**Wageningen University – Department of Social Sciences**

Development Economics Group

# *Effects of Climate Shocks on Household Food Security in rural Ethiopia: Panel Data Estimation.*

**May 2014**

***Program:*** Mangagement, Economics, and Consumer Studies (*Research Master Variant*)
***Specialization:*** Economics, Environment and Governance
***Thesis code:*** DEC-80436

***Student:*** Abebayehu Girma Geffersa
***Supervisor:*** Marrit van den Berg, PhD

WAGENINGEN UNIVERSITY
WAGENINGEN UR

# ACKNOWLEDGEMENT

First of all, the author would like to thank his major Supervisor **Dr. Marrit Van Den Berg,** whose contributions through critical and constructive comments have improved the quality of the thesis. The author greatly acknowledges his supervisor's unmatched assistance, unlimited encouragement and provision of related study materials starting from the inception of the research career, as without her encouragement the thesis work could not have been completed.

The author would also like to express his great appreciation to his study advisor **Prof. Edwin Kroese** for his remarkable advice all the way through the course and research works. The author also thanks and appreciates the Netherlands Fellowship Program (**NFP**) for their financial support throughout his stay in the Netherlands.

The author remains thankful to **Dr. Guush Berhane** and **Dr Getaw Tadesse** for their unforgettable encouragement and support in the course of his stay at IFPRI campus. The researcher also likes to thank and acknowledge the Economics Department, Addis Ababa University (AAU), and the Centre for the Study of African Economies (CSAE), University of Oxford and the International Food Policy Research Institute (IFPRI) for their effort to collect and make these data available for different studies. The researcher also thanks ESRC, SIDA, USAID, and World Bank who took a part in funding the data collection and the preparation of the public release version of these data.

The author would like to extend his genuine gratitude to his beloved family and all friends at WUR who have been the source of his inspiration.

Finally, above all, the author thanks his almighty God for everything done to him throughout his career.

## ABBREVIATIONS AND ACRONYMS

**AAU:** Addis Ababa University

**CCI:** Complementary Community-based Infrastructure Program

**CSA**: Central Statistical Authority

**CSAE:** Centre for the Study of African Economies

**df:** degree of freedom

**DFID:** Department for International Development

**DR:** Dependency Ratio

**IFPRI:** International Food Policy Research Institute

**ERHS**: Ethiopian Rural Household Surveys

ETB: Ethiopian Birr

**FSP:** Food Security Program

**FAO:** Food and Agriculture Organization

**FCPC:** Food Consumption Per Capita

**FE:** Fixed Effects

**FE-2SLS:** Fixed Effects two Stage Least Squares

**FE-IV**: Fixed Effects Instrumental Variable

**GDP:** Gross Domestic Product

**GMM**: Generalized Method of Moments

**HH:** Household Head

**HABP:** Household Asset Building Program

**IV:** Instrumental Variable

**m.a.s.l:** meters above sea level

**OLS:** Ordinary Least Square

**PA**: Peasant Association

**PSNP**: Productive Safety-Net Program

**RE:** Random Effects

**SLF:** Sustainable Livelihood Framework

**SNNPR:** Southern Nations, Nationalities Peoples Regional State

**WFP:** World Food Program

## TABLE OF CONTENTS

## TABLE OF CONTENTS Continued ...

# LIST OF TABLES AND FIGURES

## *Effects of Climate Shocks on Household Food Security in rural Ethiopia: Panel Data Estimation.*

### *ABSTRACT*

*With a general objective of assessing the impact of climate shocks on Ethiopian household food security over time, this study addresses two specific objectives. The first specific objective is to analyze the effect of climate shocks on household food security, whereas the second objective is to identify other determinants of household food security over time. The study used a longitudinal household dataset drawn from the Ethiopia Rural Household Survey (ERHS) from 15 rural Ethiopian villages. We used monthly per capita food consumption as a food security indicator, whereas; an occurrence of drought was used as a climate shock indicator. The study answers the following two specific research questions which directly follow from the aforementioned objectives. To examine the causal relationship between climate shock and food security, our model estimations employed a Fixed Effects econometric analysis technique. Generally, as we anticipated prior to our analysis, climate shock is found to be negatively and significantly associated with food security over time. A negative climate shock variable implies that, households vulnerable to drought tends to be more food insecure than their counterparts. Our findings are also in agreement with the Sustainable Livelihood Framework (SLF) which states that a household livelihood is hugely determined by their own resource endowments. Among the variables representing human capital endowments, large family size is the most underlying cause of food insecurity in rural Ethiopia. Among the basic physical (natural) resource endowments, land and livestock play a vital role in determining the household food security. Moreover, our study identified that, credit use is an important financial capital influencing household food security in the study area. Our finding generally suggests that, unfavorable climatic conditions combined with the lack of necessary households' resource endowments, adversely affects the rural household food security. Finally, our findings suggest that; provided that all necessary households' resource endowments are not binding, a given households resource endowment reduces household's vulnerability to food insecurity. Therefore, we recommend that efforts towards improving the adaptive mechanisms and policies that can contribute to the improvement of households' resource endowments should not be undermined. We also recommend that, improving the household's food security status requires attention towards mitigating climate shocks; such as drought and rainfall failure.*

***Key words: food security, climate, drought, and resource endowments***

# 1. INTRODUCTION

## 1.1. Background and Justification

Global as well as household level food availability can be affected by climate change for it directly affects agriculture production through changes in agro-ecological conditions (Schmidhuber and Tubiello, 2007). Some scholars also argue that; *"Global food security will remain a worldwide concern for the next 50 years and beyond"* (Rosegrant and Cline, 2003 p. 1917). Compared to other parts of the world, food insecurity is greatest in developing countries particularly in sub-Saharan African countries (Haile, 2005). More specifically, there could be adverse effect of temperature and precipitation variability on crops production which in turn results in food insecurity. The extremes of precipitation, both droughts and floods, are also detrimental to crop productivity under rainfed conditions (Rosenzweig et al., 2001). The problem may be severe in developing countries, since the livelihood of the majority of the household depends on agricultural sector. For instance, more than 85% of people in Ethiopia depend on agriculture as their primary source of income. Hence their livelihoods can be vulnerable to climatic conditions (Taye et al., 2010).

Ethiopian rural households are vulnerable to shocks, such as drought, that affect agricultural production. Famine and drought affect food security and livelihood of rural households in the country. The country suffered the worst food shortages during two periods of drought; 1968-1973 and 1979-1984 (Mattsson and Rapp, 1991). According to Taye et al. (2010), the famines caused the death of 200 thousand people and millions of cattle in the country. Among these, the 1973 famine have seriously affected over 300,000 lives in the country (Taye et al., 2010). In 1985, approximately 10 million people were reported to be in serious starvation, with approximately 300,000 were dead at the end of the year (Taye et al., 2010). In the recent few decades droughts occurred and led to food shortage in different part of the country. Unpredictable weather conditions and climatic shocks still have a direct effect on Ethiopian households. In recent times, increasing uncertainties in the country raise critical questions about how to viably and sustainably manage various shocks that affect the farm households livelihood and food security (Von Braun, 2009). In order to overcome famine and pervasive poverty so as to ensure food security for its nations, the Ethiopian government's strategy has currently focused on increasing the availability of food grains (Bogale and Shimelis, 2009). This is majorly executed through huge investments in agricultural technologies so as to improve livelihood of the nations, thereby boost economic growth (Bogale and Shimelis, 2009).

The country recorded a better economic growth in recent years, according to the World Bank figures. The annual growth rate of the country's GDP, which was -

11.14% in 1985 increased to 8.45% in 2012. However, frequent drought and adverse climatic conditions which have been causing major fluctuations in agricultural production are rendering the country one of the poorest in the world. Despite an immense agricultural potential, it is still difficult for the country to feed its population and depends on foreign donations of food to sustain millions of its citizens. As estimated by FAO/WFP (2012), to assist about 13.7 million beneficiaries of the country, Ethiopia required a minimum of about 1 million tonnes of food in 2012. Though agriculture (particularly small-holder crop production) has been historically a major contributor in the country's economy, the sector suffers high yield variability in recent years. For instance, the sector accounts about 48.76% of the GDP in 2012, employs more than 80% of the population, and accounts for 94% of the country's export (World-Bank, 2013). However, its contribution in country's GDP decreased from 57.82% in 1985 to 48.76% in 2012.

The impact of adverse climatic conditions may be exacerbated by a number of other factors such as; underdeveloped farming technology, communication networks, transport, and environmental degradation. Rapidly growing density of rural population in the country is another factor aggravating the condition due to its consequent pressure on land (Taye et al., 2010). According to Taye et al. (2010), population pressure caused fragmentation of farm holdings as a result environmental degradation and loss of land fertility in the country. The population of the country is still growing at an alarming rate. For instance, if we compare total population of 2012 with that of 2002, the population of the country increased by more than 20 million persons over the last 10 years. According to an estimation by World-Bank (2013), the country became among the most populous countries in Africa having an estimated total population of about 91.73 million in 2012, with an average annual growth rate of 2.6%. On top of the aforementioned problems, some studies in some particular areas of the country have confirmed that, recurrent drought has been depleting the already scarce resources of the country. There is evidence that the frequency of drought and its severity shows an increasing trend in last few decades, as a result, the population of the country became less resilient and more vulnerable even in the occurrence of some minor shocks (Canali and Slaviero, 2010).

As a result of frequent drought and unpredictable climate shocks, rural households would likely become food insecure. Though the effect of climate shocks depend on the capacity of a household to respond to impacts of the shocks, appropriate long-run policy interventions and formulations require estimating yesterday's impact of these shocks to improve at least tomorrow's food security situations. Recently, to improve food security of chronic and transitory food insecure households, the government of the country launched number of food security programs. The programs aimed to put households on a trajectory of asset stabilization and accumulation to let the households gradually food secure. According to FAO/WFP (2012), the programs have four components: the Productive Safety Net Program (PSNP); the Household Asset Building Program (HABP); the Complementary Community-based Infrastructure Program (CCI); and the Resettlement Program. Broadly, the PSNP's objectives are the reduction of household vulnerability, the improvement of household and community resilience to shocks and breaking the cycle of dependence on food aid (FAO/WFP, 2012). As reported by FAO/WFP (2012), the PSN program currently targets 7.57 million chronically food-insecure rural people and it is expected to reach 8.3 million people in 320 *woredas*[1] by 2015 in eight regions of the country.

Despite remarkable efforts from different stakeholders to implement these policies, the impacts of the policies have been shadowed as there are still millions of people who experience extreme hunger in the country (Bogale and Shimelis, 2009). According to FAO/WFP (2012), the PSNP represented a significant transformation of the government's food security policy, moving toward a more articulated development-oriented plan rather than appealing for emergency food aid to address the causes of household food insecurity. Given the dependency of agricultural production, which is frequently affected by highly variable climatic conditions, food security problem is still recurrent in the country. This may not only be due to limited capacity of the households to cope in the event of climatic shocks, it may also be due to lack of information on how to cope in the event of the shocks. The condition may be worsening because households do not have information on what are the basic causes of the food insecurity.

## 1.2. Problem Statement

Over the past few decades, it has generally been a debating issue in Ethiopia over the determinants and causes of food insecurity. As some researchers argue, to overcome rural households food insecurity in Ethiopia dates back a long period (Bogale and Shimelis, 2009). The situation still demands a lot of struggle and effort to identify the root causes of the problem. The causes of the problem at household as well as at national level are various and hence struggling to achieve food security goal in the country remain a challenging goal to date (Bogale and Shimelis, 2009). A food insecurity problem, be it a result of sudden shocks or not, usually requires the government and other humanitarian donor organizations' assistances. These assistances may not make a structural change for the deep rooted food insecurity problems unless the fundamental cause of the problem are identified. Thus, identifying the fundamental causes of the food insecurity problem may play a vital role in directing to a long lasting solution to mitigate the problem. In this regard,

[1] ***Wereda*** refers to the local small administrative unit under the regional states of the country

empirical assessment of whether or not climatic shock exacerbates food insecurity has a paramount importance to make better-informed policy decisions. It seems important if the assessments also include some other time variant determinants of food insecurity.

An event of sudden shocks may play a role in aggravating the households' food insecurity problem. Therefore, assessing the past challenges on food security due to climate shocks may have paramount importance in reducing the future vulnerability of the people by providing appropriate early warnings towards mitigation and adaptation of future climate shocks. Previous studies have shown that changes in climatic condition largely affect global food security (Bohle et al., 1994, Heltberg et al., 2009, Mattsson and Rapp, 1991, Parry et al., 1999, Rosenzweig et al., 2001, Schmidhuber and Tubiello, 2007). For instance, Rosenzweig et al. (2001) revealed that the livelihood of the households in the Sahel region of Africa is hugely affected by persistent drought. Similarly, Haile (2005) has shown that climate variability affect food security in Sub Saharan Africa.

However, a bunch of other previous studies on food security aspects in Ethiopian context are more of region specific; none of them assessed the determinants of food insecurity at national level. The studies gave more emphasis on identifying determinants of food security in a given point of time (i.e. they are cross-sectional studies). Some of the cross-sectional studies are; Feleke et al. (2005), Hussein and Janekarnkij (2013), Ramakrishna and Demeke (2002), Kassa et al. (2002), and Bogale and Shimelis (2009). However, there are a few studies which identified climate as one of the potential determinants of food security at national level. The prominent examples are; Demeke et al. (2011) and Holden and Shiferaw (2004). In addition to these, there are some other studies which have been conducted using Ethiopian Rural Household Surveys (ERHS, 1994-2009) data which our current study utilized; (Dercon, 2004, Dercon et al., 2005, Dercon and Krishnan, 2000). Some of them focused merely on identifying the determinants of consumption growth rather than the food security issue in particular; e.g. Dercon et al. (2005). However, direct assessments of the effect of climate shock on food security over years and identifying the time-variant food security determinants remain limited.

It is obvious that, evidences from cross sectional data provide information only about current situations at a point in time. Cross sectional data may not give adequate evidence to study forward looking on food security and vulnerability analyses. These facts brought a use of national level longitudinal data to study time-variant food security analysis to our interest. Our current study thought to better addresses the time variant food insecurity issues and the incoming negative impacts from several events. Most recently, Demeke et al. (2011) conducted a study on the impact of rainfall shock on food security using the ERHS dataset (from 1994-2004). Though their study examined how household food security is associated with rainfall variation over a specified period of time, it did not include recent information (data from 2004 onwards). The major contribution of the current study is that, first we offer a unifying conceptual framework that links household's resource endowments with food security and climate variability using Sustainable Livelihood Framework (SLF). Then, the study attempts to contribute to the existing literature by empirically assessing the impact of climate shocks on the household food security over a period of 1994-2009. The study uses, occurrence *Drought* as a climate shock indicator. On top of this, it identifies other time variant determinants of Ethiopian household food security. Finally, it provides useful information to different policymakers in the area of poverty alleviation and food security in the Ethiopian context.

## 1.3. Objectives of the Study

The overall objective of this study is to assess the impact of climate shocks on the Ethiopian household food security over a period of ***1994-2009***. More specifically, this study addresses the following objectives;

***i)*** to analyze the impact of climate shocks on household food security over time, and

***ii)*** to identify other time variant determinants of food security.

## 1.4. Research Questions

This study answers the following specific research questions in Ethiopian households' food security context:

a) Do climatic shocks have a significant effect on household food security?
b) What are the time variant determinants of household food security?
c) Is the household food security associated with their various resource endowments?

## 1.5. Organization of the Thesis

The thesis encompasses five major chapters from which the next chapter (chapter two) is devoted to conceptualizing the concept food security and review of literatures in the area of food security. Chapter three presents the methodologies adopted for this study together with a brief description of the study area. Moreover, this section gives some highlights about the physical and demographic features of the study area, sampling procedure and data source for the study followed by the methods of data analysis and definition of variables. In chapter four, the descriptive results obtained from the study are presented. The fifth chapter presents and discusses the empirical results for the effects of climate shock and food security from estimates of an appropriate econometric model. It also presents and discusses the results of determinants of household food security. The sixth and the final chapter give some important conclusions and policy implications based on the major findings of the study.

# 2. LITERATURE REVIEW AND CONCEPTUAL FRAMEWORK

*Prior* to reviewing studies related to causal relationship between our variable of interest and food security, it is important to conceptualize the basic concepts such as; food security and shocks. The following sub-sections conceptualize the "food security" and define indicators to provide a starting point for the choice of appropriate indicator of food security from a bunch of available indicators. The preceding sections review some studies related to the effect of climate on household food security and summarize other food security determinants identified by previous studies in the Ethiopian context.

## 2.1. Food Security: *Definitions and Concepts*

Core concepts of household livelihood revolve around either household level food security which is broadly known as food security or individual level food security known as nutrition security (Haddad et al., 1994). Different scholars commonly conceptualize food security as it is resting on three pillars: availability, access, and utilization (Barrett, 2010). According to Barrett (2002), there are problems on precisely measuring and conceptualizing the incidence of food insecurity. Given an unobservable and complex nature with multi-factorial causality, Barrett (2002) underlined that it is impossible to someone to easily define and precisely measure a broad concept; food security. We have various definitions currently in use, among these the prevailing definition agreed upon at the 1996 World Food Summit: "*food security represents a situation that exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life*" (Barrett, 2010 p. 825). As indicated by (Bickel et al., 2000), food security at a minimum includes the following two conditions. The first one is "*an availability of nutritionally adequate and safe foods*", whereas the second condition is "*an assured ability to acquire acceptable foods in socially acceptable ways*". Food insecurity and hunger are often confusing and synonymous terms. Both of them are conditions resulting from *financial resource constraint*. Most of the time, the latter is a potential consequence of the former.

Hunger can be defined as *"the uneasy or painful sensation caused by a lack of access to food"* (Bickel et al., 2000 p. 6). Whereas, food insecurity can be defined as "*Limited or uncertain availability of nutritionally adequate and safe foods or limited or uncertain ability to acquire acceptable foods in socially acceptable ways*" (Bickel et al., 2000 p. 6). Most of the time, hunger is seen as a severe stage or level of food insecurity, rather than as a distinct or separate condition from the more general experience of food insecurity. According to Haddad et al. (1994), nutrition security is a less common but broader concept than food security. Typically, food security can be considered as a necessary, but not a sufficient condition, for nutrition security. Nutrition security can be defined as "*the appropriate quantity and combination of inputs such as food, nutrition and health services, and caretaker's time needed to ensure an active and healthy life at all times for all people*" (Haddad et al., 1994 pp. 329-330).

### 2.2. Climate Shocks

Poor people face various shocks that directly or indirectly affect their livelihoods and food security (Von Braun, 2009). Generally, shock is a broad concept which is defined in different ways in different literatures. For instance, Dercon et al. (2005) p. 5, define shocks as "*adverse events that lead to a loss of household income, a reduction in consumption and/or a loss of productive assets*". Dercon et al. (2005) defined a particular shock as a *serious shock* if the event leads to the household to a serious reduction in asset holdings, causes the household income to fall substantially, or if the event results in a significant reduction in his/her consumption. Household level shocks can either be *idiosyncratic or covariate. Idiosyncratic* shocks include adverse events that specifically affect particular individual household in the community. Whereas, *covariate* shocks include events that simultaneously affect many people in the same geographical location (Von Braun, 2009). For instance, by its nature, rainfall shock and drought are kinds of *covariate shock* as they affect all households in the village and possibly those nearby. Susceptibility to *idiosyncratic risks* often claimed to be a result of various factors such as social status, occupation, and geographic location (Von Braun, 2009). Dercon et al. (2005), divided shocks into a number of broad categories; climatic, economic; political; crime; and health related shocks. The most common climatic shocks could be idiosyncratic; floods, too much rain, pests/diseases that affect field crops or crops in storage, and pests/diseases that affected livestock. In some cases, pests and diseases affecting crops or livestock may appear to be a mix of idiosyncratic and covariate shocks. The climate shock is severe in developing countries since the majority of the poor depend on agriculture as a source of food and income. According to Von Braun (2009), climate shock includes an increase in the incidence of extreme weather events such as droughts and floods which result in a decrease in agricultural yields and hence lower food availability. On top of the obvious examples of climatic shocks such as drought and flooding, Dercon et al. (2005) also mentioned erosion, occurrence of frosts and pestilence affecting crops or livestock as climate shocks.

### 2.3. Measuring Food Security

Identification of valid and reliable indicators is a key task *prior* to analysing causal relationship between food security and its potential factors or determinants. Bickel et al. (2000), suggested that a household level food insecurity or hunger must be determined by obtaining a combination of various pertinent information on specific conditions so that our indicator incorporate varying degrees of severity of the conditions. Despite the fact that food insecurity and hunger stem from constrained financial resources, Bickel et al. (2000), mentioned that traditional income and poverty measures fail to provide such a clear information regarding the severity of food insecurity. They found evidence supporting their argument that many low-income households may still appear to be food secured, while non-poor households appear food insecure.

From the existing broad literatures suggesting potential food security indicators, most of them span a wide range of disciplines such as anthropology, nutrition, sociology, geography, public health, and economics. The frequently available and utilized indicators which potentially measure food security according to Maxwell et al. (2008), are "*nutritional status, actual food consumption at household level by a 24-hr recall, and coping strategies index*". Moreover, Maxwell et al. (2008) suggested proxy indicators such as calorie intake, household income, productive assets, food shortage, dietary diversity, and household food insecurity access scale. However, Maxwell et al. (2008) themselves argued that, by their nature, such indicators fail to provide a comprehensive picture as designate only a small portion of the problem. Each of these indicators has their own pros and cons. If we take 24-hour recalls of food consumption as an example, it has a number of drawbacks associated with it. For instance, there might be memory lapses of respondent, observer bias, respondent fatigue, short and possibly unrepresentative recall period and high cost of data collection (Timothy and Sharon, 2012). Thus, the best available estimates of the incidence or intensity of food insecurity remain highly imprecise. It is also criticized that, this method does not capture vulnerability, access, and suitability aspects of food security, it only captures element of dietary sufficiency.

Among a bunch of literatures, Haddad et al. (1992) is the most widely known study suggesting various traditional as well as alternative food security indicators. The traditional indicators of food and nutrition security are identified to be calorie adequacy and *anthropometric*[2] indicators. For the fact that policymakers and implementers in developing countries found the traditional indicators difficult to incorporate into ongoing monitoring and evaluation systems on food security aspects, Haddad et al. (1992) identified some "*alternative*" food security indicators. They developed a conceptual framework to identify and evaluate alternative indicators of food and nutrition security. In the end, they made several suggestions for the choice of indicators for food security and nutrition monitoring in Africa. Using Haddad et al. (1992) as a benchmark, Haddad et al. (1994) tried to find indicators of food and nutrition security that correctly classify a high proportion of

[2] According to **Haddad et al. (1992),** a*nthropometric* indicators are measures of nutritional outcomes at the individual level by classifying individuals as ***stunting*** (low height-for-age), ***underweight*** (low weight-for-age), and ***wasting***.

households as food or nutrition insecure across different cultures. Their results from empirical analysis of four different data sets show that relatively simple indicators perform well in locating the food and nutrition insecure households. Haddad et al. (1994) confirmed that, indicators such as; *food expenditure per capita*, *number of unique foods consumed*, *consumption expenditure per capita*, *household income*, and *dependency ratio* are good indicators of household food security.

Haddad et al. (1994), revealed that variables that are relatively easy to collect – *household dependency ratio*, *household size*, and *number of unique food groups* - do nearly well. In locating the food and nutrition insecure households, *household size* and total expenditure per capita or household income per capita, also do similarly good job and were found to be nice predictors of household calorie adequacy. Though not so strong as household incomes or total expenditure, finding of Haddad et al. (1994) further confirmed that, higher *household dependency ratios* also show a positive association with membership of the lowest calorie adequacy. As Haddad et al. (1994) indicated further, *land used* and *land owned per capita* also do fairly well, particularly in rural areas. They confirmed, in terms of the household calorie adequacy definition, the *number of income sources* doubtfully useful in identifying households that are at nutritional risk. Haddad et al. (1994) p. 334, finally concluded that *"the number of unique foods at various levels of aggregation seems a promising indicator in both urban and rural areas in all countries"*. In the end, Haddad et al. (1994), came up with a conclusion that, in identifying food insecure households *food expenditure per capita* is relatively better indicator since it encompasses the access and availability components of food security. *"Of the more complex indicators, food expenditure per capita does better than total expenditure per capita, which in turn does better than household income in identifying food insecure households"(Haddad et al., 1994 p. 336).*

## 2.4. Conceptual Framework: *Food Security and Shocks*

*Prior* to our empirical model estimation, it is important to discuss the relationship between household food security and shocks. Each suggested indicator (under section 2.1.2) reflects how to measure food insecurity, but it has nothing to tell us about what determines food insecurity at the household level. That is, the measurements of food insecurity may be able to measure current nutritional status of an individual but may not give us a clue on future possibilities towards improving the food security status of an individual. Haddad et al. (1992), generally suggested that, household level food stores and qualitative/quantitative changes in diet are major factors influencing food security. In this regard, one can hypothesize food security to be mainly influenced by various household's resource endowments based on an economics notion that the wealth status of an individual household depends on its resource endowments. This is what the general Sustainable Livelihood

Framework (SLF) also suggests. SLF (DFID, 1999) suggests that, households resource endowments are the basic "*poverty reducing factors*". The following two sub-sections are devoted to discussions related to how different household resource endowments can be related to shocks and food security.

### 2.4.1. Household's Resource Endowments

Based on the Department for International Development (DFID) 1999 Sustainable Livelihood Framework (SLF), we have five broad categories of households' resource endowments. The five broad categories identified by SLF framework include; *human capital*, *social capital*, *physical capital*, *financial capital* and *natural capital* endowments.

**Human capital:**

Human capital basically represents a good health of human beings combined with good skills, knowledge, and ability to perform certain tasks. It is obvious that the managerial ability of an individual should enable him/her to pursue different livelihood strategies in a given household. Hence, DFID (1999) considers human capital as a basic building block in achieving livelihood outcomes. The managerial ability of a household head may vary according to the size of the household, skill levels of the household members, and leadership potential (or formal education). At household level, human capital is a production factor that represents the amount and quality of labour available (DFID, 1999). The quality of labour can be improved either through providing better education or by availing necessary health facilities. For instance, there may be remarkable difference between skilled and unskilled laborers with respect to agricultural production thereby on the food availability.

**Social capital:**

So far, the term 'social capital' has arisen much debate about what exactly it is meant by. It is usually considered as the social resources which enable or assist people to achieve their livelihood objectives. In the context of the SLF framework, DFID (1999), the social resources can be developed through creating certain networks within a community, being a member of more formalised groups in a community, creating a trustworthy relationships with individuals, and so forth. In SLF framework, networks and connectedness are assumed to increase people's trust and ability to work together and improve their access to local institutions. Membership of more formalised groups on the other hand "*entails adherence to mutually-agreed or commonly accepted rules, norms and sanctions*" (DFID, 1999); whereas, trustful relationships may facilitate co-operation and avoid unnecessary transaction costs amongst the poor. All of these concepts are inter-related. If we take for instance, membership of groups and associations, they can extend people's influence over other institutions, whereas, trust is likely to develop among peoples who are connected through a kind of kinship relations (DFID, 1999).

**Natural capital:**

Natural capital, can be broadly defined as natural resource stock providing services useful to those who derive all or part of their livelihoods from resource-based activities (DFID, 1999). It refers to *"environmental assets such as land, and common property resources or 'free' natural resources such as forests, water or pasture land"* (Farrington et al., 2002 p. 20). Typical examples of assets, used directly for production in small households, are trees and land. Based on the capacity of nutrient cycling and erosion protection, there is a wide variation in the resources that make up natural capital. Within the SLF framework, natural capital and the vulnerability are often interlinked for the fact that many of the shocks that devastate the livelihoods of the poor themselves are natural processes that destroy natural capital (DFID, 1999). Some of these natural processes are fires that destroy forests, floods and earthquakes that destroy agricultural land.

**Physical capital:**

According to DFID (1999), physical capital comprises the basic infrastructure consisting changes to the physical environment that provide basic service to people to meet their basic needs. In this regard, producer goods are the tools and equipment that people use to function more productively given well established infrastructure. DFID (1999), identified the following components of infrastructure as essential for sustainable livelihoods: affordable transport, affordable energy, secure shelter and buildings, adequate and clean water supply, and access to information or communications.

**Financial capital:**

Financial resources that people use to achieve their livelihood objectives may include financial services provided by either formal or informal organizations (DFID, 1999). Financial resources may include flows as well as stocks which may contribute to consumption as well as production at the same time. Most of the time, financial capital is adopted to try to capture an important livelihood building block such as; the availability of cash that enables people to adopt different livelihood strategies (DFID, 1999). According to DFID (1999), there are two main sources of financial capital. The first source is *Available stock* which comprises savings. Savings are the preferred type of financial capital because they do not have any liability attached to the resource (DFID, 1999). The second source is *Regular inflows* of money which comprises pensions, or other transfers from the state, and remittances that are provided by relatives or any other entity (DFID, 1999).

### 2.4.2. Livelihood, Food Security and Shocks

The SLF indicates that the livelihood of a given household or state is mainly dependent on its asset endowments. The SLF framework is developed to enable information about people's assets to be presented visually using the so called the "*Asset pentagon*" which lies at the core of the vulnerability context. Though the framework may not be considered as an exact representation of the existing reality, it yields important inter-relationships among the various household's assets (DFID, 1999).

When peoples are viewed as vulnerable to certain shocks, while having access to various household assets (which play role in poverty reducing), the framework provides a way of thinking towards improving performance in poverty reduction. *"The Vulnerability Context frames the external environment in which people exist. People's livelihoods and the wider availability of assets are fundamentally affected by critical trends as well as by shocks and seasonality – over which they have limited or no control"* (DFID, 1999 section 2.2). Therefore, asset endowments (poverty reducing factors), are assumed to enable households to pursue a sustainable livelihood. Generally, the availability as well as the quality of any of the resource endowment listed above, may directly or indirectly affect the food security of the household.

Some shocks which directly affect one of the endowments may also indirectly affect the availability or quality of another endowment. *"Clearly, financial capital, in terms of access to employment and earnings, is strongly dependent on adequate human capital. In turn, human capital is highly dependent on adequate nutrition, health care, safe environmental conditions, and education"* (Farrington et al., 2002 p. 20). For instance, if a given household face deterioration in *human capital* (e.g. poor health), agricultural production can be directly affected as a result the household may face food shortage. Similarly, if a household faces a *financial capital* problem (e.g. cash constraint to purchase agricultural inputs), there will be lower agricultural yield. Broadly speaking, some of these resources may also be affected by natural processes (e.g. *Drought*), as a result, there will be low food availability at household level. Therefore, there are potential forward and backward linkages among these resource endowments, occurrence of shocks, and food security. Figure 1 outlines the possible inter-linkages based on the SLF livelihood contexts.

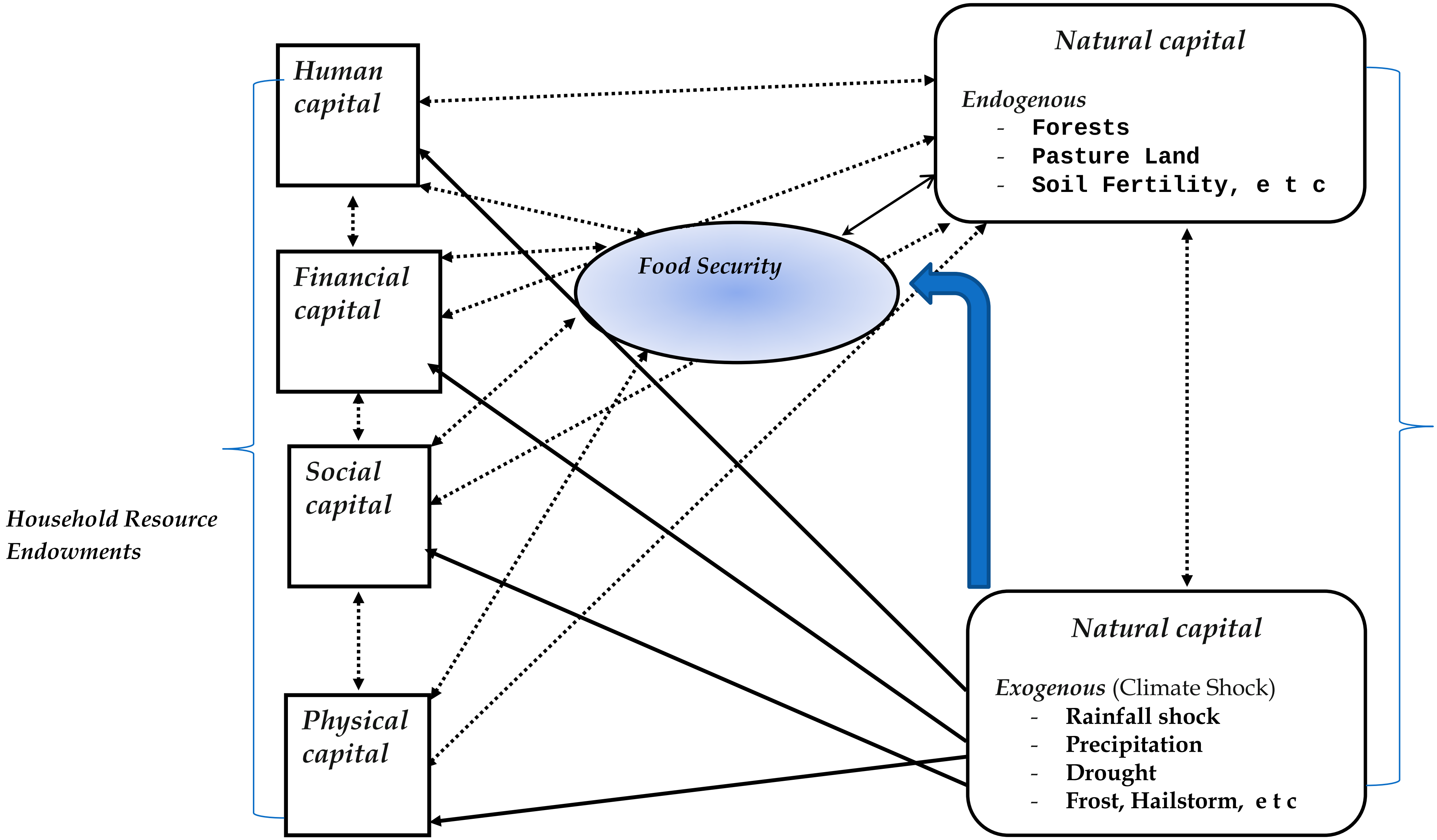


Figure 1: Food security framework; {*Based on,* DFID (1999), *sustainable livelihood framework (SLF)*}

### 2.4.3. General Hypothesis

Our study has two leading hypotheses which directly follow from our conceptual framework. The first general hypothesis states that, *"households with better position in household's resource endowments are more food secured than their counterparts".* Our second hypothesis states "climate shocks have a negative impact on Ethiopian household food security". Given the fact that climate shock is one of the natural processes that destroy natural capital endowments, generally, we hypothesize a negative relationship between climate shocks and food security. It also follows from the general hypothesis that, a better position in households' resource endowments leads the households to better the food security situation.

## 2.5. Food Security in Ethiopia

### 2.5.1. General overview

Ecological changes due to climatic variations combined with wars, natural disasters, and political instability are mentioned to be direct causes of food insecurity for millions of people in the world (Canali and Slaviero, 2010). FAO's most recent estimates, FAO/WFP (2012), indicate that, about 842 million (12%) of the global population was unable to meet their basic dietary requirements in 2012. Ethiopia is one of the countries taking the lion's share of this estimate. During the widely known famine periods, early 1970's, very severe social as well as environmental problems affected Ethiopia seriously. Again a serious drought struck occurred in the country early in period 1979-1984 (Taye et al., 2010). In the country, availability of fresh water as well as food from the harvest of major crops is subject to rainfall variability (Haile, 2005). Currently Ethiopian government is putting much more effort with a key goal to enable chronically food insecure household to acquire sufficient assets and income (FAO/WFP, 2012). However, an identification of the key determinants of Ethiopian household food security still requires further investigation. The following summary of some empirical studies on food security offers some important insights into the determinants of household food security in the Ethiopian context.

### 2.5.2. Determinants of Ethiopian Households' Food Security

As previous studies on a role of climate on food security confirmed, climate variability is a key determinant of global food security; (Bohle et al., 1994, Heltberg et al., 2009, Mattsson and Rapp, 1991, Parry et al., 1999, Rosenzweig et al., 2001, Schmidhuber and Tubiello, 2007). Climate change may severely affect food security in developing countries because the livelihood of the majority of the poor primarily depend on agricultural sector (Von Braun, 2009). As Bogale and Shimelis (2009) mentioned, the food insecurity condition in Ethiopia may be subject to agro-climatic conditions which force the farmers to base their livelihood on marginal, heavily degraded, less productive land in moisture stress areas of the country. Regarding the effect of climate on Ethiopian rural household food security, applying a fixed effects instrumental variable technique, Demeke et al. (2011) have shown that climate variability is an important determinant of food insecurity in Ethiopia. The mean rainfall at main rainy season is found to be positively associated with food security over time. Hence, Demeke et al. (2011) suggest that, unless rainfall is favourable, improving the Ethiopian households food security may be difficult.

The finding of Demeke et al. (2011) also confirm that rainfall variability measured by the deviation from its long-run mean negatively affects the food security condition of the household in the country. Using entirely different approach (bio-economic model), Holden and Shiferaw (2004) found that, drought has both direct and indirect effect on the Ethiopian households welfare and food security. The direct effect they mentioned is the effect of drought via production effect; whereas, the indirect effects are the effect of drought through livestock and crop prices. In addition to climate variability as a determinant of food security, Demeke et al. (2011) also identified other determinants of household food security over time. They identified; *household size, age, off-farm income, credit, fertilizer use, livestock ownership, and participation in local savings groups* as other important factors determining Ethiopian household food security. According to their finding, except *credit,* all these factors affect food security positively.

Another most recent study on determinants of Ethiopian household food security is a study by Hussein and Janekarnkij ( 2013). The study focused on identifying determinants of rural household food security, particularly in Jigjiga district of the country. The study used a stratified sampling technique to collect data from 160 rural households. A cross-sectional regression model; a binary Logit, was used for the empirical analysis. Hussein and Janekarnkij ( 2013), finally revealed that 37% of the sample households in the study area were food insecure, while the remaining 63% of the households were food secure. Among the factors hypothesised and included in the analysis, Hussein and Janekarnkij ( 2013) found; fertilizer use, total household income, extension service, veterinary service, and access to credit as positive determinants food security. They found, agro-ecology as negatively related to the household food security. Similarly, using a binary Logit for cross-sectional data collected from 115 sample households, Bogale and Shimelis (2009) assessed factors that influence food security of rural households of Dire Dawa regional administration. Bogale and Shimelis (2009),indicated that among the thirteen variables hypothesized to influence household food security, only seven variables are important determinants of food security. Among these variables; farm size, annual income, access to irrigation, amount of credit received, livestock resource, family size and age of household head are significant determinants of food security.

By using a cross-sectional data collected from 247 sample households in Southern Ethiopia, Feleke et al. (2005) also identified number of food security determinants in the Ethiopian households' context. In a slightly different approach to the above mentioned studies, Feleke et al. (2005) defined the indicator of food security by calorie availability and consumption needs of calories. Accordingly, Feleke et al. (2005) determined households food security by the difference between calorie availabilities and needs. Feleke et al. (2005), identified among the nine proposed factors included in the logistic regression model; farming system, technological adoption, farm size, household size, per capita aggregate production, land quality, and access to market as determinants of household food security.

Both Bogale and Shimelis (2009) and Feleke et al. (2005) have found a positive effect of *livestock resource ownership* and *total cultivated land* in a given year. However, Bogale and Shimelis (2009) estimated that number of dependency ratio and oxen owned have inconsistent effect on household food security. Moreover, estimated coefficients of total off-farm income, sex of household head, education of the head and amount of food aid received in a given year were found to be statistically insignificant in determining household level food insecurity. The findings by Bogale and Shimelis (2009) finally revelled that improvement in food security requires building assets, improving the functioning of rural financial markets, and promoting family planning. Based on the data collected from a sample of 108 households from *Koredegaga* Peasant Association (PA) of Oromia region, Kidane et al. (2005) also examined the determinants of households food security. Kidane et al. (2005), included eleven variables in their analysis and found six variables namely; farm size, ox ownership, fertilizer application, education level of household heads, household size, and per capita production as important determinants of food security. One additional thing Kidane et al. (2005) conducted was to simulate food security determinants. The simulations were conducted on the basis of the base category of farmers, which represent food secure households the simulation result revealed that both educational levels of household heads and fertilizer application have relatively high potential following improvements in these factors.

Giving important focus on the role of livestock in determining the food security of smallholders, Kassa et al. (2002) carried out a study in 1999/2000; in the Harar Highlands of Eastern Ethiopia. They first ranked the households into poor, medium, and well-to-do categories by a well-being instrument. The instrument was developed on the basis of community level data and the energy content of the food consumed by a farm family was used as proxy indicators for household food balance. Kassa et al. (2002), generally found that livestock production accounted for about one-fourth of the total food produced by livestock rearing households. Poor with little livestock ownership were not food self-sufficient. It was also revealed that, the poor category was found to have a food supply of 15% below the adequacy level. As Kassa et al. (2002) finally confirmed, livestock accounted for 27% of the total household energy supply. For the poor-group, according to their findings, livestock contributed only 2% of the total household energy supply.

Finally, it is important to make some remarks from the studies on determinants of Ethiopian households food security we introduced above. The summary of the key findings of the studies is given in Table 1. Though various key determinants have been suggested by different studies; factors related to *Human Capital endowments* such as education level, age, and family size are most widely suggested determinants of Ethiopian household food security. Moreover, *physical capital* and *Financial Capital* endowments such as; access to credit, farm size, access to irrigation, livestock resource, amount of credit received, and off-farm income of a household are among the most widely suggested determinants. For instance; from the studies we introduced above; Bogale and Shimelis (2009); Feleke et al. (2005); Kidane et al. (2005); and Kassa et al. (2002), found a negative impact of number of family members in a given household; except Demeke et al. (2011), who found negative effect of family size. *Financial capital endowments* are also found to be basic determinants of the farm households of Ethiopia.

Among the thirteen variables hypothesized to influence household food security Bogale and Shimelis (2009) indicated that, *physical capital endowments* such as; farm size, annual income, access to irrigation, amount of credit received, and livestock resource as important determinants of food security. On top of these they found that, *Human capital endowments* such as; family size and age of household head are significant determinants of food security.

*Table 1: Summary of major findings on determinants of households food security*

| *Author (s)* | **Determinants of food security** | | | | | **Study design** | |
|---|---|---|---|---|---|---|---|
| | **Human Capital** | **Physical Capital** | **Financial Capital** | **Social Capital** | **Natural Capital** | **Cross-sectional** | **Panel** |
| Bogale and Shimelis (2009) | Age of the HH (+)<br>Family size (-) | Land (+)<br>Livestock Holding (+)<br>Use of irrigation (+) | Credit (+) Income (+) | | | √ | |
| Hussein and Janekarnkij ( 2013) | Extension service (+) | Livestock Holding (+)<br>Fertilizer use (+)<br>Veterinary service (+) | Income (+)<br>Access to credit (+) | | Agro-ecology (-) | √ | |
| Demeke et al. (2011) | Household size (+)<br>Age (+) | Livestock Holding (+)<br>Fertilizer (+) | Credit (-)<br>Off-farm income (+) | Savings group (+) | Mean rainfall (+)<br>Rainfall variability (-) | | √ |
| Holden and Shiferaw (2004) | | | | | Drought(-) | | |
| Feleke et al. (2005) | Technology adoption (+)<br>Household size (-) | Livestock Holding (+)<br>Farm size(+) | Off-farm jobs (+)<br>Per capita production(-) | | Land quality (+) | √ | |
| Kidane et al. (2005) | Household size (-)<br>Education(+) | Farmland size (+)<br>Ox ownership (+)<br>Fertilizer (+) | Per capita production (-) | | | | |
| Kassa et al. (2002) | | Livestock Holding (+) | | | | | |

# 3. RESEARCH METHODOLOGY AND DATA

This section gives some overview of the future of the study area; define variables of interest, such as climate shock and food security. The subsequent sub-sections also discuss the study design, data source we have relied on, an appropriate econometric model we applied, followed by definitions and hypothesis of other control variables hypothesized to determine food security in the study area.

## 3.1. Description of the Study Area

The description in this section is based on data collected from different sources; World Development bank (World-Bank, 2013), Central Statistical Authority (*CSA*) of Ethiopia, and many others.

### 3.1.1. Physical Characteristics

The study area, the Federal Democratic Republic of Ethiopia (FDRE), is a landlocked country in the horn of Africa, specifically located in East Africa. The country borders Eritrea to the North, Djibouti and Somalia to the East, Kenya to the South, and Sudan to the west. The country is a home to more than 90 million people speaking more than 80 languages. Geographically, the country lies within the tropics between 3°24` and 14°53` North; and 32°42′ and 48°12′ East (Mengistu, 2003). It comprises nine regional states, one City Council, and one City Administration. Regarding the agroclimatic conditions of the country, climatic heterogeneity is a general characteristic of the country. For it is located near the equator and with an extensive altitude range, the country has a wide range of climatic features suitable for different agricultural production systems. However; climatic elements, such as temperature, precipitation, humidity, wind, and sunshine are affected by geographic altitude and location in the country (Mengistu, 2003). The country covers 1,127,127 $km^2$ and it is geologically active with Great *Rift Valley* susceptible to earthquakes, volcanic eruptions, and frequent droughts. The climate of the country is temperate on the plateau, while it ranges from extremely hot to moderately hot in the lowlands (Corti, 2013). At the capital, Addis Ababa, which ranges from 2,200 to 2,600 meters above sea level (m.a.s.l), maximum temperature is 26°C and minimum 4°C (Corti, 2013). Though some of the regions in the country (e.g. Somali and Harari regions) are characterized by having only a few hills and the dominantly level topography, most of the regions in the country have agriculturally unsuitable land in terms of mechanization.

Some regions have low soil fertility, in line with drought, rainfall shortage and irregularity in a given season. Rainfall has been a major limiting factor in agricultural production in the country. The climate of Ethiopia and its neighboring countries varies greatly· Because of Ethiopia's location in the tropics and its diverse topography, rainfall and temperature patterns vary widely. In general, the highlands above 1,500 m.a.s.l, enjoy relatively conducive (temperate) climate. The daytime temperatures of the highlands range between 16°C and 30°C with cool nights (Rosenberg, 2014). Relatively, the highlands of the country receive the most rainfall in a year. In areas below 1,500 m.a.s.l, daytime temperatures range from 30°C to 50°C (Rosenberg, 2014).

### 3.1.2. Agricultural Production and Natural Resource Endowments

Agriculture is considered as a backbone of the country as it plays an important role in economic development. The sector is also the livelihood of the overwhelming majority of Ethiopians. Three major crops are believed to have originated in Ethiopia: coffee, grain sorghum, and castor bean. Despite recurrent droughts and declining natural resources which made poverty a common problem, Ethiopia is naturally endowed. The country has small reserves of gold, platinum, copper, potash, natural gas, and hydropower. In the main agricultural regions in Ethiopia, there are two rainy seasons; *Belg* and *Meher* seasons. The commonly used cropping system is a double cropping system in which crops are grown in the two seasons in a year. Meher is the main cropping season, which encompasses crops harvested between *Meskerem* (September) and *Yeaktit* (February). Whereas, crops harvested between *Megabit* (March) and *Nehase* (August) are considered as Belg season crops (Barrett, 2002). This cropping system is characterized by bi-modal nature of the rainfall distribution. Some of the major lowland crops grown in the country are maize, haricot bean, *Teff*, sweet potato, potato, *Enset*, coffee, chat, and pepper. There are both state owned and private farms, however; small private farms are the major sources of crop production in most regions of the country. In most of the regions, farmers mainly use systems of multiple cropping to maximize production per unit area due to land shortage. Given the land shortage, mixed-cropping is usually practiced in most parts of the country so that yield per area can be maximized.

### 3.1.3. Demographic Characteristics

Ethiopia is one of the most populous countries in Africa having an estimated population of about 91.73 million in 2012 with an average annual growth rate of 2.6% (World-Bank, 2013). The death rate and birth rate were 8.1% and 34.1%, respectively, in 2012. If we go about ten years back, 2002, the population growth rate was 3.4% which shows that population growth rate is decreasing in recent years. However, the total population increased from 69.95 million in 2002 to 91.73 million in 2012. Out of this total population, the rural population is about 82.7%, whereas the rest (17.3%) is the urban population. The male to female ratio was 1 in 2012; this implies that the

50% of the population is female. It generally suggests, though population growth rate decreases, the total population is increasing year to year (World-Bank, 2013).

## 3.2. Study Design and Data

### 3.2.1. Study design and data source

Panel data are usually preferred as they are suitable to model or explain why individual units behave differently. According to Verbeek (2008), panel data have a number of advantages over cross-sectional as well as time series data. Some of these advantages are; panel data enable separation of time and individual's heterogeneity effects (i.e. separation of variations *within individual* and *between individuals*). Using panel data, a problem of potential omitted variable bias is minimal since we include unit specific effects in the models. Moreover, a panel is expected to yield even more efficient estimators than using a series of cross-sectional data. Unlike time series or cross-sectional data, using panel data we do not fail to identify certain parameters which basically require restrictive assumptions (Semykina and Wooldridge, 2010). Hence, using panel data one gets a chance to model why a given unit behaves differently at different time periods. Bearing these advantages in mind, we used a longitudinal household data collected from rural households of Ethiopia in different time periods.

Our data are drawn from the Ethiopia Rural Household Survey (ERHS), a longitudinal household dataset collected in seven survey rounds from 1989-2009 in 15 rural Ethiopian villages. The Data collection was conducted with supervision of Economics Department of Addis Ababa University (AAU), Centre for the Study of African Economies (CSAE), University of Oxford (UK), and the International Food Policy Research Institute (IFPRI), in order to study the response of rural households to food crises in Ethiopia (Dercon and Hoddinott, 2004). The dataset contains information on food consumption per capita and different shock indicators. Moreover, the ERHS dataset includes various household demographic information and many other household characteristics which we used as control variables.

### 3.2.2. Sampling Frame and Sample Size

Generally, ERHS data were collected using a stratified sampling technique on the main agroecological zones (excluding pastoral and urban areas) of the country. The village sample sizes were chosen to generate an approximate self-weighting sample in terms of farming system (Dercon and Hoddinott, 2004). In 1989, IFPRI conducted a survey in seven Peasant Associations (PAs) located in the regions; Amhara, Oromiya and the Southern Ethiopian. In this year, civil conflict prevented survey work from being undertaken in Tigray region. About 450 households were randomly selected within each PA and were asked to give information about their food and non-food consumptions, asset ownership, and income.

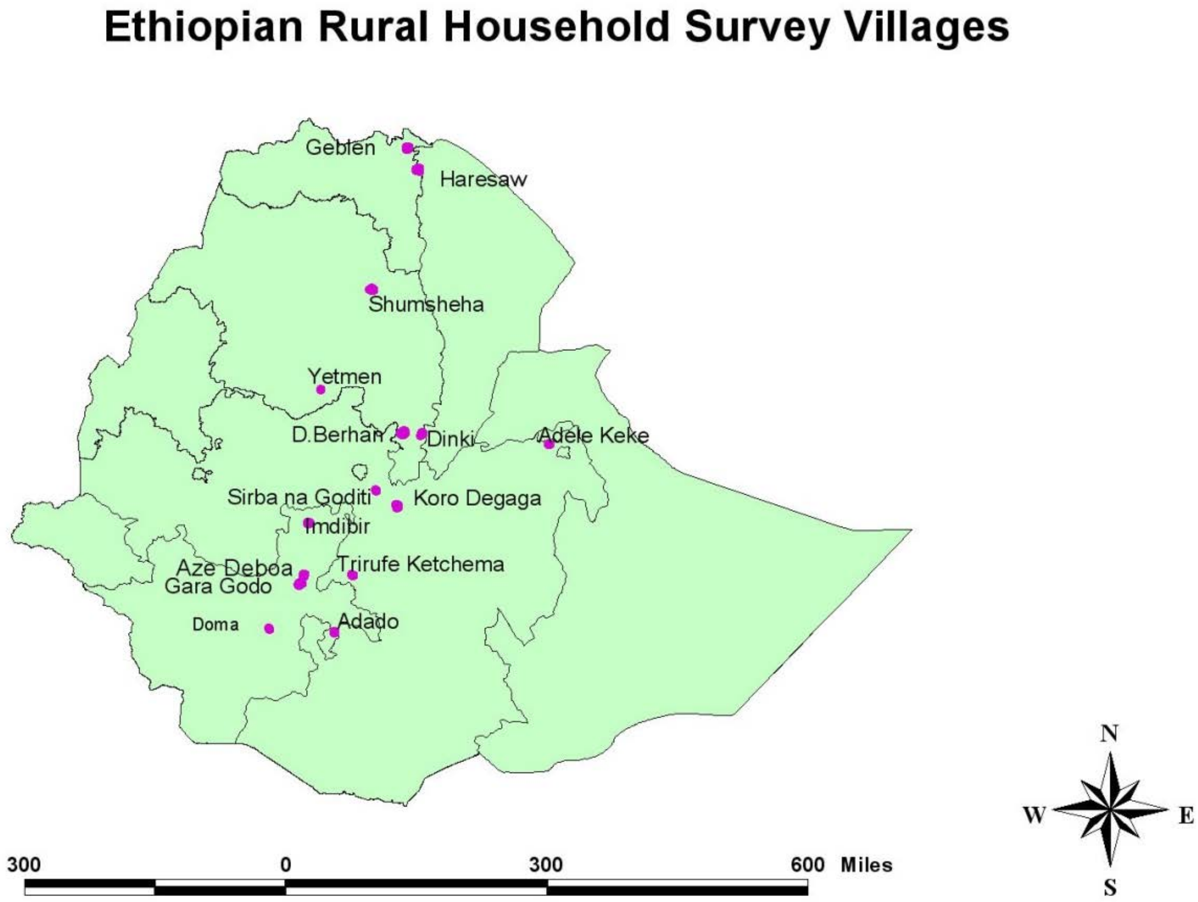


*Figure 2: Map of the study area; source: Dercon and Hoddinott (2004)*

The PAs selected were mainly areas that had suffered from the 1984-1985 famine and other droughts that followed between 1987 and 1989. In 1994, CSAE and department of Economics of AAU started a panel survey incorporating Tigray region and six of the seven villages earlier surveyed in 1989 by IFPRI (Dercon and Hoddinott, 2004). In addition to the villages visited in 1989, nine new villages were selected giving a total sample of 1477 households. According to Dercon and Hoddinott (2004), the nine additional communities were selected to account for the diversity in the farming systems in the country. The survey also included the grain-plough areas of the Northern and Central highlands, the *Enset*[3]-growing areas and the sorghum-hoe areas of the country. Figure 2 shows the map of the country including list of regions, *Woreda* and PA's included in the survey.

We used a part of these longitudinal household survey data over a period of 1994-2009. So as to keep the panel nature of the data, we allowed for even time spacing,

---

[3] Enset *(sientifically known as Ensete ventricosum)* is a drought resistant food crop indigenous to Ethiopia; particularly Southern Ethiopia.

hence our analysis is performed only on four rounds of household panel data sets which are spaced five years apart. That is, we utilized the first (1994a)[4], the fifth (1999), the sixth (2004), and the seventh (2009), rounds of the survey.

## 3.3. Econometric Model and Specification Tests

Before describing and defining the variables we used in this study, it is worthwhile mentioning the econometric technique we applied to study the linear causal relationship between our dependent and independent variables.

### 3.3.1. Panel Data Models

The general Ordinary Least Square (OLS) linear regression technique is the most widely applied technique to estimate cross-sectional relationships. In cross-sectional models, an outcome variable is treated as a function of other explanatory variables across individuals. In contrast to this, in panel data, an outcome variable of an individual $i$ at time $t$, is a function of explanatory variables across individuals over time. Given longitudinal data, there are two versions of linear regression models prominent candidates for a panel dataset. They are the Fixed Effects (FE) and the Random Effects (RE) models. These models are chosen in most cases as they provide a better control for the influence of missing or unobserved variables (Verbeek, 2008). Moreover, these models are able to account for intertemporal as well as individual differences among our units of analysis. Verbeek (2008), suggested the following simple panel data model (equation 1):

$$\boldsymbol{Y_{it} = \alpha_i + \beta X'_{it} + \varepsilon_{it}} \quad \text{--------------------------------------------} \quad (1)$$

where: $Y_{it}$ is a dependent variable observed for unit $i$ at time $t$, $X_{it}$ is a $k$-dimensional vector of explanatory variables for unit $i$ at time $t$, $\beta$ is a vector of coefficients to be estimated, $\alpha_i$ denotes unobserved unit specific effects which are assumed to be fixed over time and vary across unit $i$, whereas $\varepsilon_{it}$ is the disturbance term.

In the standard case, $\varepsilon_{it}$ is assumed to be independent and identically distributed over individuals and time, with mean zero and variance $\sigma_\varepsilon^2$. If we treat the $\alpha_i$ as $N$ fixed unknown parameters, the model in equation 1 is referred to as the standard FE model. The FE model is simply a linear regression model in which the intercept terms vary over the individual units $i$. *"An alternative approach assumes that the intercepts of the individuals are different but that they can be treated as drawings from a distribution with mean $\mu$ and variance $\sigma_\alpha^2$"* (Verbeek, 2008 p.342). The idea essentially centres on the assumption that the intercepts are independent of the explanatory

[4] Note that the dataset contains two different rounds in 1994 (1994a and 1994b) of which we used the first round, 1994a which keeps the even time spacing better than 1994b.

variables in $X_{it}$. This leads to the RE model, where the individual specific effects, $\alpha_i$, are treated as a component of the random term. Therefore; whether to use FE or RE is basically based on whether to treat the individual effects, $\alpha_i$, as fixed or random. Since one has advantage over the other, identification of which one to use is not so easy as we may expect (Verbeek, 2008). For instance, when we have only a few observations for each individual unit, the most efficient use of the data we have is required. In this regard, Verbeek (2008) further argued that RE model yields a more efficient estimator than the FE, because the former exploits the within individual dimension of the data. On the other hand, when we have large number of observations, it is very important to see the heterogeneity among the observations. In such a condition, for the very nature that the FE model captures the *"within individuals"* differences, it may be preferred. However, *"the fixed effects estimator eliminates anything that is time-invariant from the model. This may be a high price to pay for allowing any of the x-variables to be correlated with the individual specific heterogeneity $\alpha_i$"* (Verbeek, 2008 p. 353).

Based on the panel data model (equation 1) we have considered the following panel data model by incorporating our variable of interest:

$$Y_{it} = \alpha_i + \gamma X'_{it} + \beta C_{it} + \varepsilon_{it} \tag{2}$$

where; $Y_{it}$ is the dependent variable (i.e. *food consumption per capita)* observed for household $i$ at time $t$, $X_{it}$ is a $k$-dimensional vector of other explanatory variables (various households resource endowments) for household $i$ at time t. $C_{it}$ represents a climate shock indicator for household $i$ at time $t$, while $\beta$ and $\gamma$ are parameters (coefficients) to be estimated, whereas $\alpha_i$ and $\varepsilon_{it}$ are as defined above. All the variables and terms, we mentioned here are discussed in detail in Section 3.4.

### 3.3.2. Specification and General Assumptions

*A prior* to the estimation of the model, it is worthwhile mentioning some assumptions and appropriate preliminary tests that are required to test which specification to use and which assumptions are generally met. As we have previously mentioned, it is important first to test whether to use FE or RE panel data model. Thus it is first required to conduct a Hausman specification test (a general *Hausman test)*[5] to test whether the FE or RE estimator is appropriate.

[5] *"Hausman (1978) has suggested a test for the null hypothesis that $x_{it}$ and $\alpha_i$ are uncorrelated. The general idea of a Hausman test is that two estimators are compared one which is consistent under both the null and alternative hypothesis and one which is consistent (and typically efficient) under the null hypothesis only. A significant difference between the two estimators indicates that the null hypothesis is unlikely to hold"* (Verbeek, 2008 pp. 351-352)

Moreover; linear regression models have some basic assumptions, hence before estimating the linear regression model it is important to check for these assumptions. What follows the Hausman specification test is an identification of appropriate explanatory variables to be included in the model. Some of the serious problems with the identification of variables to be included in a regression model is an assumption that, there should not be serial correlations (*no perfect multicollinearity*) among the explanatory variables. The problem is that, as the variables become highly correlated, it becomes more and more difficult to determine which variable is actually explaining the dependent variable (Gujarati and Porter, 1999). Thus we also conduct a *collinearity diagnostics test*, the variables included in the model before we include them in the regression. Another linear regression model assumption is; there should be constant variance of the error term across observations (i.e. the variance of the error term should be *homoscedastic*). Therefore; we also conduct a test to detect whether the variance of the residuals is *homeskedastic* in the specified model. Above all, one important assumption we are supposed to test is that, the error terms in the linear regression model should be uncorrelated with the explanatory variables (*exogenous* explanatory variables or "*no endogeneity"*)[6]. If this assumption is violated, our model may suffer from endogeneity problem. Endogeneity is one of the most major challenges in econometric analysis. In the presence of endogeneity the OLS estimator will no longer be unbiased and consistent (Verbeek, 2008).

In our model (equation 2) endogeneity may be a problem due to the endogenous nature of some of the explanatory variables. Compared to RE model, in a FE model a problem of endogeneity related to individual specific characteristics, $\alpha_i$, is eliminated because the model separates the individual specific characteristics from the random disturbance term or error component (Verbeek, 2008). However, in both FE and RE models, the endogeneity problem related to the error component, $\varepsilon_{it}$, should still be paid an attention. In this case, a *General Method of Moments (GMM)* estimator which is unbiased and consistent in the presence of any endogenous regressor is suggested (e.g. Griliches and Hausman, 1986, Verbeek, 2008). GMM requires applying an instrumental variable *(IV)*[7] regression procedure. In many cases, panel data provide *internal instruments* for regressors that are endogenous or subject to measurement error. According to Verbeek (2008) p. 345, *"transformations of the original variables can often be argued to be uncorrelated with the model's error term and correlated with the explanatory variables themselves and no external instruments are needed."* Following this argument, for the variables with endogenous nature we used their lagged values as

[6] From a textbook context, endogeneity is a quite straightforward concept. The problem exists when the error distribution fails to be independent of the explanatory variables' distribution. Some examples of such situations are; the presence of a lagged dependent variable and autocorrelation in the error term, measurement errors in the regressors, and simultaneity/**endogeneity** of regressors (Verbeek, 2008).

[7] An instrumental variable is a variable that is correlated with the explanatory variables in the system, but uncorrelated with the error term.

instruments. "*It is clear that once one has a time series and one is willing to assume that errors of measurement are serially uncorrelated then one can use lagged values of the relevant variables as instruments*" (Griliches and Hausman, 1986 p. 94). With respect to climate shocks, we assumed strict exogeneity since by their nature, weather shocks; such as *drough*t are kinds of *covariate shock* which affect all households in the village rather than a single household alone. Thus, we do not expect climate shock to be endogenous as it is not majorly influenced by individual household's decisions.

### 3.4. Definition of Variables and Hypotheses

The model under equation (2) involves both dependent variable (food security indicator) and different explanatory variables likely to affect Ethiopian household food security. This section introduces the food security indicator we used and the explanatory variables expected to determine food security in the study area, followed by our *prior* expectations about their relationship with food security.

#### 3.4.1. Dependent Variable

We have indicated in equation (2) that our dependent variable is food security. As our discussion in section 2.1.*3* shows that *food expenditure per capita* encompasses the access and availability components of food security, hence suggested by Haddad et al. (1994). Following this suggestion, in the present study, we used *monthly food expenditure per capita* as a measure of food security in the context of rural Ethiopian households. We would have used the consumption expenditure in real terms, however, due to the absence of relaible food price index, we did not deflate the varible. To account for the potential effect of inflation trend, we used a series of time and region dummies which we introduce earlier in this section. As factors determining food consumption per capita, this study included variables from a pool of variables identified based on the Sustainable Livelihood Framework (SLF) context. The specification used in equation 2 allows controlling for household's resource endowments as potential determinants of household food security. Under the five broad categories of the household's resource endowments or "*poverty reducing factors*" as of DFID (1999), we included various variables linking food security to *human capital, physical capital, natural capital, social and Financial capital endowments.* The following sub-sections give descriptions of these variables and our prior expectations about their relationship with food security.

#### 3.4.2. Climate Shock Indicators

Given that people's livelihoods and the assets availability are fundamentally affected by shocks (DFID, 1999), it is important to analyse the effect of climate variability on households food security. In equation (2), a climate shock variable, $C_{it}$, for household *i* at time t is an ordinal variable representing whether the household experienced a particular type of climate shock, atleast once in a given year over a period of 1994-2009. Based on the available data, we have identified the most important climate shock indicators *prior* to our analysis. Based on our general hypothesis stated in *section 2.4* that *"households with better position in household's resource endowments are more food secured than their counterparts",* we hypothesized negative effect of climate shock on household food security. As climate shock is one of the natural processes that destroy households *Natural capital endowments*, it is assumed that such shocks worsen the natural capital endowments' position of the households.

### 3.4.3. Other Explanatory Variables

To control for potential omitted variable biases and to identify important time invariant determinants of household food security, this study included some control variables from a pool of variables identified based on the SLF context (section 2.4) and the socioeconomic conditions of the study area. The central question for empirical economics is which explanatory variables to include and which to exclude. For instance, if we exclude some important variables from our regression model, the regression may result in potential omitted variables bias. Therefore, in econometric analysis, we should use control variables to see the clear and robust effect of our interest variable. If we simply look at the bivariate causal relations, we may find a strong relationship between the two variables which may be meaningless for the fact that another variable might drive the result. If we do not take those deriving factors into account, we may get completely spurious regression.

The specification used in equation 2 allows controlling for household's resource endowments as potential determinants of household food security. Based on the SLF, the following specific variables are expected to be potential determinants of food security. In addition to climate shock indicator which captures the availability of *natural capital endowments* we used different variables representing households' resource endowments. The *human capital* factors we used include; Gender, Age, Education, and Household size, whereas, ownership of Livestock, and Land represents *physical (natural)*[8] *capital;* are expected to be important determinants of food security. In our regression model, we have also included a Membership in Savings organization as *social capital endowment* whereas; Off-farm employment and use of Credit as *Financial capital endowments.* Though our general hypothesis stated in *section 2.4* indicates our expectation that, *"households with better position in household's resource endowments are more food secured than their counterparts",* it did not indicate

[8] NB: Land and Livestock can be considered either as physical or natural capita endowments for the fact that sometimes they can be improved in such a way that the farmer increases their productivity (capture physical dimension) thereby increase agricultural production.

our expectations about the specific factors under the five categories. Below we have defined and hypothesized all explanatory variables included in our model.

### 1) Gender

According to Gittinger et al. (1990), as a result of cultural factors and bad policies, women own the least property right and hence have the poorest nutritional status. In most of the rural areas of developing countries, the households headed by females are worsen due to lower access to resources, including the labour (Gittinger et al., 1990). For instance, in most rural areas of Ethiopia, female becomes a head of a given household only in some exceptional situations; when the male household head dies, when a male has more than one wives, or in the case of divorce. In such situations the women leave with limited resources; such as land, livestock and other productive assets (Demeke et al., 2011). In general, given limited access to resources and lack of enough experience in managerial decisions, it is expected that the female-headed households may have lesser bargaining power. Therefore; we anticipate our dummy variable taking a value of 1, if the household is male-headed and 0; otherwise, to have a positive effect on food security status.

### 2) Education of the household head

Education is used as a proxy variable for managerial ability of the decision making unit (farmer). *"Education, broadly defined as 'all deliberate learning activities', is usually used as an approximation to human capital"* (Asfaw and Admassie, 2004 p. 215). It is assumed that, through education the quality of labor is improved and he/she becomes active to adopt new technologies. Access to education together with increased experience could guide to better management of farm activities. The better managerial ability of the farm household head in turn indicates better position in human capital endowment. Moreover; by improving the level of production, education provides substantial externality benefits since formally educated farmers may take the initiative in adoption of new technologies (Weir and Knight, 2000). Therefore, education of the household head taking a value of one if the farmer is literate and zero; otherwise; is hypothesized to affect food security positively.

### 3) Age of a household head

Age of the household head measured in years is assumed as a proxy measure of farming experience, which in turn represents a better position in human capital. The more farming experience the farmer gets; he/she becomes proficient in the methods of production and optimal resource allocation which in turn improves food availability in the household. It is assumed that young farmers lack experience of farming, whereas relatively old farmers could have enough experience on farm activities, technology adoption or risk aversion. Thus, as the age of the farmer increases the food security of the household may get better. Hence, we hypothesize that head's age affects food security positively. Though relatively old farmers could have enough experience on farm activities and technology adoption, as the household head gets older and older, age may have a diminishing effect on managerial ability. To account for the diminishing effect of age, we used the squared term of age as another explanatory variable. We anticipate that ***age squared*** affects food security negatively since as the age of the farmer increases beyond certain limit the labor participation rate and managerial skill of the household head decreases.

### 4) Household size and Dependency ratio

In smallholders' agriculture, it is evident that family members are the major sources of labor force for agricultural production. This combined with quality education and training may broadly represent *Human capital endowment*. Besides labor participation, household members are the primary consumers of the agricultural products. In the case when a family is majorly composed of children, the production contribution on participating in most farming activities may be outweighed by the consumption effect. Haddad et al. (1992), indicated that it is difficult to assess the impact of household size without some knowledge of composition of the household. Households composed of larger numbers of children with age of < 15 and very older members; of age > 65, will suffer from labour shortages relative to the household composed of individuals aged between 15 and 65 (Haddad et al., 1992). Thus, it is expected that households with many family members under the middle/working age category may have an advantage particularly during peak production periods. On the other hand, consumption effect may be bigger in the case when the majority of the family members are not economically active (i.e., aged <15 and >65). In one way or another, total family size may have an effect on food security, however its direction may not be decided beforehand since we fail to clearly anticipate whether consumption or production effect outweigh. In order to see these two effects separately, we have also included Dependency *ratio* as another explanatory variable. A dependency ratio measures the proportion of economically non-productive (total family members aged between 0 to 14 and > 65) to those who are economically productive (family members aged between 15 and 65).

### 5) Livestock Ownership

This variable is also entered our model as a proxy variable for the availability of *physical capital* for the household. As they help intensify and diversify production, livestock are very important components of the farming system, and reduce potential risk and vulnerability (Kassa et al., 2002). However, livestock production activities can also be competitive with crop husbandry in the case when they compete for different resources; such as land, labor and managerial skill, where these resources are scarce. In this case, we may argue that the size of livestock has a positive association with food insecurity. However, livestock are reared for various production objectives; such as milk, meat, power, hide, and play an important role in converting non-utilized plant products into food (Kassa et al., 2002), the complimentary effect may be expected to outweigh their competing effect. Besides agricultural work, cattle can also be used for pulling carts to carry wood and water from one place to the other, among other different transport duties (Barrett, 1992). Considering all these contributions, in the present study, we hypothesized that the size of livestock ownership measured in Tropical Livestock Units (TLU)[9] has a positive impact on food security.

### 6) Land holding

It is important to evaluate whether relatively large holder farmers are more food secured than small holders. Total land owned, in hectares, is expected to determine the yield differential among farmers in the study area. As large farmers have the capacity to use compatible technologies that could increase the yield, relatively large farmers in the area are expected to get more access to food hence may be more food secured than the small holders. Among the basic physical resource endowments, land plays a vital role in agricultural production hence determines household food availability. Given this fact, we clearly anticipate a positive effect of farm size on food security.

### 7) Use of Credit

To address the issues of development and food insecurity, financial capital plays a vital role. Use of credit (a dummy variable that takes a value of 1, if any of the household members has borrowed money for production purpose and 0; otherwise) represents a *Financial capital endowment* or household wealth. There is wide consensus that financial credit play an important role in smoothing consumption and relaxing a short-term financial liquidity, thereby improving household food security (Demeke et al., 2011). Therefore, we anticipate the use of credit to have a positive influence on food security because it enables farmers apply more inputs by easing short term liquidity constraints, thereby influencing food production.

### 8) Off-farm employment

Ethiopian agriculture does not provide sufficient employment for the increasing number of rural job seekers, though it plays a vital role in enhancing the country's economic growth (Van Den Berg and Kumbi, 2006). Therefore, it is common to

[9] One TLU is about 250 kg live weight of livestock **(Bogale and Shimelis, 2009)**

supplement farm income with non-farm income in the country. Off/non-farm activities can supplement the agricultural activities in terms of providing cash income thereby purchase necessary inputs timely. This effect, may increase the farm output and hence food availability by solving short-term liquidity constraint. Moreover, as the household gets more cash the purchasing power increases, which in turn increases a level of food consumption. To capture the effect of income the household gets from different activities outside his farm in the production period, we entered a dummy variable having a value of 1 if the household earns off-farm income, and 0; otherwise as another control variable in our model. It is hypothesized that a farmer engaged in off/non-farm activities may be more food secured than his/her counterpart as off-farm income improves the *Financial capital* position of the household. Though, this income may affect production activity negatively when there is less time allocation for crop production management practices, it is usually assumed that farmers tend to work off/non-farm only when there is more time available off-farm.

### 9) Membership in Savings group (*Equb*)[10]

This is a dummy variable that represents participation in traditional revolving saving and credit associations. We used the variable as a proxy for *Social capital endowment.* The variable takes a value of 1, if any of the household members is a member of local credit and saving associations and 0; otherwise. According to Demeke et al. (2011), when a household becomes a member of traditional saving and credit associations he/she gets better position in social as well as financial capital endowments which in turn reduce potential household liquidity problems. As a result, the household is expected to be in better food security position. The involvement in these associations may have a positive impact in improving the purchasing power of the household head by relaxing the short-term liquidity. Moreover, it motivates farmers to organize themselves as a group for sustainable production and income generation which in turn capacitates the farmers financially (Demeke et al., 2011). Therefore, participation in traditional revolving saving and credit associations is hypothesized to have a positive impact on food security.

### 10) Time and Region dummies

In our regression, we also introduced different dummies to control for any time and region specific changes which may result in potential omitted variable biases. As we mentioned earlier, we used the consumption expenditure in nominal terms due to

[10] *In Ethiopia,* ***Equb*** *is a traditional voluntary saving association in which members form a group and contribute a fixed amount of money usually in monthly or weekly basis. Finally, the money will be collected together and paid back to an individual who will be selected in lottery bases. The process continues until every member gets totally amount of money turn by turn.*

absence of reliable data for food price index. Therfore, we used the dummies to account partly for the potential effect of inflation trends. We introduced three year dummies for the four survey rounds and five month dummies for six different months of the interview. We included different interview months as dummies basically due to the fact that there may be sudden shifts in household food consumption due to seasonality. For instance, a household may consume more food during the pick harvesting month or consumption of particular foods may be affected during some sorts of festivities; such as religious, wedding, funeral... etc. Therefore, dummies for interview months were included to control for any potential seasonality problem with respect to food consumption. To control for region specific variations, we also included five region dummies in our regression model for a total of six regions included in the study. We introduced the region dummies to control for unobservable spatial differences in food consumption (and all other factors, such as inflation trend) across regions.

# 4. DESCRIPTIVE RESULTS

So far, appropriate models together with variables that are hypothesized to determine household food security were specified. The following sections devoted to a brief description of the socioeconomic and farm-specific variables using appropriate descriptive statistics.

## 4.1. Food Security and Climate Shocks

The ERHS dataset includes number of climate related information, such as too much rain or flooding, soil erosion, occurrence of pests or diseases, drought, and occurrence of frost or hailstorm. Some of these indicators, for example; pests or diseases and soil erosion may occur more frequently because of certain weather, but they may not be exclusively linked to climate variability. Therefore, we selected purely covariate shocks, such as occurrences of *Drought, Flooding,* and *Frost/Hailstorm* as climate shock indicators. Table 2 summaries the survey result based on the household's recall of extreme events. The summary gives some overview of the relationship between per capita food consumption and climate shock indicators (such as occurrence of *Drought, Flooding, and Frost/Hailstorm)*. As the summary result indicates, only about 2% of the sample households faced drought early in 1994 (table 2). The number of the households experienced drought increased a bit in the year 1999 and 2004. Out of the sample households, 18% and 21% suffered from extreme drought in 1999 and 2004, respectively.

As the survey result further shows, the two other climate shocks; *flooding* and *Frost/Hailstorm* are not common shocks in the Ethiopian context. As summarized in table 2, only about 0.02% of the sample households faced an extreme frost/hailstorm early in 1994. Though the number of the households faced this extreme shock increased a bit in year 2004 (was about 8%), it remarkably dropped to 1.80% in 2009. If we compare the result across the years, except for the first and last rounds, in the rest of the rounds there is no clear difference between the two groups with respect to *mean per capita food consumption*. To see whether the overall mean difference between the two groups is statistically significant in the entire panel, we conducted an independent samples t-test. The result of the independent samples t-test (with a t-value of 0.89 and a p-value = 0.37) doesn't show that the mean difference of the two groups is statistically significant with respect to mean *per capita food consumption*. Regarding extreme flooding, out of the sample households, only 0.5% and 3% suffered from extreme flooding in 1994 and 1999, respectively. Though remarkably increased to 10% in 2004, it was dropped to 3% in 2009.

*Table 2: Relationship between food security and climate shocks*

| Climate shock | 1994 Number of HH head | 1994 Mean food consumption per capita | 1999 Number of HH head | 1999 Mean food consumption per capita | 2004 Number of HH head | 2004 Mean food consumption per capita | 2009 Number of HH head | 2009 Mean food consumption per capita |
|---|---|---|---|---|---|---|---|---|
| **Drought** | | | | | | | | |
| Yes | 24 | 49.90 | 104 | 65.32 | 275 | 61.21 | 104 | 32.02 |
| | (2%) | (41.60)* | (18%) | (58.72) | (21%) | (65.50) | (8%) | (24.60) |
| No | 1253 | 52.96 | 1222 | 77.20 | 1073 | 76.91 | 1243 | 47.37 |
| | (98%) | (56.50) | (92%) | (71.75) | (79%) | (82.53) | (92%) | ( 36.40) |
| **Flooding** | | | | | | | | |
| Yes | 5 | 24.36 | 31 | 66.61 | 135 | 87.26 | 45 | 71.53 |
| | (0.5%) | (25.71) | (3%) | (66.84) | (10%) | (98.07) | (3%) | (58.86) |
| No | 1280 | 53.25 | 1302 | 76.16 | 1220 | 72.40 | 1307 | 45.26 |
| | (99.5%) | (56.21) | (97%) | (70.31) | (90%) | (77.61) | (97%) | (34.43) |
| **Frost & Hailstorm** | | | | | | | | |
| Yes | 2 | 17.72 | 12 | 72.40 | 112 | 73.20 | 24 | 39.30 |
| | (0.02%) | (11.28) | (0.03%) | (50.30) | (8%) | (80.42) | (1.80%) | (30.43) |
| No | 1276 | 53.26 | 1314 | 76.30 | 1236 | 73.70 | 1328 | 46.26 |
| | (99.80%) | ( 56.37) | (9.97%) | (71.21) | (92%) | (80.16) | (99.8%) | (35.90) |

*Source: Own computation (2014) from 1994-2009 ERHS dataset*

** all values in parenthesis, below the means, are standard deviations*

Despite our *prior* expectation that occurrences of *flood* and *Frost or Hailstorm* can be good indicators of climate shock, our descriptive result reveals that they are relevant only for very few households (table 2). Therefore, our further discussion and analysis exclude these two shock indicators and rely only on a *drought* as an important indicator of climate shock. The summary statistics reported in table 3 show the relationship between drought and *per capita food consumption* across different years for our sample households. The summary generally indicates an increasing trend in households' total food consumption over time. The total food consumption increased by about three fold in 2009 compared to that of 1994. Similarly, the average per capita food consumption increased by about fourfold in 2009 compared to 1994 (increased from 53 ETB in 1994 to 164 ETB in 2009).

*Table 3: Summary statistics for food consumption of sample households*

| | 1994 | 1999 | 2004 | 2009 |
|---|---|---|---|---|
| **Total Food consumption (ETB)**[11] | | | | |
| Number of observations | 1476 | 1447 | 1363 | 1355 |
| Mean | 268.75 | 436.40 | 421.76 | 850.67 |
| Std. dev. | 251.56 | 389.24 | 414.80 | 687.45 |
| **Per capita Food consumption (ETB)** | | | | |
| Number of observations | 1471 | 1444 | 1362 | 1352 |
| Mean | 53.14 | 88.37 | 85.34 | 164.38 |
| Std. dev. | 62.28 | 88.25 | 93.70 | 130.10 |

*Source: Own computation (2014) from 1994-2009 ERHS dataset*

As the bar graph (Figure 3) shows, the occurrence of extreme drought reduces per capita food consumption. As it is clearly shown in the graph, despite the overall fluctuation in mean consumption across years, the *per capita food consumption* is lower for sample households who faced drought in each round of the survey. Comparing the early rounds with the latter ones looks difficult for the fact that the survey was conducted based on the household recalls of shock occurrences ten years back. However, we assumed that the ability of people to recall extreme events can be very high since the impact of the shocks in a given year may persist for a long time in the family members' life. Our comparison shows that, except for the first round in which only about 2% of the sample households faced drought, in the rest of the rounds there is a remarkable difference between the two groups with respect to *mean per capita food consumption*.

When we consider the entire panel (from 1994-2009), the *mean per capita food consumption* is higher for the sample households who did not experince an extreme

[11] *Official exchange rate (in terms of USD) was 5.50, 7.94, 8.64, and 11.78 in year 1994, 199, 2004, and 2009; respectively.*

drought in a given year. The mean *per capita food consumption* for sample households who experienced extreme drought is 99.80ETB, whereas for those who did not experience drought is about 79.02ETB. We have also conducted an independent samples t-test to test whether there is a significant difference in the mean scores of *per capita food consumption* between the two groups. The result of independent samples *t-test* (t-value = 4.32 with a p-value of < 0.001), suggests that there is a significant difference between the two groups with respect to the *average capita food consumption*. The output of the two-sample t-test is reported in Appendix A1.

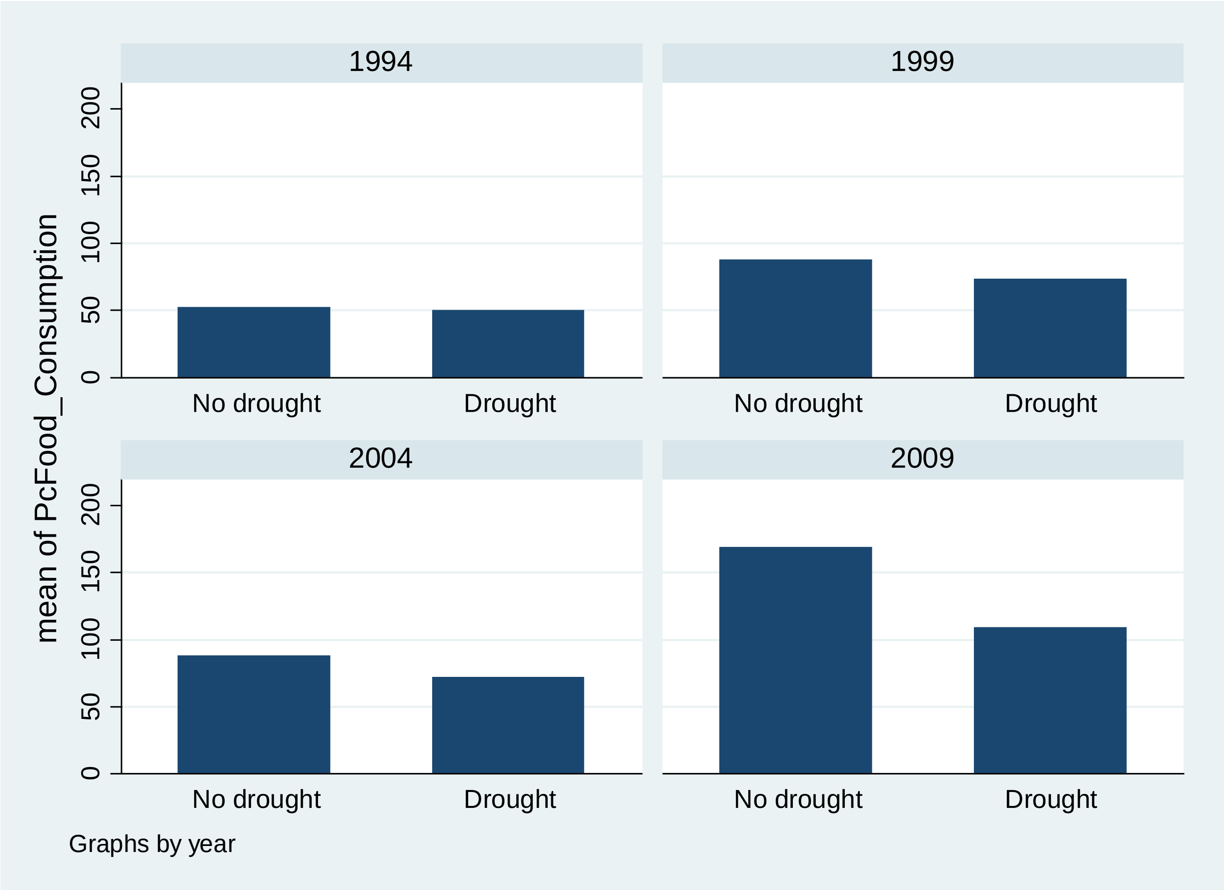


*Figure 3: Partial relationship between drought and food consumption across years*

### 4.2. Human capital

On top of the climate indicator we discussed so far, we also included different explanatory variables such as; *Gender, Age, Education*, and *Household size,* as proxies for human capital endowments. The relationship between human capital and food security indicator is described in table 4.1 and table 4.2. As the summary result in table 4.1 indicates, the number of female headed households shows an increasing trend over the panel, except for the year 2004. The proportion of male headed households increased from 22% in 1994 to 39% in 2009, while the proportion of female headed households decreased from 78% to 61% in the same years, respectively. Given the fact that males are often the head of the household in the case of rural Ethiopia, the decreasing number of male headed households over the years might have happened as a result of migration, illness, divorce or sudden death of the male heads.

No matter what the gender of the head of the household is, the ***mean food consumption per capita*** shows an increasing trend from the early rounds of the survey to the latter ones. The average monthly *per capita food consumption* for male headed households is 53, 83, 107, and 161 ETB for year 1994, 1999, 2004, and 2009; respectively. Similarly, for female headed the monthly *per capita food consumption* shows an increasing trend. On average, the food share of female headed households is a bit higher than that of the male headed counterparts. Similarly, for the entire panel (from 1994 to 2009) the *mean per capita consumption* of female headed households is higher than that of the male headed counterparts. The female headed households spend about 63.00 ETB per individual; while the male-headed households spend 59.72 ETB. We also conducted an independent-samples t-test to test whether the mean difference in per capita food consumption between male and female headed households is significantly different from zero. The test result also supports our findings summarized in table 4.1. The t-value of 6.73 (with a corresponding p-value of $< 0.001$) suggests a rejection of the null hypothesis that the mean difference between the two groups is zero. The test confirms that the main difference in per capita food consumption between the two groups is statistically insignificant with respect to *per capita food consumption*.

Regarding the literacy of the household head, it is observed from table 4.1 that illiteracy gradually decreased over the panel, while literacy relatively increased from 1994 to 2009, except a bit decrease in 1999. The proportion of the literate household heads increased from 27% in 1994 to 51% in 2009, while the proportion of illiterate households decreased from 73% to 49% in the same years, respectively. This might have happened as a result of better financial position reached by the household. For instance, the household head might have got educated *prior* to the next surveys as a result of lower consumption expenditure. This may be so, because the number of dependent family members shows decreasing trend across years. On average, the household size of the sample household decreased from 6 in 1994 to 5.6 in 2009 (table 4.2). Let alone the production effect (via labor participation), consumption expenditure may be reduced as a result of the reduced number of family members. This may be either due to members who get married and formed their own household, or family members who were dead. The maximum number of household members in the sample households decreased from 23 in 1994 to 16 in 2009 with a standard deviation of 3.1 and 2.6, respectively.

Table 4.1: Relationship between food security and demographic characteristics of the sample household heads

| | 1994 | | 1999 | | 2004 | | 2009 | |
|---|---|---|---|---|---|---|---|---|
| | ***Number of Household head*** | ***Average food consumption per capita*** | ***Number of Household head*** | ***Average food consumption per capita*** | ***Number of Household head*** | ***Average food consumption per capita*** | ***Number of HH head*** | ***Average food consumption per capita*** |
| **Gender** | | | | | | | | |
| Male | 1143(78%) | 52.84 (61.93) | 1036 (72%) | 83.31 (85.74) | 122(74%) | 107.31 (104.52) | 826(61%) | 160.96 |
| Female | 323(22%) | 54.43 (63.98) | 393(28%) | 100.64 (93.19) | 44(26%) | 101.31 (91.12) | 526(39%) | 169.75 |
| **Education** | | | | | | | | |
| Literate | 390(27%) | 55.32 (49.82) | 314(26%) | 76.70 (70.13) | 72(44%) | 103.71 (90.93) | 667(51%) | 171.20 (130.90) |
| Illiterate | 1074(73%) | 52.32 (66.31) | 889(74%) | 92.51 (91.46) | 91(56%) | 109.15 (109.63) | 640(49%) | 155.57 (125.52) |

*Source: Own computation (2014) from 1994-2009 ERHS dataset*

** all values in parenthesis (below the means) are standard deviations*

This trend indicates that single household members in a given year would likely get married and became independent household heads in subsequent years or they may be dead. In both scenarios, expenditure cost which could have been spent for him/her may be diverted to the education of the parents.

Regardless of the education of the head of the household, the average food consumption per capita shows an increasing trend from the early rounds of the survey to the latter ones. The average monthly per capita food consumption for households having a literate heads increased from 55ETB in 1994 to 171ETB in 2009, while that of households with illiterate heads increased from 52ETB in 1994 to 156ETB in 2009. We also conducted an independent-samples t-test to test whether the mean difference in monthly per capita food consumption between households with educated heads and uneducated ones. The t-value of 6.94 (with p-value < 0.001) suggests that we reject the null hypothesis that the mean difference between the two groups is zero. The test confirms that there is statistically significant difference between the households headed by educated and uneducated heads, with respect to food security.

***Table 4.2: Demographic characteristics of the sample household heads***

| **Year** | **1994** | **1999** | **2004** | **2009** |
|---|---|---|---|---|
| **Household size** | | | | |
| Observation | 1476 | 1447 | 1363 | 1355 |
| Mean | 6 | 5.78 | 5.65 | 5.60 |
| Std. dev. | 3.03 | 2.74 | 2.52 | 2.56 |
| **Age (Years)** | | | | |
| Observation | 1464 | 1588 | 163 | 1513 |
| Mean | 46.28 | 49.10 | 54.23 | 52.67 |
| Std. dev. | 15.71 | 15.38 | 14.71 | 14.36 |

*Source: Own computation (2014) from 1994-2009 ERHS dataset*

The average age of households' head is slightly increasing over the years. It increased from 46 to 53 years from 1994 to 2009, respectively (Table 4.2), except slight decrease in 2009. The average age of the household head decreased from 54 in 2004 to 53 in 2009.

Generally, our descriptive results for the relationship between human capital and food security give an indication that, households with better position in human capital are more food secured than their counterparts.

### 4.3. Physical or Natural Capital Endowments

In addition to the variables representing the households' human capital endowments, we also included *Land* and *Livestock* as proxies for households physical or capital endowments in our model. The relationship between the capital endowments and food security is described in table 5. As the summary results indicate, there is an overall increase in land holding from the early rounds to the latter ones. The land holding of the sample households increased from 1.34 hectares in 1994 to 2.05 hectares in 2009.

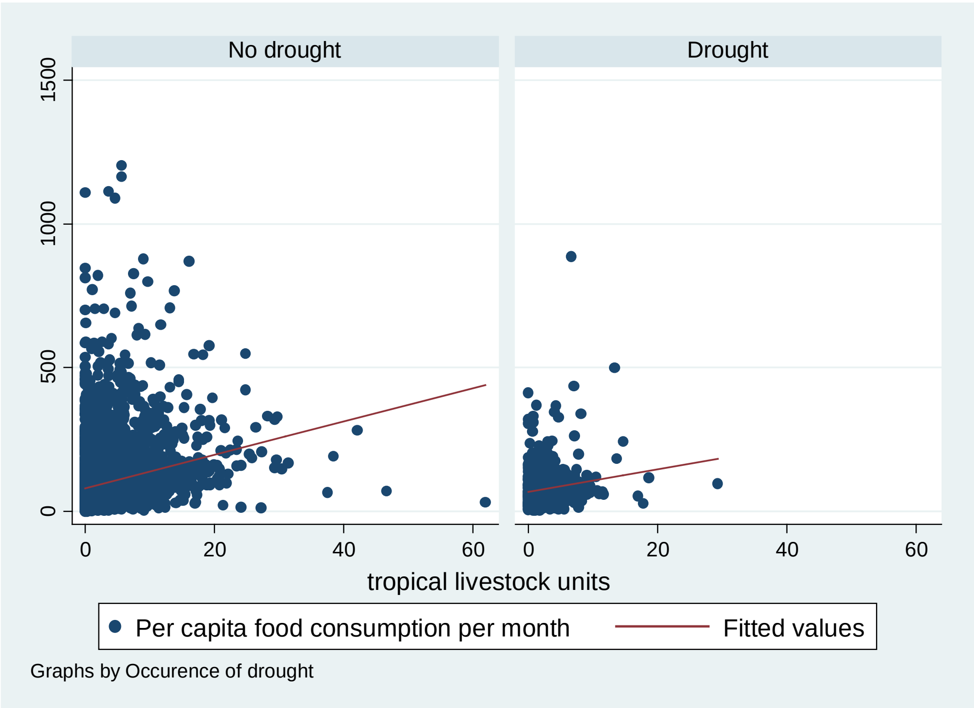


*Figure 4: Partial relationship between livestock ownership and food consumption*

Within the panel, the households' livestock ownership measured in Tropical Livestock Units (TLU) also shows an increasing trend. The summary result reported in table 5 shows that the livestock resource of the sample household increased almost by twofold in 2009 compared to that of 1994. It increased from 2.43TLU in 1994 to 5.10TLU in 2009. It is also observed from figure 4 that there is a clear positive relationship between food consumption and livestock holding. As it is depicted in figure 4, the positive relationship holds even in the occurrence of drought. Generally, our descriptive results on the relationship between households' physical or natural capital endowments and food security gives some indications that, households with better position in physical capital are more food secured than their counterparts. This may be due to the fact that, physical capital endowments play vital role in agricultural production as they are the basic production inputs. Hence, households having a better position in physical and Natural capital are expected to meet their basic food requirements.

*Table 5: Relationship between food security and Physical capital endowments of the sample household heads*

| | | 1994 | | 1999 | | 2004 | | 2009 |
|---|---|---|---|---|---|---|---|---|
| | *Number of HH head* | *Average food consumption per capita* | *Number of HH head* | *Average food consumption per capita* | *Number of HH head* | *Average food consumption per capita* | *Number of HH head* | *Average food consumption per capita* |
| Year | | **1994** | | **1999** | | **2004** | | **2009** |
| **Livestock (TLU)** | Observation | 1468 | | 1448 | | 1351 | | 1575 |
| | Mean | 2.43 | | 2.71 | | 2.88 | | 5.10 |
| | Std. Dev. | (3.23) | | (2.75) | | (3.18) | | (5.63) |
| **Land (Hectares)** | Observation | 1389 | | 1448 | | 1355 | | 1572 |
| | Mean | 1.34 | | 1.22 | | 1.59 | | 2.05 |
| | Std. Dev. | 1.37 | | 1.11 | | 2.09 | | 3.86 |

*Source: Own computation (2014) from 1994-2009 ERHS dataset*

## 4.4. Social and financial capital endowments

In our analysis, we also included variables representing social capital as well as Financial capital endowments such as; *Membership in Savings organization*s, *Off-farm employment,* and *use of Credit*. The use of credit represents whether an individual sample household had taken out a loan of at least 20ETB, in cash or in kind, in the past 12 months before the specific survey round. Similarly, off farm employment represents whether the household head worked on someone else's land or other employment in the year prior to the survey year. Generally, credit and off-farm employment show an overall increasing trend across years. In all survey rounds, the proportion of households using credit consistently increases. For instance, the number of sample households getting credit access increased from 47% in 1994 to 62% in 2009. However, one can easily identify that the pattern in sample households' off-farm participation is mixed.

*Table 6: Summary results for independent two-samples t-test for mean per capita food consumption*

| **Group** | **Yes** | **No** | **t-ratio** |
|---|---|---|---|
| | Mean (Std. Dev.) | Mean (Std. Dev.) | |
| **Off-farm Employment** | 99.95 (102.73) | 94.60 (105.04) | 1.89* |
| **Use of Credit** | 99.81 (109.98) | 93.10 (96.79) | 2.241** |
| **Membership in Saving organizations** | 104.40 (106.60) | 95.25 (103.63) | 2.39** |

*, **, ***, significant at 10%, 5%, and 1% level of significance respectively

Though there is a slight increase from 1999 to 2009; there is a noticeable drop in 1999 compared to 1994. Number of sample households working off-farm decreased from 35% in 1994 to 27% in 1999, but, in a late survey rounds the trend is reversed and off-farm participation gradually increased to 48% and 49% in 2004 and 2009, respectively. The summary result of membership in savings groups (*Equb*) indicates that the number of sample households registered as members of social saving groups has a decreasing trend over the years. Number of sample households registered as members in *Equb* decreased from 18% in 1994 to 14% in 2009.

However, the pattern of the relationship between all these variables and food security indicator (per capita food consumption) is rather mixed. To see whether there is a noticeable mean difference in per capita food consumption over the entire panel, we have conducted an independent-samples t-test for each of the groups. The test results for participation in off-farm employment, use of credit, and membership in local saving organization are summarized in table 6. The test results for all groups suggest a rejection of the null hypothesis that the mean difference between the two groups is zero. The test confirms that the mean difference between the two groups (in all cases) is statistically significant with respect to per capita food consumption.

Generally, the statistical tests confirm that, there is a significant positive difference in food security between sample households having the better position in social, natural and physical capital endowments and those who have not. The *mean per capita food consumption* of the sample households having a better position in social, natural and physical capital endowments is a bit higher than their counterparts.

# 5. ECONOMETRIC RESULTS AND DISCUSSION

Though the results and discussion presented in chapter 4 provide a detailed overview on the relationship among various explanatory variables and household food security, they do not give us a quantitative sense of the consequences of the variation in these variables on food security. So, in this sub-section, we complement our descriptive analysis with an econometric assessment. For this particular econometric analysis, we employed a ***STATA Version 11.0*** statistical package.

Our first analytical step involves, identifying the causal relationship between food security indicator and climate shock. The next step involves identifying other factors determining the household food security on top of climate shock. To assess the basic causal relationship between food security and climate shock as well as other factors, we used *per capita food consumption* as a dependent variable. Though we proposed to use three different climate shock indicators *prior* to our analysis, the occurrence of *flood* and the occurrence of *Frost/Hailstorm* are found to be relevant only for very few households (as indicated in section *4.1*). Inclusion of a shock that is only relevant for very few households would not probably give informative results. Therefore, this study used, whether a household experienced *drought* at least once in a given year over a period of 1994-2009 as an important indicator of climate shock. The results and appropriate preliminary tests are provided herein below.

## 5.1. Assumptions and Preliminary Tests

Though our next logical step is an estimation of the econometric model, *prior* to an estimation of the model, it is worthwhile mentioning some of the preliminary tests that were conducted to verify the general assumptions. Results of some important preliminary tests are provided in ***Appendix A.***

As we have mentioned in chapter 3, whether the efficient RE estimator should be preferred over the less efficient, but the consistent FE estimator should be tested using a general Hausman test. The test checks the existence of correlation between the unobserved individual heterogeneity, $\alpha_i$, and the explanatory variables, $x_{it}$ (Verbeek, 2008). We conducted the test under a null hypothesis ($H_0$) that, the explanatory variables and the unobserved individual heterogeneity are uncorrelated; i.e. $cov(x_{it}, \alpha_i) = 0$. Rejection of the null hypothesis indicates a presence of such a correlation that the efficient RE estimator is inconsistent, whereas the FE estimator remains consistent. Our test result, ($x^2$ = 86.26 with a p-value of < 0.01), suggests a rejection of the null hypothesis in favor of the FE estimator (see ***Appendix A4*** for the test result). Therefore, this study used the results of FE regression model in subsequent sections. The F-test for the overall fitness of our FE model (with F-value = 46.38 and a p-value of < 0.01), suggests that; all the coefficients of our explanatory variables are jointly different from zero. In other words, the explanatory variables included in the FE model are jointly significant at 1% error probability, implying that our FE regression model fits well.

As we mentioned in *section 3.3.2,* while using a linear regression model, some of the basic textbook auxiliary assumptions should be met. Some of them are; there should be a constant variance of the error term across observations and there should not be serial correlation among explanatory variables entered into the model (no perfect multicollinearity). Multicollinearity is a serious problem with the identification of variables to be included in a regression model, hence; we conducted a collinearity diagnostics test, for the explanatory variables included in the model. The test result reported in ***Appendix A3*** (with a mean Variance Inflation Factor, VIF, of 5.36) indicates that there is no serious multicollinearity problem in our model. For the constant variance assumption, we tested whether or not the variance of the error term is homoscedastic. We used a modified Wald test for *group wise heteroskedasticity in* the FE regression model. Under the null hypothesis that, $Ho\text{: } Constant\ variance$, the test result (with p-value of < 0.01) suggests a rejection of null hypothesis (see ***Appendix A5*** for the test result). The test implies that, the variance of the residuals is not homeskedastic in the specified model. Unless we take this problem into consideration, the model yields parameter estimates with large standard errors (less efficient estimates). Therefore, we used *robust and consistent standard errors* which are corrected for heteroskedasticity in the estimation of the FE model. In the following subsequent sections, we focus on the parameter estimates of FE model that are heteroskedasticity robust.

In addition to the various control variables, to control for any time and region specific changes which may result in potential omitted variable biases, we have included a number of dummy variables we introduced in section 3.4. More importantly, we used the consumption expenditure in nominal terms which requires controlling for the potential effect of inflation trends. Besides the theoretical justifications for including the time fixed effects, we should also carryout statistical test to confirm whether including the dummies does or does not bias our result. To check this, we have conducted a simple test diagnostic suggested by Torres-Reyna (2007). It tests whether the time fixed effects (the dummies we used) are important to be included in our FE model. The test is called a "*testparm test*", which is a joint test to see if the dummies we used are jointly equal to zero. According to Torres-Reyna (2007), if the test fails to reject the null that all coefficients of the dummies are jointly equal to zero, there is no need to include the time fixed effects. As our test result reported in ***Appendix A6*** indicates, we reject the null hypothesis that all our dummy variables are jointly equal to zero and conclude that there is remarkable unobservable heterogeneity across households due to difference in time and regions.

Therefore, our further discussion and interpretations rely on the FE model with all dummies are included.

## 5.2. Fixed Effects Vs Instrumental Variable (IV) estimation

*Prior* to our model estimation (as we discussed in section 3.3.2), another assumption to be met is the strict exogeneity of all the regressors. If any endogenous regressor is included in the model, we cannot argue that the FE estimator is unbiased or inconsistent. In such a circumstance, we need to consider alternative estimators, therefore; it is essential to test whether or not the IV method is required to estimate the model.

In our model, endogeneity problem may arise due to the endogenous nature of some of the explanatory variables (*use of credit*, *off-farm employment*, and *involvement in local saving organizations*). For instance, in the case when it is not clear that a household's participation in off-farm employment influences household food security or being food (in) secured influences his/her participation in off-farm employment, may lead to this problem. To address this concern, an instrumental variables estimator implemented using the Generalized Method of Moments (*GMM)*[12]. The IV-GMM estimator is unbiased and consistent with the presence of endogenous regressors. We used the lagged values of each of the aforementioned potential endogenous variables as instruments (*internal instruments)* for the regressors. Before we test for a presence of endogeneity, we really need to be sure that the "*instrumental variables*" satisfy the two necessary conditions. The first condition is that, the instrumental variables should be uncorrelated with the error term so that they can be valid instruments. Secondly, they should be strongly correlated with the variable they are instrumenting; otherwise they are considered as weak instruments.

The Hansen J-test (see ***Appendix*** B2 for the test output) indicates that, the instruments we used are not valid. The test yields *a strong rejection of the* null-hypothesis (with J is identical to zero). The test implies that, the instruments we used are strongly correlated with the error term, thus it casts a doubt on the validity of our instruments. Let alone the validity of the instruments, our test result (with a test statistic; $x^2 = 2.726$ and a p-value of 0.4358), does not give us a privilege to reject the null hypothesis that the specified endogenous regressors can be treated as exogenous. Generally, the GMM-IV Fixed Effects regression suggests that, there is no endogeneity problem in our regression model. However, it doesn't make sense to conclude that the variables are exogenous as long as we cannot get valid instruments.

[12] *"The optimal General Method of Moments (GMM) estimator is asymptotically no less efficient than two-stage least squares under homoskedasticity, and GMM is generally better under heteroskedasticity"* **(Wooldridge, 2001 P. 92).**

Given that invalid instruments are likely to cause more problems than weak ones (Wooldridge, 2001), our analysis and further interpretations rely on the FE estimator. As part of a robustness check, we have also investigated alternative specification to see whether totally excluding the potential endogenous variables would affect our results, with respect to climate shock indicator. We estimated FE regression model including climate indicator with all exogenous explanatory variables in the regression.

Table 7: Estimation results of the FE model (with and without endogenous variables)

| ***Dependent variable*** | *Per capita food consumption* | |
|---|---|---|
| **Variables** | **Coef. For FE Model with Potentially Endogenous variables** | **Coef. For FE Model without Potentially Endogenous variables** |
| Constant | 86.715* | 84.85* |
| Drought | -13.074** | -11.795** |
| Land | 4.461** | 4.629** |
| Household Size | -12.490*** | -12.325*** |
| Dependency ratio | -2.009 | -2.339 |
| Livestock | 1.934* | 1.902* |
| Off-farm Employment | 4.496 | - |
| Credit Use | 7.993** | - |
| Saving Group | 5.861 | - |
| Sex | 1.966 | 2.121 |
| Age | 1.057 | 1.172 |
| Age Squared | -0.011 | -0.012 |
| Education | 7.889 | 8.354 |
| $R^2$ within | 0.4163 | 0.4150 |
| $R^2$ between | 0.2206 | 0.2272 |
| $R^2$ overall | 0.2725 | 0.2809 |
| F-Value | 46.38 | 50.90 |
| $Prob > F$ | 0.0000 | 0.0000 |
| Observations | 3468 | 3471 |

* p<0.10, ** p<0.05, *** p<0.01. Region and Time dummies (for survey rounds and months of interviews) are included in the model, but not reported here (see *Appendices B1 and* B2).

The result reported in ***Appendix* B3** shows that, though the size of the coefficients and standard errors slightly change, this specification produces almost similar result with respect to the significance of our interest variable (*climate shock*). This suggests that, the result is robust to inclusion and exclusion of potential endogenous variables from the control variables used in the FE model. That is, no matter whether we control for "*use of credit*, *off-farm employment*, and *involvement in local saving organizations*", the result for the effect of *drought* on food security remain the same.

As long as estimating our FE model with and without the potentially exogenous control variables doesn't alter our result with respect to our interest variable, for further interpretation and discussion, it is better to use our first specification in which all hypothesized explanatory variables are included. One can observe that, the overall fit of the model is not hugely affected when all potential endogenous variables are included in the model (F-value decreases from 50.90 to 46.38 with p-value remains the same). This indicates that, all hypothesized variables used in our FE model are jointly significant no matter we included or exclude the potentially endogenous variables. The model outputs (presented in *Appendices B1 and* B3) are summarized in Table 7.

## 5.3. Parameter Estimates of Fixed Effects Regression

Although our major objective is to analyze the effect of climate shock on food security, so as to see the clear direction of the climate shock indicator, we have included control variables which represent different households resource endowments based on the SLF framework (see section 2.4.). Meanwhile, our study identifies the important determinants of household food security. From the five broad categories of the households resource endowments or "*poverty reducing factors*" (DFID, 1999), nine explanatory variables representing household's resources endowments are included as potential determinants of household food security. Moreover; to reduce the threat of omitted variable bias, we introduced time and region dummies to control for any temporal and spatial changes (such as seasonality, inflation trend, etc.). The following two sub-sections are devoted to our important results based on the summarized results in Table 8 (the model output is presented in *Appendix* B1).

### 5.3.1. Climate Shock and Food Security

In this sub-section, we examine the effect of climate shock on household food security, followed by the related discussion. The summarized results (Table 8) show that, the climate variable together with the nine explanatory variables included in the FE model, explain about 27% of the overall variation in households *per capita food consumption*. The estimated coefficient corresponding *drought* suggests a rejection of the null hypothesis that, *drought has no effect on per capita food consumption*. The sign of the coefficient indicates that, there is negative relationship between drought and *food consumption per capita*. Our finding suggests that an occurrence of drought is associated with a *decrease in per capita food consumption*. In line with our general hypothesis, we found a negative effect of climate shock on household food security over time. The negative climate variable implies that, households vulnerable to drought tends to be more food insecure than their counterparts.

Table 8: The estimation results of FE model

| **Dependent variable** | ***Per capita food consumption*** | | |
|---|---|---|---|
| **Variables** | **Coefficient** | **Robust Std. Error** | **t-ratio** |
| ***Climate Shock*** | | | |
| Drought | -13.074** | 5.8595 | -2.23 |
| ***Human Capital*** | | | |
| Household Size | -12.490*** | 1.1415 | -10.94 |
| Dependency ratio | -2.009 | 2.3738 | -0.85 |
| Sex | 1.966 | 8.3591 | 0.24 |
| Age | 1.057 | 1.0031 | 1.05 |
| Age Squared | -0.0107 | 0.0096 | -1.12 |
| Education | 7.889 | 5.6127 | 1.41 |
| ***Physical (Natural) Capital*** | | | |
| Land | 4.461** | 2.1103 | 2.11 |
| Livestock | 1.934* | 1.0096 | 1.92 |
| ***Financial Capital*** | | | |
| Off-farm Employment | 4.496 | 3.8775 | 1.16 |
| Credit Use | 7.993** | 3.5394 | 2.26 |
| ***Social Capital*** | | | |
| Saving Group | 5.861 | 5.0335 | 1.16 |
| Constant | 86.715* | 45.8894 | 1.89 |
| $R^2$ within | 0.4163 | | |
| $R^2$ between | 0.2206 | | |
| $R^2$ overall | 0.2725 | | |
| F(25,1381) | 46.38 | | |
| $Prob > F$ | 0.0000 | | |
| Observations | 3468 | | |

*, **, ***, significant at 10%, 5%, and 1% level of significance, respectively. Time dummies for survey rounds and months of interview are included in the model, but not reported here (see *Appendix* B1).

Generally, our finding confirms that climate shock is one of the critical determinants of household food security in Ethiopia. This is possibly because, as rural households are vulnerable to extreme weather events; such as *drought*, agricultural output (crop and livestock production) can be directly affected. As a result, there will be a low level of food available in the household.

The effect mainly rests on the effects of climate shocks on the households' ***Natural capital endowments.*** In general, climate shock (drought) is one of the natural processes that disrupt the households' ***Natural capital endowments*** position. The natural capital endowments, such as rainfall availability directly affect agricultural production thereby the household's food availability. In this regard, the effect of drought rests on the rainfall shortage which seriously affects crop production, particularly in areas where agricultural production is primarily rain-fed. Moreover, persistent drought may result in crop yield reduction (crop productivity loss) due to less response to chemical fertilizers and soil nutrient depletion, which in turn hurt the food security status of the households. For instance, serious drought may result in a depletion of the most critical, but volatile nutrients, such as Nitrogen from the soil. When there is a frequent drought, the less fertilizer response of the crops may also lead to an accumulation of some toxic nutrients which may result in yield loss in subsequent cropping seasons.

Other chanels through which climate affects the household livelihoods' and food security may be reflected via the effct of drought on *households' resource endowments,* such as *human and physical resource endowments*. The major households' resource endowment that can be directly affected by drought are the *physical capital endowments*. As a household faces extreme weather events, the quantity as well as the quality of the households' *physical capital endowments* can be affected. Obviously, in bad years where food availability gets lower, households sell their livestock so that they can buy food for household consumption. In some situations that it is difficult to meet immediate food consumption needs, there may also be distressed sale of a part of the land which would generate a long-term income. In such situations, apparently, household food security can be affected via the effect of drought on households' physical resource endowments.

Our descriptive as well as econometric results, which suggest a negative association between occurrence of drought and physical resource endowments, support this argument. Given that physical capital endowments are positively associated with household food security, consequently, there is an effect of drought on crop production as a result of reduced production inputs (physical capitals). Moreover, *physical resources* such as Land and Livestock can support crop production in many ways. They can be used as collateral to get credit (*financial capital*) so as to purchase agricultural inputs. Given the positive effect of Credit on food security, drought can also indirectly affect the availability of *financial resources* by directly affecting the *physical capital endowments*.

The finding is consistent with other previous studies conducted in Ethiopia. The two prominent studies our study is in agreement with are; Holden and Shiferaw (2004) and Demeke et al. (2011). Similar to our finding, Holden and Shiferaw (2004); found that, combined with lad degradation and population pressure on land, drought exacerbates food insecurity in the study area. According to their findings, there is an increasing trend in risk of drought on household agricultural production and food security. Different to what we did in our current study, Holden and Shiferaw (2004) emphasised on the indirect effects of drought on household welfare via the impact on commodity prices (crop and livestock prices). They mentioned that, these indirect effects are even higher than the direct effects of drought. Almost similar to our finding, Demeke et al. (2011) have shown that climate variability is an important determinant of Ethiopia households food security. Demeke et al. (2011), found that, the mean rainfall of main rainy season is positively associated with food security over time.

In addition to climate shock indicator, all other hypothesized variables also have their expected sign, indicating that households' resource endowments matter in explaining sample household food security. Among the nine variables, which were hypothesized to influence the food security, four were found to be statistically significant at different levels of significance. Namely; *household size, land holding, livestock ownership,* and *use of credit* have statistically significant effect on household food security. The results for these important determinants of household food security (representing the *households' resource endowments*) are presented in detail in the subsequent sections.

### 5.3.2. Household's Resource Endowments and Food Security

So far, we have examined how household food security is associated with climate shock using *drought* as a climate shock indicator. The estimation results of the FE model summarized in Table 8 also show that, on top of climate indicator; various variables representing household's resource endowments are found to be important determinants of food security of sample households. Our study confirmed that; household size, livestock ownership, land holding, and credit use are important factors determining sample household food security. Despite meeting our *prior* expectation with respect to their signs, parameter estimates of all other hypothesized variables are not found to be statistically significant.

Our results generally show that, the food security status of a household is partly determined by its various resource endowments. On top of adverse climatic conditions such as *drought*, we also identified that; *physical capital, human capital,* and *financial capital* are the basic determinants of household food security over time. Particularly, we found availability of *physical capital***,** such as Land and Livestock hugely determine household food security. The results are consistent with our *prior* expectation and a general hypothesis that, *"households with better position in household's resource endowments are more food secured than their counterparts"*. Our findings are also in line with the Sustainable Livelihood Framework (SLF) context that a household livelihood depends on its own resource endowments. The results for each category of households resource endowments are provided and discussed herein below:

### Human Capital Endowments

The estimated coefficient corresponding total family size suggests that we reject the null hypothesis that *the number of family members has no effect on per capita food consumption (*Table 8*)*. This implies that, total family size has a negative and statistically significant effect on household food security. The negative estimated coefficient corresponding total family size indicates an increase in family size reduces the per capita food consumption. This generally suggests that large family size, which represents the ***human capital endowment,*** is among the important determinants of rural Ethiopia household food security. Though the parameter estimate of dependency ratio, which indicates the household composition; is not statistically significant, the sign is negative as we anticipated. Among other variables representing ***human capital endowments,*** the sex of the household head is positively associated with food security, but not statistically significant. Similarly, age and education level of the head of the household have been found to be positively associated with food security, though they have no statistically significant effect on household food security.

The negative estimated coefficient corresponding total family size in general suggests that large family size is among the underlying causes of food insecurity in rural Ethiopia. Probably, the reason behind the negative impact of family size is that, given less productive land due to miss management and natural hazards combined with lack of access to improved technology, households may face low agricultural yields which fail to meet the increased food demand. Another important implication of the negative effect of family size on food security is that, large families put additional pressure on farm income for food and other non-food consumptions, such as; clothing, education, and health; while not ensuring availability of enough family labor for farm operations to be performed in time. In other words, there are a large number of mouths to feed than hands to work which end up with unmatched food demand with the existing food supply in the household, which may finally result in food insecurity. In general, the finding is consistent with the previous findings of Bogale and Shimelis (2009); Feleke et al. (2005); and Kidane et al. (2005) in Ethiopian context.

Finally, one important point we can figure out from the relationship between human capital endowments and food security is that, the clear impact of human capital apparently influenced by other households' resource endowments. Generally, the effect of one type of resource endowment may be influenced by another one. One important result supporting this argument is the negative impact of large family size in a given household. As we argued previously, unmatched food demand with the existing food supply in a given household may arise due to physical capital constraint (e.g. Land). That is, given land shortage in a household, diminishing marginal productivity may lead to lower food production in the household.

## Physical Capital Endowments

In the SLF context, physical capital is the basic building block that provides an important service for people to meet their basic needs. Among these basic *physical resource endowments*, land and livestock play vital roles in agricultural production, hence expected to determine households' food availability. In agreement with our hypothesis, among the variables representing the households' ***physical capital endowments***; Land holding and Livestock ownership are identified to be important factors reducing household food insecurity. The result implies that, there is a statistically significant positive effect of households land holding on food security. In line with our expectation, the estimated coefficient indicates that an increase in total land holding increases the household's per capita food consumption. Our finding suggests that, relatively large holder farmers are more food secured than the small holders. Our result also suggests that, Livestock ownership measured in TLU affects food security positively and significantly. The positive parameter estimate of livestock ownership implies that an increase in Livestock ownership increases household's per capita food consumption.

The result generally suggests that, a better position in livestock holding improves the food security position of the sample households. This can be due to the fact that, as rural households hold more hectares of land the food production can be increased which in turn leaves the households in a better food security position; provided that all other important production inputs are available. Another justification can be, as large farmers have the capacity to use compatible technologies that could increase the yield, and they may also have a better chance of diversifying crops to be grown thereby increase access to food. Furthermore, given a collateral value of land, larger farmers may get better credit from formal institutions to finance their food production. The result is in agreement with other studies previously conducted in Ethiopia. Some of these studies are; Kidane et al. (2005) and Bogale and Shimelis (2009).

Another important physical capital our study identified as an important determinant of household food security is Livestock ownership. Livestock in a mixed crop-livestock farming system may have much importance in that they supply oxen power for ploughing and threshing, provide draught power, and are sources of food and income for the family. Timely ploughing and threshing is decisive in the production of crops, thus livestock ownership is important to better food production. Given this fact, we hypothesized a positive effect of livestock ownership on household food security *prior* to our analysis. In agreement with our expectation, the result generally suggests that, a better position in livestock holding improves the food security position of the households. This is so possibly because, provided that there is enough land, livestock play a vital role as a basic production input in crop production. Though it is sometimes expected that livestock compete with crop production for different scarce resources, our finding supports the theoretical complementarities between livestock production and general crop production. Besides directly fulfilling the households' nutritional requirements, livestock may improve household food security for the reason that income can be obtained from the sale of livestock products such as; milk, butter, etc. The income could be used for the purchase of agricultural inputs and may also augment financing of household consumption expenditures which would otherwise put pressure on the farm income itself.

Besides agricultural work, livestock can also be used for different income generating activities in the Ethiopian context. For instance, they can be used to pull carts and provide a petty transportation service to the nearby people, thereby generate income, which in turn supplement the household food consumption. Moreover; in case of short-term liquidity constraint, livestock can be used as collateral to get loans from the informal lenders. All these direct and indirect roles of livestock combined with other various households' resource endowments, possibly result in an improved food security situation of the households. The finding is consistent with previous food security studies such as; Bogale and Shimelis (2009); Hussein and Janekarnkij ( 2013); Demeke et al. (2011); Feleke et al. (2005); and (Kassa et al. (2002)), in Ethiopia.

## Financial and Social Capital Endowments

From our ***Financial*** and ***Social capital endowments'*** category, Credit use is found to be an important factor identified to influence household food security in the study area. The positive and significant coefficient suggests that, use of credit has a positive and significant effect on household food security. Our finding generally suggests that, Credit use is an important ***Financial capital*** influencing household food security in the study area. The result indicates, on average, the per capita food consumption increases when households use credit. Though off-farm employment and involvement in local savings organizations are positively associated with household food security, they are not found to have a statistically significant effect.

Credit use is found to be an important ***Financial capital*** influencing Ethiopian household food security may be because; credit plays a vital role in contributing to the immediate household's consumption as well as production activities. Credit improves, the financial position of a household by availing cash that enables people to adopt different livelihood strategies. Credit can build household's capacity to expand production through the purchased production inputs such as; seeds and fertilizers. Besides its role as a financial source, credit obligations can also reinforce a household to produce more so that the loan can be paid back properly, thereby improving household food security. Generally, our finding is in agreement with our hypothesis as well as with the wide consensus that financial credit plays an important role in smoothing consumption and relaxing short-term financial liquidities.

The result generally reveals that, credit use representing financial capital endowment, reduces household food insecurity. The finding is consistent with some previous studies conducted in Ethiopia; Bogale and Shimelis (2009) and Hussein and Janekarnkij (2013).

## 5.4. Robustness of the Results

As part of our basic robustness check, we experimented by excluding the time and region dummies, turn by turn, from our original specification. First, we experimented whether the result changes when all time and region dummies are excluded from our FE regression reported in Table 8. The summary of the results for the robustness check (reported in Appendix C) are summarized in Table 9.

As the summary results indicate, with respect to our climate shock indicator, the experiment provides evidence that the effect of climate shock on food security is not robust for an exclusion of all dummies together. The climate shock indicator (*drought*) turned out to be insignificant when we exclude both time and region dummies together. This implies that, to see the clear effect of climate on food security, the seasonal and regional variations should be taken into account. We also investigated whether the result varies when we exclude time dummies only; while keeping region dummies in the model and *vice versa*. As the result reported in (Table 9) indicates, the significance of the parameter estimate for the effect of climate shock on food security is robust to exclusion of region dummies; however, the magnitude of the estimate hugely changes. One can observe from the result that, the magnitude of the parameter estimate for the climate shock indicator increases when we exclude regional dummies (it increases from 13.07 to 21.89 in absolute terms). This suggests that, our result with respect to the effect of climate shock on food security, is barely robust to unobservable regional differences. In contrast to this, our result is not robust to an exclusion of all time dummies suggesting that the results may be partly driven by time and inflation trends within individuals. The result generally suggests that, our estimate for climate shock indicator is sensitive to unobservable region and time differences across sample households.

*Table 9: Different specifications to see the robustness of the results*

| ***Dependent variable*** | Coef. for FE Model | | | |
|---|---|---|---|---|
| **Variables** | Excluding all dummies | Excluding time dummies | Excluding region dummies | Excluding "drought" |
| ***Climate Shock*** | | | | |
| Drought | -6.90 | -6.18 | -21.89*** | - |
| ***Human Capital*** | | | | |
| Household Size | -14.49*** | -14.65*** | -11.98*** | -12.48*** |
| Age DR | -8.64*** | -8.47*** | -2.49 | -2.39 |
| Sex | -53.42*** | -52.59*** | 1.53 | 5.58 |
| Age | 4.489*** | 4.43*** | 0.824 | 0.68 |
| Age Squared | -0.026** | -.026** | -0.01 | -0.01 |
| Education | 40.48*** | 40.39*** | 10.92* | 7.88 |
| ***Physical(Natural) Capital*** | | | | |
| Land | 2.83 | 2.95 | 2.16 | 4.48** |
| Livestock | 5.90*** | 5.95*** | 2.26** | 2.01** |
| ***Financial Capital*** | | | | |
| Off-farm | 8.60** | 8.61** | 3.40 | 4.07 |
| Credit Use | 15.72*** | 15.71*** | 7.39** | 7.34** |
| ***Social Capital*** | | | | |
| Savings | 1.26 | 1.78 | 8.99 | 3.48 |
| Constant | 32.9 | -32.54 | 90.62*** | 51.81 |
| $R^2$ within | 0.2698 | 0.2730 | 0.4007 | 0.4250 |
| $R^2$ between | 0.1144 | 0.2200 | 0.1971 | 0.2029 |
| $R^2$ overall | 0.1896 | 0.2290 | 0.2967 | 0.2898 |
| F-Value | 43.96 | 36.35 | 54.96 | 51.20 |
| $Prob > $ F | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Observations | 3468 | 3468 | 3468 | 3715 |

* p<0.10, ** p<0.05, *** p<0.01

Similarly, regarding other determinants of household food security, except a slight difference in the size of the coefficients; the results for previously identified determinants are more or less robust. In contrast to the first specification; in a series of specifications, we mentioned above, all variables representing households' ***human capital endowments*** turned out to be statistically significant. We have also investigated another alternative specification to see whether or not the results for determinants of food security are robust to the exclusion of the climate shock indicator. To see this, we used all bunches of hypothesized variables representing the household's resource endowments in the FE regression model, excluding *Drought*.

The result reported in Appendix C and summarized in Table 9 shows that, though there is a slight difference in the size of the coefficients, the latter specification produces almost similar result with respect to the significance and the signs of the hypothesized variables. For instance, the coefficient corresponding ***household size, which*** was -12.49 in the original specification turns out to be -12.48, which is virtually identical to the previous one. This generally suggests that, regardless of controlling for the effect of climate shock, we get robust and consistent results for the determinants of household food security.

# 6. SUMMARY, CONCLUSION AND POLICY IMPLICATIONS

By using a longitudinal household dataset drawn from the Ethiopia Rural Household Survey (ERHS) from 1989-2009 in 15 rural Ethiopian villages, we assessed the effect of climate shock on Ethiopian household food security over time. Though the primary objective of this study is to assess the impact of climate shocks using data from 1477 sample households, the study also identified a number of other determinants of Ethiopian household food security over time. Among the five broad categories of household's resource endowments based on the Sustainable Livelihood Framework (SLF), we included; *human capital*, *social capital*, *physical capital*, and *financial capital* endowments. We used Sex, Age, and Education level of the household head; and Household size as variables representing human capital endowments. The ***physical capital*** factors include**:** Livestock ownership and Land holding**.** Our analysis also included a Membership in Savings organization as a proxy for ***social capital endowment*** whereas; Off-farm employment and use of credit as proxies for ***Financial capital endowments.*** Moreover; to reduce the threat of omitted variable bias, we introduced time and region dummies to control for any temporal and spatial changes. A short summary of our major findings is given in the following sub-section, followed by some recommendations and suggestions for future research.

## 6.1. Summary and Conclusion

Using monthly per capita food consumption as an indicator of food security, the current study tested two general hypotheses. The first hypothesis we tested was, **"***there is a negative effect of climate shock on households food security"*. In addition to this hypothesis, our study also tested a general hypothesis that, *"households with better position in household's resource endowments are more food secured than their counterparts".* The first hypothesis aimed to identify the effect of climate shock on household food security. Despite our *prior* expectation that the occurrence of *floods* and occurrence of *frost or hailstorm* can be good indicators of climate shock, we excluded them from the analysis as they are relevant only for very few sample households. *Prior* to our econometric estimation, we examined the relationship between food security and various explanatory variables using appropriate descriptive statistics. The descriptive results indicate that, there is a negative association between food security and drought. That is, the occurrence of extreme drought reduces *per capita food consumption*, over the entire panel. It was also found that there is statistically significant difference in *mean per capita food consumption* between the sample households faced drought at least once in a given year and those who did not. Our descriptive results for the relationship between the various households resource endowments and food security also indicated that, households with better position in *human, physical,* and *social capital endowments* are more food secured than their counterparts.

To examine the causal relationship between climate shock and food security, our model estimations employed a Fixed Effects (FE) econometric analysis technique by using *drought* as an indicator of climate shock. We used the FE estimator since the general Hausman test confirmed that the less efficient, but the consistent FE estimator preferred over the efficient Random Effects estimator as the sample households' characteristics are remarkably heterogeneous. The FE estimation result confirmed that, both the sign of the coefficient as well as its significance is in agreement with our general hypothesis. The result revealed that, there is negative relationship between drought and *food consumption per capita*. In line with our general hypothesis, we found that there is a negative effect of climate shock on household food security. All other hypothesized variables also have their expected sign, indicating that household's resource endowments matter in explaining sample household food security. Generally, as we anticipated *prior* to our analysis, climate shock is negatively and significantly associated with food security over time. In other words, drought reduces the *mean per capita food consumption* by about 13.10ETB. A negative climate shock indicator implies that, households vulnerable to drought tends to be more food insecure than their counterparts.

Our findings are also in line with the Sustainable Livelihood Framework (SLF) context that a household livelihood centers around its own resource endowments. Among the variables representing ***human capital endowments,*** large family size is the most underlying cause of food insecurity in rural Ethiopia. The negative estimated coefficient corresponding total family size indicates that, as family size increases the per capita food consumption reduces. Among the basic ***physical resource endowments,*** land and livestock play a vital role in determining the household food security. Our finding suggests that relatively large holder farmers are more food secured than small holders. The positive parameter estimate of livestock ownership also implies that, an increase in Livestock ownership by one Total Livestock Units (TLU) increases household's per capita food consumption by about 1.9 ETB. This generally suggests that, a better position in livestock holding improves the food security position of the households. Finally, our study identified that, Credit use is an important ***Financial capital*** influencing household food security in the study area. It indicates, on average, the per capita food consumption increases when households use credit.

Finally, our findings yield some important conclusions in relation to Ethiopian household food security. It has been confirmed that, the climate is one of the critical determinants of household food security in the Ethiopian context. Our finding generally suggests that unfavorable climatic condition adversely affects the rural household food security. In addition to climate as an important determinant, various households' resource endowments are also found to be important determinants of food security. With respect to the relationship between households' resource endowments and food security, we have confirmed that an economic notion that the wealth of an individual household basically depends on its resource endowment is applicable.

This finding is also in agreement with the general Sustainable Livelihood Framework (SLF) which suggests that household's resource endowments are basic *"poverty reducing factors"*. However, among households' resource endowments, our study found household size to have a statistically significant negative effect on household food security. This indicates that, the effect of one type of resource endowment may be influenced by the availability of another resource endowment. For instance, the negative impact of large family size in a given household may result from the unmatched food demand with the existing food supply in the household as a result of physical (natural) capital constraint (e.g. Land). Therefore, our findings conclude that; provided that all necessary ***households resource endowments*** are not binding, households resource endowments reduce household's vulnerability to food insecurity.

## 6.2. Recommendations and Policy Implications

Based on the results of this study, improving household's food security status requires attention towards mitigating climate shocks, such as drought and rainfall failure. Based on our findings, even though climate shock is not endogenously determined by a single country, appropriate long-run policy interventions at the national level are required to mitigate the future consequences. In this respect, we strongly recommend policy interventions on reforestation and natural resource conservations. Efforts towards improving the adaptive mechanisms will also have a positive impact on the household food security in the future. Therefore, we recommend that the national government to play a prime responsibility to keep on provision of early warning with respect to predictable future climate variability based on the past climate trends. Moreover, despite the exogenous nature of climate shocks, the regional governments may also play a role in creating special adaptation mechanisms to climate shocks. In this regard, our study recommends promoting drought resistant crops in the areas where households are frequently affected by drought. We recommend promoting drought-tolerant cross-bread variety of different cereal crops as well as the promotion of some indigenous drought resistant crops (e.g. ***Enset***).

Given the vital role the households resource endowments have in reducing food insecurity, policies that can contribute to the improvement of ***households' resource endowments*** should not be undermined. In this regard, improving household's *human capital endowment* should be given an attention. For instance, a burden of family size calls for policy on appropriate family planning so as to decrease a burden of the large family size of the household food security. Policy makers should also give due attention towards improving the ***physical, natural, and financial capital endowments***. The positive effect of Livestock ownership, Land holding, and Credit call for financial strengthening together with awareness creation towards improving livestock production so as to reduce vulnerability to food insecurity. We strongly recommend credit facility which may capacitate the households to avoid distress land and livestock sales in the case of various financial obligations. Therefore; concerned bodies and different institutions should give emphasis towards establishing rural financial institutions. Moreover, widening the scope of introducing highly productive, improved breeds of animals and solving the crucial livestock feed and health problems may also have a remarkable contribution.

## 6.3. Limitations and Suggestions for Future Research

Though our study yields important findings, which are generally in line with our hypothesis, readers should bear some limitations in mind while referring and using this paper for future studies. Basically, the result may be subject to the recalling capability and event perception of the sample households since some important variables included in our study are obtained from retrospective questions during the survey. For instance, households were supposed to recall drought and food consumed in a specific week *prior* to the time the survey was conducted. Moreover, this study majorly included *covariate* shocks; events that simultaneously affect many people in the same location. By their nature, weather shocks, such as *drough*t are kinds of *covert shock* since they affect all households in the village and possibly those nearby. However, a given household may also face various *idiosyncratic shocks (*shocks specific to the household). In some cases, the mere occurrence of a *covariate* climatic shock may not imply that the shock had led to a loss of individual household welfare unless *Idiosyncratic shocks* are also considered. Most importantly, the food security indicator (food consumption expenditure) is not deflated due to the absence of a reliable food price index. Hence, the results may be partly driven by time and inflation trends within individuals. Thus to fill these gaps in the future, it may be important to pay attention to these limitations.

## REFERENCES


ASFAW, A. & ADMASSIE, A. 2004. The role of education on the adoption of chemical fertiliser under different socioeconomic environments in Ethiopia. *Agricultural Economics,* 30**,** 215-228.

BARRETT, C. B. 2002. Food security and food assistance programs. *Handbook of agricultural economics,* 2**,** 2103-2190.

BARRETT, C. B. 2010. Measuring food insecurity. *Science,* 327**,** 825-828.

BARRETT, J. C. 1992. *The economic role of cattle in communal farming systems in Zimbabwe*, Overseas Development Institute London.

BICKEL, G., NORD, M., PRICE, C., HAMILTON, W. & COOK, J. 2000. Guide to measuring household food security. *Alexandria. Department of Agriculture Food and Nutrition Service*.

BOGALE, A. & SHIMELIS, A. 2009. Household level determinants of food insecurity in rural areas of Dire Dawa, Eastern Ethiopia. *African Journal of Food, Agriculture, Nutrition and Development,* 9.

BOHLE, H. G., DOWNING, T. E. & WATTS, M. J. 1994. Climate change and social vulnerability: toward a sociology and geography of food insecurity. *Global Environmental Change,* 4**,** 37-48.

CANALI, M. & SLAVIERO, F. 2010. Food insecurity and risk management of smallholder farming systems in Ethiopia. Vienna: BOKU - University of Natural Resources and Applied Life Sciences.

CORTI, G. 2013. *The Ethiopian rift valley* [Online]. Italy: National Research Council of Italy, Institute of Geosciences and Earth Resources. Available: http://ethiopianrift.igg.cnr.it/rift%20valley%20seismicity.htm [Accessed April 01 2014].

DEMEKE, A. B., KEIL, A. & ZELLER, M. 2011. Using panel data to estimate the effect of rainfall shocks on smallholders food security and vulnerability in rural Ethiopia. *Climatic change,* 108**,** 185-206.

DERCON, S. 2004. Growth and shocks: evidence from rural Ethiopia. *Journal of Development Economics,* 74**,** 309-329.

DERCON, S. & HODDINOTT, J. 2004. The Ethiopian rural household surveys: Introduction. *International Food Policy Research Institute, Washington, DC Photocopy*.

DERCON, S., HODDINOTT, J. & WOLDEHANNA, T. 2005. Shocks and consumption in 15 Ethiopian villages, 1999-2004. *Journal of African Economies*.

DERCON, S. & KRISHNAN, P. 2000. Vulnerability, seasonality and poverty in Ethiopia. *The Journal of Development Studies,* 36**,** 25-53.

DFID, D. F. I. D. 1999. *Sustainable livelihoods guidance sheets* [Online]. Available: http://www.eldis.org/vfile/upload/1/document/0901/section2.pdf [Accessed November 11 2013].

FAO/WFP. 2012. *Food and Agricultural Organization/World Food Program Crop and Food security Assessment Mission for Ethiopia* [Online]. ROME: Food and Agriculture Organization and World Food Program. Available: http://documents.wfp.org/stellent/groups/public/documents/ena/wfp246872.pdf [Accessed April 03 2014].

FARRINGTON, J., RAMASUT, T. & WALKER, J. 2002. Sustainable Livelihoods Approaches in Urban Areas: General Lessons, with Illustrations.

FELEKE, S. T., KILMER, R. L. & GLADWIN, C. H. 2005. Determinants of food security in Southern Ethiopia at the household level. *Agricultural Economics,* 33**,** 351-363.

GITTINGER, J. P., CHERNICK, S., HORENSTEIN, N. R. & SAITO, K. A. 1990. *Household food security and the role of women*, World Bank.

GRILICHES, Z. & HAUSMAN, J. A. 1986. Errors in variables in panel data. *Journal of econometrics,* 31**,** 93-118.

GUJARATI, D. N. & PORTER, D. C. 1999. Essentials of econometrics.

HADDAD, L., KENNEDY, E. & SULLIVAN, J. 1994. Choice of indicators for food security and nutrition monitoring. *Food Policy,* 19**,** 329-343.

HADDAD, L., SULLIVAN, J. & KENNEDY, E. 1992. Identification and evaluation of alternative indicators of food and nutrition security: some conceptual issues and an analysis of extant data. *Food and Nutrition Monitoring Project. International Food Policy Research Institute, Washington, DC Mimeo*.

HAILE, M. 2005. Weather patterns, food security and humanitarian response in sub-Saharan Africa. *Philosophical Transactions of the Royal Society B: Biological Sciences,* 360**,** 2169-2182.

HELTBERG, R., SIEGEL, P. B. & JORGENSEN, S. L. 2009. Addressing human vulnerability to climate change: toward a 'no-regrets' approach. *Global Environmental Change,* 19**,** 89-99.

HOLDEN, S. & SHIFERAW, B. 2004. Land degradation, drought and food security in a less-favoured area in the Ethiopian highlands: a bio-economic model with market imperfections. *Agricultural Economics,* 30**,** 31-49.

HUSSEIN, W. & JANEKARNKIJ, P. Determinants of Rural Household Food Security in Jigjiga District of Ethiopia.

KASSA, H., GIBBON, D. & SINGH, B. P. 2002. Livestock improve household food security and sustainability of Ethiopian small farms. *Journal of Sustainable Agriculture,* 21**,** 73-93.

KIDANE, H., ALEMU, Z. G. & KUNDHLANDE, G. 2005. Causes of Household Food Insecurity in Koredegaga Peasant Association, Oromiya Zone, Ethiopia. *Agrekon,* 44**,** 543-560.

MATTSSON, J. O. & RAPP, A. 1991. The recent droughts in western Ethiopia and Sudan in a climatic context. *Ambio***,** 172-175.

MAXWELL, D., CALDWELL, R. & LANGWORTHY, M. 2008. Measuring food insecurity: Can an indicator based on localized coping behaviors be used to compare across contexts? *Food Policy,* 33**,** 533-540.

MENGISTU, A. 2003. Country Pasture/Forage Resource Profiles. *Addis Ababa, Ethiopia: Addis Ababa University, Faculty of Science, Biology Department*.

PARRY, M., ROSENZWEIG, C., IGLESIAS, A., FISCHER, G. & LIVERMORE, M. 1999. Climate change and world food security: a new assessment. *Global Environmental Change,* 9**,** S51-S67.

RAMAKRISHNA, G. & DEMEKE, A. 2002. An empirical analysis of food insecurity in Ethiopia: the case of North Wello. *Africa Development,* 27**,** 127-143.

ROSEGRANT, M. W. & CLINE, S. A. 2003. Global food security: challenges and policies. *Science,* 302**,** 1917-1919.
ROSENBERG, M. 2014. *About.com Geography* [Online]. Available: http://geography.about.com/library/cia/blcethiopia.htm [Accessed April, 03 2014].
ROSENZWEIG, C., IGLESIAS, A., YANG, X., EPSTEIN, P. R. & CHIVIAN, E. 2001. Climate change and extreme weather events; implications for food production, plant diseases, and pests. *Global change & human health,* 2**,** 90-104.
SCHMIDHUBER, J. & TUBIELLO, F. N. 2007. Global food security under climate change. *Proceedings of the National Academy of Sciences,* 104**,** 19703-19708.
SEMYKINA, A. & WOOLDRIDGE, J. M. 2010. Estimating panel data models in the presence of endogeneity and selection. *Journal of Econometrics,* 157**,** 375-380.
TAYE, A., MARIAM, D. H. & MURRAY, V. 2010. Interim report: review of evidence of the health impact of famine in Ethiopia. *Perspectives in public health,* 130**,** 222-226.
TIMOTHY, S. & SHARON, C. 2012. An Econometrics Assessment of Food Security Estimation Using Fuzzy Logics: A Case in the Arid and Semi Arid Lands of Kenya. *Global Journal of Science Frontier Research,* 12.
TORRES-REYNA, O. 2007. *Panel Data Analysis Fixed & Random Effects* [Online]. Available: http://dss.princeton.edu/training/Panel101.pdf [Accessed 15 March 2014].
VAN DEN BERG, M. & KUMBI, G. E. 2006. Poverty and the rural nonfarm economy in Oromia, Ethiopia. *Agricultural Economics,* 35**,** 469-475.
VERBEEK, M. 2008. *A guide to modern econometrics*, Wiley. com.
VON BRAUN, J. 2009. *Food security risks must be comprehensively addressed*, International Food Policy Research Institute.
WEIR, S. & KNIGHT, J. 2000. *Adoption and diffusion of agricultural innovations in Ethiopia: the role of education*, University of Oxford, Institute of Economics and Statistics, Centre for the Study of African Economies.
WOOLDRIDGE, J. M. 2001. Applications of generalized method of moments estimation. *Journal of Economic perspectives,* 15**,** 87-100.
WORLD-BANK. 2013. *World Development Indicators* [Online]. Washington, DC USA: The World Bank Group. Available: http://databank.worldbank.org/data/home.aspx [Accessed March 30 2014].

# APPENDICES

# Appendix A: Summary of preliminary testes

## *Appendix A1:* Independent samples t-tests

```
. ttest  PcFood_Consumption, by( Drought)

Two-sample t test with equal variances
------------------------------------------------------------------------------
   Group |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
       0 |    4793    99.80095    1.520189     105.245    96.82068    102.7812
       1 |     507    79.01681    3.498459     78.7736    72.14351     85.8901
---------+--------------------------------------------------------------------
combined |    5300    97.81273    1.417322    103.1826     95.0342    100.5913
---------+--------------------------------------------------------------------
    diff |            20.78415    4.810762                11.35307    30.21522
------------------------------------------------------------------------------
    diff = mean(0) - mean(1)                                      t =   4.3203
Ho: diff = 0                                     degrees of freedom =     5298

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 1.0000         Pr(|T| > |t|) = 0.0000          Pr(T > t) = 0.0000

. ttest  PcFood_Consumption, by( Frost_Hailstorm)

Two-sample t test with equal variances
------------------------------------------------------------------------------
   Group |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
       0 |    5156    98.03438    1.441537      103.51    95.20835    100.8604
       1 |     150    91.87202    7.709608    94.42303    76.63773    107.1063
---------+--------------------------------------------------------------------
combined |    5306    97.86017    1.417596     103.261     95.0811    100.6392
---------+--------------------------------------------------------------------
    diff |            6.162358    8.553372               -10.60577    22.93049
------------------------------------------------------------------------------
    diff = mean(0) - mean(1)                                      t =   0.7205
Ho: diff = 0                                     degrees of freedom =     5304

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.7644         Pr(|T| > |t|) = 0.4713          Pr(T > t) = 0.2356

. ttest  PcFood_Consumption, by(Flooding)

Two-sample t test with equal variances
------------------------------------------------------------------------------
   Group |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
       0 |    5111    96.54841    1.403172    100.3145    93.79759    99.29923
       1 |     216    125.8545    10.21531    150.1337    105.7195    145.9895
---------+--------------------------------------------------------------------
combined |    5327    97.73672    1.410506    102.9476    94.97155    100.5019
---------+--------------------------------------------------------------------
    diff |           -29.30608    7.140569               -43.30452   -15.30764
------------------------------------------------------------------------------
    diff = mean(0) - mean(1)                                      t =  -4.1042
Ho: diff = 0                                     degrees of freedom =     5325

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.0000         Pr(|T| > |t|) = 0.0000          Pr(T > t) = 1.0000
```

## *Appendix A2:* Correlation matrix

```
. pwcorr PcFood_Consumption Land HH_Size Livestock Age Age_Squared HH_Dependenc

             | PcFood~n     Land  HH_Size Livest~k      Age Age_Sq~d HH_Dep~y
-------------+---------------------------------------------------------------
PcFood_Con~n |   1.0000 
        Land |   0.1697*  1.0000 
     HH_Size |  -0.2480*  0.1385*  1.0000 
   Livestock |   0.2153*  0.5322*  0.2680*  1.0000 
         Age |   0.1063*  0.0450*  0.0292*  0.0991*  1.0000 
 Age_Squared |   0.1085*  0.0297* -0.0170   0.0831*  0.9857*  1.0000 
HH_Depende~y |  -0.1611* -0.0306*  0.2312* -0.0402* -0.0547* -0.0364*  1.0000
```

*Appendix A3:* **Collinearity diagnostics for explanatory variables used in FE model**

Collinearity Diagnostics

| Variable | VIF | SQRT VIF | Tolerance | R-Squared |
|---|---|---|---|---|
| Drought | 1.08 | 1.04 | 0.9244 | 0.0756 |
| Land | 1.62 | 1.27 | 0.6168 | 0.3832 |
| HH_Size | 1.50 | 1.22 | 0.6682 | 0.3318 |
| HH_Dependency | 1.15 | 1.07 | 0.8680 | 0.1320 |
| Livestock | 1.77 | 1.33 | 0.5635 | 0.4365 |
| Off_farm | 1.15 | 1.07 | 0.8698 | 0.1302 |
| Credit | 1.12 | 1.06 | 0.8909 | 0.1091 |
| Saving_EQUB | 1.13 | 1.06 | 0.8879 | 0.1121 |
| Sex | 1.27 | 1.12 | 0.7903 | 0.2097 |
| Age | 41.98 | 6.48 | 0.0238 | 0.9762 |
| Age_Squared | 40.64 | 6.38 | 0.0246 | 0.9754 |
| Education | 1.36 | 1.17 | 0.7327 | 0.2673 |
| Year2 | 3.36 | 1.83 | 0.2980 | 0.7020 |
| Year3 | 1.05 | 1.02 | 0.9530 | 0.0470 |
| Year4 | 6.76 | 2.60 | 0.1479 | 0.8521 |
| Region2 | 3.32 | 1.82 | 0.3013 | 0.6987 |
| Region3 | 3.12 | 1.77 | 0.3205 | 0.6795 |
| Region4 | 2.71 | 1.65 | 0.3686 | 0.6314 |
| Region5 | 1.76 | 1.33 | 0.5680 | 0.4320 |
| Region6 | 1.90 | 1.38 | 0.5274 | 0.4726 |
| Month2 | 2.02 | 1.42 | 0.4952 | 0.5048 |
| Month3 | 4.34 | 2.08 | 0.2304 | 0.7696 |
| Month4 | 4.39 | 2.10 | 0.2276 | 0.7724 |
| Month5 | 1.58 | 1.26 | 0.6337 | 0.3663 |
| Month6 | 1.87 | 1.37 | 0.5345 | 0.4655 |
| Mean VIF | 5.36 | | | |

*Appendix A4:* **Hausman Specification test (FE vs RE)**

| | Coefficients (b) FE_model | Coefficients (B) RE_model | (b-B) Difference | sqrt(diag(V_b-V_B)) S.E. |
|---|---|---|---|---|
| Drought | -13.07409 | -15.42141 | 2.347321 | 4.255156 |
| Land | 4.461468 | 2.685362 | 1.776105 | 1.302547 |
| HH_Size | -12.48955 | -10.58855 | -1.900997 | .6301314 |
| HH_Depende~y | -2.008684 | -4.87922 | 2.870536 | 1.477142 |
| Livestock | 1.934041 | 3.161348 | -1.227307 | .4702828 |
| Off_farm | 4.49583 | .8868032 | 3.609027 | 2.222079 |
| Credit | 7.99337 | 6.464889 | 1.528481 | 2.37547 |
| Saving_EQUB | 5.860858 | 13.24912 | -7.388261 | 3.477445 |
| Sex | 1.965698 | -.6689173 | 2.634615 | 5.608164 |
| Age | 1.057324 | .3492918 | .7080319 | .6447779 |
| Age_Squared | -.0106786 | -.0000781 | -.0106005 | .0060688 |
| Education | 7.889389 | 10.35813 | -2.468745 | 3.630476 |
| Year2 | 32.87732 | 35.06426 | -2.18694 | 3.019642 |
| Year3 | 2.121837 | -21.02099 | 23.14283 | 32.73173 |
| Year4 | 119.5881 | 105.3346 | 14.25355 | 6.195446 |
| Region2 | -26.93307 | 17.10132 | -44.03439 | 60.17172 |
| Region3 | 97.34121 | 64.12714 | 33.21407 | 58.76125 |
| Region4 | -93.47675 | -4.160246 | -89.31651 | 79.32582 |
| Region5 | -52.18634 | 17.83488 | -70.02122 | 79.52439 |
| Region6 | -32.8809 | 17.00037 | -49.88127 | 78.68762 |
| Month2 | -1.355342 | 14.92865 | -16.284 | 8.177142 |
| Month3 | -20.84336 | -13.8334 | -7.009967 | 6.381102 |
| Month4 | -15.86486 | -15.85076 | -.0141029 | 3.760695 |
| Month5 | 45.90879 | 41.32456 | 4.584231 | 6.428363 |
| Month6 | 7.28688 | -12.47663 | 19.76351 | 4.5336 |

b = consistent under Ho and Ha; obtained from xtreg
B = inconsistent under Ha, efficient under Ho; obtained from xtreg

Test: Ho: difference in coefficients not systematic

chi2(24) = (b-B)'[(V_b-V_B)^(-1)](b-B)
= 86.26
Prob>chi2 = 0.0000

### *Appendix A5:* Heteroskedasticity test

```
Modified Wald test for groupwise heteroskedasticity
in fixed effect regression model

H0: sigma(i)^2 = sigma^2 for all i

chi2 (1382)  =  3.9e+38
Prob>chi2 =      0.0000
```

### *Appendix A6: Test for time fixed effects*

```
.        testparm Year1 Year2 Year3 Year4 Region1 Region2 Region3 Region4 R

 ( 1)  Year2 = 0
 ( 2)  Year3 = 0
 ( 3)  Year4 = 0
 ( 4)  Region2 = 0
 ( 5)  Region3 = 0
 ( 6)  Region4 = 0
 ( 7)  Region5 = 0
 ( 8)  Region6 = 0
 ( 9)  Month2 = 0
 (10)  Month3 = 0
 (11)  Month4 = 0
 (12)  Month5 = 0
 (13)  Month6 = 0

       F( 13,  1381) =   29.84
            Prob > F =    0.0000

. testparm Year1 Year2 Year3 Year4 Month1 Month2 Month3 Month4 Month5 Month

 ( 1)  Year2 = 0
 ( 2)  Year3 = 0
 ( 3)  Year4 = 0
 ( 4)  Month2 = 0
 ( 5)  Month3 = 0
 ( 6)  Month4 = 0
 ( 7)  Month5 = 0
 ( 8)  Month6 = 0

       F(  8,  1381) =   47.01
            Prob > F =    0.0000

. testparm Region1 Region2 Region3 Region4 Region5 Region6

 ( 1)  Region2 = 0
 ( 2)  Region3 = 0
 ( 3)  Region4 = 0
 ( 4)  Region5 = 0
 ( 5)  Region6 = 0

       F(  5,  1381) =   13.77
            Prob > F =    0.0000
```

## Appendix B: Regression outputs of various specifications

### *Appendix B1: FE model with all exogenous variables (Specification 1)*

```
Fixed-effects (within) regression               Number of obs      =      3468
Group variable: Unique_HHID                     Number of groups   =      1382

R-sq:  within  = 0.4163                         Obs per group: min =         1
       between = 0.2206                                        avg =       2.5
       overall = 0.2725                                        max =         4

                                                F(25,1381)         =     46.38
corr(u_i, Xb)  = -0.4888                        Prob > F           =    0.0000

                           (Std. Err. adjusted for 1382 clusters in Unique_HHID)
```

| PcFood_Con~n | Coef. | Robust Std. Err. | t | P>\|t\| | [95% Conf. | Interval] |
|---|---|---|---|---|---|---|
| Drought | -13.07409 | 5.859483 | -2.23 | 0.026 | -24.56854 | -1.57964 |
| Land | 4.461468 | 2.110344 | 2.11 | 0.035 | .3216414 | 8.601294 |
| HH_Size | -12.48955 | 1.14149 | -10.94 | 0.000 | -14.72879 | -10.25031 |
| HH_Depende~y | -2.008684 | 2.373756 | -0.85 | 0.398 | -6.665241 | 2.647873 |
| Livestock | 1.934041 | 1.009596 | 1.92 | 0.056 | -.046467 | 3.914549 |
| Off_farm | 4.49583 | 3.877544 | 1.16 | 0.246 | -3.110682 | 12.10234 |
| Credit | 7.99337 | 3.539493 | 2.26 | 0.024 | 1.050005 | 14.93673 |
| Saving_EQUB | 5.860858 | 5.033475 | 1.16 | 0.244 | -4.013225 | 15.73494 |
| Sex | 1.965698 | 8.359105 | 0.24 | 0.814 | -14.43222 | 18.36361 |
| Age | 1.057324 | 1.00313 | 1.05 | 0.292 | -.9104994 | 3.025147 |
| Age_Squared | -.0106786 | .0095657 | -1.12 | 0.264 | -.0294436 | .0080863 |
| Education | 7.889389 | 5.612737 | 1.41 | 0.160 | -3.121024 | 18.8998 |
| Year2 | 32.87732 | 5.045482 | 6.52 | 0.000 | 22.97969 | 42.77496 |
| Year3 | 2.121837 | 34.21088 | 0.06 | 0.951 | -64.98908 | 69.23275 |
| Year4 | 119.5881 | 9.725293 | 12.30 | 0.000 | 100.5102 | 138.6661 |
| Region2 | -26.93307 | 32.35452 | -0.83 | 0.405 | -90.40239 | 36.53625 |
| Region3 | 97.34121 | 76.17657 | 1.28 | 0.202 | -52.09309 | 246.7755 |
| Region4 | -93.47675 | 48.04069 | -1.95 | 0.052 | -187.7174 | .7638692 |
| Region5 | -52.18634 | 47.87335 | -1.09 | 0.276 | -146.0987 | 41.72601 |
| Region6 | -32.8809 | 47.11215 | -0.70 | 0.485 | -125.3 | 59.53822 |
| Month2 | -1.355342 | 13.68913 | -0.10 | 0.921 | -28.20908 | 25.4984 |
| Month3 | -20.84336 | 9.420007 | -2.21 | 0.027 | -39.32243 | -2.364294 |
| Month4 | -15.86486 | 6.425604 | -2.47 | 0.014 | -28.46986 | -3.259861 |
| Month5 | 45.90879 | 11.01466 | 4.17 | 0.000 | 24.30153 | 67.51606 |
| Month6 | 7.28688 | 6.946922 | 1.05 | 0.294 | -6.34078 | 20.91454 |
| _cons | 86.71478 | 45.88939 | 1.89 | 0.059 | -3.305672 | 176.7352 |
| sigma_u | 79.179246 | | | | | |
| sigma_e | 75.765974 | | | | | |
| rho | .52201821 | (fraction of variance due to u_i) | | | | |

## *Appendix B2: 2-Step GMM estimation for FE regression model (Specification 2)*

2-Step GMM estimation

Estimates efficient for arbitrary heteroskedasticity
Statistics robust to heteroskedasticity

| | | | |
|---|---|---|---|
| | | Number of obs = | 1817 |
| | | F( 24, 886) = | 10.55 |
| | | Prob > F = | 0.0000 |
| Total (centered) SS | = 9105605.176 | Centered R2 = | -0.4775 |
| Total (uncentered) SS | = 9105605.176 | Uncentered R2 = | -0.4775 |
| Residual SS | = 13453135.26 | Root MSE = | 121.6 |

| PcFood_Con~n | Coef. | Robust Std. Err. | z | P>\|z\| | [95% Conf. | Interval] |
|---|---|---|---|---|---|---|
| Off_farm | 225.2214 | 266.4489 | 0.85 | 0.398 | -297.0089 | 747.4516 |
| Credit | 26.76933 | 105.3245 | 0.25 | 0.799 | -179.6629 | 233.2016 |
| Saving_EQUB | 51.94255 | 134.2696 | 0.39 | 0.699 | -211.2211 | 315.1062 |
| Drought | -9.936391 | 15.71086 | -0.63 | 0.527 | -40.7291 | 20.85632 |
| Land | 4.518508 | 6.201021 | 0.73 | 0.466 | -7.635269 | 16.67228 |
| HH_Size | -16.09662 | 4.410256 | -3.65 | 0.000 | -24.74057 | -7.452682 |
| HH_Depende~y | 1.251782 | 6.580528 | 0.19 | 0.849 | -11.64582 | 14.14938 |
| Livestock | 1.752665 | 3.304441 | 0.53 | 0.596 | -4.723921 | 8.229252 |
| Sex | -5.35855 | 15.04962 | -0.36 | 0.722 | -34.85527 | 24.13817 |
| Age | 1.659813 | 2.469435 | 0.67 | 0.501 | -3.18019 | 6.499816 |
| Age_Squared | -.0123112 | .0230868 | -0.53 | 0.594 | -.0575604 | .0329381 |
| Education | -2.06787 | 12.62414 | -0.16 | 0.870 | -26.81072 | 22.67498 |
| Year2 | -8.606415 | 95.81491 | -0.09 | 0.928 | -196.4002 | 179.1874 |
| Year3 | -85.53014 | 82.24254 | -1.04 | 0.298 | -246.7226 | 75.66228 |
| Region2 | -80.53857 | 82.38751 | -0.98 | 0.328 | -242.0151 | 80.93798 |
| Region3 | 145.4498 | 61.18561 | 2.38 | 0.017 | 25.52818 | 265.3714 |
| Region4 | -139.4096 | 106.5509 | -1.31 | 0.191 | -348.2456 | 69.42638 |
| Region5 | -121.6989 | 114.2475 | -1.07 | 0.287 | -345.6199 | 102.222 |
| Region6 | -68.13316 | 119.4007 | -0.57 | 0.568 | -302.1541 | 165.8878 |
| Month2 | 83.97512 | 171.7794 | 0.49 | 0.625 | -252.7064 | 420.6567 |
| Month3 | 66.03953 | 162.6512 | 0.41 | 0.685 | -252.751 | 384.8301 |
| Month4 | 42.19696 | 101.7008 | 0.41 | 0.678 | -157.133 | 241.5269 |
| Month5 | 175.1592 | 192.2064 | 0.91 | 0.362 | -201.5584 | 551.8768 |
| Month6 | 84.45396 | 120.1863 | 0.70 | 0.482 | -151.1069 | 320.0148 |

Underidentification test (Kleibergen-Paap rk LM statistic): 1.042
Chi-sq(1) P-val = 0.3073

Weak identification test (Cragg-Donald Wald F statistic): 0.391
(Kleibergen-Paap rk Wald F statistic): 0.341
Stock-Yogo weak ID test critical values: <not available>

Hansen J statistic (overidentification test of all instruments): 0.000
(equation exactly identified)
-endog- option:
Endogeneity test of endogenous regressors: 3.835
Chi-sq(3) P-val = 0.2798
Regressors tested: Off_farm Credit Saving_EQUB

Instrumented: Off_farm Credit Saving_EQUB
Included instruments: Drought Land HH_Size HH_Dependency Livestock Sex Age Age_Squared Education Year2 Year3 Region2 Region3 Region4 Region5 Region6 Month2 Month3 Month4 Month5 Month6
Excluded instruments: L5.Off_farm L5.Credit L5.Saving_EQUB
Dropped collinear: Year4

*Appendix B3: FE model without potential endogenous variables (Specification 3)*

```
Fixed-effects (within) regression               Number of obs      =      3471
Group variable: Unique_HHID                     Number of groups   =      1382

R-sq:  within  = 0.4150                         Obs per group: min =         1
       between = 0.2272                                        avg =       2.5
       overall = 0.2809                                        max =         4

                                                F(22,1381)         =     50.90
corr(u_i, Xb)  = -0.4577                        Prob > F           =    0.0000

                         (Std. Err. adjusted for 1382 clusters in Unique_HHID)
```

| PcFood_Con~n | Coef. | Robust Std. Err. | t | P>\|t\| | [95% Conf. | Interval] |
|---|---|---|---|---|---|---|
| Drought | -11.79462 | 5.832041 | -2.02 | 0.043 | -23.23524 | -.3540067 |
| Land | 4.628794 | 2.119888 | 2.18 | 0.029 | .4702444 | 8.787343 |
| HH_Size | -12.32464 | 1.134443 | -10.86 | 0.000 | -14.55005 | -10.09922 |
| HH_Depende~y | -2.338517 | 2.365432 | -0.99 | 0.323 | -6.978746 | 2.301712 |
| Livestock | 1.901828 | 1.001067 | 1.90 | 0.058 | -.0619483 | 3.865605 |
| Sex | 2.120932 | 8.390472 | 0.25 | 0.800 | -14.33852 | 18.58038 |
| Age | 1.172377 | 1.003994 | 1.17 | 0.243 | -.7971408 | 3.141894 |
| Age_Squared | -.0119618 | .0095773 | -1.25 | 0.212 | -.0307493 | .0068258 |
| Education | 8.35382 | 5.640313 | 1.48 | 0.139 | -2.710686 | 19.41833 |
| Year2 | 34.39361 | 5.100212 | 6.74 | 0.000 | 24.38861 | 44.39861 |
| Year3 | 7.595674 | 34.82531 | 0.22 | 0.827 | -60.72055 | 75.9119 |
| Year4 | 123.6695 | 9.807601 | 12.61 | 0.000 | 104.4301 | 142.9089 |
| Region2 | -18.35234 | 33.17711 | -0.55 | 0.580 | -83.43533 | 46.73065 |
| Region3 | 97.04849 | 77.70912 | 1.25 | 0.212 | -55.39219 | 249.4892 |
| Region4 | -85.2332 | 49.93731 | -1.71 | 0.088 | -183.1944 | 12.72799 |
| Region5 | -43.35479 | 49.75815 | -0.87 | 0.384 | -140.9645 | 54.25494 |
| Region6 | -24.69938 | 49.08416 | -0.50 | 0.615 | -120.987 | 71.5882 |
| Month2 | -4.174586 | 13.50644 | -0.31 | 0.757 | -30.66995 | 22.32078 |
| Month3 | -23.70099 | 9.408538 | -2.52 | 0.012 | -42.15756 | -5.244418 |
| Month4 | -18.32236 | 6.310213 | -2.90 | 0.004 | -30.701 | -5.943723 |
| Month5 | 41.66783 | 10.8863 | 3.83 | 0.000 | 20.31235 | 63.02331 |
| Month6 | 5.228093 | 6.933495 | 0.75 | 0.451 | -8.373228 | 18.82941 |
| _cons | 84.84794 | 46.85192 | 1.81 | 0.070 | -7.06068 | 176.7566 |
| sigma_u | 77.138803 | | | | | |
| sigma_e | 75.796253 | | | | | |
| rho | .50877789 | (fraction of variance due to u_i) | | | | |

### *Appendix C: Robustness of the results*

```
. estimates table Exc_Alldummies Exclude_time Exc_regions Exc_Drought, star stats(N r
```

| Variable | Exc_Alldumm~s | Exclude_time | Exc_regions | Exc_Drought |
|---|---|---|---|---|
| Drought | -6.897261 | -6.177245 | -21.88846*** | |
| HH_Size | -14.493792*** | -14.650267*** | -11.984966*** | -12.475235*** |
| HH_Depende~y | -8.643206** | -8.4679938** | -2.4894215 | -2.386263 |
| Sex | -53.417425*** | -52.585539*** | 1.5301704 | 5.5788556 |
| Age | 4.4886431*** | 4.4367609*** | .82355875 | .67528619 |
| Age_Squared | -.02614865* | -.02613397* | -.00782613 | -.00751968 |
| Education | 40.478333*** | 40.394506*** | 10.917007 | 7.8798234 |
| Land | 2.8304965 | 2.9471504 | 2.1648008 | 4.4767886* |
| Livestock | 5.8976132*** | 5.9523935*** | 2.2629447* | 2.0058928* |
| Off_farm | 8.5993281* | 8.6087904* | 3.3974342 | 4.0724835 |
| Credit | 15.718736*** | 15.707387*** | 7.3688742* | 7.3378954* |
| Saving_EQUB | 1.2644224 | 1.7812212 | 8.9927792 | 3.4759041 |
| Region2 | | 51.534086 | | -2.6773904 |
| Region3 | | 150.20301* | | 118.44198** |
| Region4 | | 36.566294 | | 7.2289599 |
| Region5 | | 17.721298 | | 47.99482 |
| Region6 | | 42.651202 | | 70.433221 |
| Year2 | | | 39.598627*** | 32.103594*** |
| Year3 | | | -5.8710157 | -19.086492 |
| Year4 | | | 113.5131*** | 119.63129*** |
| Month2 | | | -3.9720502 | 1.0016473 |
| Month3 | | | -24.985494** | -19.390111* |
| Month4 | | | -22.088685*** | -15.399094* |
| Month5 | | | 32.740623** | 43.178943*** |
| Month6 | | | -5.0231259 | 10.09132 |
| _cons | 32.907557 | -32.536439 | 90.622232*** | 51.806152 |
| N | 3468 | 3468 | 3468 | 3715 |
| r2 | .26981747 | .2729639 | .40066161 | .425012 |
| r2_a | .26728138 | .26938141 | .39718416 | .42127224 |

legend: * p<0.05; ** p<0.01; *** p<0.001