiopia (For more details, see: Smith and Todd, 2005; Briggeman et al., 2009; and Kassie et al., 2009).

We identify the outcome of interest (which is the real crop revenue per hectare) from the following equation:

$$E[Y_1 - Y_0 \mid D = 1] = E[Y_1 \mid D = 1] - E[Y_0 \mid D = 1] \qquad [7.14]$$

where Y is the real crop revenue (rcr) per hectare and D indicates to which credit constraint category the household belongs. D takes the value 1 for credit constrained farmers (treatment group) and it takes the value of 0 for unconstrained borrowers (control group). Thus, the outcome of interest is the average difference in Y_1 and Y_0. However, this matching exercise tries to estimate only $E[Y_0 \mid D = 1]$, which is the counterfactual or the unobservable case, since one farmer falls only in one state (either in the treatment group or in the control group) at a time. In our case, this means trying to estimate the impact of being credit constrained on the real crop revenue for those farmers who are actually unconstrained.

If we have an experimental data in which the farmers are randomly assigned to the treatment and control groups, it would have been possible to estimate the average treatment effect as:

$$E[Y_1 \mid D = 1] - E[Y_0 \mid D = 0] \qquad [7.15]$$

However, we have only observational data and hence, we follow Rosenbaum and Rubin (1983) to solve the selection bias by estimating the equation below:

$$E[Y_1 - Y_0 \mid Z, D = 1] = E[Y_1 \mid Z, D = 1] - E[Y_0 \mid Z, D = 1] \qquad [7.16]$$

where Z is set of covariates which determine the credit constraint status of farmers. If the probability of being credit constrained is determined by Z, then it is possible to establish a control group of unconstrained farmers that are similar in Z relative to the constrained farmers (the treatment group). Thus, from equation (7.16), it is possible to estimate the average treatment effect on the treated (ATT) as:

$$ATT = E[Y_1 - Y_0 \mid P(Z), D = 1] = E[Y_1 \mid P(Z), D = 1] - E[Y_0 \mid P(Z), D = 0] \qquad [7.17]$$

where P(Z) is the probability of selection conditional on Z or it is the propensity score (Pscore) which is: $P(Z) \equiv \Pr(D = 1 \mid Z)$. Hence, we did the PSM in two stages. First, using stata's "pscore" command, we calculated the propensity scores (Pscores), which are the conditional probabilities that a given farmer is credit constrained. Calculating the propensity score is crucial since it is difficult to do the matching on each explanatory variable when we have many covariates. The main purpose of the propensity score estimation is to balance the observed distribution of covariates across the constrained and unconstrained groups. Following Lee (2008), we also conducted a matching test after matching to check whether or not the differences in covariates in the two groups in the matched sample have been eliminated. In the second stage, we estimated the ATT using Stata's "psmatch2" command and the results are discussed here under.

7.5. Results and Discussion

7.5.1. Impact of Being Unconstrained Borrower on Agricultural Productivity under Changing Climatic Conditions

The determinants of being unconstrained borrower is estimated first using the propensity score matching method (Table 7.1), checked whether the balancing property is satisfied, and then estimated its impact on the average crop revenue per hectare in the second stage. Climatic factors, membership in social networks and associations such as rotating saving and credit associations (ROSCA), socio-economic condition of the household, and location are found to be correlated with the probability of being unconstrained borrower. The result shows that experiencing drought shock reduces the probability of being unconstrained borrower by about 17 percent. This might be because of the dependence of agricultural production in the study area on rainfall, and lenders do not want to take uninsured risk of loan default in the case of crop failure due to various climatic shocks including drought.

The probability of being unconstrained borrower found to be higher for female-headed households, and married farmers in the study area and this agrees with our findings in chapter four above. Farmers living in west Gojjam zone are less constrained while, those in south Wollo are more constrained compared to households residing in north Shewa zone. This also confirms with the results in chapter four that credit constraint condition of farmers varies across the study sites.

From the second stage regression, we found that being unconstrained borrower significantly increases the average crop productivity or crop revenue per hectare. Controlling for the effects of several covariates and the selection bias, having full access to credit is associated with significant crop revenue improvement. Unconstrained borrowers tend to enjoy Ethiopian birr 169 higher crop revenue per hectare compared to constrained borrowers (Table, 7.5A). This is the average treatment effect on the treated (ATT), which is statistically significant.

7.5.2. Impact of Being Discouraged Borrower on Agricultural Productivity under Changing Climatic Conditions

Adopting various agricultural technologies is a common strategy used by farm households to insure themselves against uncontrollable climatic factors. It also ensures their food security, and helps them to adapt to different agro-ecological production conditions, and to meet market demands (Winters *et al.,* 2006). However, as we discussed in detail in chapter 5, credit constraints have significant negative effects on technology adoption, since such investments require cash layouts.

In this chapter, before estimating the impact of being discouraged borrower on real crop revenue per hectare, we identified the key factors influencing the probability of being discouraged in the study area. Consistent with our results in chapter four, we found that, climatic factors such as drought and rainfall variability, and year dummies to have significant positive effect on the probability of being discouraged (Table 7.2).

Table 7.5A shows the average effect of being discouraged on agricultural productivity in the study area. The estimated average treatment effect (ATT) shows that discouraging credit market conditions significantly reduce real crop revenue per hectare by ETB 443, which is much lower than the productivity of unconstrained borrowers. This implies the serious adverse effect of credit constraints on agricultural productivity in the study area.

7.5.3. Impact of being Quantity Constrained Borrower on Agricultural Productivity under Changing Climatic Conditions

The result in table 7.3 shows that climatic factors, membership in social networks and associations, socio-economic condition of the household, the year dummy, and location of residence to be correlated with the probability of being quantity constrained borrower, though some variables are insignificant. The sign and significance of the year dummy agrees with the results in chapter four and the reader may refer to that chapter for more details.

Table 7.5A shows the average effect of being quantity constrained borrower on agricultural productivity in the study area. Quantity constrained borrowers would have earned crop revenue in real terms of about ETB 275 higher had they not been constrained in the credit market. In other words, the estimated average treatment effect (ATT) shows that quantity constraint has a negative and statistically significant effect on crop revenue per hectare for constrained farmers.

7.5.4. Impact of Being Risk Rationed Borrower on Agricultural Productivity under Changing Climatic Conditions

Experiencing drought shock and rainfall variability found to significantly increase the probability of being risk-rationed borrower (Table 7.4). This might be because such farmers do not want to borrow from the formal credit market not to take the risk of loan default in the case of crop failure.

After controlling for the potential selectivity bias, we found that being risk-rationed borrower has a negative but insignificant effect on agricultural productivity in the study area.

Table 7.5A: Effect of different credit constraints on agricultural productivity (Real Crop revenue per Hectare): Propensity Score Matching

Adaptation strategies	Sample	Treated	Controls	Difference (ETB)[‡]	std.err.	T-stat
	Unmatched	1275.55	903.29	372.26	62.85	5.92
Unconstrained borrowers	ATT	1310.42	1141.89	168.53*	94.42	1.78
	Unmatched	814.16	1025.18	-211.02	127.23	-1.66
Discouraged borrowers	ATT	809.03	1252.08	-443.05***	187.85	-2.36
	Unmatched	848.94	1158.35	-309.40	92.22	-3.36
Quantity Constrained borr.	ATT	848.87	1124.02	-275.15***	120.20	-2.29
	Unmatched	1027.80	1025.18	2.62	78.18	0.03
Risk-rationed borrowers	ATT	1028.00	1040.91	-12.91	104.79	-0.12

[‡]*ETB = Ethiopian Birr, 1 USD = 18.5 ETB as of March 2013,* *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Source: Own computation from EPIICA's 2011 and 2013 survey data

7.6. Conclusions and Implications

The main objective of this chapter was to investigate the effect of different credit constraint conditions on agricultural productivity among smallholder farmers in selected zones of the Amhara Regional State in the northern highlands of Ethiopia. A recent household level survey data were used to estimate these effects. To mitigate biases stemming from observed heterogeneity, the propensity score matching (PSM) method was applied to measure the effect of the treatment (being credit constrained) on the treated farmers.

The results provide strong evidence for the adverse effects of being credit constrained (falling in discouraged or quantity constrained borrower group) in improving agricultural productivity in the study area. It is a rational decision to invest in fertilizers, improved seeds, and drought-resistant crops which can increase productivity in the face of changing climatic conditions. However, as our results in chapter five clearly showed, adoption of such technologies is hampered by credit constraints and this has a direct negative effect on agricultural productivity in the study area, as shown in this chapter.

The result from the impact estimates using the propensity score matching method indicated that relaxing credit constraints has significant positive impact on agricultural productivity, while higher transaction costs and discouraging credit market policies found to reduce productivity significantly. At the household level, the average treatment effect (ATT), which is the actual effect that constrained households experience, are ETB 443 and ETB 275 lower real crop revenue (productivity) for discouraged, and quantity constrained borrowers, respectively.

The results also suggest the importance of climatic variables in explaining the probability of farm households to fall in different credit constraint categories. Discouraged and risk averse farmers are not willing to participate in the credit market not to lose their assets in the case of crop failure. A feasible strategy to encourage these farmers to participate and benefit from agricultural loans is linking credit with crop insurance to manage the uncertainty in agricultural production. Designing "productivity-based credit" (PBC) product may also help both lenders and borrowers in two ways. First, it can motivate farmers to work hard and this may ease the moral hazard problem; and second, it can also reduce the probability of adverse selection, since lenders now target right borrowers who really need the loan to invest it on productivity-enhancing agricultural technologies.

Thus, the solution to the low productivity and credit constraint problems of farm households is not a mere injection of loanable funds into the rural credit market. Instead, government interventions should focus on improving the institutional setup of lending institutions, investing on human capital formation, and building the capacity to innovate new loan products and efficient ways of serving genuine borrowers. This involves designing creative and climate-smart credit policies and procedures which can tackle the information asymmetry problem entailed in rural lending without reducing the welfare of borrowers. For instance, to help farmers better adapt to the changing climatic condition, it is crucial to think of a flexible climate adaptation loan product. Among the study sites, south Wollo and north Wollo zones of the region are more vulnerable to drought and climate variability, and this calls for designing climate-smart loan (CSL) products so that farmers in these zones may have better access to the rural credit market and build their adaptive capacity. Relaxing collateral requirements for small loans and increasing the loan repayment period to more than a year may also encourage farmers to participate in the rural credit market.

Generally, the results suggest that credit constraints are significant determinants of participation in adaptation strategies and agricultural productivity. This highlights the need to recognize the complex relationships between financial provision and climate change policies, and the implications for situation–specific policy design regarding rural credit and adaptation to climate change in the study area.

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Table 7.1: Determinants of the propensity to be unconstrained borrower

Variables used for the PSM regression	Pscore(PSM Stage 1) coefficient	std.err.
Dependent variable: Probability of being unconstrained borrower		
Rainfall variability (CV)	0.078	(0.123)
HH experienced drought shock	-0.170**	(0.081)
Market-related shocks	0.123	(0.118)
Idiosyncratic shocks	0.096	(0.144)
Participation in Productive Safety net prg (PSNP)	0.30**	(0.132)
Head is member in a ROSCA (Ekub)	1.220***	(0.074)
Age of head	-0.008***	(0.003)
dummy for female head of the household	0.478**	(0.208)
Dummy for a married head	0.448**	(0.199)
Household size	0.001	(0.020)
Head has no education	0.087	(0.090)
Head attended some formal education	0.033	(0.106)
Dummy for west Gojjam	0.365***	(0.097)
Dummy for south Wollo	-0.603***	(0.151)
Dummy for north Wollo	-0.072	(0.155)
Constant	-1.457***	(0.282)
Diagnostic tests		
Number of observations		2,146
Log likelihood		-816.64
LR chi2(15)		502.75
Prob > chi2		0.00
Standard errors in parentheses *** p < 0.01, ** p < 0.05, * p < 0.1		

Source: Own computation from EPIICA's 2011 and 2013 survey data

Table 7.2: Determinants of the propensity to be discouraged borrower

	Pscore(PSM Stage 1)	
Variables used for the PSM regression	coefficient	std.err.
Dependent variable: Probability of being discouraged borrower		
Rainfall variability (CV)	1.976***	(0.182)
HH experienced drought shock	1.289***	(0.186)
Crop damage due to wild animals	-0.138	(0.292)
Market-related shocks	-0.209	(0.220)
Idiosyncratic shocks	-0.336	(0.288)
Participation in Productive Safety net prg (PSNP)	-0.225	(0.194)
Trust farmers' cooperative	-0.088	(0.141)
Year effect	0.487***	(0.133)
Head is member in a ROSCA (Ekub)	-0.158	(0.158)
Age of head	-0.008*	(0.004)
dummy for female head of the household	-0.077	(0.292)
Dummy for a married head	-0.201	(0.261)
Household size	-0.015	(0.033)
Head has no education	-0.167	(0.147)
Head attended some formal education	-0.064	(0.173)
Dummy for west Gojjam	0.037	(0.223)
Dummy for south Wollo	0.776***	(0.206)
Dummy for north Shewa	-0.791***	(0.214)
Constant	-1.418***	(0.436)
Diagnostic tests		
Number of observations		1,412
Log likelihood		-281.51
LR chi2(19)		233.05
Prob > chi2		0
Standard errors in parentheses *** p < 0.01, ** p < 0.05, * p < 0.1		

Source: Own computation from EPIICA's 2011 and 2013 survey data

Table 7.3: Determinants of the propensity to be Quantity constrained borrower

Variables used for the PSM regression	Pscore (PSM Stage 1) coefficient	std.err.
Dependent variable: Probability of being Quantity constrained borrower		
Rainfall variability (CV)	0.086	(0.125)
HH experienced drought shock	0.205**	(0.089)
Market-related shocks	-0.054	(0.129)
Idiosyncratic shocks	-0.186	(0.156)
Participation in Productive Safety net prg (PSNP)	0.341***	(0.112)
Trust farmers' cooperative	-0.022	(0.087)
Year effect	0.394***	(0.081)
Age of head	0.001	(0.003)
dummy for female head of the household	0.136	(0.188)
Dummy for a married head	0.008	(0.172)
Household size	0.006	(0.021)
Head has no education	-0.204	(0.160)
Head attended some formal education	-0.050	(0.206)
Dummy for west Gojjam	-0.136	(0.163)
Dummy for south Wollo	0.359***	(0.121)
Dummy for north Shewa	-0.491***	(0.142)
Head has no education time avg.	-0.197	(0.190)
Head attended some formal education time avg.	-0.028	(0.238)
Head is member of farmers' coop time avg.	-0.003	(0.158)
Land holding time avg.	-0.118	(0.075)
Constant	-0.589*	(0.309)
Diagnostic tests		
Number of observations		1,723
Log likelihood		-866.64
LR chi2(20)		136.38
Prob > chi2		0
Standard errors in parentheses *** p < 0.01, ** p < 0.05, * p < 0.1		

Source: Own computation from EPIICA's 2011 and 2013 survey data

Table 7.4: Determinants of the propensity to be Risk rationed borrower

Variables used for the PSM regression	Pscore (PSM Stage 1) coefficient	std.err.
Dependent variable: Probability of being Risk rationed borrower		
Rainfall variability (CV)	0.791***	(0.148)
HH experienced drought shock	0.247***	(0.096)
Market-related shocks	0.018	(0.133)
Idiosyncratic shocks	-0.350*	(0.187)
Participation in Productive Safety net prg (PSNP)	0.240	(0.158)
Trust farmers' cooperative	-0.132	(0.096)
Year effect	0.181**	(0.090)
Age of head	0.000	(0.003)
dummy for female head of the household	-0.022	(0.216)
Dummy for a married head	-0.004	(0.196)
Household size	-0.003	(0.022)
Head has no education	-0.085	(0.097)
Head attended some formal education	-0.090	(0.120)
Dummy for west Gojjam	0.026	(0.197)
Dummy for south Wollo	-0.196	(0.183)
Dummy for north Shewa	0.052	(0.181)
Constant	-1.496***	(0.338)
Diagnostic tests		
Number of observations		1,600
Log likelihood		-677.66
LR chi2(16)		122.38
Prob > chi2		0
Standard errors in parentheses *** p < 0.01, ** p < 0.05, * p < 0.1		

Source: Own computation from EPIICA's 2011 and 2013 survey data

CHAPTER 8 SUMMARY, CONCLUSION AND RECOMMENDATIONS FOR POLICY AND FUTURE RESEARCH

8.1 Summary of key findings, conclusion and implications

In the face of increasing risk of climate change, reducing vulnerabilities and strengthening adaptive capacity of farm households is a top priority for poor developing countries like Ethiopia. This dissertation demonstrates the link between credit constraints, choice of adaptation strategies and welfare outcomes by illustrating the Ethiopian case under eight chapters divided into three sub themes. Objective of the current chapter is to summarize the key results of four core chapters (chapters 4 to 7) and discuss the policy and research implications.

The first core chapter attempted to explore the extent to which credit constraints stem from demand or supply-side factors and the implications for borrowing behavior. Estimations using the generalized linear latent and mixed model (gllamm) show that credit constraint status and borrowing behavior are significantly affected by: (i) borrower's perceived probability of rejection due to institutional rigidities; (ii) location, borrower's exposure to climatic shocks and risk preference behavior; (iii) availability of mortgage-able livelihood assets; (iv) transaction cost of borrowing; and (v) Household demographic characteristics such as: gender, age, education, family size, and marital status.

The results suggest the need for understanding household socio-economic conditions in designing and implementing credit market policies. For instance, the result that the probability of being credit constrained decreases for female-headed households is in line with the broader narrative that targeting female-headed households would enhance their asset building capacity and pull them out of abject poverty.

The result also hints that education is an important determinant of credit constraint status of farm households. Mobilizing and sensitizing literate people about the need for and importance of credit would be easier, and this may imply that more investment on education in rural areas would reduce credit constraints and improve participation of farm households in the rural credit market. In Ethiopia, in contrast with Reyes and Lensink's (2011) findings for Chile, demand side factors such as risk aversion behavior of farm households play important role in access to rural credit as confirmed by the results discussed in chapter four. The key lesson from these results is that increasing the supply of credit alone is not the solution for the credit constraint problems of farm households. It is crucial to understand farmers' attitude towards risk and to design a bottom-up credit policy that encourages farm households to take risk. This results also stand in stark contrast to the credit policy environment in Ethiopia where the credit market is basically supply-driven in the sense that borrowers take only what the lender offers and do not ask too many questions. The type of loan products, prices (interest rate), quality and reliability of the services are determined by the supplier, and innovative loan products are not very common in this market. This implies that institutional issues of the credit market need more attention of the macro, meso and micro level policy makers and practitioners to make the market demand-driven, inclusive and more competitive.

The sign and significance of the location and climate shock dummies also call for credit market policies which consider location-specific key variables. For instance, farm households in south Wollo zone found to be more vulnerable to drought shock and they are discouraged in the rural credit market. As the sign and statistical significance of the year dummy reveals, there is an increasing demand for formal credit and yet the number of quantity constrained borrowers has increased over the years 2011 and 2013. This is consistent with the general situation in access to credit in Ethiopia as discussed in chapter three. For instance, micro-financing institutions, which are the major formal credit providers to rural farm households, reach only about 20 percent of farm households (EEA, 2011; AEMFI, 2011). A possible cause of this supply side constraint is lack of loanable funds in the hands of the rural credit service providers. Compared to the bigger commercial banks that have excess liquidity, the rural credit service providers possess better information and enforcement mechanisms and are typically more flexible and innovative. However, these institutions are constrained by shortage of resources and infrastructure to reach more number of clients. Hence, collaboration between commercial banks and the rural credit institutions may lead to a win-win situation to both parties. This can increase the supply of credit and improvement in the operating environment of the rural credit institutions, so that farm households will have better access to credit.

The second core chapter empirically investigated the links between alternative adaptation strategies and different forms of credit constraints using the household level panel data described in chapter two above. Key determinants of the choice of adaptation strategies include: credit constraint status (being a quantity constrained, risk rationed, discouraged, or unconstrained borrower); exposure to climatic factors; household demographic characteristics; ownership of livelihood assets; and other control variables such as location. The quantitative analysis points to the fact that the type of credit constraint matters for the choice of adaptation strategies of households.

We found that credit constraints reduce the adaptive capacity of farm households. For instance, discouraging credit policies and procedures found to reduce the probability of participation in off-farm employment. The results also showed that relatively better credit access encourage irrigation, while credit constraint seems to have discouraged crop diversification. This significant impact of the different credit constraint categories on participation in alternative adaptation strategies confirms the critical role credit availability has in adaptation investment. Similarly, the importance of the interaction terms between rainfall variability and credit constraint categories in the choice of adaptation strategies indicates the importance of credit, especially with greater effect of climatic factors.

The role of credit in the uptake of the different adaptation strategies underlines the need to understand the links between credit institutions and other institutions directly linked with the different adaptation strategies, such as seed delivery mechanisms (in relation to diversification), land tenure arrangements (in relation to tree planting and soil conservation), and general agricultural extension systems (in relation to irrigation activities). Further, given the links between credit constraints and climatic factors noted in this study, increasing awareness about how the credit market works and provision of climate information can help farmers better adapt to climate change.

The third main chapter tried to show the effect of climatic shocks and credit constraints on household asset accumulation using the fixed effects instrumental variable (FE-IV) technique to control for a potential bias in the estimates stemming from endogeneity of the credit constraint status. The results show that rainfall variability, experiencing drought shock, crop damage due to wild animals, death of livestock and exposure to various idiosyncratic shocks all have significant negative effects on household asset holdings in the study area. Compared to unconstrained borrowers, farmers who are discouraged and quantity constrained found to have significantly lower amount of asset holdings and the amount reduces further, when climatic shocks are coupled with credit constraints. This demonstrates the adverse effect of climatic shocks intertwined with credit constraints.

The findings also show that social networks play crucial role in managing climatic shocks and in building productive assets as evidenced by the sign and significance of key indicators of social capital. This may imply that public policy aiming at strengthening community-based approaches to adapt to climate change can help in building farmers' adaptive and asset building capacity. Further, this chapter showed that investing in off-farm self-employment has positive effect on asset holdings in the face of climatic shocks and credit constraint conditions. Agriculture being rain-fed and subsistence in rural Ethiopia, the findings suggest that public policies which encourage investment in rural non-farm sector by creating better performing rural credit markets, can serve as a risk-diversification and asset-building mechanism. It may also facilitate employment creation, household income growth, poverty reduction, and rural development in general.

Participating in productive safety net programs (PSNP) also found to have a significant positive effect on the real value of household assets, suggesting the positive role of the PSNP in the gradual shift of participants from high vulnerability and dependence on humanitarian food aid to less vulnerability and better adaptive capacity. Investing in soil conservation and tree planting also found to increase household asset holdings in the studied zones. This illustrates the positive role of adaptive measures in improving household asset building capacity and hence, calls for scaling up and sustaining existing efforts to cope with the ever increasing climate variability.

Ethiopian farm households live in varied agro-ecological and socio-economic conditions. This implies that their exposure to various shocks, their coping strategies and their level of production and asset accumulation differ across different zones. A generic "*one-size-fits-all*" type of policy package and blanket recommendation may not help them to enhance their adaptive capacity. Hence, understanding the types of shocks which significantly affect household's asset holdings in a particular socio-economic context is important in designing and implementing public policies to help farmers in building assets and becoming more resilient to climatic shocks.

The main objective of the fourth core chapter was to investigate the effect of different credit constraint conditions on agricultural productivity among smallholder farmers in the study area using the propensity score matching (PSM) method. The results provide evidence for the adverse effects of credit constraints on improving agricultural productivity. It is a rational decision to invest in fertilizers, improved seeds, and drought-resistant crops which can increase productivity in the face of changing climatic conditions. However, as the results suggest, adoption of such technologies is hampered by credit constraints and this found to have a direct negative effect on agricultural productivity. The impact estimates indicated that relaxing credit constraints has significant positive impact on agricultural productivity, while higher transaction costs and discouraging credit market policies found to reduce productivity significantly.

These results may suggest the importance of linking credit with crop insurance to manage the uncertainty in agricultural production. Designing "productivity-based credit" (PBC) product may also help both lenders and borrowers in two ways. First, it may motivate farmers to work hard and this may ease the moral hazard problem; and second, it may also reduce the probability of adverse selection, since lenders now target right borrowers who really need the loan to invest it on productivity-enhancing agricultural technologies.

Thus, the solution to the low productivity and credit constraint problems of farm households may not be a mere injection of loanable funds into the rural credit market. Instead, government interventions should focus on improving the institutional setup of lending institutions, investing on human capital formation, and building the capacity to innovate new loan products and efficient ways of serving genuine borrowers. This involves designing creative and climate-smart credit policies and procedures which can tackle the information asymmetry problem entailed in rural lending without reducing the welfare of borrowers. For instance, to help farmers better adapt to the changing climatic condition, it could be crucial to think of a flexible climate adaptation loan product. Among the study sites, south Wollo and north Wollo zones of the region found to be more vulnerable to drought and climate variability, and this calls for designing climate-smart loan (CSL) products so that farmers in these zones may have better access to the rural credit market and build their adaptive capacity. Relaxing collateral requirements for small loans and increasing the loan repayment period could also encourage farmers to participate in the rural credit market.

While this dissertation makes an important stride in analyzing the role of credit constraints in different climate adaptation strategies, it has three key short comings. First, responsiveness of adaptation strategies may differ depending on whether credit is accessed from the informal or formal sector. It should be noted that this dissertation does not go into the potentially differing impacts of formal and informal credit access and their possible interactions. Given the lack of detailed information on the nature of credit access from the informal sector, as opposed to the kind of information we were able to extract on formal sector credit access, it was not possible to look in depth into credit access by degree of formality. For the future, a more detailed analysis of credit access by the nature of formality is required. Second, it is important to understand the links between credit institutions and other institutions directly linked with the different adaptation strategies, such as seed delivery mechanisms (in relation to crop diversification), land tenure arrangements (in relation to tree planting and soil conservation), and general agricultural extension systems (in relation to irrigation activities). Hence, in future research, it is worth investigating the role of such institutions in the context of climate change adaptation since policies that enhance and strengthen institutional support may be valuable in enhancing adaptive capacity of households. Third, our analysis in this dissertation focuses on the responsiveness of adaptation strategies to climatic factors and we did not go into the details of mitigation actions. Further, this study uses measures such as the average temperature and rainfall as well as the coefficient of variation of rainfall for the past 30 years. This does not encompass predictions about possible future scenarios under different credit constraint conditions and this gap is also a subject worthy of further investigation.