ANALYSIS OF VULNERABILITY TO FOOD INSECURITY IN RURAL HOUSEHOLDS' OF ETHIOPIA

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ANALYSIS OF VULNERABILITY TO FOOD INSECURITY IN RURAL HOUSEHOLDS' OF ETHIOPIA

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DECLARATION

I, the undersigned, declare that this Master's thesis paper entitled *"Analysis of Vulnerability to Food Insecurity in Rural households' of Ethiopia"* is my original work prepared under the guidance of Sisay Debebe (PhD). All sources of materials used for this thesis preparation have been duly acknowledged. I also declare that this paper has not been submitted either in part or in full to any other higher learning institution for earning degree.

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APPROVAL SHEET

This is to Certify that the thesis prepared by **TSIGE ZERAY**, entitled: "**Analysis of vulnerability to food insecurity in rural households' of Ethiopia**" submitted in partial fulfillment of the requirements for the degree of *Master of science in Development Economics* complies with the regulations of the University and meets the accepted standards with respect to originality and quality. Signed by the Examining Committee:

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ACRONYMS AND ABBREVIATIONS

COVID-19	Corona Virus Disease of 2019
CSA	Central Statistical Authority
FAO	Food and Agricultural Organization
GLS	Generalized Least Squares
IFPRI	International Food Policy Research Institute
MOARD	Ministry of Agriculture and Rural Development
MoFED	Ministry of Finance and Economic Development
EAs	Enumeration Areas
ESS	Ethiopian Socio-Economic Survey
TLU	Tropical Livestock Unit
UNICEF	The United Nations Children's Fund
VA	Vulnerability Analysis
VEP	Vulnerability as Expected Poverty
VER	Vulnerability as Uninsured Exposure to Risk
VEU	Vulnerability as Low Expected Utility
VIF	Variance Inflation Factor
WHO	World Health Organization

DEDICATION

This thesis work is dedicated to my father Zeray Demoz, my mother Tseadu Tetemke and my sister Meseret Zeray for nursing me with affection and love and for their dedicated partnership in the success of my life.

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ABSTRACT

This study examines Analysis of vulnerability to food insecurity in rural households of Ethiopia, using a sample data of 3115 rural households from the Ethiopian socio economic Survey (ESS). Calorie method was employed to determine food insecurity and vulnerability. In addition to descriptive statistics, GLS and the Logit models was used to analyze the data. The Results indicates that, Majority of the households were found to be food insecure, which is 62.95% were found to be food insecure (1961 out of 3115) whereas the rest 37.05% of the households were found to be food secure. Furthermore, the estimated logit model result revealed that Rainfall shock, Death of livestock were positively and significant influence current food insecurity status of household, on the other hand, age of household head, Education level of the household head, annual household farm income, participation in off farm activity, access to credit and remittance were negatively affected the extent of households' food insecurity. General Least Squares regression results indicate that Total land holding in ha of household head has a significantly positive correlation with calorie intake and Households access to credit significantly increase expectation of food consumption. Empirical finding also shows that rain fall shocks (environmental shocks) have larger impact on vulnerability to food insecurity. Based on the intensity of their vulnerability, households were grouped highly vulnerable-food secure (18.4 percent), and low vulnerable-food secure (45.84 percent).Overall, about 54.4 percent of households were categorized as vulnerable to food insecurity.

Key words: *Vulnerability as expected poverty, Vulnerability to food insecurity, Food insecurity, Ethiopia*

Chapter 1 : INTRODUCTION

1.1 Background of the study

According to the latest FAO estimates, roughly 10% of the world's population, or 770 million people, were affected by acute food insecurity in 2017. Values range from 1.4 percent in Northern America and Europe to around 30 percent in Africa at the regional level. As in the case of the prevalence of undernourishment (PoU), severe food insecurity has been on the rise at the global level, driven by trends observed in Africa and Latin America, (FAO, 2018).

Globally, the world is not on track to achieve targets for any of the nutrition indicators by 2030.With the Corona Virus Disease of 2019 (COVID-19) pandemic and related containment measures, the obstacles have increased. In 2020, about 12% of the world's population was extremely food insecure, accounting for 928 million people that is 148 million more than in 2019 (FAO, 2021). The State of Food Insecurity and Nutrition's of the World 2021 showed that it is projected that between 720 and 811 million people in the world faced hunger in 2020. Considering the middle of the projected range (768 million), around 118 million more people were facing hunger in 2020 than in 2019 or as many as 161 million more, considering the upper bound of the range. More than half of the worlds undernourished are found in Asia (418 million) and more than one-third in Africa (282 million). Compared with 2019, about 46 million more people in Africa, 57 million more in Asia, and about 14 million more in Latin America and the Caribbean were affected by hunger in 2020. And almost all low- and middle-income countries were affected by pandemic-induced economic downturns, and the increase in their number of undernourished was more than five times greater than the highest increase in undernourishment in the last two decades. When those countries were also affected by other drivers, particularly climate-related disasters, conflict, or a combination, the largest increase in undernourishment was seen in Africa, followed by Asia, (FAO, 2021).

According to international food policy research institute, Global food Security is currently under stress and 2020, which brought the pandemic, was a year of crisis. And the terrible loss and disruption experienced worldwide will continue in many places through this year and even beyond. Increased poverty, food insecurity, malnutrition, and unemployment have pushed the Sustainable Development Goals further out of reach for many countries, and shined a harsh light on the disparities in our food systems, (IFPR, 2021).

In 2016, Africa had the greatest rate of acute food insecurity, with 27.4% of the population, over four times that of any other area. Food insecurity is on the rise in the region, particularly in Sub-Saharan Africa, with an increase of nearly three percentage points from 2014 to 2016. In Latin America, food insecurity increased over the three-year period, rising from 4.7 percent to 6.4 percent. Between 2014 and 2016, the prevalence of severe food insecurity in Asia decreased slightly, from 7.7% to 7.0 percent overall, driven mainly by the reduction observed in Central Asia and Southern Asia, (FAO, 2017).

Nearly 33 million Ethiopians suffer from chronic malnutrition and food insecurity, with dry land areas accounting for the majority of the food-insecure population. According to the report of the ministry of agriculture and rural development (MoARD, 2009), arid and semiarid rangelands of Ethiopia comprise nearly 13% of the population, while these areas constitute about 63% of the country's landmass (Bezu, 2018). Prolonged drought, conflict, and political instability are the main causes of food insecurity in Ethiopia's dry lands, as are crop disease, flooding, the long-term effects of previous bad seasons, desert locusts, low household income, and the cost of nutritious foods and knowledge about nutritious food factors, (FAO, 2018).

Ethiopia already facing one of the worst food crises in the world. The compounding impacts of conflicts, desert locusts, the effects of the coronavirus disease 2019 (COVID-19) pandemic, natural hazards, and the poor macroeconomic context continue to threaten the food security and livelihoods of millions of Ethiopians, limiting their capacity to cope with future shocks and stressors (FAO,2021).According to the Food Security Information Network, Ethiopia was the most food-insecure country in the area, with 8.1 million people in need of immediate assistance, followed by Sudan with 6.2 million and South Sudan with 6.1 million. The situation is particularly severe in the region's dry land areas, where extended dry weather and flash floods have harmed pastoral and agro-pastoral livelihoods by creating lower-than-average crop

production, grazing, and limited water sources for both, resulting in chronic and acute food insecurity. As a result, these regions have become heavily dependent on external food aid, (FSIN, 2020).

Conflict can increase food insecurity through its negative effects on agricultural production. And it affects agriculture directly when crops are destroyed or taken for militant groups, inputs are destroyed or prevented from reaching farmers, land is inaccessible to farmers and cannot be utilized normally, agricultural equipment and infrastructure are damaged, and agricultural labor is reduced due to injury, death, or displacement, (Adelaja and George, 2019).

1.2 Statements of the problem

We are living in the world where about 842 million people are food insecure, and the majority of food insecure people live in developing countries in general and Sub Saharan African countries in particular, FAO (2013). Sub-Saharan Africa is the area in the world that is mostly hit by food insecurity and is not in the right track to reduce vulnerability to food insecurity, GAO (2008). Sub-Saharan Africa is the lowest in terms of general food insecurity index in the world showing the lesser degree of resilience of the region to food insecurity, EIU (2014). Food insecurity is one of the development challenges of developing countries in general and African countries in particular, FAO (2010). About one billion people are estimated to be undernourished where 98% of these people are living in developing countries. Sub Saharan Africa (SSA) has the highest prevalence of under-nourishment among developing regions, World Bank (2013).

As part of SSA, Ethiopia faces daunting poverty and food insecurity challenges that have been worsening overtime. The percentage of undernourished people in Ethiopia was 35 percent in 2014, and Ethiopia is ranked first in terms of the number of people in state of under nourishment with 32.1 million under nourished people in Africa, FAO (2015). The high-level food insecurity in Ethiopia is mainly caused by the poor performance of the agricultural sector and this poor performance of agricultural sector in Ethiopia attributes to both policy and non-policy factors, Temesgen et'al (2016).and also it is well thought-out that over 928 million people in the world are affected by food insecurity according to assessments made by the Food and Agriculture Organization of the United Nations (FAO) in the years 2020.

Large portions of the Ethiopian population have been affected by chronic and transitory food insecurity. The situation of chronically food insecure people is more and more severe. Food security situation in Ethiopia is highly linked up to severe, recurring food shortage and famine, which is associated with recurrent drought. Currently, there is a growing consensus that food insecurity and poverty problems are closely related in the Ethiopian context. More than 50% of the total population, of whom the majority reside in rural areas, does not have access to the medically recommended minimum average daily intake of 2100 kcal per person per day, USAID (2012).

A review of the literature on the household food insecurity shows that there are limited numbers of studies carried out in Ethiopia. There are some studies that have been conducted on determinants of food insecurity in general. Mesfin (2014) conducted a study on the household's food insecurity and the extent of future vulnerability in Ethiopia's Amhara region, using WMS and HCES of CSA. The Results indicates that, demand side factors related to socio economic factors like family sizes, education, consumption, employment opportunities and asset ownership was a significant predictor of vulnerability and food insecurity. In rural areas, supply side factors like farm inputs and farm size are also related to food insecurity. Moreover, future vulnerability of households is highly related with current food insecurity.

Agidew & Singh (2018) conducted a study on the determinants of food insecurity in rural farm households in Ethiopia's South Wollo zone, using a sample of 215 households and logistic regression to find that about 79.1% of households were food insecure, with the age of the household head, land size, recurrent drought, lack of rainfall, and land degradation being the determining factors. Similar analysis has been undertaken by Getahun and Beyene (2014) examined the status and factors affecting food insecurity in rural households in Babile district, Ethiopia. Their result show that the educational status of the household head, annual farm income, use of irrigation schemes, and size of cultivated land were associated negatively with household food insecurity levels while insect and pest infestation demonstrated a positive and significant association with household food insecurity.

Previous studies on food insecurity in many developing countries, including Ethiopia, have mainly focused on current food insecurity, lacking the ex-ante analysis. This study attempts to fill the gap by undertaking Vulnerability analysis (VA). The approach is explicitly dynamic and forward-looking, in the sense that it not only concerned with current outcomes but also looks at their future incidence. Vulnerability to Food Insecurity (VFI) is a function of not only exposure to shocks but also the capacity of each household to deal with the welfare impacts of the shocks. The level of risk exposure and the capacity to absorb shocks are changing, making vulnerability dynamic.

Unlike previous literatures which are based up on region specific studies, the current study relies on data from country representative. The current study utilizes relatively recent data which can show the latest food security status of the rural household. Therefore, it is believed that this study will be an addition to the existing literatures. The study gives more clarity on the factors of household vulnerability to food insecurity and addresses this gap by applying the VEP model to a sample size of 3115 rural households.

1.3 Objective of the study

The main objective of the study is to examine the rural household's vulnerability to food insecurity in Ethiopia.

Specific objectives:

In order to achieve the above objective, the specific objectives are: -

- To measure the statistical status of food insecurity situations.
- To identify determinants of food insecurity and vulnerability in the study area.
- To measure the level of vulnerability to food insecurity in Ethiopia.

1.4 Research Questions

In line with the above stated objectives, principal motivation of the present analysis is thus to explore the following questions.

1. What is the current rate of food insecurity in Ethiopia?
2. Who is vulnerable to food insecurity and what are the characteristics of households with vulnerability?
3. What is the degree of households' vulnerability to food insecurity in Ethiopia?

1.5 Significance of the Study

This study is important to identify the food secure and insecure households with in communities and try to predict how the different segments of population will be affected by un expected adverse events.

This study has benefits to the community, stakeholders', private investors, local community and planners to give proper attention for the food security. It also fills the knowledge gap that the study on vulnerability of food insecurity. It gives direction for the government, privet sector and local community about the current and future food security status in Ethiopia. In addition, it can serve as a starting point for further analysis and research work in household food security and vulnerability to food insecurity in rural areas.

1.6 Scope of the study

The key concern of this study is analyzing the Rural Households' Vulnerability and Food Insecurity in Ethiopia. The ESS wave 4 data is a nationally representative data, thus the results of the study could be nationally representative findings as far as rural Ethiopia is concerned. The study addresses the stability dimension of food security.

1.7 Limitation of the study

The study used a cross sectional secondary data from World Bank Survey which is collected by Socio-Economic Survey (ESS) and Central Statistics Agency of Ethiopia (CSA).Some observations were excluded due to missing information and reducing the sample size into 3115 rural households and sizable samples are dropped from the empirical analysis.

1.8 Organization of the thesis

There are five main chapters in this thesis. The study's first chapter includes a background section that includes the statement of the problem, objectives, research questions, as well as the study's significance, scope and limitations of the study. Chapter two, review of literature, illustrates the concepts as well as the theoretical and empirical basis of the study. Chapter three presents the setting, materials and methods used in the study. Chapter four presents the results and discussion in detail. Conclusions and recommendations based on the findings of the research work are presented in chapter five. Finally, some of the regression analysis outputs and conversion factors used in the data analysis are included in Appendix Tables.

Chapter 2 REVIEW OF RELATED LITERATURE

2.1 THEORETICAL REVIEW

2.1.1 Definitions and concepts of food security

Food security as a concept originated only in the mid-1970s, in the discussions of international food problems at a time of global food crisis. The initial focus of attention was primarily on food supply problems of assuring the availability and to some degree the price stability of basic foodstuffs at the international and national level. That supply-side, international and institutional set of concerns reflected the changing organization of the global food economy that had precipitated the crisis. A process of international negotiation followed, leading to the World Food Conference of 1974, and a new set of institutional arrangements covering information, resources for promoting food security and forums for dialogue on policy issues (ODI. 1997).

The 1996 World Food Summit adopted a still more complex definition: "Food security, at the individual, household, national, regional and global levels is achieved when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life" (world food summit,1996).

This definition is again refined in The State of Food Insecurity 2001: "Food security is 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" (FAO, 2001).

Food security is a broad concept, encompassing issues related to the nature, quality, and security of food supply as well as issues of food access. FAO recognizes four essential pillars of food security.

1. Food availability. It is the measure of food that is, and will be, physically available in the relevant vicinity of a population during the given consumption period through a combination of domestic production, stocks, trades and transfers. The availability of sufficient quantities of food of appropriate quality, supplied through domestic production or imports (including food aid).

2. Food accessibility. It is a measure of populations ability to acquire available food during the given consumption period through a consumption of its own production and stocks, market transactions or transfer. Access is a key determinant of healthy diets. Nearly three-quarter of Africans cannot afford a "healthy diet," and 51 percent cannot afford a "nutrient adequate" diet. Even an "energy sufficient" diet is beyond the means of 11.3 percent of. For the nearly 430 million Africans that live in extreme poverty, the "energy sufficient" diet costs about 50 percent of their food expenditure budgets. No household living in extreme poverty can afford a "nutrient adequate" or "healthy diet." In low-income African countries, the energy sufficient diet costs about 56 percent of the food poverty line, and in lower- and upper-middle income African countries, the share is 64 percent and 70 percent, respectively. The cost of nutrient adequate and healthy diets significantly exceeds the food poverty line, (FAO, 2017).

3. Food utilization. It is a measure of whether a population will be able to derive sufficient nutrition during the given consumption period from available and accessible food to meet its dietary needs.

4. Food stability. It is related to regular intake of food. Even if one's food intake is adequate today, one is still considered to be food insecure if one has inadequate access to food on a periodic basis, risking a deterioration of one's nutritional status. Adverse weather condition, political instability or economic factors (unemployment, rising food prices) may have an impact on one's security status.

Hunger and Malnutrition are the direct consequences of food insecurity, with significant repercussions for individual, household, and societal well-being. According to a report by the Millennium Project Hunger Task Force, labor productivity losses due to malnutrition and hunger account for 6 to 10% of GDP on average, and significant declines in children's cognitive capacities are also linked to malnutrition (Sanchez et al. 2005). The report in addition shows that food insecure and hungry people face political and social segregation. Another study shows that at the household level food insecurity leads to "physical impairment" through hunger and illness; "psychological suffering" through stress, fear and departure from norms; and "socio-familial perturbations" through distorted means of food acquisition and modification of eating patterns (Hamelin et al. 2002).

Food insecurity is classified into five phases by the Integrated Food Security Phase Classification [IPC], 2020: phase one (people who are minimally food insecure), phase two (people in stress), phase three (people in crises), phase four (people in an emergency), and phase five (people who are severely food insecure) (people in catastrophe). According to the report, out of Ethiopia's 8 million food insecure people, 21% are severely food insecure at the IPC Phase three level, 38% at the IPC Phase two level, 34% at the IPC Phase one level, 6% at the IPC Phase four level, and 0% at the IPC Phase five level. All food-insecure households, including current internally displaced persons and returnees, are included in the study, regardless of whether they receive assistance from a productive safety net program (PSNP).

2.1.2 The Concept of Vulnerability

In the broad academic literature, vulnerability is a term with a variety of discipline specific implications. The disaster management literature generally associates vulnerability with natural hazards (Alwang et al. 2001), while both human geography and human ecology relate vulnerability to environmental change (Adger 2006). Food insecurity and poverty literature, as well as social risk management literature, define vulnerability in terms of future negative effects on welfare (Mansuri and Healy 2001; Dercon 2001; Holzmann and Jørgensen 2000; World Bank 2000). Others define vulnerability in terms of the level of risk and capacity to recover and respond to it. Thus, not only does vulnerability imply a measure of risk associated with physical, social, and economic aspects, it also describes the ability to cope with different risks and shocks (Chambers 1989; Proag 2014). Accordingly, there are two components of vulnerability: the external side referring to the structural elements that determine sensitivity and risk to exposure (Chambers 1989; Moser 1998; McCarthy et al. 2001), while the internal side concerns the ability of households to respond and cope with stressors and the actions required to overcome them (Chambers 1989; Bohle 2001; Hart 2009).

In the framework of social risk management, vulnerability to poverty was first applied in early 2000s and thereafter, thus increasing awareness about vulnerability in the context of food insecurity (Scaramozzino 2006; Bogale 2012; Sharaunga et al. 2015;Ozughalu 2016). In the context of food insecurity, vulnerability is defined as a household‟s probability to fall, or stay, below food poverty line within a given period time (Løvendal et al. 2004; Løvendal and Knowles 2005;Capaldo et al. 2010).

Definitions of vulnerability are plentiful; the real difficulty has been in finding a robust measurement of vulnerability that is consistent with the basic tenets of risk analysis. There are two main approaches to vulnerability measurement. The outcome approach measures vulnerability in terms of expected poverty (Chaudhuri, 2001; Chaudhuri, Jalan and Suryhadi 2002). The utility-based approach measures vulnerability as the difference between the utility a household would derive from the consumption of a particular bundle with certainty and the expected utility of consumption (Ligon and Schecter, 2003, 2004).

Vulnerability analysis has two main advantages. First, it is explicitly dynamic; vulnerability analysis does not just focus on the current status, but it is also forward-looking (ex-ante). Secondly, it is also emphasis on given shock or set of shocks and the coping strategies that household and communities can adopt in order to reduce the probability of being food insecure (Bogale, 2012; Mutabazi et al., Ozughalu., 2016; Scaramozzino, 2006).

The main difference between food insecurity and VFI analysis is that the former summarizes food insecurity as a deficiency of a given household or society at a particular point in time, thus a static measure of welfare that categorizes households as either “food secure” or “food insecure”. On the other hand, the later takes into account the different shocks and risks, such as climate change, land degradation, drought, erratic rainfall, and environmental degradation, that may affect households and society in the future, determining if consumption will move below a given threshold level. Further vulnerability analysis will sort households into four food security statuses: “chronically food insecure,” “transitory food insecure,” “permanently food secure,” and “transitory food secure” (Scaramozzino, 2006; Bogale, 2012).

According to FAO (2002), Løvendal and Knowles (2005), Ligon and Schechter (2004), just as there is no unique indicator of food security, there is also no single method to analysis vulnerability of food insecurity (VFI). However, there are three principal methods to assessing vulnerability of food insecurity (VFI): vulnerability as expected poverty (VEP), vulnerability as low expected utility (VEU), and vulnerability as uninsured exposure to risk (VER) (Deressa et al. 2009; Hoddinott and Quisumbing 2003; Scaramozzino, 2006).

VEP focuses on the probability that a given shock or set of shocks will move the wellbeing of individuals or households below the benchmark (such as below the food poverty line) in the near future (Pritchett et al. 2000; Chaudhuri et al. 2002; Chaudhuri 2003; Christiaensen and Subbarao 2005; Bogale 2012). VEU focuses on the change of utility derived from a certainty equivalent level of consumption (a benchmark) to the household‟s own expected utility (Ligon and Schechter 2003; Hoddinott and Quisumbing 2003). VER is a measure of the extent to which a given shock or set of shocks impose a welfare loss due to the absence of effective and efficient risk management tools. In addition, this approach is in essence an *ex post* assessment and not an attempt to construct an overall measure of vulnerability (Hoogeveen et al. 2004).

In the estimation, all the three approaches are based on expected mean and variance of household‟s consumption or income. While VEP can be evaluated using both crosssectional and panel data, VEU and VER require lengthy panel data. Due to the lack of appropriate panel data, we analyze the VFI of households and examine the factors associated with vulnerability of households to food insecurity using the VEP approach and cross sectional data. However, obtaining a good estimate of household VFI requires consideration of the distribution of food consumption across households and ensuring that the household characteristics at one time capture the time-series variation of food consumption of the household (Chaudhuri et al. 200; Gaiha and Imai 2008).

2.1.3 Measurements of food security and vulnerability

Food security is mainly measured indirectly, using food balance sheets, national income distribution, and consumer expenditure data (Faridi, 2010). When hunger is linked to insufficient food intake, food insecurity can be measured in terms of the availability and apparent consumption of staple foods or energy intake. This type of measurement corresponds to the earlier narrower definitions of chronic food insecurity.

The percentage of households in a population group who do not consume sufficient dietary energy is determined in the above measure. It is measured by assessing if a household receives enough food during the reference period to meet all of its members' dietary energy requirements. If the estimated total energy in the food that the household acquires daily is lower than the sum of its members' daily requirements, the household is classified as food energy deficient.

WHO (1985) recommendation is followed which is based on normatively specified minimum energy consumption levels given a minimum acceptable body weight for healthy people at each age and sex group. When the percentage of people, as opposed to households, is measured, each person is assigned the energy deficiency status of her or his household.

FAO (2013) stated that dietary or calorie intake is one measure of food security that captures availability and access dimension. Therefore, taking in to consideration all these points in relation to the available data source, the study opts to use the disappearance methods as a means to compute the per capita per day calorie consumption.

The government of Ethiopia has set the minimum acceptable weighted average food requirement per adult equivalent (AE) per day at 2200 kcal (MoFED, 2002). The determination of the adult equivalent takes into account the age and sex of each household member (Gassmann et al., 2006).

There is no established consensus in the literature regarding the most appropriate approach in analysis of vulnerability and most the analysis of vulnerability focuses on poverty rather than on food insecurity, Scaramozzino (2006). Basically, there are two main approaches to vulnerability measurement namely; outcome approach and utility approach. Outcome approach measures vulnerability in terms of expected poverty, Chaudhuri (2001), Chaudhuri, Jalan and Suryhadi (2009). The utility-based approach measures vulnerability as the difference between utility that household would derive from the consumption of a particular bundle with certainty and the expected utility of consumption, Ligon (2003) and Schecter (2004). The outcome approach to vulnerability can help provide a quantitative measure of incidence of vulnerability, which is useful in placing households with respect to the reference threshold, Kamanou and Morduch (2002). Though there is no universally accepted approach of measuring vulnerability to food insecurity, this study uses outcome approach of vulnerability measurement by adopting ''Vulnerability as Expected Poverty'' method to analyze the determinants of vulnerability to food insecurity.

While measuring vulnerability to food insecurity, first we have to model food consumption measured in kilocalorie on the household's observable characteristics. This assumption allows us to estimate vulnerability using cross-sectional data from a single point in time, thereby limiting data requirements. The analytical methodology is similar with Christiansen and Boisvert (2000) and Bogale (2012) in that food consumption is approximated by kilocalorie consumption. In order to project future consumption, we first estimate a model of calorie consumption whereby the latter is a function of a number of household characteristics. Since the residuals that will be generated by this estimation may correlate to each other and exhibit different variances, the model is unable to capture all the systematic variability of the dependent variable, consumption in this case. To address this, we take a second step which involves estimating weighted least squares, a model of the residuals that explains their variability. This second step gives us estimates of the residual variance. Lastly, we use the estimate of variance of the residuals to calculate the probabilities that kilocalorie consumption, which we assume normally distributed, may be lower than an acceptable threshold, Chaudhuri (2000) and Mesfin (2014).

This study follows the first approach, Outcome approach measures vulnerability in terms of expected poverty (VEP), Chaudhuri (2001), Chaudhuri, Jalan and Suryhadi (2009). Defining vulnerability as the threat of future deprivation.

2.2 Empirical Literature Review

There are few analytical papers that look on Ethiopia's food security and vulnerability. Even those that are available are primarily descriptive, concentrating on understanding the scope of food insecurity and its determinants. Among a number of studies that made use of various methodologies to identify determinants of food security in different parts of Ethiopia, some are as follows.

Over 30% of the Ethiopian population is below the food poverty line, unable to afford the minimum caloric intake for a healthy and active life, CSA (2014). Furthermore, FAO (2012) finding figured out that 52% of the rural population was food insecure i.e. consume below the minimum recommended daily intake of 2100 kcal/ AE /day, which led the rural households to temporarily depend on relief food assistance. As a result, more than 8.5 million people were in need of emergency food aid and assistance, (WFP, 2017).

Getahun and Beyene (2014) examined the status and factors affecting food insecurity in rural households in Babile district, Ethiopia. Their result show that the educational status of the household head, annual farm income, use of irrigation schemes, and size of cultivated land were associated negatively with household food insecurity levels while insect and pest infestation demonstrated a positive and significant association with household food insecurity.

According to a study conducted by Sani and kemaw (2017) on analyzed households' food insecurity and its determinants along with the coping mechanisms opted against food insecurity and shortage in Assosa zone, western Ethiopia. The study used a primary data collected from 276 randomly selected households for 7 consecutive days from each sample using weighed records method. This study employed descriptive statistics, food insecurity index and Tobit model to analyze the data. The finding of the study revealed that, in the study area, the incidence of food insecurity was 53.62%, with the depth and severity of food insecurity being 16.84% and 7.32%, respectively. The study finding also pointed out that the mean kilocalorie intake of food insecure

households was 1440.37kcal/AE/day, with the minimum and maximum being 597.65 kcal and 2048.13 kcal, respectively. Furthermore, the estimated Tobit model result revealed that age of the household head, family size and off-farm and non-farm income positively affected extent of household's food insecurity; whereas access to irrigation, farm income, distance to market and access to credit negatively affected the extent of households' food insecurity.

Determinants of food security from Ethiopian Rural Household Survey (ERHS) using pooled cross-sectional study were explored by Abegaz (2017). Binary multivariable logistic regression was employed to identify the determinants of food security and majority of the households were found to be food insecure, Food security was significantly determined by rain shock, lack of off-farm income, and region of the households. To assure food security, the farmers should have to consider every rain season in the farming activity and the availability of off-farm income-generating activities should have to be enhanced.

According to a study conducted by Sisha (2018) on household level food insecurity assessment in Ethiopia using panel data and a sample of 5000 households, mean years of schooling of household members, access to service centers, assets, and availability of credit services positively affect household food security, whereas dependency ratio and shocks increase the odds of a household being food insecure. Furthermore, Agidew & Singh (2018) conducted a study on the determinants of food insecurity in rural farm households in Ethiopia's South Wollo zone, using a sample of 215 households and logistic regression to find that about 79.1% of households were food insecure, with the age of the household head, land size, recurrent drought, lack of rainfall, and land degradation being the determining factors. Ayele et al. (2018) used a sample of 504 rural households using a multivariate partial proportional odds model to investigate the prevalence and associated factors for rural household food insecurity in northern Ethiopia. In the east Gojjam zone, 74.4 percent of households were food insecure. Furthermore, the size of the property, the size of the family, the usage of irrigation, and the number of children were all factors in this study. In the research areas, livestock are the most important determinants of food security.

Food insecurity and coping methods among agropastoral households in Ethiopia's Lare district were explored by Tesfaye and Ruach (2019). They used households' food or calorie acquisition/ consumption per adult per day to identify the food secure and food-insecure households. For the preceding 7 days before the survey day, data was gathered from available food for consumption from home production, purchase, and/or gift/loan/wage in kind on available food for consumption from home production, purchase, and/or gift/loan/wage in kind. As a result, they found that from all 160 respondents, 40 (33.75%) were food insecure.

Sileshi et al. (2019) used a sample of 408 households using the Vulnerability as Expected Poverty (VEP) approach to investigate Analysis of Households' Vulnerability to Food Insecurity and Its Influencing Factors in East Hararghe, Ethiopia. The Feasible General Least Squares regression results indicate that the age of the household head, family size, access to irrigation, adoption of soil and water conservation, size of cultivated land, and received credit were all significant in determining vulnerability to food insecurity. The log likelihood estimates of the logit regression model indicate that age of household head, adult equivalent, use of irrigation, adoptions of SWC and coping strategy index were significantly influence on current food insecurity. Based on the intensity of their vulnerability, households were grouped as chronic food insecure (24.27 percent), transient food insecure (11.77 percent), highly vulnerable-food secure (18.38 percent), and low vulnerable-food secure (45.59 percent). Overall, about 54 percent of households were categorized as vulnerable to food insecurity.

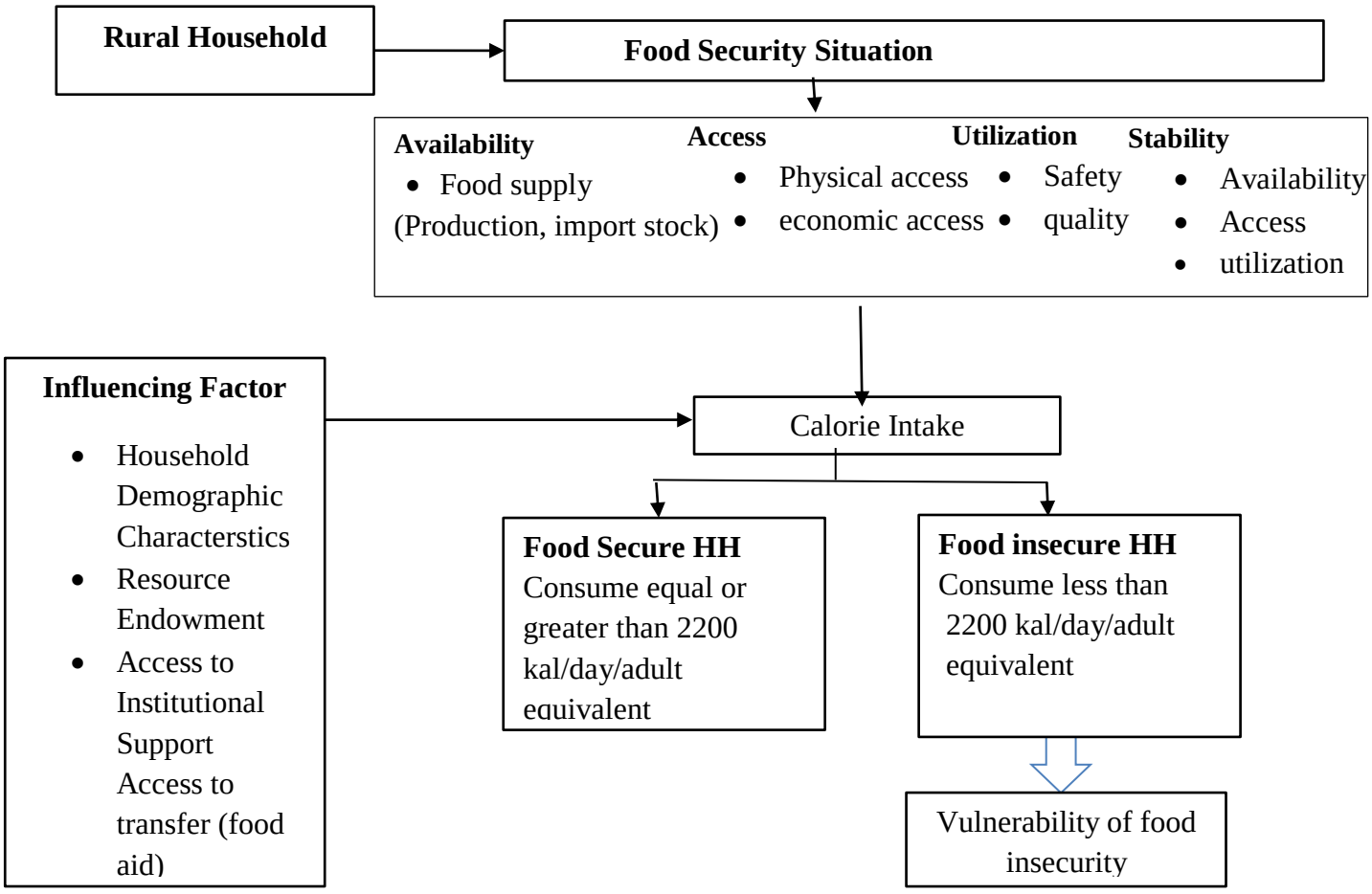
Using 150 sampled respondents, Kahsay et al. (2020) investigated food security and its determinants in pastoral and agro-pastoral districts of Ethiopia's Afar regional state. As a result, 72.67% of the sample households were found to be food insecure at an average consumption of 2100 Kcal/AE/day. Since, the district is arid, dry land/rain-fed agriculture is practiced with a major barrier to consuming nutritious/healthful foods.

The majority of empirical data on Ethiopia's food insecurity study is based on calorie intake and self-reported food consumer behavior of households as a measure of food security. Furthermore, the majority of studies was conducted at the district, regional, or provincial levels and fail to capture the diversity in agro-ecology and livelihood patterns in the country.

Vulnerability to Food Insecurity (VFI) is a function of not only exposure to shocks but also the capacity of each household to deal with the welfare impacts of the shocks. The level of risk exposure and the capacity to absorb shocks are changing, making vulnerability dynamic. The study gives more clarity on the factors of household vulnerability to food insecurity and addresses this gap by applying the VEP model to a sample size of 3115 rural households.

2.3 CONCEPTUAL FRAMEWORK

Figure 2-1 : Conceptual Framework



Source: Adoption + Modification

Chapter 3 : RESEARCH METHODOLOGY

3.1 Description of the study Area

Ethiopia is a landlocked country in the Horn of Africa. The country lies completely within the tropical latitudes and is relatively compact, with similar north-south and east-west dimensions. It shares borders with Eritrea and Djibouti to the north, Somaliland to the northeast, Somalia to the east, Kenya to the south, South Sudan to the west and Sudan to the northwest. Ethiopia has a total area of 1,100,000 square kilometers (420,000 sq. mi) and over 117 million inhabitants. The capital is Addis Ababa, located almost at the center of the country. Ethiopia's current population is approximately 115 million, with a projected population of 200 million by the end of 2049. Ethiopia's population is increasing at a rate of about 2.7 percent per year, with no projected peak year or period of decline. Ethiopia has a birth rate of 36 births per 1,000 people in 2021.

Figure 3-1: Regions of Ethiopia

3.2 Research design

The study used an explanatory research design and cross-sectional data from a World Bank survey conducted in 2018-19 by the Ethiopian Socioeconomic Survey (ESS) and the Central Statistics Agency of Ethiopia (CSA). Descriptive analyses, multivariate analysis, and vulnerability estimation by the VEP model using cross-section data were used.

3.3 Ethical consideration

The dataset was demanded and retrieved online from the International World Bank Group - International Development website that is released for public use; the link is https://microdata.worldbank.org/index.php/catalog/3823 with a title of Ethiopian Socio Economic Household Surveys (ESS), 2018–2019.

3.4 Data Type and Source

We used a cross sectional secondary data from World Bank Survey which is collected by Socio-Economic Survey (ESS) and Central Statistics Agency of Ethiopia (CSA). The total sample size of households covered in the survey was 6,894 in 541 urban and rural Enumeration Areas (EAs), this study is restricted to 3, 239 rural households in 297 EAs. Some observations were excluded due to missing information, reducing the sample size into 3115 rural households.

3.5 Methods of Analysis

In the analysis of the data different models were used with the view of addressing the objectives set forth in the present study. To attain the first objective that is related to the current food security status of the households in the study area, the first step taken was distinguishing the food secure and food insecure. In order to classify into two groups, demarcation points or line is required. The government of Ethiopia has set the minimum acceptable weighted average food requirement per adult equivalent (AE) per day at 2200 kcal (MoFED, 2002). The determination of the adult equivalent takes into account the age and sex of each household member (Gassmann

et al., 2006). Hence, for this study 2200 kcal per adult equivalent (AE) per day is employed as a cut-off value between food-secure and food-insecure households.

In order to address the second objective of this study, that is to estimate vulnerability to food insecurity; following (Capaldo et al. 2010) a three-step process is passed. In order to project future food consumption, first a model of food consumption measured in kilocalorie where by the latter is a function of a number of household characteristics is estimated. In the second step, a model of the residuals that explains their variability is estimated. This second step gives us estimates of the residual variance. Lastly, the estimate of variance of the residuals is used to calculate the probabilities that kilocalorie consumption, which is assumed normally distributed, may be lower than an acceptable threshold. Estimation procedures and variables used are detailed subsequently.

3.6 Estimation of the Food Consumption Model

3.6.1 Definition of variables, measurement and hypothesis

- **Dependent variable**

The dependent variable used in consumption model, which serves as a vehicle to vulnerability estimation, in this study is food consumption measured in kilocalories. Consumption based rather than income-based measure of household food security status is used in this study. This is because consumption better captures long-run welfare, and it better reflects household's ability to meet their basic needs. Consumption is preferable to measure household food security status than income because it is less vulnerable to seasonality and life-cycle, less vulnerable to measurement errors because respondents have less reasons to lie, it is closer to the utility that people effectively extract from income, and for the poor most of income is consumed (FAO, 2002). The level of house hold calorie consumption is measured using the consumption approach based on the World Bank Survey data collected by ESS, in collaboration with CSA.

Following this approach, level of house hold calorie consumption was set on the basis of the caloric content of consumed food items. To do this, first the bundle of food items acquired by households (either from own production, purchase, gift) is listed and measured in terms of kilo gram of solid food using conversion factors for the liquid food items. Second, for each food item a caloric content value was assigned based on the 1998 food composition table by Ethiopian Nutrition and Health Research Institute (ENHRI) which is given in appendix table 1. Total food consumption was based on a list of 26 regularly consumed local foods from the different food groups (cereals, pulses, vegetables, and meat, milk and milk products).

The estimate of calorie acquired by a given household is done using the formula below: $C_i = \sum A_{ij} B_j$

Where, C_i = level of kilocalorie acquired by the i^{th} household in the study area.

A_{ij} = the weight in kilo grams of the food commodity j by the i^{th} household

Bj = the standardized food energy content of the j^{th} food commodity.

Calorie acquired encompass the calorie amount of all food acquired (own produced, purchased and obtained as gift and other transfers).

- **Explanatory Variables**

Households do have differences manifested in sets of characteristics including size, composition, age structure, sex, occupation, etc. that affect the pattern of demand for food consumption. For this reason, different household characteristics were included in food consumption model as explanatory variables.

Age of the household head (AGE)

Age of household head also matters for household food consumption. Rural households mostly devote their lifetime or base their livelihoods on agriculture. The older the household head, the more experience s/he has in farming and weather forecasting. Moreover, older persons may accumulate more wealth than younger ones. However, if they have insufficient labor in their households, older household heads in rural areas may be in a disadvantaged position

economically in undertaking the heavy physical labor required in agriculture this may result in food deprivation. Therefore, the effect of age on hose hold food consumption may be indeterminate a priori.

Gender of the household head (sex)

It is a dummy variable taking the value 1 if the sex of household is male and 0, otherwise. As to Baten and Khan (2010) finding, female-headed households can find it difficult than men to gain access to valuable resource, which helps them to improve production and gain more income, this in turn increases their probability of being food insecure. Thus, in this study, it was expected to affect extent of households' food insecurity negatively.

Educational level of head of household (EDU)

It is a continuous variable measured in years of schooling of the household head. Education, which is a social capital, has a positive impact on household ability to take good and well-informed production and nutritional status (Babatunde 2007).

Family size (FS)

It is a continuous variable which refers to the number of family members of the household. Studies argued that larger family size tends to exert more pressure on households' consumption than the labor it contributes to production (Stephen and Samuel 2013; Muche et al. 2014). Therefore, in this study, larger household size was expected to affect extent food insecurity positively.

Land size (LS)

It is a continuous variable which is measured in hectare. In rural areas, land is the most decisive factor of production which determines the resilience or vulnerability of a household to food insecurity. Different previous studies also indicated that land size and food insecurity are negatively correlated (Kwadwo et al., 2013; Seid & Biruk, 2018). Thus, this study hypothesizes a negative relationship between land size and the level of food insecurity in the study areas.

Distance from Markets (DRM): It is a continuous variable which measures the distance from the markets of the household to all season roads in kilometer. This variable may affect food insecurity via its effect on household access to input and output markets. Many studies found that distance from all season roads in kilometers and food insecurity are positively related (Fekede et al., 2016; Getachew et al., 2018; Girum, 2016). Thus, a positive relationship between distance from all season road and the level of food insecurity is hypothesized in this study

Farm income (FI): This variable is a continuous variable which measures the monetary value of all farm output in Ethiopian Birr. Farm income positively affects the food availability and the food access dimensions of food security and reduces vulnerability to food insecurity. Evidences from previous studies also showed that farm income and food insecurity are negatively related (Ejigayhu, 2011). Thus, a negative relationship between farm income and the level of food insecurity is hypothesized in this study.

Off farm income (OFI)

This is dummy variable taking a value 1 if the household have off farm income and 0; if not. Off farm income is one of an important financial capital which reduces vulnerability to food insecurity of rural households (Indris & Adam, 2013). This study also hypothesized an inverse relationship between off farm income and the level of food insecurity.

Credit user (CREDIT)

This is dummy variable taking a value 1if the household has used credit and 0, if not. Credit may serve as an important source of income to smooth consumption over time. Those households which received the credit they requested have better possibility to spend on activities they wish. Either they purchase agricultural input (improved seed and/or fertilizer) or they purchase livestock for resale after they fattened them. Therefore, it is expected to be positively correlated with food consumption.

Irrigation use (IRR)

It is a dummy variable for irrigation use which assumes value of 1 for irrigation users and 0 otherwise. Access to irrigation water is one key determinant of productivity and food availability at household level. Some studies on food security found that irrigation participation and food insecurity are negatively correlated (Shishay, 2014; Teklay et al., 2013). Hence, this study hypothesizes negative relationship between irrigation use and food insecurity.

Livestock use (LV): a dummy variable which is the farmers is use livestock or not, Farmers' ownership to livestock has a negative impact on food insecurity.

Fertilizer use (FER)

Haile et.al (2005) stated, fertilizer use is taken to be a proxy for technology in most literatures. How a given technology is being used is a key point in determining level of production and it is actually influenced by many government interventions, incentives and disincentives. Calorie intake and food security are influenced by use of fertilizer as it boosts agricultural production. Based on the questioner, fertilizer use is thus a dummy variable representing whether the household uses a fertilizer or not. Thus "1" represents if the household uses a fertilizer and '0" otherwise.

Remittance and aid (AID)

These are dummy variables, which takes the value 1 if the household had access to remittance and aid in the past one year and 0 otherwise. Both remittance and aid, from governmental and non-governmental organizations are important to smooth consumption in the case of shock and shortage for the time of emergency (Okyere et al. 2013; Mesfin 2014). Thus, for this study, it was expected to negatively affect extent of households' food insecurity.

Rain falls shock (RAIN)

Irregularities in weather have adverse consequences due to the rain fed nature of agriculture in Ethiopia (Demeke 2011). Similarly, in the current study, rain fall shock is taken to be a deviation from what it supposed to be. Thus, it is actually considered bad and is a disaster for given harvest year. Accordingly, a dummy is created if the rain stops too late and too early. It is expected that rainfall shock to have a positive effect on food insecurity.

Death of Livestock (DL)

This is a dummy variable to capture the existence of a shock to the household which takes value of 1 for household who experienced death of animal in the past one year and 0 otherwise. Studies conducted by Tagese and Berhanu (2015) and Teklay et al. (2013) found that shocks like death of household member, crop failure and death of animals have positive and significant effect on household food insecurity. This study also found a positive relationship between food vulnerability to food insecurity and the death of animals. The below table 3.1, explains Expected hypothesis of dependent variable with independent variables.

Table 3-1: Expected hypothesis of dependent variable with independent variables

Dependent variables	Food consumption		
Independent variables	Data type	Expected sign	References
Sex	Dummy variable	+,-	Baten and Khan (2010)
Education level	Continuous variable	+,-	Sisha(2018), mesfin(2014)
Age	Continuous	+ ,-	Baten and Khan (2010)
Family size	Continuous	+	(Stephen and Samuel 2013; Muche et al. 2014), Ayele etal (2018),mesfin (2014)
Land size	Continuous	-	(Kwadwo et al., 2013; Seid & Biruk, 2018)
Distance from market	Continuous	+	(Fekede et al., 2016; Getachew et al., 2018; Girum, 2016)
Farm income	Continuous	-	(Ejigayhu, 2011)
Off farm income	Dummy variable	-	(Indris & Adam, 2013)
Credit use	Dummy variable	-	Sisha(2018)
Irrigation use	Dummy variable	-	(Shishay, 2014; Teklay et al., 2013)
Livestock use	Continuous variable	-	
Fertilizer use	Dummy variable	-	Teklay et.al,2013), Foster

			1992).
Access to remittance	Dummy variable	-	(Okyere et al. 2013; Mesfin 2014)
Rain falls shock	Dummy variable	+	(Demeke 2011)
Death of animals	Dummy variable	+	Tagese and Berhanu (2015) and Teklay et al. (2013)

3.7 Empirical strategy toward measuring determinants of food insecurity and vulnerability

To identify the determinants of household food insecurity, a binary logit model was used. The dependent variable for this case was not continuous instead it was binary as such either logit or probit could be used. Both the logit and probit models estimate parameters using maximum likelihood. The probit model assumes normally distributed error term whereas the logit model assumes a logistic distribution of the error term. The logit model is often preferred due to the consistency of parameter estimation associated with the assumption that the error term in the equation has a logistic distribution (Baker 2000; Ravallion 2001). Therefore, the logit model was used to identify the factors associated with household food insecurity status.

According to Aldrich and Nelson (1984) andGujarati (2003), the mathematical formulation of logit model is specified as follows:

$$P_i = \frac{e^{z_i}}{1 + e^{-z_i}} \qquad (10)$$

Where, $P_i$is the probability of food insecurity.

The probability that a household is food secure can be specified as:

$$1 - p_i = \frac{1}{1 + e^{z_i}} \qquad (11)$$

Therefore,

$$\frac{P_i}{1-p_i} = \frac{1+e^{z_i}}{1+e^{-z_i}} \tag{12}$$

Now equation (12) is simply the odds ratio in favor of food insecurity. The ratio of the probability that the household is food insecure to the probability that it is food secure. Finally, taking the natural log of equation (12) we obtain:

$$L_i = \ln\left(\frac{p_i}{1-p_i}\right) = Z_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots \beta_n X_n + \mu_i \tag{13}$$

Where L_i is log of the odds ratio, which is not only linear in X_i(vector of household characteristics) but also linear in the parameters;β_i represents vectors of parameter; andμ_i represents an error term.

The reduced form of logit model is written as:

$$zi = ln\left[\frac{pi}{1-pi}\right] = \alpha + \sum \beta_i X_i + \mu_i \tag{14}$$

Therefore,

$$\frac{P_i}{1-p_i} = \frac{1+e^{z_i}}{1+e^{-z_i}} \quad (12)$$

Now equation (12) is simply the odds ratio in favor of food insecurity. The ratio of the probability that the household is food insecure to the probability that it is food secure. Finally, taking the natural log of equation (12) we obtain:

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Where L_i is log of the odds ratio, which is not only linear in X_i(vector of household characteristics) but also linear in the parameters;β_i represents vectors of parameter; andμ_i represents an error term.

The reduced form of logit model is written as:

$$zi = ln\left[\frac{pi}{1-pi}\right] = \alpha + \sum \beta_i X_i + \mu_i \quad (14)$$

Following (Capaldo et al., 2010) a three-step process is passed. In order to project future food consumption, first a model of food consumption measured in kilocalorie where by the latter is a function of a number of household characteristics is estimated. Then in the second step, a model of the residuals that explains their variability is estimated. This second step gives us estimates of the residual variance. Lastly, the estimate of variance of the residuals is used to calculate the probabilities that kilocalorie consumption, which is assumed normally distributed, may be lower than an acceptable threshold. Then generalized least square (GLS) methods were used for determinants of vulnerability to insecurity.

Algebraic structure

For a generic household h let Ch indicate kilocalorie consumption and *Xh* be a vector of, observable household Characteristics such as household size, location, educational attainment of the household head, etc. that serve as explanatory variables of per capita kilocalorie consumption.

Assuming for simplicity a linear dependence, each household's calorie consumption can be expressed as follows:

$$C_h = X_h^{'}\beta = \beta_1 x_{h1} + ... + \beta_2 x_{h2} + ... + \beta_j x_{hj} \quad (1)$$

Where, β is a vector of parameters that are the same for all households.

Considering all households in one multivariate equation, we have:

$$C = X\beta = \begin{bmatrix} \beta_1 x_{11} + ... + \beta_2 x_{12} + ... + \beta_j x_{1j} \\ . \quad . \quad . \\ \beta_1 x_{h1} + ... + \beta_2 x_{h2} + ... + \beta_j x_{hj} \\ . \quad . \quad . \\ \beta_1 x_{H1} + ... + \beta_2 x_{H2} + ... + \beta_j x_{Hj} \end{bmatrix}$$

$$\text{Where } C = [c_1 ... c_h .... c_H] \text{ and } X = [X_1^{'} ..... X_h^{'} ..... X_H^{'}] \quad (2)$$

The first step of three step generalized least square (GLS) procedure consists of estimating the multivariate equation and obtaining estimates **β**ˆ of the parameters that explain calorie consumption.

But for the residual component,

$$u = [u_1 ..... u_h ..... u_H]$$

$$C = X\hat{\beta} + u \quad (3)$$

As a second step, assess their dependence on the same explanatory variables through a set of parameters γ. Estimate the equation:

$$u = X\hat{\gamma} + \varepsilon \quad (4)$$

Where ε is the vector of residuals of this second estimation, showing all the desirable properties of residuals that u does not have. From the deterministic part of equation (4) and after correcting again for heteroskedasticity, one can derive a consistent estimate of the house hold variance of food consumption ,$\hat{\delta}_{u}^{2}$.

In the last step of the procedure, $\hat{\delta}_{u}^{2}$ is used to compute each household's vulnerability to food insecurity. Assuming that vulnerability distributes normally, each household's probability of food insecurity is given by a determination of:

$$vh \sim N\left(E(uh),\sigma h^{2}\right) \qquad (5)$$

In this context for a given household *h*, the vulnerability is defined as the probability that each household faces of falling below the minimum energy requirement in the future.

Chapter 4 : RESULTS AND DISCUSSION

The data analysis is done using STATA. The results of the analysis are divided into three sections: descriptive analysis results, Results from food consumption estimation, Extent of Vulnerability to Food insecurity. These results and their discussions are presented below.

4.1 Descriptive Analysis

4.1.1 General description of socio-demographic and economic characteristics of sample households

Table 4.1 presents Households' food security status, based on a calorie requirement of 2200 kcal per day per person, out of the 3115 sample rural households in the study area 1154 (37.05%) and 1961 (62.95%) were found to be food secure and food insecure respectively.

Table 4.2 presents the Mean acquired kilocalorie per day per adult equivalent for food insecure households is (1612.42) kilocalorie which is below the minimum required level (2200 kilocalorie). This shows on average the food insecure far below the minimum threshold by 587.58 kilocalories. The mean acquired kilocalorie per day per adult equivalent for food secure households is 2847.95 kilocalories. This seems far above the minimum required level 2200 kilocalories but with high Standard deviation of about1431.04. Hence it is rational to expect that there might be possibility for the food secure to fall in to food insecurity or there will be high vulnerability to food insecurity in view of the fact that the mass of the household occupation is farming where risk and uncertainty are common features.

Table 4-1: Households' food security status

Food security status	Frequency	Percentage
Food secure	1154	37.05
Food insecure	1961	62.95
Total observation	3115	

Source: own computation based on ESS (2018) data

Table 4-2: Households' food security status by mean acquired kilocalories

Food security status	Food secure	Food insecure
Number of observations	1154	1961
Mean	2847.95	1612.42
Standard deviation	1431.04	445.71

Source: own computation based on ESS (2018) data

For this study 3115 sampled household heads were used, 73.52% of household heads were male and the rest 26.48% were female, and it indicates that male headed households were owners of major livelihood assets as usual. Majority of the households (47.06%) are reported to have a size of 4–6 family members followed by 0-3 (30.95%) and only 22.06% and 0.65% of the households are 7-10 and 10+sized households, respectively. It is also observed that the computed mean household family size for the study is about 4.85 with an average age of 44 years.

When we see the educational status of the study participants, it was found out that 69.85 % of the respondents are literate, while the remaining 30.15% are categorized as illiterate. The percentage distribution of the Household heads by educational status reveals that 65.11% of the respondents are at primary level of education. The secondary and college levels account for about 3.34%and 1.42% of the respondents, respectively, with an average grade of 3.01.

Less than half (30.1%) of sample households owned less than 0.25 hectare of farm land, 17.39% own 0.25–0.5 hectare, about 28.91% half to one hectare and 23.6% owned 1–2 hectare. On average, land holding size per household was found to be 0.91 hectare. Moreover, 58.05% of household market distance from their residence was greater than 10 km followed by distance between 5 and 10 km (19.04%) and less than 5 km (30.18%). The average household distance to market is 15.83 km. regarding the income earning from farming activities, 32.2% of the households were earning between 7000-1000birr per year followed by 20000–40000birrper year (30.68%), greater than 40000 birr per year (20.37%) and 10000-20000 birr per year (16.55%). Besides, the majority (65.30%) of the households was not engaged in any type of off-farm and non-farm activities and the rest (34.70%) were earning a positive income from off-farm and non-farm activities.

Furthermore, the study finding showed that 75.83% of the sampled households had no access to credit service in the study area, implying that the majority of the households did not receive any type of credit from formal and informal sources. As to household access to remittance and aid, only 13.07% of the households had obtained remittance and aid from different sources.

In addition, it showed that 21.51% of the sampled households had access to irrigation, about 10.63% of the sample household reported to use fertilizer and on average the study households owned 3.78 total livestock unit (TLU). From the total sample (53.03%) have experienced rain fall shock and 26.77% also experienced Death of livestock.

Table 4-3: Summary Statistics for Continuous variables

Variable	Viable label	Mean	Std. Dev.
Acquired kilocalorie	Acquired kilocalorie per adult equivalent	2709.06	1402.01
Age	Age of the household head in years	44.36	15.35
Education	Level of education in numbers of years	3.01	2.07
Total family size	Number of Family size	4.85	2.33
Total land holding	Total cultivated land holding	0.91	0.53
Distance to the markets	Distance to the market (km)	15.83	12.77
Farm income	Total annual income in birr	25837.69	19140.46
Livestock TLU	Livestock owned (Tropical Livestock Unit)	3.78	2.29

Source: own computation based on ESS (2018) data

Table 4-4: Summary Statistics for categorical variables

VARIABLE	Viable label	Frequency (N)	Percentage (%)
Sex	Dummy of sex of household sex (1=male)		
Female		825	26.48
Male		2290	73.52
Off-farm Activity	Dummy for participation to off farm activity (Yes=1)		
Yes		1081	34.70
No		2034	65.30
Use of credit	Dummy for receiving credit (Yes=1)		
Yes		753	24.17
No		2362	75.83
Use of fertilizer	Dummy for use to fertilizer (Yes=1)		
Yes		331	10.63
No		2784	89.37
Use of irrigation	Dummy for use to irrigation (Yes=1)		
Yes		670	21.51
No		2445	78.49
Death of livestock	Dummy for death of livestock (Yes=1)		
Yes		834	26.77
No		2281	73.23
Remittance and aid	Dummy for aid (yes=1)		
Yes		407	13.07
No		2708	86.93
Rain fall shock	Dummy for rain fall shock (Yes=1)		
Yes		1652	53.03
No		1463	46.97

Source: own computation based on ESS (2018) data

4.2 Logit model Results

4.2.1 Determinants of households' food insecurity

Table 4.5 presents the results of logit model. Before interpreting the significant variables, it is essential to determine the statistical validity of the model. Our model fitted the data reasonably well [Wald Chi-squared = 2013.10 P= 0.000)]. Thus, the hypothesis that all coefficient of independent variables are jointly equal to zero was rejected. The logit model result reveals that a total of 15 explanatory variables were considered in the econometric model, out of which, 10 variables were found to significantly influence the food insecurity status of household.

The log likelihood estimates of the logit regression model indicate that age of household head, Education level of the household head, annual household farm income, participation in off farm activity, access to credit, livestock user and remittance were negatively and significantly influence on food insecurity whereas, death of livestock, rainfall shock were positively and significant influence current food insecurity status of household with different level of significance.

Age of household head was one of the factors, which negatively and significantly influenced the food insecurity of household ($P<0.01$). Accordingly, age of household head increase the probability to food insecure also decrease. This means, the older household family was more like to food insecure than young household head family. The model outcome indicated that age of household head increase by 1, the probability of food insecurity decrease by 0.3 percent.

The results of the logit model reveal that, **Land size** measured by hectare in the household negatively and significantly affect household food insecurity($P<0.01$). The possible explanation is that, most of farm households with a large number of land size can produce different products and can engaged in different agricultural activity and can have income by renting and by sharing their land to different peoples to obtain income so this will decrease household vulnerability to food insecurity so a unit change in the discrete variable will lead to 15.4%.

Household engagement in **off farm income** is another important factor which was negatively related to the dependent variable. The marginal effect result indicates that a discrete change in dummy variable from 0 to 1, the probability of being food insecure decreases by 40.7 percent and it is significant (P<0.01). This implies that, the farmer who is engaged in off farm activities like trading, and other activity are capable of outstanding the issue of food insecurity.

Household **Access to credit** is another important factor which was negatively related to the dependent variable. The marginal effect result indicates that a discrete change in dummy variable from 0 to 1, the probability of being food insecure decreases by 27.1 percent and it is significant (P<0.01). This implies that, used credit has a less probability to directly involve in different activity will expand household ability to obtain income by involving in different activities

The results of the logit model reveal that, **Farm income** of household which is measured by the annual income obtained by the household is negatively and significantly affect household food insecurity(P<0.01). The possible explanation is that, most of farm households with a huge annual income can buy a food and can survive so their vulnerability to food insecurity will be minimized as seen in the table below a unit change in annual household farm income will leads to 0.1% change in food insecurity.

Households who have **Remittance and Aid** from different government and non-governmental supporters were another factor which was negatively related to the food insecurity. The marginal effect result indicates that a discrete change in dummy variable from 0 to 1, the probability of being food insecure decreases by 1.11 percent and it is significant (P<0.01).

Households who use **livestock** were another factors which was negatively related to the food insecurity. The marginal effect result indicates that a discrete change in dummy variable from 0 to 1, the probability of being food insecure decreases by 5.1 percent and it is significant (P<0.1).

Rain fall shock is an important factor which was positively related to the food insecurity. The marginal effect result indicates that a discrete change in dummy variable from 0 to 1, the probability of being food insecure increase by 1.22 percent and it is significant (P<0.01). This implies that, the households who is face more rain fall shock is highly vulnerable to food insecurity because rain fall is the major input in our production system especially in rural areas which have more people depends on agriculture.

Education level of the household was one of the factors, which negatively and significantly influenced the food insecurity of household (P<0.1). Accordingly, education level of household head increases the probability to food insecure will decrease. This means, the more educated household was less like to food insecure than illiterate household. The model outcome indicated that education level of household head increase by 1, the probability of food insecurity decrease by 0.8 percent.

Existence of **Death of livestock** is also another important factor which was positively related to the food insecurity. The marginal effect result indicates that a discrete change in dummy variable from 0 to 1, the probability of being food insecure increase by 1 percent and it is significant (P<0.01). This implies that, the households who is face more death of livestock is highly vulnerable to food insecurity because livestock by themselves are food and they are among the assets in which the households uses in many of their activity.

Table 4-5: Determinant of food insecurity

Food insecurity	Coef.	St..Err.	Mfx
Fertilizer	-.139	.185	-0.033
Irrigation	-.118	.144	-0.028
Rainfall shock	.523***	.117	0.122
Death Livestock	.444***	.134	0.100
Remittance	-.462***	.169	-0.111
Livestock	-.222*	.116	-0.051
CREDIT	-1.129***	.127	-0.271
Off Farm	-1.758***	.117	-0.407
Farm income	-0.001***	0.00	-0.010
DRMD	.004	.004	0.001
Total land	-6.59***	.27	-1.534
Total family	.002	.025	0.001
Education	-.035*	.02	-0.008
Age	-.012***	.004	-0.003
Sex	.064	.128	0.015
Constant	3.299***	.298	
Mean dependent var	0.630	SD dependent var	0.483
Pseudo r-squared	0.491	Number of obs	3114
Chi-square	2016.700	Prob > chi2	0.000
Akaike crit. (AIC)	2120.148	Bayesian crit. (BIC)	2216.847

*Note: *** p<.01, ** p<.05, * p<.1*

Source: Own computation based on ESS (2018) data

4.3 Vulnerability to food insecurity

A household is then considered highly vulnerable to food insecurity if its vulnerability level exceeds some threshold, in our case this is, following, Chaudhuri (2003), 0.5. Based on this a vulnerability profile for rural Ethiopia is estimated.

Any operationally useful assessment of households' vulnerability status depends essentially on the choice of vulnerability threshold, that is, the minimum level of vulnerability above which all households are defined to be vulnerable. In the vulnerability estimation each estimate takes values in the interval [0 1]. The extremes of the interval represent two opposite certainties: when, vh=1 household will consume in the future with certainty at least the minimum amount of calories prescribed by the threshold; when, vh=0 household will consume less calories in the future than prescribed by the threshold. In all intermediate cases, when, 0<vh.

4.3.1 Determinants of vulnerability to food insecurity

The binary logistic regression model is employed to examine an association of each factor with vulnerability to food insecurity. To analyze the factors that determine vulnerability to food insecurity households were classified in to two categories as low vulnerable and highly vulnerable using the threshold chosen (0.5) Variable. Thus, the dependent variable in this case, vulnerability, is a dummy variable, which takes a value zero or one depending on whether or not a household vulnerability index is less than or greater than the chosen threshold.

In widely used economic literature for estimating binary choice models the linear probability, logit and probit are the possible alternative models and have been widely used for a binary response variable. A linear probability model is plagued by several problems such as non-normality of the disturbance term (ui), hetroscedaciticity of ui, possibility of predicted y hat lying outside the range (0-1) and generally lower R2 values (Gujirati, 2003). As a result, hypothesis testing and constructing confidence interval become inaccurate and misleading. And moreover, the predicted values (y hat) lie outside 0-1 range and violate the basic idea of probability. The shortcomings of linear probability model suggest that nonlinear specifications may be more appropriate. For this reason, in the studies involving qualitative factors, usually a choice has to be made between logit and probit models. According to Amemiaya (1981), the statistical

similarities between the two models make the choice between them difficult. However, Maddala (1989) and Kmenta (1986) reported that many authors tend to agree on the logistic model since the cumulative normal functions are very close to the mid-range but the logistic function has slightly heavier tails than the cumulative normal functions. It is also argued that the logit and probit formulations are quite comparable, the main difference being that the former has slightly fatter tails; that is, the normal curve approaches the axes faster than the logistic curve. Moreover, a logistic distribution (logit) has advantages over the other in the analysis of dichotomous outcome variable in that it is an extremely flexible and easily usable model from mathematical point of view and results in a meaningful interpretation.

Thus, in this study the logit model was selected to identify the determinants of vulnerability to food insecurity in the study area. To scrutinize the determinants of vulnerability to food insecurity the measure of vulnerability is regressed on the set of house hold characteristics

$$vh = \delta xh + £h$$

$$=0 \text{ otherwise.}$$

Where vh is vulnerability to food insecurity, δ is a Kx1 vector of unknown parameters, xh is 1xK vector of explanatory variables and £h are the models residuals. To scrutinize the determinants of vulnerability to food insecurity the measure of vulnerability is regressed on the set of house hold characteristics.

Table 4-6: GLS Regression: The expected value and variance of log per adult equivalent Food Consumption (measured in kilocalories).

Vulnerability	Log kilocalorie consumption per adult equivalent per day E(lnC / X).	Variance of kilo calorie consumption Var(lnC / X)
Sex of household head	0.0237	-0.00938
	(0.031)	(0.048)
Age of household head	-0.067	0.047
	(0.0068)	(0.020)
Education level of household head	0.028	0.019
	(0.237)	(0.0207)
	(0.016)	(0.044)

Total family size	.002	.025
	(0.206)	(0.028)
Total land owned	6.637	3.27
	(0.0116)***	(0.0116)**
DRMD	-2.104	.004
	(0.347)	(0.16)
Annual farm income	0.0087	0.0054
	(0.126)***	(0.016)*
Off Farm income	1.724	0.0116
	(0.047)	(0.047)
Access to credit	1.136	0.0126
	(0.067)***	(0.004)*
Remittance	.383	0.0154
	(0.547)**	(0.047)
Death Livestock	-.485	0.0132
	(0.47)***	(0.037)**
Rainfall shock	-.00507	-0.0116
	(0.567)***	(0.0851)*
Irrigation	-0.0185	-0.0018
	(0.030)	(0.031)
Fertilizer	.14	.184
	(0.047)	(0.047
Total livestock owned	-.003	.017
Constant	-2.852***	291

Column (1) of table above shows that consumption expenditure which is used as a proxy variable for income has a positive and significant correlation with the level of calorie consumption among the households. The result is also in agreement with those of other previous studies from Nigeria (Aromolaran, 2004; Agboola et al., 2004) who found farm income has a positive and significant relationship with calorie consumption.

The results further show that total land holding in ha of household head has a significantly positive correlation with calorie intake. This is probably because land in rural are often highly needed for adequate nutrition intake. Moreover, the capacity to access sufficient calories increase with land holding. So dependent land size of the household will economically active and

contribute to the family's food consumption level. The higher land ownership, the higher expected food consumption will be.

Possibly puzzling result is the correlation of Death Livestock, Rainfall shock and level of food consumption. The level of food consumption is strong and negatively correlated with drought shock. This seems counter intuitive; nevertheless, this could possibly be due to well established relief assistance in the country and high calorie content in the food items like oil and wheat provided by relief assistance.

Households access to credit significantly increase expectation of food consumption. It is well-known that families with good access to credit can participate in any activity by taking a credit form the credit source to increase their annual income. No evidence is found on gender of the household head to be associated with expected food consumption.

Then determined the VFI status of each household using a 0.5 vulnerability score as the threshold level (Pritchett et al. 2000). Accordingly, a household was inferred as having low VFI, when the vulnerability score was less than 0.5 and was considered highly VFI when the score was greater than or equal to 0.5. The current food insecurity status of a household was determined using the yardstick of food poverty line. In this regard, a household was considered as food insecure when the PCFCE was less than the threshold level; otherwise the household was inferred as food secure. By considering both the vulnerability status of household and its current food insecurity status, we extended our analysis into several food insecurity and vulnerability categories as shown in Table 4-7 below.

Table 4-7: Vulnerability and food security status of households

Vulnerability	Food security						$\chi 2$ test
	Food secure		Food insecure		Total		
	N	%	N	%	No.	percent	
Low-vulnerable	942	45.84	195	9.76	1137	55.6	45.41 ***
High –vulnerable	212	18.4	1766	26	1978	44.4	
Total	1154	64.24	1961	35.76	3115	100	

Vulnerability to food insecurity computed as a probability to fall, or stay, below a given food security threshold in the next period. Because vulnerability is linked to the uncertainty of events, everyone is vulnerable to food insecurity, but some more so than others. Using the method specified in the methodology part of this thesis vulnerability index for each households is estimated. Following the regression analysis, the vulnerability indicator is computed using predicted kilocalorie consumption and its variance for each household. After computing vulnerability index for each household's, households with vulnerability index greater or equal to 0.5 are grouped as less as vulnerable group and households with vulnerability index greater than 0.5 are grouped as low vulnerable group.

The results indicate that about 45.84 percent of the sample food secured households had stable food security levels. These households were food secure and had low probabilities of being food insecure in the near future (less VFI). On the other hand, about 26 percent of the total households were categorized as food insecure for an extended period of time (high VFI) and were considered as suffering from chronic food insecurity. Overall, about 54.4 percent of households were categorized as vulnerable to food insecurity.

Chapter 5: CONCLUSIONS AND RECOMMENDATIONS

5.1. Conclusions

Food insecurity and poverty are two major issues that most Ethiopians face today. Various studies have revealed that improving the rural poor's livelihood is critical to reversing the prevalence of these issues. To be effective, improvement projects for the welfare of rural communities must be backed up by empirical evidence that provides essential information on household's food security to relevant entities.

The problem of food insecurity is extensive in the study area. Among the sampled households in rural areas of Ethiopia 62.95% were found to be food insecure (1961 out of 3115) where as 37.05% of the households were found to be food secure. Mean acquired kilocalorie per day per adult equivalent for food insecure households is (1612.42) kilocalorie which is below the minimum required level (2200 kilocalorie). This implies that, on average, the food insecure far below the minimum threshold by 587.58 kilocalories.

In addition, the estimated logit model results revealed that Age of household's head, Education level of the households head, Farm income, off farm activity, Access to credit, Livestock user and Remittance and aid were negatively and significantly influence on food insecurity whereas, Death of livestock, Rainfall shock were positively and significant influence of current food insecurity status of households with different level of significance.

Most of the findings in descriptive analysis are consistent with the results of logistic regression model. General Least Squares regression results indicate that Total land holding in ha of household head has a significantly positive correlation with calorie intake and Households access to credit significantly increase expectation of food consumption. And the level of food consumption is strong and negatively correlated with Death Livestock, Rainfall shock, which means Rain fall shock and death of livestock positively affects the probability of vulnerability to food insecurity, also the results indicate that about 45.84 percent of the sample food secured households had stable food security levels. These households were food secure and had low probabilities of being food insecure in the near future (less VFI). On the other hand, about 26 percent of the total households were categorized as food insecure for an extended period of time

(high VFI) and were considered as suffering from chronic food insecurity. Overall, about 54.4 percent of households were categorized as vulnerable to food insecurity.

5.2. Recommendations

First, rain shock and death of livestock are found to be the main determinants for households' food security. The problem of rain shock is a result of global climate change. Second, off-farm income has a significant contribution in moving households to food security. As a result, off-farm employment opportunities should have to be created and expanded. Third, Death of livestock was also the main determinant of food security. As a result, urgent actions aimed at reducing and/or eliminating food insecurity in rural households in the study area should focus on:

- There is a need for an international policy regarding the adoption of mitigation strategies to control climate change, the main cause of agricultural and rain shocks and this strategy should be integrated into the development planning.
- The creation of awareness about effective family planning and the effects of big family size on food security, as well as the creation of awareness and capacity building for elder households by guaranteeing the availability and transmission of accurate information, should be emphasized.
- Improving rural households' access to credit allows them to purchase various inputs to improve their production of consumption items, reducing and/or eliminating food insecurity and improving their overall well-being.
- Construction of irrigation schemes is important because it allows households to produce more than once a year by reducing water stress and the risk of crop failure, hence reducing and/or eliminating food insecurity.
- Enhancing households' farm income-earning prospects by providing sufficient input to enhance agricultural production and productivity; and improving households' technical skills and understanding of how to employ off-farm and non-farm income to improve their food security situation.
- Generally, as a policy implication the government should exhaustively work on promoting irrigation, facilitating credit availability and subsidize the farmers to reverse

the problem of food insecurity and to enhance households coping capacity to food shortage and/or insecurity.

5.3 Areas for Future Research

This study tried to examine the vulnerability to food insecurity in rural households of Ethiopia using cross sectional data. Since the focus of this study is rural Ethiopia, future studies can examine the rural household's vulnerability to food insecurity for by including urban areas too. To see the long term the rural household's vulnerability to food insecurity status, future studies can also employ panel data.

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Appendix

Appendix 1

Food item	kcal/100 gram
Teff	341
Barley	354
Wheat	351
Karka'eta*	352
Maize	362
Sorghum	347
Lentil	353
Bean	344
Fieldpeas	341
Chickpeas	364
guaya	347
Finger milet	312
Coffee	2
Sugar	400
Berbere	318
Salt	0
Oil	884
Onion	42
Garlic	149
Potato	87
Tomato	18
Milk	39
chease	132
Beef	235
chicken	140
Egg	68

**note for karka 'eta (a mix of wheat and barley)we used average of calorie content of the two*

Source: Ethiopian Nutrition and Health Research Institute (ENHRI) and world health organization(WHO)

Appendix 2

Logistic regression — Number of obs = 3,114; LR chi2(15) = 2016.70; Prob > chi2 = 0.0000; Log likelihood = -1044.0742; Pseudo R2 = 0.4913

food_insecurity	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
fertilizer	-.1391849	.1849552	-0.75	0.452	-.5016905	.2233207
Irrigation	-.1181732	.1443758	-0.82	0.413	-.4011446	.1647983
rainfall_shock	.5233839	.116604	4.49	0.000	.2948443	.7519235
Death_Livestock	.44351	.1344529	3.30	0.001	.1799873	.7070328
Remittance	-.4616166	.1687934	-2.73	0.006	-.7924456	-.1307877
LiveStock	-.2216892	.1158866	-1.91	0.056	-.4488228	.0054444
CREDIT	-1.129289	.1269582	-8.89	0.000	-1.378123	-.8804559
OffFarm	-1.75846	.1172406	-15.00	0.000	-1.988247	-1.528673
FARMINCOME	-.0000115	3.25e-06	-3.52	0.000	-.0000178	-5.09e-06
DRMD	.0041489	.0044348	0.94	0.350	-.0045431	.0128409
Total_land	-6.590178	.2702639	-24.38	0.000	-7.119885	-6.06047
Total_family	.0024329	.0249434	0.10	0.922	-.0464552	.051321
EDUCATION	-.0346623	.0196687	-1.76	0.078	-.0732123	.0038876
AGE	-.0118688	.0037983	-3.12	0.002	-.0193133	-.0044243
SEX	.0643191	.1277581	0.50	0.615	-.1860821	.3147203
_cons	3.298686	.2978157	11.08	0.000	2.714978	3.882394

Appendix 3

Marginal effects after logit
y = Pr(food_insecurity) (predict)
= .63130425

variable	dy/dx	Std. Err.	z	P>|z|	[95% C.I.]		X
fertil~r*	-.032832	.04415	-0.74	0.457	-.119374	.05371	.106294
Irriga~n*	-.0277362	.03415	-0.81	0.417	-.094671	.039198	.215157
rainfa~k*	.1217627	.02685	4.54	0.000	.069142	.174384	.530186
Death_~k*	.0999398	.02912	3.43	0.001	.04286	.15702	.267823
Remitt~e*	-.1111525	.04157	-2.67	0.008	-.192632	-.029673	.1307
LiveSt~k*	-.0513758	.02672	-1.92	0.055	-.103752	.001001	.560373
CREDIT*	-.2712444	.02995	-9.06	0.000	-.329939	-.21255	.24149
OffFarm*	-.4072053	.02466	-16.51	0.000	-.455532	-.358879	.346821
FARMIN~E	-2.67e-06	.00000	-3.52	0.000	-4.2e-06	-1.2e-06	25825
DRMD	.0009657	.00103	0.94	0.349	-.001057	.002989	15.8391
Total_~d	-1.533924	.07339	-20.90	0.000	-1.67777	-1.39008	.189322
Total_~y	.0005663	.00581	0.10	0.922	-.010813	.011945	4.85678
EDUCAT~N	-.008068	.00458	-1.76	0.078	-.017044	.000908	3.01285
AGE	-.0027626	.00088	-3.13	0.002	-.004495	-.001031	44.361
SEX*	.0150286	.02996	0.50	0.616	-.043689	.073746	.735067

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

Appendix 4

Variable	Obs	Mean	Std. Dev.	Min	Max
Food insecurity	3,115	.3704655	.4830069	0	1
SEX	3,115	.7351525	.4413228	0	1
AGE	3,115	44.36597	15.35557	15	97
EDUCATION	3,115	3.014446	2.070586	0	15
Total family	3,115	4.858106	2.330668	1	15
Total land	3,115	0.91219	.5311456	0	2.03
DRMD	3,115	15.83467	12.77097	1	47
FARMINCOME	3,115	25837.69	19140.46	7000	65550
Off-Farm	3,115	.3470305	.476102	0	1
CREDIT	3,115	.2417335	.4282024	0	1
Livestock	3,115	3.760513	2.2964043	0	1
Remittance	3,115	.1306581	.3370802	0	1
Death_ Live~k	3,115	.2677368	.4428507	0	1
rainfall_ ~k	3,115	.5303371	.4991589	0	1
Irrigation	3,115	.2150883	.4109495	0	1
Fertilizer	3,115	.10626	.3082196	0	1

Appendix 5

Logistic regression — Number of obs = 3,114; LR chi2(15) = 2004.09; Prob > chi2 = 0.0000; Log likelihood = -1050.3784; Pseudo R2 = 0.4882

vulnerabiltiy	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
SEX	-.0711249	.127348	-0.56	0.576	-.3207224	.1784726
AGE	.0050827	.0036855	1.38	0.168	-.0021406	.0123061
EDUCATION	.0278168	.0194434	1.43	0.153	-.0102916	.0659253
Total_family	.0020995	.0248514	0.08	0.933	-.0466083	.0508074
Total_land	6.636921	.2701213	24.57	0.000	6.107493	7.166349
DRMD	-.0039603	.0044116	-0.90	0.369	-.0126069	.0046862
FARMINCOME	.0000112	3.26e-06	3.43	0.001	4.81e-06	.0000176
OffFarm	1.724454	.1161275	14.85	0.000	1.496848	1.952059
CREDIT	1.13566	.1264935	8.98	0.000	.8877374	1.383583
Remittance	.3831194	.1540143	2.49	0.013	.081257	.6849817
Death_Livestock	-.4851357	.1318014	-3.68	0.000	-.7434616	-.2268098
rainfall_shock	-.5073842	.1162371	-4.37	0.000	-.7352048	-.2795636
Irrigation	.1367084	.1432992	0.95	0.340	-.1441529	.4175698
fertilizer	.1399382	.183862	0.76	0.447	-.2204247	.5003011
total_livestock_owned	-.00341	.0172426	-0.20	0.843	-.0372048	.0303848
_cons	-2.851537	.2911087	-9.80	0.000	-3.422099	-2.280974

Appendix 6

Marginal effects after logit
y = Pr(vulnerabiltiy) (predict)
= .36869403

variable	dy/dx	Std. Err.	z	P>|z|	[95% C.I.]		X
SEX*	-.0166253	.02988	-0.56	0.578	-.075198	.041947	.735067
AGE	.0011831	.00086	1.38	0.168	-.000498	.002864	44.4088
EDUCAT~N	.0064746	.00453	1.43	0.153	-.002399	.015348	3.01285
Total_~y	.0004887	.00578	0.08	0.933	-.010849	.011826	4.85678
Total_~d	1.544801	.07349	21.02	0.000	1.40077	1.68883	.189322
DRMD	-.0009218	.00103	-0.90	0.369	-.002934	.001091	15.8391
FARMIN~E	2.61e-06	.00000	3.43	0.001	1.1e-06	4.1e-06	25825
OffFarm*	.3999593	.02456	16.28	0.000	.351817	.448102	.346821
CREDIT*	.2727492	.02981	9.15	0.000	.214324	.331175	.24149
Remitt~e*	.091718	.03763	2.44	0.015	.017957	.165479	.152216
Death_~k*	-.1089322	.02831	-3.85	0.000	-.164426	-.053439	.267823
rainfa~k*	-.1180584	.02679	-4.41	0.000	-.170557	-.06556	.530186
Irriga~n*	.0321255	.03397	0.95	0.344	-.03446	.098711	.215157
fertil~r*	.0330119	.0439	0.75	0.452	-.053029	.119053	.106294
total_~d	-.0007937	.00401	-0.20	0.843	-.00866	.007073	3.78783

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

Appendix 7

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. vif
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Variable	VIF	1/VIF
EDUCATION	1.08	0.922897
AGE	1.08	0.923265
Total_land	1.02	0.981960
LiveStock	1.02	0.984826
FARMINCOME	1.01	0.989715
Total_family	1.01	0.994857
DRMD	1.00	0.997300
Mean VIF	1.03	

Appendix 8

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. estat hettest

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

         chi2(1)      =    72.64
         Prob > chi2  =   0.0000

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