THE ROLE OF CROP DIVERSIFICATION TO HOUSEHOLD FOOD SECURITY: THE CASE OF ENDERTA WOREDA, TIGRAY, ETHIOPIA

BY

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DECLARATION

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

Declared by:

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January 2019

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This is to certify that the Thesis prepared by Chanie Ejigu Berhie entitled: *The Role of Crop Diversification to Household Food Security: The Case of Enderta Woreda, Tigray, Ethiopia* and submitted in partial fulfillment of the requirements for the Degree of Master of Science in Food Security complies with the regulations of the University and meets the accepted standards with respect to originality and quality**.**

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I would have been happy if my mother is alive for few extra moments. Unfortunately she breached her promise to wait for me

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List of Acronyms

ADLI	Agricultural Development Led Industrialization
BOARD	Bureau of Agriculture and Rural Development
CDI	Crop Diversification Index
CSA	Central Statistical Agency
CSPro	Census and Survey Processing System
DA	Development Agent
EDHS	Ethiopian Demography and Health Survey
FGD	Focus Group Discussion
FAO	Food and Agricultural Organization
GDP	Gross Domestic Product
GTP	Growth and Transformation Plan
HDDS	Household Dietary Diversity Score
HFIAS	Household Food Insecurity Access Scale
HI	HerfindahlIndex
GLM	Generalized Linear Model (GLM)
OLS	Ordinary Least Squares
MoA	Ministry of Agriculture
NNP	National Nutrition Programme
NSA	Nutrition Sensitive Agriculture (NSA

Abstract

Reducing food and nutrition insecurity in the developing countries continues to be a major public policy challenge. Food insecurity has become a global challenge for policy makers particularly in Sub-Saharan Africa where the rate of population growth far exceeds the quantity and quality of food needed to feed the population. Most of poor population in Ethiopia depends on agriculture and especially small-scale farming systems as the primary source of their livelihoods. Agriculture is considered as a strong option and fundamental instrument for prompting growth and sustainable development, poverty reduction, and enhancing food security in developing countries like Ethiopia. Crop diversification has been viewed as one of the solutions which can help small holder farmers to diversify their production and thereby improve food security. This study was designed to assess the role of crop diversification to food security of smallholder farmers in Enderta woreda. Primary data was collected from 203 sample farm households selected randomly from three kebeles of the woreda. Household survey questionnaire, key informants interview and focus group discussion were used to collect the primary data. Descriptive statistics such as mean, percentage, t-test were employed to analyze the quantitative data. Ordinary least square (OLS) was used to measure the influence of crop diversification, as measured by crop diversification index, on household food security as measured by household dietary diversity score and household food insecurity access scale. Censored Tobit model was used to analyze the determinants of crop diversification in the study area. The result of the OLS model shows that crop diversification has a strong and positive impact on household food security. The OLS result also indicated that ownership of oxen has a positive impact on household food security whereas family size and distance to the markets negatively influence household food security. The result of the censored Tobit models shows that ownership of oxen, level of education of the household head and number of plots owned were the major factors that positively determine crop diversification. The result of the censored Tobit model indicted that distance to the market negatively influence crop diversification in the study area. From these results, it can be concluded that food security status of farm households can be improved through crop diversification and therefore farmers should be stimulated to more diversify their cropping activities.

CHAPTER ONE: INTRODUCTION

1.1. Background of the Study

Agriculture is considered as a strong option and fundamental instrument for prompting growth and sustainable development, poverty reduction, and enhancing food security in developing countries. It is also assumed to be a vital development tool for achieving the sustainable development goals, one of which is to 'end hunger, achieve food security and improved nutrition and promote sustainable agriculture'. It is also a risky business as it involves uncertain factors such as weather and market situations which in turn influence various decisions that farmers make in particular season (Ame *et al*., 2016).

While Ethiopia has registered impressive economic growth in the last two decades, more than 80 percent of its population still subsists on rain-fed agriculture (Guush *et al*., 2015). An agrarian based economy like Ethiopia is dominated by small subsistence and marginal farmers where their small operational base makes it unfeasible to enhance their incomes and food security only by raising the existing crop yields.

Improving income and food security requires articulation of policies that encourage and support subsistence farmers to produce over and above their own needs and use their natural and human resources for high value crops that can easily be sold in the market. Considering the importance of the agricultural sector in improving food and security, the government of Ethiopia has recently designed a nutrition sensitive agricultural strategy where crop diversification is explicitly stated as one of the initiative to year round availability and access of diversified foods by smallholder farmers (MoA, 2016).

Crop diversification is one of the solutions in reducing the variability in farm income, while it provides the farmers with the viable option to grow a variety of crops on their land. It reduces risks and uncertainty and has a positive impact on soil fertility (Njeru, 2013). Crop diversification implies increasing the variety of agricultural commodities produced at the farm level and is the response of subsistence farmers to reduce risks (Degye *et al*., 2012).

Enderta woreda, where the present study was conducted, has low agricultural production and productivity due to various interrelated problems including erratic rainfall distribution, land

degradation, and loss of soil fertility (Gedlom, 2008). As a result, seasonal food shortage and vulnerability of households to food insecurity have been the major challenges of the woreda.

This study assessed the role of crop diversification to household food security in Enderta woreda and found that crop diversification improves household food security as measured by dietary diversity and food insecurity access scale.

1.2. Statement of the Problem

Hunger and malnutrition are complex global problems. The total number of food insecure and hungry people in the world was estimated as 925 million in 2010 (FAO, 2010). This figure has declined to 795 million in 2015 (FAO, 2015). Though the number of food insecure and hungry people in the world is declining, the hunger remains high and likely to persist and even increase in developing countries (Meskerem and Degefa, 2015). The majority of people suffering from hunger live in developing countries and many of them are smallholder farmers (Kibrom *et al*., 2015).

The number of food insecure and hungry people living in sub-Saharan Africa was estimated as 239 million in 2010 and this figure declined to 220 million in 2014-16 (FAO, 2015).The cause of failure of sub-Saharan Africa to feed its increasing population is mainly attributed to rapid population growth, unsustainable farmland management practices, recurrent drought, rising food prices, political instability, widespread epidemics, technology stagnation, continuous civil strife and conflicts (Meskerem and Degefa, 2015).

Subsistence rain-feed agricultural production is the main source of living for more than 84% of the population of Ethiopia (CSA, 2008). Empirical evidence on food security in Ethiopia verify the prevalence of high level of food insecurity with significant idiosyncratic and spatial features. The specific food security studies by Samuel (2004), Ayalneh and Shimelis (2009), Hadleya *et al*. (2011) and Hailu (2012) generally suggest that depth and intensity of food insecurity is high, influenced by poor functioning of marketing systems and household and socioeconomic factors.

Agriculture, predominately mixed farming with crop production with livestock, is the main economic stay of Enderta woreda, the study area. The farming season is dependent on the '*kiremt*' rains that start in June and last until September. Rain fall in the woreda is low and highly variable and there exist frequent drought periods. Lack of suitable farm land, declining

soil fertility, caused by extensive land degradation diminishes the prospectus of food production in the area. The main crops produced in the woreda are wheat, barely, *teff*, sorghum, maize and pulses. Oxen are the main traction power and are considered to be important production resources in the woreda.

Population pressure and erratic rainfall patterns coupled with lack of suitable lands for crop cultivation among the factors that contribute to food insecurity in the woreda (Tagel, 2012). Enderta woreda is one of the 16 woredas identified by the regional government as chronically food insecure woredas in the region. The woreda has low agricultural production and productivity due to various interrelated problems including erratic rainfall distribution, land degradation, and loss of soil fertility (Gedlom, 2008). As a result, seasonal food shortage and vulnerability of households to food insecurity have been the major challenges of the woreda.

Crop diversification has been viewed as one of the solutions which can help small holder farmers to diversify their production and thereby improve food security. Empirical evidence by Bittingen (2010), Wondimagegn e*t al*. (2011) and Bereket and Zenebe (2011) identified factors determining different aspects of diversification and verified that rural households in Ethiopia are risk averse. In addition, the studies conducted (Clifton *et al*., 2016; John et al.,2015; Ame *et al*., 2016 and Immink and Alarcon, 1991) elsewhere on the links between crop diversification and household food security revealed mixed results implying the need to empirically justify their links. The only study conducted in Ethiopia on the impact of crop diversification on household food security was a study conducted by Degye *et al.* (2012) and found that crop diversification enhances calorie intake of rural households in eastern and central highlands of Ethiopia.

Despite the theoretical benefits associated with crop diversification often discussed in the literature and empirical evidences elsewhere, there is dearth of study to date attempted to examine the role of crop diversification on smallholder households' food security in northern Ethiopia. In addition, results from studies conducted elsewhere on the links between crop diversification and household food security revealed mixed results. Furthermore, these studies were conducted in various agro-ecological, socio-cultural and economic settings implying the need to empirically justify their links. Therefore, this study was designed to assess the role of crop diversification to farm households' food security in Enderta woreda.

1.3. Objective of Study

The overall objective of this study is to assess the role of crop diversification to household food security in Enderta woreda of Tigray regional state.

The specific objectives of the study are to:

a) estimate the food security status of farming households in Enderta woreda
b) measure the role of crop diversification to household food security in Enderta woreda,
c) identify the factors that determine crop diversification in Enderta woreda

1.4. Research Questions

The study is designed to answer the following research questions.

- What is the food security status of households in the study area?
- Does crop diversification improve household food security in Enderta woreda?
- What are the major factors that determine crop diversification in the study area?

1.5. Significance of the Study

The finding of this study could be used as an input for government, policy makers, international organizations in their endeavors in designing policies, programs and projects related to agriculture and food security. As there is scarcity of empirical evidence on the impacts of crop diversification on household food security, the result of the study will contribute to the literature. Besides, the study will incite and uncover a way for further research and could also be used as a reference for MSc students in food security and related disciples.

1.6. Scope and Limitation of the Study

The study is designed to assess the role of crop diversification to household food security in Enderta woreda of northern Ethiopia. The scope of the study is limited to assessing the role of crop diversification on household food security as measured by household dietary diversity score (HDDS) and household food insecurity access scale (HFIAS). These two indicators of food security mainly measure the access dimension of food security. It is often stated in the literature that it is difficult to distinguish food availability and food access at household level especially in rural areas since rural households generally depend on food production as a means to have access to food. This implies that local food availability and food access strongly overlap. Given this in

mind, the study is limited to the access dimension of food security. The other dimensions of food security were not considered in this study which is the limitation of the study.

1.7. Justification of the Study Area

The rationale for the choice of Enderta for the study is based on logistical feasibility and previous contact of the researcher with the locality. Though Enderta is found in the outskirt of the regional capital, Mekelle, it has been one classified as one of the food insecure woredas in the region. Recently, the woreda is exhibiting production of vegetable crops, which have demand by the urban community, apart from production of the tradition and dominant cereal crops. This implies that smallholder farmers are inclined to diversifying their agricultural activities which require through investigation of the role of this diversification in improving household food security.

1.8. Organization of the Thesis

The Thesis is organized into five chapters. The first chapter provides introduction including the statement of the problem, objective of the study and research questions. The second chapter deals with related literature of the concepts of crop diversification and food security and the theoretical basis of these concepts. The third chapter is about the research methods used and detail description of the study area. The fourth chapter presents results of the study and discusses the results by giving due emphasis on the research objectives. The final chapter presents summary, conclusion and recommendations.

CHAPTER TWO: LITERATURE REVIEW

Since the topic of this study entails two big concepts-crop diversification and food security, this section reviewed the existing literature related to these concepts. Accordingly, concept of crop diversification and specialization, definition of crop diversification, reasons for diversification have been reviewed and presented first followed by the concept of food security, definition of food security, dimensions of food security. The Crop diversification pathways to food security and empirical evidence on linkages between crop diversification and household food security and determinants of crop diversification have also been reviewed. Agriculture and food security in Ethiopian context and the conceptual frameworks are presented in the final sections.

2.1. The Concepts of Crop Diversification and Specialization

One of the most important factors determining the economic performance of the agricultural farm is carried out in the production lines. They determine whether the farm is specialized or diversified. Much of the literature on smallholder cropping decisions is framed as a debate over whether it is better to specialize or diversify. Cash crops are often promoted to alleviate poverty through welfare gains as part of a strategy based on comparative advantage (Jeffrey and Anna, 2017) while a diverse crop portfolio is promoted as part of a strategy to manage production risk. Specializing in cash crops, which are assumed to have a higher value than food crops, may directly increase a household's income. The production and sale of cash crops allows the household to earn, and thus consume, more than could be done by allocating the same resources to own-food production though the benefits of specializing in cash crops may be limited by agro-climatic conditions (Orr, 2000 as cited in Jeffrey and Anna, 2017). The following sections discuss about the two concepts in detail.

2.1.1. The Concept of Crop Diversification

The concept of diversification conveys different meaning to different people at different levels. According to Ellis (2000), the diversification of activities is defined as the process by which rural households build a growing portfolio of activities and various assets to survive and improve their standard of living. Based on this definition, Niehof (2004) envisages diversification as an important strategy which makes it possible to reduce vulnerability. Diversification is the process

by which households construct increasingly diverse livelihood portfolios, making use of increasingly diverse combinations of resources and assets (Niehof, 2004).

Two forms of diversification are identified: farm diversification or crop diversification and farm income diversification (or diversification of activities (Emrys and Ngau, 1991). The difference between both diversifications is based on the nature of the activities. According to Emrys and Ngau (1991), whereas farm diversification is located within the farm and implies primarily activities in the agricultural sphere, diversification of activities refers to income diversification coming from activities undertaken inside and outside the farm.

According to Swades and Shyamal (2012), crop diversification in the developing countries is a pungent applied concept to remove the plight of subsistence agricultural economy and to ensure diversified nutrition status of the poor countrymen. Crop diversification is intended to give a wider choice in the production of a variety of crops in a given area so as to expand production related activities on various crops and also to lessen risk. Crop diversification is generally viewed as a shift from traditionally grown less remunerative crops to more remunerative crops. Crop diversification and also the growing of large number of crops are practiced in rain fed lands to reduce the risk factor of crop failures due to drought or less rains.

Diversification of crops can be an effective tool to help farmers deal with several types of risk, such as price risk. The farmer can use what he knows about the means and variances of the prices for each crop to choose a mix of crops that have a low correlation of profitability (Coyle, 1992). The farmer can use diversification and choose an optimal portfolio of crops to help insure against drops in profit or utility that occur if the price for one crop is lower than average in a given year. Farmers can also use diversification in response to output risks or input market risks; by choosing crops with different characteristics (i.e. crops that are more or less droughtresistant, or crops that are harvested in different seasons.

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availability. These types of constraints can take the form of limited availability of inputs, limited water or nutrient availability, public and private payments for ecosystem services and consumer demand for quality-differentiated products or products with environmental attributes (such as organic or pesticide-free varieties). The contrary to crop diversification is crop specialization which is discussed in the following section.

2.1.2. The Concept of Crop Specialization

Specialization of agricultural production means reducing the assortment of diversity, or increasing the production of the selected product, which is accompanied by maintaining the production of the remaining products at the unchanged level. The fewer products the farm produces the more specialized it is. Full specialization is the production of a single product (Andrzej, 2015). The opposite of specialization of production is its diversification, which is to increase the number of courses conducted on the farm or to eliminate the dominating course and to introduce a few others in its place. It leads to the creation of a multi-directional farm. The process of moving from a farm of multilateral forms to the specialized form is most frequently a long-term process, because it means the need to invest, associated with the modernization understood as technical modernization, technological or organizational (Andrzej, 2015). The most frequently mentioned positive effects of specialization processes that determine the effectiveness of the farms are:

- The possibility of reducing unit costs through an increase in the scale of production and, consequently, increase of the value added from agricultural activities.
- Economization of effort leading to an increase in productivity and production levels, by performing repetitive tasks, increasing accuracy, improving the practical and theoretical knowledge about the direction that is the subject of specialization, resulting in a reduction of production costs.
- Disclosure of comparative advantages and increase of the competitiveness of specialized farms
- A change in the structure of expenditures by limiting their versatility and simplifying the organization.
- Increase in the effectiveness of marketing of agricultural products, by reducing the transaction costs associated with trade.

- Lower material consumption resulting from better control of technological processes.

Thus, in the traditional approach simplifying agricultural production leads to an increase in the efficiency of specialized farms as compared with the multidirectional ones. You cannot, however, forget about the main advantage of the diversified production, mentioned in the following sections. It is the dispersion of risk arising from fluctuations in prices on different agricultural markets. It ensures that in times of economic downturn the diversified farm efficiency may be greater than that of specialized ones (Andrzej, 2015).

2.2. Definition of Crop Diversification

Crop diversification is the practice of cultivating more than one variety of crops belonging to the same or different species in a given area in the form of rotations and or intercropping (Joshi, 2005). Crop diversification is perceived as one of the most ecologically feasible, cost effective, and rational ways of reducing uncertainties in agriculture especially among smallholder farmers (Joshi, 2005).

The aim of crop diversification is to increase crop portfolio so that farmers are not dependent on a single crop to generate their income. When farmers only cultivate one crop type they are exposed to high risks in the event of unforeseen climate events that could severely impact agricultural production, such as emergence of pests and the sudden onset of frost or drought. Introducing a greater range of varieties also leads to diversification of agricultural production which can increase natural biodiversity, strengthening the ability of the agro-ecosystem to respond to these stresses, reducing the risk of total crop failure and also providing producers with alternative means of generating income. With a diversified plot, the farmer increases his/her chances of dealing with the uncertainty and/or the changes created by climate change. This is because crops will respond to climate scenarios in different ways. Whereas the cold may affect one crop negatively, production in an alternative crop may increase.

This study adopts the definition provided by Joshi (2005) and considers the number of crops grown by a farm household in the 2016 production year.

2.3. Why Diversifying Agricultural Activities

One of the most important objective of diversification in agricultural activities is to decrease the overall production risk by selecting a mix of crops whose productivity has a low or negative correlation and whose nutritional values are important for the household's diet. Crop diversification strategies have been pursued worldwide as a way to improve household income in less-developed countries (Papademetriou and Dent, 2001 as cited in Lorenzo and Luca Tasciotti 2014). The rational for diversification strategies is based on the facts that i) rotating the crops has a beneficial effects for the soil guaranteeing environmental protection; ii) it potentially reduces pest and diseases; and iii) it increases food security, by offering farmers access to sufficient, nutritious and diversified food in areas where markets are not available (Lorenzo and Luca Tasciotti, 2014).

Furthermore, crop diversification has gained renewed interest due to the liberalization of agricultural policies and the globalization of agricultural markets. State interventions in the recent past have moderated domestic prices fluctuations. Nowadays, as domestic prices follow international prices more closely, farmers are forced to cope with the implications of larger fluctuations in commodity prices (Lorenzo and Luca Tasciotti, 2014).

Relying on food imports to satisfy domestic nutritional needs promotes food insecurity by subjecting developing countries to the fluctuations of the world market prices. Lastly, in remote areas where physical access to markets is costly or markets are not available, households diversify their crop production patterns to satisfy their own consumption needs (Lorenzo and Luca Tasciotti, 2014). The major driving forces for crop diversification according to Clements et al. (2011) include:

- Increasing income on small farm holdings
- Withstanding price fluctuation
- Mitigating effects of increasing climate variability
- Balancing food demand
- Improving fodder for livestock animals
- Conservation of natural resources
- Minimizing environmental pollution

- Reducing dependence on off-farm inputs
- Depending on crop rotation, decreasing insect pests, diseases and weed problems
- Increasing food security.

Within the literature on crop diversity, production risk, and income the focus is generally on estimating the determinants of diversity. Several studies such as (Ellis, 1998, 2000; Barrett et al., 2001; Caviglia-Harris and Sills, 2005 as cited in Jeffrey and Anna, 2017) found a positive relationship between household income and agricultural diversity. Empirical evidence in Ethiopia shows that crop diversification helps farm households to move out of poverty. A study conducted by Jeffrey and Anna (2017) found that households which grow a diverse set of crops are less likely to be poor than households that specialize in their crop production. Additionally, crop diversity reduces the probability that a non-poor household will fall into poverty and the probability that a poor household will remain in poverty.

Diversification is viewed as an important way to increase food security. This is particularly true when faced with increasing variability in production due to climate change (Jeffrey and Anna (2017). Several studies conducted in Ethiopia found that combinations of different farming techniques, including greater crop diversity, may mitigate food insecurity and help farmers cope with climate change (Jeffrey and Anna, 2017). The present study will contribute to the literature on the influence of crop diversification to household food security in arid region of the country.

2.4. Measurement of Crop Diversification

There are several ways to measure crops diversification for crop diversification which indicate the extent of dispersion and concentration of activities in a given time and space by a single quantitative indicator. The extent of crop diversification at a given point in time may be examined by using several indices namely: Herfindahl Index (HI), Ogive Index (OI), Entropy Index (EI), and Simpson Index (SI). Another common method for measuring the crop diversification is to count the number of crop grown by farmer.

Herfindahl index (HI): The Herfindahl index is a concentration index which is often used to determine the concentration of industry. It decreases gradually as the level of diversification

increases. It takes the value 1 when there is total concentration and tends to zero as the level of diversification increased (Swades and Shyamal, 2012). In the context of crops diversification, Herfindahl index is used to study the extent of crops diversification. The formula is given as below.

$$HI=\sum_{i=1}^{N} p_i$$

Where$N$ is the total number of crops cultivated and p_i accounts for the land share of the ith crop in total cropped area.

Simpson diversity index (SDI): it was introduced in 1949 to assess the degree of concentration when individuals are grouping into type. The same index is often used to measure the extent of diversification. The square root of the index has already been introduced by Hirschman. As a result, the same measure is usually known as the SDI in ecology and as the HI or the HHI (Herfindahl–Hirschman Index) in economics (Adjimoti and Kwadzo, 2018).

$$SDI=1- HI=\sum_{i=1}^{N} p2_i$$

$p$iis the proportionate area of the ith crop in the gross cropped area; n is the total number of crops grow by the household.

Ogive index (OI): Ogive Index is used to evaluate countries specialization and concentration. It has been also used to estimate the diversification at the farm level. The description of the index is given in the following formula.

$$OI= \frac{\sum_{i=0}^{n}\left[p_{i-(\frac{1}{N})}\right]2}{(\frac{1}{N})}$$

Nrepresents the number of crops; Pi is the proportionate area of the ith crop in the gross cropped area.

Entropy measures for crop diversification: Entropy Index evaluates the shares of farm activity in logarithm term with the inverse measure of the shares. The Entropy Index of Diversification (DIE) is computed using the formula DIE = Σ[P2it × In(1/Pit)].

Where Pi the proportion of cultivated land for the ith crop. DIE is supposed to increase as the level of diversification increases and vice versa. The difference between the first level of

diversification and the perfect diversification for a given number of crops is measured by the Berry's index as DIB/[1–(1/n)], while for Entropy Index as DIE/In(n) more the Entropy or Berry's measures value expected is the result or otherwise (Swades and Shyamal, 2012). .

All these indices are computed on the basis of proportion of gross cropped area under different crops cultivated in a particular geographical area. Simpson Index is usually known as Simpson Diversity Index in ecology and as the HHI (Herfindahl–Hirschman Index) in economics (Adjimoti and Kwadzo, 2018).

This study employs Simpson Diversity Index because it is widely used in the literature of agricultural diversification. One of the advantages of using Simpson Diversity Index in the present study is that it does not required farmers to produce all type of crops.

2.5. Empirical Studies on Determinants of Crop Diversification

This section summarizes the empirical studies conducted to identify the factors that affect crop diversification in Ethiopian and elsewhere. Several studies have attempted to describe the factors that may influence smallholder farmers in developing countries to diversify. These studies have identified factors affecting the decision and level of crop diversification.

Kiru (2014) used Tobit model and identified that land size, distance to the market, quantities of fertilizer use and tillage time were the main determinants of crop diversification in Zambia. Weiss and Briglauer (2000) on their part applied instrumental-variable regression model and found out that farm size, part-time farming, education, family size and the location of the district are significant determinants of farm diversification in Australia.

Moreover, Joshi et al. (2004) applied the Generalized Least Square (GLS) technique and found that relative profitability, irrigation, road, markets, rural literacy, the proportion of small holders, income from crop, urbanization, rainfall and production year affected crop diversification in South Asia. To find the determinants of agricultural diversification in Central Queensland of Australia, Windleand Rolfe (2005) employed the Nested Multinomial Logit model and observed that debt, age, education, number of children, off-farm income, farm size, start-up cost, net income, other crops grown and risk time are the most determinant factors.

By using Poission and Tobit models, Gauchan et al. (2005) discovered that growing rice varieties was significantly affected by the age and education of the household heads, adult labour, livestock, subsistence ratio, irrigation, land type, plot dispersion, modern variety sold and market access in Nepal. To come across the determinants of crop diversification in Pakistan, Ashfaq's et al. (2008) applied multiple regression model and found that farming experience, education, land size, farm distance from main road and farm machinery are the significant factors.

Rahman (2008) used bivariate Probit analysis and found that Bangladesh's crop diversification was significantly affected by farm asset, irrigation access, rented in land, education, farming experience, infrastructure and non-agricultural income. Moreover, Ibrahim et al. (2009) employed multiple linear regression model and identified that age and education of the household heads, extension visits, availability of tractor hiring, income from crop and road access to be the significant determinants of crop diversification in Nigeria.

Studies that deal with the role of crop diversification in Ethiopia and its determinant factors are few. Wondimagegn *et al*. (2011) using Tobit model and revealed that extension, livestock, market information, access to irrigation, number of farm plots and ownership of farm machinery significantly affected crop diversification in eastern Ethiopia. Rehima *et al*. (2013) using Heckman Two-Stage model,in their study of the determinants of crop diversification in southern Ethiopia, found that crop diversification is determined by gender, education and trade experience, membership in cooperatives, resource ownership, features of the land owned, access to extension services and transaction costs.

Another study by Benin et al. (2004), using censored the least absolute deviations estimators, found that land size, the proportion of male, ownership of livestock and oxen, farm fragmentation, number of fragmented plots, farm distance and regional location were the significant factors that affected cereal diversity in northern part of the country. Other researchers used Generalized Linear Model (GLM) and OLS model and observed that proximity to town, access to road, education, liquid wealth, and irrigation access are significant factors that affected crop choices in Northern Ethiopia (Seid and Seebens, 2008).

Fetien*et al.* (2009) used Tobit model and revealed that barley variety diversity was affected by age, age square, male headed household, number of children, livestock, fragmentation index, farm size, altitude, rainfall, extension and temperature in Tigray, Ethiopia.

Given, the mixed results of the various studies done so far elsewhere and the dearth of studies in Ethiopian context, the present study adds to the literature by providing empirical evidence on factors affecting crop diversification using censored Tobit model in Enderta woreda.

2.6.The Concept of Food Security

Food security is a flexible concept as reflected in the many attempts at definition in research and policy usage. Even a decade ago, there were about 200 definitions in published writings (Maxwell and Smith, 1992). Whenever the concept is introduced in the title of a study or its objectives, it is necessary to look closely to establish the explicit or implied definition (Maxwell, 1996).

The continuing evolution of food security as an operational concept in public policy has reflected the wider recognition of the complexities of the technical and policy issues involved. The most recent careful redefinition of food security is that negotiated in the process of international consultation leading to the World Food Summit (WFS) in November 1996.

The contrasting definitions of food security adopted in 1974 and 1996, along with those in official FAO and World Bank documents of the mid-1980s, are set out below with each substantive change in definition underlined. A comparison of these definitions highlights the considerable reconstruction of official thinking on food security that has occurred over 25 years. These statements also provide signposts to the policy analyses, which have re-shaped our understanding of food security as a problem of international and national responsibility.

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 initial focus, reflecting the global concerns of 1974, was on the volume and stability of food supplies. Food security was defined in the 1974 World Food Summit as: availability at all times of adequate world food supplies of basic foodstuffs to sustain a steady expansion of food consumption and to offset fluctuations in production and prices.

In 1983, FAO expanded its concept to include securing access by vulnerable people to available supplies, implying that attention should be balanced between the demand and supply side of the food security equation i.e., ensuring that all people at all times have both physical and economic access to the basic food that they need".

In 1986, the highly influential World Bank report "Poverty and Hunger" focused on the temporal dynamics of food insecurity. It introduced the widely accepted distinction between chronic food insecurity, associated with problems of continuing or structural poverty and low incomes, and transitory food insecurity, which involved periods of intensified pressure caused by natural disasters, economic collapse or conflict. This concept of food security is further elaborated in terms ofaccess of all people at all times to enough food for an active, healthy life.

By the mid-1990s food security was recognized as a significant concern, spanning a spectrum from the individual to the global level. However, access now involved sufficient food, indicating continuing concern with protein-energy malnutrition. But the definition was broadened to incorporate food safety and also nutritional balance, reflecting concerns about food composition and minor nutrient requirements for an active and healthy life. Food preferences, socially or culturally determined, now became a consideration. The potentially high degree of context specificity implies that the concept had both lost its simplicity and was not itself a goal, but an intermediating set of actions that contribute to an active and healthy life.

2.7. Definition and Dimensions of Food Security

The most widely used definition of food security is the one adopted by the 1996 World Food Summit and it is read as:

"Food security exists 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" (FAO, 1996).

This definition integrates access, availability, utilization and stability of food. Furthermore, this definition implies the time dimension, i.e. long-term sustainability of food security. Sustainability of food security has been introduced as an issue of international concern through the notion of sustainable development. Sustainability in the context of rural household food security is mainly determined by long-term availability of household food production, sustainable food access, and stability of household food consumption. The present study adopts the definition provided by FAO.

As mentioned above, we distinguish four major dimensions of the food security status: food availability, food access, food utilization and stability. These dimensions are strongly interlinked. The realization of food availability is a necessary but not sufficient condition for the realization of food access. In turn, the realization of food access is a necessary but not sufficient condition for the realization of food utilization. Each of these dimensions is discussed in more detail below.

A. Food Availability

Food availability can be described as the extent to which food is within reach of households (for example in local shops and markets), both in terms of sufficient quantity and quality (FAO, 2006). It is often difficult to distinguish food availability from food access; their interrelation will be discussed in more detail in the next subsection.

Food availability at the micro-level is strongly related to the overall availability of food, which is determined by domestic food production, commercial food imports and food aid (FAO, 2006). These are in turn influenced by domestic policies regarding food production, such as

policymakers' focus on food self-sufficiency or food self-reliance. Other policies directly affecting food availability are agricultural subsidy programs, exchange rate policies affecting international trade opportunities and policies creating stable and attractive conditions for agricultural investments.

In general, the food availability dimension reflects the supply side (Barrett and Lentz, 2009) and will therefore be affected by all the drivers and determinants that have an impact on the domestic supply of food and the ability to finance food imports. At a more local level, food availability is strongly contingent on road and market infrastructure, the degree of market integration, and local market institutions.

B. Food Access

Household-level food access is considered to be achieved when a household has the opportunity to obtain food of sufficient quantity and quality to ensure a safe and nutritious diet (FAO, 2006). To realize this, not only domestic and local food availability must be realized; households must also have access to the necessary resources to acquire food. Important drivers of food access are household resources, food prices, food preferences and socio-political factors such as discrimination and gender inequality.

Food access is to a large extent determined by food prices and household resources. Every household has a limited amount of resources at its disposal, including assets, labor, human capital, and natural resources. These resources are allocated across different income and non-income generating activities (Hoddinott, 2012). Access to natural resources such as fields, forests, grasslands and water resources is a major determinant of the productive capacity of the food producing household and therefore of household food supply decisions (Pieters *et al.,* 2013). Access to income-generating activities is a major determinant of the ability of households to purchase food.

In general, the allocation of household resources to food production, wage labor or other business activities allows the household to access food, either directly through food production or indirectly through income generation (Hoddinott, 2012). The returns to the investment of

household resources in productive activities can be complemented by income and in-kind transfers from family, neighbours or the state to improve food access (Hoddinott, 2012).

Income generation and food production possibilities of the household are directly affected by individual characteristics such as the education level and health status. Education is linked to the development of cognitive skills that are likely to support income generation and food production (Pieter *et al.*, 2013). Enhanced cognitive skills may raise income levels and employability through better decision-making in the allocation and distribution of resources and an increased marginal productivity (Pieters *et al.,* 2013). Education may also play an important role in household production decisions through a better knowledge of nutrition and health practices (Luo *et al*., 2012). For instance, a better knowledge of the amount of essential micronutrients contained in different crops might lead households to increase their production of nutritious crops. The health status of an individual directly affects his/her ability to learn and to work. An improvement (worsening) of the health status can give rise to a virtuous (vicious) cycle. A better nutritional and health status enhances the returns to education (Behrman, 1996) and increases an individual's labor time and labor productivity (Luo *et al*., 2012). The increased resources made available by a better health status can be subsequently invested in an improved diet and hence lead to further health improvements.

The quantity and quality of food that a household can acquire given its resources will depend on domestic food prices, which are generally determined by food availability and aggregate food demand. For given prices and income, individual preferences will determine the consumption of different commodities, including food. Dietary preferences can be influenced by factors such as culture, religion and social status (Atkin, 2013 cited in Pieters *et al.,* 2013).

Socio-political factors such social discrimination and gender inequality may also have an important impact on food access (Dohrmann and Thorat, 2007). Gender inequality in access to labor markets, financial services and productive resources such as land still pervades many developing countries and poses important constraints on the productive capacity of women, who in many societies play an important role in the provision of food through direct production or income generation (FAO, 2011).

It needs to be stressed that at household level it is difficult to distinguish food availability from food access. In regions where local markets are malfunctioning, households generally depend on food production as a means to have access to food, in which case (local) food availability and food access strongly overlap.

Even in regions were local markets are well developed, it is not always straightforward to distinguish between the food availability and food access. Household food production is often an important source of income in developing countries. An increase in food prices will generally raise the returns to household farm labor and may boost food production. A price increase may therefore positively affect food access through an improved food availability. The resulting increase in income may further improve food access, although this effect can be counteracted by the higher cost of food. In any case, this example illustrates that food availability cannot always be easily separated from food access (Pieters *et al.,* 2013).

C. Food Utilization

Food utilization refers to an individual's dietary intake and his/her ability to absorb nutrients contained in the food that is eaten. Hence, food utilization relates not only to the quantity of food that is eaten, but also to the quality of the diet. In particular, the food consumed by an individual must be of sufficient quantity and quality to satisfy not merely subsistence needs, but also energy needs for daily activities, notably income generation (FAO, 2011).

Food access, as described in the previous section, is a necessary but not a sufficient condition to ensure an adequate food and nutrition status (Barrett and Lentz, 2009). For example, a household might have access to all the necessary food products for a balanced diet, but still prefer to buy hypo- or hyper-caloric food. An increase in household income does not necessarily lead to an increase in the quantity or quality of food consumed, but can be spent on items such as alcohol or fast-food (Banerjee and Duflo, 2006 as cited in Pieters *et al,.* 2013). Alternatively, an unequal distribution of food within the household might cause some members to eat more and others less than required. In both cases, at least some household members will not absorb the required amount of micronutrients, resulting in a poor food and nutrition status.

In general, staple foods are cheaper than high-value foods such as vegetables, meat, fish and dairy, which contain more essential micronutrients. As households grow richer, they tend to shift to more diversified diets that include larger proportions of these high-value food products (Pieters *et al.,* 2013). Increases in the real incomes of households will therefore generally lead to improvements in the food and nutrition status of household members by improving their dietary intake

In addition to relative price considerations, an individual's dietary intake is also to a major extent determined by care practices applied in the surrounding environment. Care is broadly defined as 'the provision in the household and the community of time, attention and support to meet the physical, mental and social needs of the growing child and other household members' (ICN 1992 as cited in Pieters *et al.,* 2013). The capacity of the caregiver - usually a woman - to meet the needs of different household members depends on resource availability, but also on her knowledge of what appropriate care is. This, in turn, is often correlated with the education level of the caregivers. Education can for instance increase awareness of the importance of breastfeeding. In general, education plays a crucial role in the dispersion of information concerning health, nutrition and hygiene (Robeyns 2006 as cited in Pieters *et al.,* 2013). An individual's personal level of education will matter for his own choice of nutrient intake, but this mostly applies from the moment an individual can decide independently what he/she will consume.

Other important determinants of food utilization that are related to care practices are the individual health status and intra-household choices regarding the distribution of food. Individual health affects one's ability to absorb nutrients, also known as "nutrient utilization". If an individual suffers from a disease, he will have a reduced desire to eat and a constrained absorption of energy and nutrients (Pieters *et al.,* 2013).

Education and knowledge once again interact with these dimensions, as they help households in creating healthier environments and taking the correct preventive actions against diseases (Pieters *et al.* 2013). Household resources also play a key role: higher real incomes allow for better access to health services and for an improved health environment within the household.

D. Stability of the Food Security Status

We now turn to the fourth major dimension of food security, which relates to the stability of the food security status and focuses on what happens to livelihoods when households are hit by temporary negative shocks (vulnerability). These negative shocks have both immediate and long term effects on the status of household food security.

Vulnerability: vulnerability at the level of food security can be described as the risk that the food status of the household is undermined by negative shocks. Households generally face multiple negative shocks over time, and each shock may affect the general welfare and food and nutrition status of the household. By adopting particular livelihood strategies to deal with these shocks, households can ease the welfare impact and reduce their vulnerability to food and nutrition insecurity. Livelihood strategies therefore are a major determinant of the degree of vulnerability of the household, and which livelihood strategies are adopted will depend on the household's resources and its ability to access saving, credit and insurance markets (Pieters *et al.* 2013).

Three possible livelihood strategies can be identified: (1) risk prevention; (2) risk mitigation; (3) risk coping. Risk prevention is an ex-ante action taken by the household to reduce the probability of unexpected events (Heitzmann *et al*., 2002 as cited in Pieters *et al.* 2013). At the household or individual level these actions may consist of less risky production, migration, proper feeding or prevention of diseases (Holzmann and Jorgensen 2000 as cited in Pieters *et al.,* 2013).

Risk mitigation strategies are also adopted before the shock has been realized and have the purpose of reducing the negative welfare impact of future shocks (Heitzmann *et al*., 2002).

Three main mitigating strategies can be undertaken by a household. The first is portfolio diversification, which reduces overall risk exposure to a specific shock by investing resources in income and non-income activities from which the returns are not perfectly interrelated (Holzmann and Jorgensen 2000 as cited in Pieters *et al.,* 2013). Having multiple jobs is an example of a strategy to reduce income volatility.

A second mitigating strategy is formal or informal insurance. Insurance relies upon the idea of risk sharing. Formal insurance mechanisms are market-based and generally have the advantage of being able to rely on a large pool of uncorrelated obligors and these formal insurances do not properly work in developing countries. Informal insurance mechanisms - which rely on social networks and relationship-based risk sharing rather than formal markets. Community arrangements such as marriage and funeral insurance groups are examples of informal insurance mechanisms (Fafchamps and Lund 2003 as cited in Pieters *et al.,* 2013).

The third mitigation strategy is hedging, which is based on exchanging future (price) risks (Holzmann and Jorgensen 2000as cited in Pieters *et al.,* 2013).

Portfolio diversification is another possibility to insure against extreme events such as droughts. In case a shock destroys the harvest, the household can focus on other economic activities and (at least partially) recover the loss of income and food. Crop diversification could also be one used to reduce risk of crop failure.

2.8. The State of Agriculture and Food Security in Ethiopia

Ethiopia's agriculture sector accounts for about 39% of the country Gross Domestic Product (GDP) and around 75% of export earnings. It is the major employer of about 83% of the labour force. The sector has registered an average real agricultural GDP growth rate of 6.6% per annum. During the Growth and Transformation Plan (GTP) I implementation period; the average productivity of major crops by smallholder farmers for the main season has increased from 15.7 quintal per hectare to 21.5. Major crops production and productivity have reached 270.3 million quintal and 21.5quintal per hectare respectively. Area of land developed with modern small scale irrigation schemes has increased to 2.3 million hectares. Productivity of smallholder farmers has improved by introducing and disseminating of modern agricultural technologies. The extension service reach has increased from 5.1 million farmers to 13.95 million by 2014/15 and the food reserve to enhance disaster prevention capacity has reached 405 thousand tons. Overall, the per capita food production has passed the 2.16 quintal grain equivalent line (MoA, 2016) and the average Kilocalorie intake is 2100. The agriculture sector has also made significant contribution to the poverty reduction in which the poverty head count index has decreased from 29% to 23%.

The above achievements have been registered as a result of government's national policies and strategies, plans and programmes. Agricultural Development Led Industrialization (ADLI) has been the central strategy of the government since the early 1900s that gave the highest priority to the transformation of agriculture from subsistence livelihood to market-oriented economic sector. This strategy has been a driving force for accelerating the country's economic growth and development. This strategy has been further elaborated through sector specific policies and strategies such as Rural Development Policy and Strategy (MoA 2003), the Food Security Strategy (2002) and its major programmes revolving around such as asset building, safety net, resettlement and community investment. These policies and strategies were also further refined by successive five year development plans such as, Sustainable Development and Poverty Reduction Programme (2001), A Plan for Accelerated and Sustained Development to End Poverty (PASDEP) (2005) and the Growth and Transformation Plan I and II. In line with the policy, the agricultural objectives were set to increase productivity through increasing the capacity and extensive use of labour, proper utilization of agricultural land, linking specialization with diversification, integrating agricultural and rural development, and strengthening the agricultural marketing system (Chanyalew *et al.,* 2010).

Despite the tremendous achievements, the problem of food and nutrition security remains the main health and development issue for the country. The prevalence of stunting among children 6-59 months old is 40% and the prevalence of wasting and underweight is recorded to be 9% and 27% respectively. Micronutrients deficiency is also pervasive and severe in the country. About 44% of under five children, 30% of adolescents, 22% of pregnant women, 17% of women of reproductive age are anaemic. Consumption of minimum acceptable diet by children is only 4 % which is very high when compared to other sub-Saharan countries (EDHS, 2014 as cited in MoA, 2016). This puts Ethiopia among the countries with high malnutrition burdens.

Dependency on rain-fed agriculture and subsistent farming system, the low educational status of most farming households, land degradation, soil infertility, lack of gender sensitivity which is explained by low participation and benefit of women from agricultural technologies and interventions are among the factors contributing to the problem of under-nutrition. On average, female farm managers in Ethiopia produce 23% less per hectare than their male counterparts. Ethiopia's female farmers face multiple challenges such as access to land, extension, inputs,

technologies and also competing household responsibilities that hinder their productivity. Differences in both the levels of productive factors used and the returns that these factors generate drive the country's gender gap to a substantial degree.

Though diversification was part of the policy framework, the agricultural sector focused primarily on increasing agricultural productivity, market oriented production of cash crops with minimum consideration of expansion of diverse food availability and overall nutrition security. Agriculture's contribution to nutrition so far has been limited as the dietary diversity of the population is very low (Goshu *et al.,* 2013). The FAO (2011) also states that the food availability per-capita is limited specially regarding meat, fruits and vegetables based sources. The agriculture sector has already put in place programs and initiatives that directly and indirectly contribute to better nutrition. The agriculture sector is one of the signatories of the NNP II implementation that needs due attention and extra efforts to translate the planned activities in to actions with more emphasis on dietary diversification and proper utilization of foods from plant and animal sources.

Considering that about 84% of Ethiopians live in rural areas and are primarily engaged in agricultural activities, initiating and strengthening Nutrition Sensitive Agriculture (NSA) in the agriculture sector is critical. NSA aims to maximize the positive impact of the food system on nutrition outcomes while minimizing any unintended, negative consequences of agricultural policies and interventions for the population. It is a food and nutrition-based approach to agricultural development that focused on year-round availability, access and consumption of diverse, safe and nutritious foods and sustainable agricultural systems at the heart of overcoming malnutrition and its consequences (MoA, 2016).

2.9. Crop Diversification Pathways for Food Security

Crop diversification provides better conditions for food security and enables farmers to grow surplus products for sale at market and thus obtain increased income to meet other needs related to household well-being. Crop diversification can enable farmers to gain access to national and international markets with new products, food and medicinal plants. Diversifying from the monoculture of traditional staples can have important nutritional benefits for farmers in developing countries and can support a country to becoming more self-reliant in terms of food

production. Diversification can also manage price risk, on the assumption that not all products will suffer low market prices at the same time. Compared to producing monocultures, management techniques for diversified crops generally consist of more sustainable natural resource practices.

Agricultural diversification through a cropping strategy can influence household food security and dietary diversity through the following pathways: (a) the production of crops for own consumption and (b) through the sale of agricultural crops that affect household incomes and household food purchasing decisions (John *et al*., 2015).Diversification into high nutritive food production has potential to improve nutritional outcomes for farm households.

Agricultural diversification and particularly crop diversification is fundamental for development in agrarian based economies. It has been promoted in developing countries for its ability to enhance household incomes and ensure food and nutrition security. Following the successes of the Asian Green Revolution, crop diversification is strongly regarded as a vital element in raising incomes, improving food security outcomes and reducing poverty (Ibrahim *et al*., 2009). At the household level, crop diversification is a potential vital pathway for household food security and nutrition through incomes realized from the sale of agricultural produce (Haddad, 2000 cited in John, 2015).

2.10. Empirical Studies on Links between Crop Diversification and Food Security

Studies that have analyzed the food and nutrition security outcomes of crop diversification have found varying effects (Jones *et al*., 2014). In their study among smallholder farmers in the highlands of Guatemala, Immink and Alarcon (1991), using probit model, found that crop diversification is associated with higher incomes but no significant nutritional changes at the individual or household level.

A study in Malawi by Jones *et al*. (2014) found that farm production diversity was consistently positively associated with farm household dietary diversity. Based on nationally representative data they also found that households whose diets relied less on subsistence production had more diverse diets even controlling for household wealth.

Other empirical studies in different African countries enforce the positive association between crop diversification and dietary diversity. In a study examining the relationship between farm diversity and dietary diversity, Herforth (2010) found that the number of crops grown is positively associated with household dietary diversity in both Kenya and Tanzania. In Mali, Torheim *et al*. (2004) found that the number of crops cultivated by a household was positively associated with adult nutrient adequacy. Joshi *et al*. (2003) find that a crop diversification portfolio that includes cultivation of high yielding and high value crops has the strongest impact on incomes at the household level. The poverty effects of crop diversification have also been documented by Mukherjee and Benson (2003) as cited in John *et al.,* 2015) who find that households that cultivate a diverse range of crops (i.e. other than the traditional maize and tobacco) are less likely to be poor.

In their study of assessment of household food security through crop diversification in Myanmar, Ame *et al.* (2016), correlation coefficient found that crop diversity improves household food security as measured by dietary diversity index and household food insecurity access scale.

In their study of the role of crop diversification in improving household food security in Malawi, Mango *et al.* (2018), sing OLS regression found that crop diversification improves food security as measured by food consumption score and household food insecurity access scale.

Adjimoti and Kwadzo (2018) using linear regression model, found that crop diversification has a positive effect on household food security status as measured by dietary diversity score in Benin. The diversity of crops grown through dietary diversity improves household food security.

Degye *et al*. (2012), in their study of does crop diversification enhance household food security in eastern and central Ethiopia, found that crop diversification has a significant positive effect on household food security as measured by dietary diversity and dietary calorie available.

Given, the mixed results of the various studies done so far elsewhere and the dearth of studies in Ethiopian context, the present study adds to the literature by providing empirical evidence on the role of crop diversification to household food security in northern Ethiopia.

2.11. Conceptual Framework

The conceptual framework on which crop diversification is anchored is depicted in Figure 1 below, in the form of a flow diagram.

According to the rational choice theory, human behavior is motivated by the desire to make a gain. Most farmers are rational in their decision making and they oftentimes choose a choice that they anticipate will yield a gain on their part, otherwise they cannot undertake the endeavor. In the context of agriculture, crop diversification is the growing of two or more crops on a piece of land by a farmer. It is a strategy that is used to maximize the use of land, water and other resources thus providing the farmers with feasible options to grow different crops on their land (Ashfaq *et al*., 2008). The factors that lead to farmers' decisions to diversify are many, but include; reducing the risk of crop failure, responding to changing consumer demands, change in government policy and more recently, as a consequence of climate change. Crop diversification is one of the sub-sets of a large matrix of production option in the cropping sector.

From an economic point of view, it is treated from two analytical viewpoints: as a problem of determining the optimal crop mix on a production possibility frontier; and second as a mechanism for incorporating risk aversion into a farmer's decision making process in which crop specialization may lead to highly unstable income due to variance in output or price for the particular crop. In a broad manner, crop diversification is seen as having two main properties; it expands the production possibility set or area allocation frontier, thereby increasing food security and opportunities for income generation among farmers. Secondly, it reduces the risk of a farmer putting all of his resources in the production of a single crop with potentially high covariance risk (Kiru, 2014).

Thus the farmer's decision to diversify is considered to be one of the major economic decisions that has a strong bearing on his welfare in terms of income level and food security (Kiru, 2014).

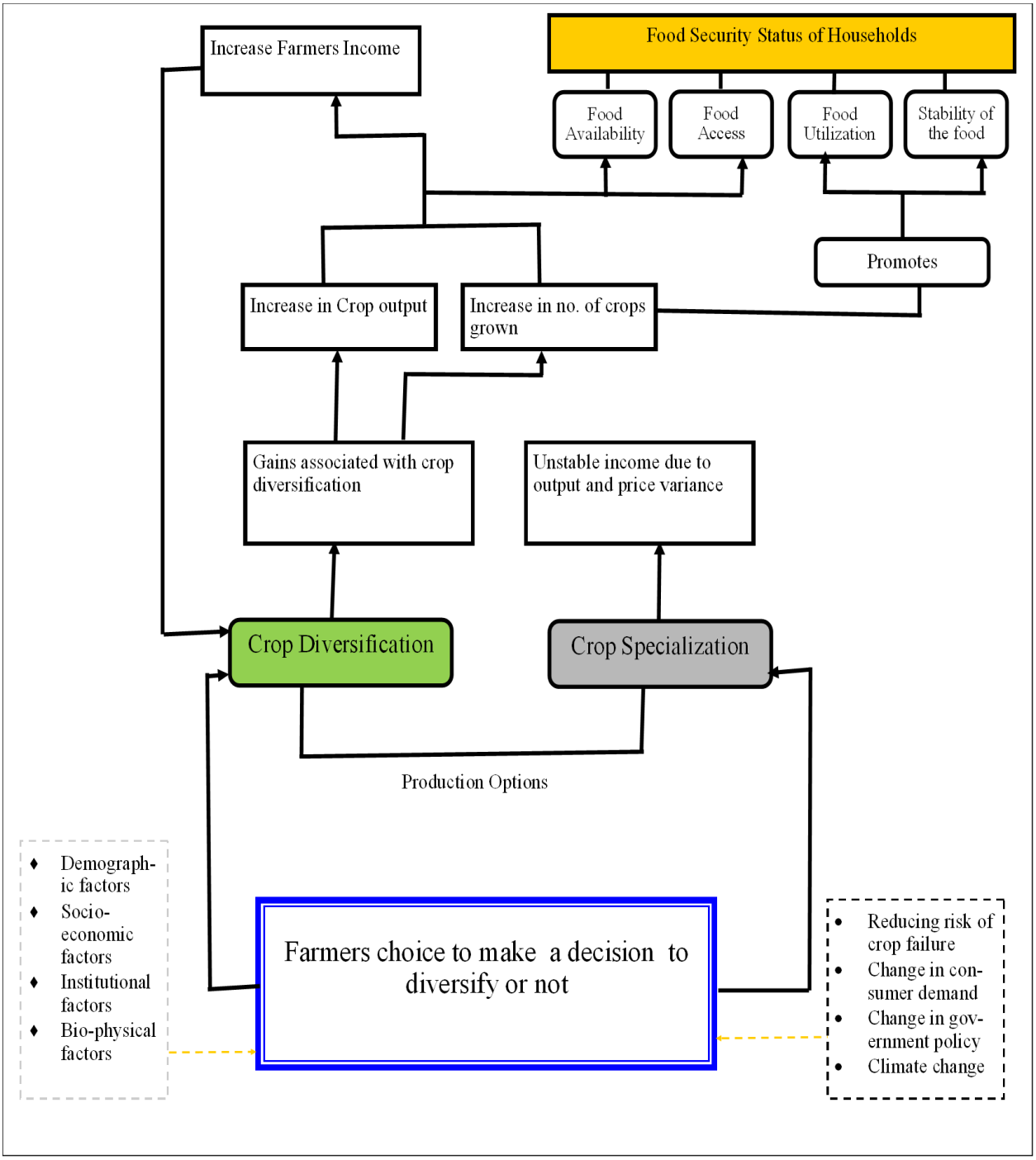

Figure 1. Conceptual Framework of the study

Sources: Adapted from FAO (2012)

CHAPTER THREE: RESEARCH METHODOLOGY

This section presents the brief description of the study area, the sampling strategy, methods of data collection and methods of data analysis.

3.1. Description of the Study Area

The study was conducted in Enderta woreda, southern zone of Tigray region. Enderta is one of the 34 rural woredas of Tigray regional state. It is located in south eastern zone of the region and shares borders with Wukro to the north, DeguaTemben to the west, Afar region to the east, and HentaloWajirat to the south. The Dry Midland Livelihood Zone spread across parts of Enderta, Seharti Samre, part of Atsbi Wonberta and Hawzen woredas. Thus, greater portion of Enderta lies in the midland agro-ecological zone and very small portion of the woreda lies in the lowland agro-ecological zone, characterized by dry climatic conditions and erratic annual rainfall of 450-600 mm. The landscape is mostly plain and hills, with bush vegetation (USAID, 2006).

Based on the 2007 national census conducted by the Central Statistical Agency of Ethiopia (CSA), this woreda has a total population of 114,297 of whom 57,482 are men and 56,815 women. According to CSA projections, the population of Enderta woreda have reached to 144,014 in 2015.

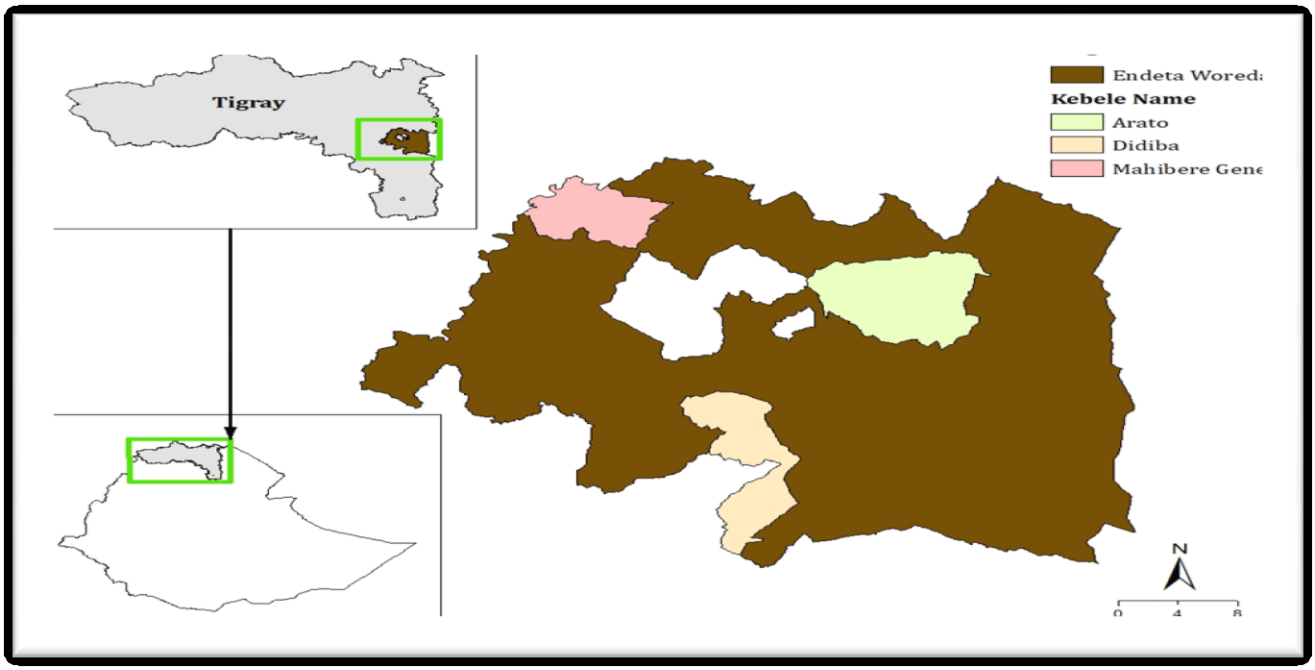

Figure 2: Map of EdetaWoreda

With an area of 3,175.31 square kilometers, Enderta has a population density of 36.00, which is less than the Zone average of 53.91 persons per square kilometer. The woreda has total area of 93,452 hectare, of which 31,184 hectare is arable land (CSA, 2007).

A total of 24,618 households were counted in this woreda, resulting in an average of 4.64 persons to a household, and 23,856 housing units. 5,406 households were female headed (BOARD, 2015).

Mixed farming which includes crop and livestock productions is the most dominant livelihood system undertaken by small-scale farming households in Enderta. The most commonly produced crops by small-scale farming households are wheat, barley, *teff*, sorghum and lentils. Vegetables such as onion, tomato and cabbage are also grown in the woreda (BOARD, 2015).According to the woreda's Bureau of Finance and Economic Planning report for 2016, the woreda's cereal production was 563,911 quintals. The productivity was 26.3 quintal per hectare. The productivity of the major cereal crops such as wheat, barley and sorghum was 26.9 Qt/ha, 23qt/ha and 31.7qt/ha respectively. In same year, the vegetable production in the woreda was 21,898 quintals and the productivity was 97 qt/ha implying the existence of huge vegetable production potential.

The rationale for the choice of Enderta for the study is based on logistical feasibility; and previous contact of the researcher with the locality. Besides, the *woreda* is exhibiting production of vegetables apart from the dominant crops which has implications for the practice of crop diversification. Moreover, the woreda is near to the regional capital, Mekelle, where there is huge demand for agricultural products specially that of vegetables.

3.2. Sampling Strategies and Sample Size

In order to get representative information and to draw important policy implications for future research and development endeavors, employing sound methodological principle is a pre-requisite. Towards this end, amulti- stage sampling technique was employed in this study.

In the first stage, three kebeles were selected purposely out of the 17kebeles in the woreda. Accordingly, Arato, Didba and Mahber-Genet were selected with a population of 2525, 1734 and 1532 households respectively, making total number of households in the three kebeles to be 5,791.These kebeles were selected based on their agricultural production potential and ability to represent the woreda in terms of agro-ecology. A greater portion of the woreda lies in the

midland agro-ecology (BOARD, 2015). The three selected kebles are from the midland agro-ecology. Physical accessibility of the kebeles was also considered given the time constraint. The purposive selection of the kebelles is made in consultation with the woreda agriculture office experts.

Though the three kebles selected lie in the same agro-ecology, there is slight difference in terms of the types of crop produced and the irrigation potential. The main cereal crops grown in Didba include wheat, barley and *teff*. This kebele has low irrigation potential compared to the other two kebeles. Arato and Mahbere-Genet are with high irrigation potential and vegetables are produced in these kebles in addition to the cereal crops.

In the second stage, total sample size was determined using the following simplified formula developed by Israel (1992).

$$n = \frac{N}{1 + N\,(e)2}$$

Where n – is the sample size

N- is the total number of the population (N= 5791)

e- is the level of precision at 0.07

Here, a 95% confidence level and 0.5 P value is considered. P is the estimated proportion of an attribute that is present in the population and shows the degree of variability of the population in terms of the attribute. In this case, crop diversification is the attribute. The formula resulted in a sample size of about 197 households.

Next, sample size from each kebele was determined using probability proportional to the size of the population of each kebele (Table1). To compensate for non-response and missing of households from the survey, 10% was added to the sample making the total sample households to be 217.

Table 1. Distribution of sample households in the study area

Kebele Name	Total Households	Percentage (%)	No. of sample households	Adjusted Sample size (after adding 10%)
Didba	1734	30	59	65
Arato	2525	44	86	95
Mahbere-Genet	1532	26	52	57
Total	5791	100	197	217

Finally, the sample household heads to be included in the survey were selected randomly from each kebele.

3.3. Data Types and Sources

The study primarily collected quantitative data though qualitative data was also collected to supplement the survey. The quantitative data include information on household demographics, socioeconomic characteristics, crop production, crop diversification, crop management, input use, food consumption, level of food insecurity, and other farm- and farmers specific characteristics. The qualitative data include the perception of households of importance and practice of crop diversification, reasons for diversifying cropping activities, etc.

Both primary and secondary data sources were utilized for the study. Majority of the primary data were collected through household survey. The primary data sources include household heads, experts from the woreda Agriculture and Rural Development Office, Development Agents (DAs) and community leaders. Secondary data about the bio-physical, socio-economic and demographic variables of the woreda were gathered from the Agriculture and Rural Development office of the woreda, regional agriculture office.

3.4. Methods of Data Collection

The study used structured questionnaire, focus group discussions and key informants interview to collect the primary data. Based on the objectives of the research survey questionnaire was prepared and administered to the selected sample households.

The survey was administered by locally recruited and trained enumerators under the close follow up of the researcher in the month of February 2017.Training was given to enumerators about the ways of approaching the respondents, the way to arrange the interview including the time when,

and the appropriate place where to conduct, and how to control the interview situation and how to record the information accurately. Mock interview was conducted by the enumerators in order to ensure their understanding of each question.

Three focus group discussions, one in each selected kebele, with member size of 7-9 was conducted. Model farmers, community leaders, female headed households were included in the focus group discussion. The selection of the focus group discussants was made in consultation with the chairmen of the respective kebeles.

Key informants interview was carried out with the woreda agriculture and rural development head, crop expert and three development agents from the selected three kebeles.

3.5. Methods of Data Analysis

The quantitative data was analyzed using descriptive statistics and econometric models. The qualitative data collected primarily from the FGD and key informants were analyzed qualitatively. The survey questionnaire was programmed in CSPRo software and the data was collected using tablet computers. The data was exported from the CSPRo to STATA version 13 which was used to manage and process the data. Though 217 households were included in the survey, 14 households were dropped during data cleaning prior to analysis as they did not have sufficient data related to crop diversification thereby reducing the sample to 203 households.

As the objective the study is to assess the impact of crop diversification on household food security and determine the factors that affect crop diversification, both crop diversification and household food security need to be measured. These are explained below.

3.5.1. Measuring Crop Diversification

Crop diversification index (CDI) was calculated using the Simpson Diversity Index. The CDI is obtained by subtracting the Herfindahl index (HI) from one (1-HI). Precisely, the CDI is calculated as follows:

The CDI index is calculated as follows:

$$p_i = \frac{Ai}{\sum_{i=1}^{n} Ai} \quad (1)$$

Where p_i = proportion of ith crop; A_i=area under ith crop; $\sum_{i=1}^{n} Ai = Total\ cropped\ area;\ i = 1,2,3,\ldots\ldots n\ (number\ of\ crops)$

$$HI=\sum_{i=1}^{n} p_i^2 \qquad Herfindahl\ index \qquad (2)$$

$$CDI=1-\sum_{i=1}^{n} p_i^2 = 1 - HI \qquad Crop\ Diversification\ Index \qquad (3)$$

The smaller the CDI, the smaller the crop diversification and the higher the CDI, the higher will be the crop diversification.

3.5.2. Measuring Household Food Security

A key step in food security analysis is finding an appropriate measure. There is no single indicator that best measures household food security. In the literature, there are several indicators that are used as a measure of food security. Webb*et al.* (2006) highlight the lack of precise measures of household food security and that the most commonly used measures of food security are based on proxy measures. This is due to the fact that food security is wider concept with four dimensions as discussed in the literature review section of this paper.

Maxwel et al. (2008), listed the widely employed measures of household food security which include food consumption score, dietary diversity score, household food insecurity access scale, coping strategy index and household income/expenditure.

Household dietary diversity score and household food insecurity access scales were used to measure the food security status of the sample household in the study area. Each of these indicators are explained below.

Household Dietary Diversity Score (HDDS)

According to Swindale and Bilinsky (2006), household dietary diversity score can be used as proxy measure of household food access. Household dietary diversity - the number of different food groups consumed over a given reference period - is an attractive indicator of household food security forfour reasons (John and Yisehac, 2002). First, a more diversified diet is an important outcome in and of itself. Second, a more diversified diet is associated with a number of improved outcomes in areas such as birth weight, child anthropometric status, and improved hemoglobin concentrations. Third, questions on dietary diversity can be asked at the household

or individual level, making it possible to examine food security at the household and intra-household levels. Fourth, obtaining these data is relatively straightforward.

This method is selected due to the fact that it measures both food security i.e., its access and diet quality.

To better reflect a quality diet, the number of different food groups consumed is calculated, rather than the number of different foods consumed. Knowing that households consume, for example, an average of four different food groups implies that their diets offer some diversity in both macro- and micronutrients. This is a more meaningful indicator than knowing that households consume four different foods, which might all be cereals (Swindale and Bilinsky, 2006).

Information on household food consumption should be collected using the previous 24 hours as a reference period (24-hour recall).Though, there are various other valid timeframes for recall, such as the previous 3 or 7 days, and in the case of some foods, the previous month, the recall period of 24 hours has been advised by FAO as it is less subject to recall error, less cumbersome for the respondent and also conforms to the recall time period used in many dietary diversity studies. Moreover, analysis of dietary diversity data based on a 24-hour recall period is easier than with longer recall periods (Swindale and Bilinsky,2006).

During the survey, households were asked series of yes or no questions whether they have consumed the food groups indicated in the questionnaire. The expanded form of the questionnaire which contains 16 food groups was used in this study. The sixteen food groups were aggregated in to form 12 food groups as recommended by FANTA. The HDDS is based on the 12 food groups proposed by FANTA (Swindale and Bilinsky, 2006).

HDDS (0-12) =Total number of food groups consumed by members of the household. Values for 1 through 12 will be either “0” or “1”. The HDDS variable is calculated for each household which ranges between 0 and 12. Then, households were categorized as low, medium or high dietary diversity.

Household Food Insecurity Access Score (HFIAS)

The HFIAS is a continuous measure of the degree of food insecurity (access) in the household in the past 30 days. HFIAS reflects the three universal domains of household food insecurity that is anxiety about household food insecurity, insufficient quality and insufficient quantity of food supplies (Deitchler *et al*.,2011 as cited in Mango *et al*. 2018). This indicator captures the household's perception about their diet regardless of its nutritional composition. This food insecurity measure focuses on consumption-related strategies and captures the household's behavioral and psychological responses to food insecurity or perceived food insecurity (Coates *et al*., 2007). The HFIAS is based on the assumption that households' experiences of food insecurity cause predictable reactions and responses that can be captured and quantified through a survey and then summarized into a score. This indicator was used to capture the level of food insecurity in the study area.

During the survey, the respondents were asked nine occurrence questions that consist of a generally increasing level of food insecurity. The occurrence questions can be summarized as follows: (Q1a) worrying about food adequacy; (Q2a) eating the kinds of less preferred foods; (Q3a) eating limited variety; (Q4a) inability to eat less preferred foods; (Q5a) eating smaller meal than needed; (Q6a) eating fewer meals in a day; (Q7a) failing to get food of any kind; (Q8a) sleeping at night hungry; and (Q9a) going the whole day or night without eating anything. Specifically, the respondents were asked whether a specific condition (Q1a–Q9a) associated with the experience of food insecurity ever occurred during the past 30 days. Respondents were asked to either say yes = 1 if event occurred or no = 0 if the event did not occur.

Each severity question is followed by a frequency of-occurrence question, which asks how often a reported condition occurred during the previous 4 weeks. There are three response options representing a range of frequencies (1 = rarely, 2 = sometimes, and 3 = often). The minimum HFIAS is zero and occurs when a household responds 'no' to all questions on the household food insecurity access scale. Alternatively, 27 is the maximum HFIAS and is obtained by summing up of all frequencies on the frequency-of-occurrence questions when a household responds yes to occurrence question and 'often' as frequency of occurrence to the nine frequency-of-occurrence questions. Following the guidelines by Coates *et al.* (2007), the HFIAS is computed as follows:

HFIAS (0–27) = summation of the frequency-of occurrence during the past 30 days for the nine food insecurity-related conditions

HFIAS $(0 - 27) = Q1a * F1 + Q2a * F2 + Q3a * F3 + Q4a * F4 + Q5a * F5 + Q6a * F6 + Q7a * F7 + Q8a * F8 + Q9a * F9$

At a household level, a high HFIAS shows that a household is very food insecure, while a low score shows that a household is less food insecure.

3.5.3. Measuring Influence of Crop Diversification on Food Security

The study used an ordinary least squares (OLS) regression, to determine role of crop diversification to household food security outcomes. Since crop diversification index (CDI) (a continuous independent variable and food security outcomes HDDS and HFIAS as dependent variables (all continuous variables), the researcher decided to use OLS regression. According to Isik-Dikmelik (2006 as cited in Mango et al. 2018), it is very sound and correct to use OLS to ascertain influence of a continuous variable on another continuous variable like in the present study. Adjimoti and Kwadzo (2018) also used this model to assess the impact of crop diversification on household food security.

The OLS model is specified as:

$$Y\ i = \alpha 0 + \alpha 1 Xi1 + \cdots + \alpha 7 Xi9 + e$$

Where, Yi = household food security outcome (either HDDS or HFIAS),
Xi1 = crop diversification as measured by CDI
Xi2 = sex of household head (1 = male; 0 = female)
Xi3 = age of household head (continues)
Xi4=education of household head (1 = AE; 2= primary; 3=secondary; 0 = illiterate)
Xi5 = household size (continues)
Xi6 = household size (continues) and
Xi7 = farm size (continues)
Xi8 = number of oxen owned (continues),
Xi9 = fertilizer use (1= yes; 0=no) and
Xi9 = distance to the market (continues)
α0 = intercept, α1 to α9 are coefficients, and e is the error term.

Below is explanation of the variables included in the model in addition to CDI. The expected sign of the explanatory variables varies for HDDS and HFIAS as the relationship of these variables inverse.

Sex of the household head: It is generally shown that female-headed household in the context of developing countries is more food insecure than maleheaded households. Recently, Magaña-lemus *et al*. (2016) also showed that due to the lack of resources, female-headed households in Mexico are more likely to be food insecure than male-headed households. It is expected that male headed households are more food secure. The expected sign of these variables is positive for HDDS and negative for HFIAS.

Age of household head: Age of the household head can significantly affect their food security status. According to Adjimoti and Kwadzo (2018), elder household (more than 45 years) heads have more experience in allocating their resources to achieve the household need. On thecontrary, Magaña-lemus *et al.*(2016) show that younger household heads are more dynamic in searching for more opportunities and so their households are more likely to be food secure. The expected effect on food security as measured by HDDS could be positive or negative.

Education: Education as the main indicator of human capital can improve the opportunities for the household head. Households with more education tend to be more food secure (Magaña-lemus *et al*. 2016). Education influences household food utilization through production management. For instance, education affects households eating habit, food preferences, food rationing and saving habits, hence, determine food utilization and access (Meskerem and Degefa, 2015).The expected effect on food security as measured by HDDS is positive but negative for HFIAS.

Household size: It is measured by the number of family members in the household. Family size affects household food consumption with regard to the number of consumers. This is, because, large family size exerts more pressure on household food consumption and causes the available dietary energy of household to decrease. Study conducted by Degefa (2002), and Arega (2014) revealed that, household food availability declines with increase in household size. The expected effect on food security as measured by HDDS is negative while the effect is positive for HFIAS.

Farm size: is the total farmland owned by the household measured in hectares. The larger the farmland, the higher will be the production level. It is thus expected that households with larger farmland are more likely to be food secure than those with smaller farmland. Several studies revealed that, landholdings in many rural parts of the country are too small for adequate food production to meet the minimum household consumption requirements. For instance, Degefa (2002) indicate that, more than 60 percent of the rural households cultivate less than one hectare. The expected effect on food security as measured by HDDS is positive and negative to HFIAS.

Ownership of oxen: Having sufficient draught power obtained from farm oxen highly determines the production capacity of households in traditional agriculture of Ethiopia. The expected effect on food security is positive for HDDS and negative for HFIAS.

Distance to the market: It is measured by the amount of time (hours) required to reach the nearest local market. The longer it takes to get to the market, the less frequently the farmer visits the market and, hence, the less likely he is to get market information. When there is lack of adequate information about prices, farmers may sell their produce at times when prices are low and buy when prices are high(Shimelis *et al.,* 2004). The expected effect on food security is negative.

3.5.4. Measuring Determinants of Crop Diversification

The Tobit model is a statistical model proposed by James Tobin (1958) to describe the relationship between a non-negative dependent variable and an independent variable (or vector). The model supposes that there is a latent (i.e. unobservable) variable y_i^*. This variable linearly depends on $x_i$via a parameter (vector) βwhich determines the relationship between the independent variable (or vector) $x_i$and the latent variable y_i^*(just as in a linear model). In addition, there is a normally distributed error term$\varepsilon_i$to capture random influences on this relationship.

The Tobit model, also called a censored regression model, was used to analyze the determinants of crop diversification. The dependent variable used to measure crop diversification the crop diversification index (CDI) and the value of this variable lies strictly between zero and one. The diversity index is censored because some of its values cluster at the limit (i.e., 0 for complete specialization and 1 for perfect diversification).

Censored regression models refer to a model in which we observe the dependent variable only if it is above or below some cut off level. Tobit model is a special case of censored regression models that arise when the dependent variable is limited (or censored) from above and/or below. The Tobit model has been applied in previous studies of crop diversification (e.g. Fetien *et al*. 2009, Allison 2010, Wondimagegn *et al*., 2011).

This model is appropriate since the dependent variable is an index, the CDI, which takes values between 0 and 1 inclusive. The dependent variable of the model can be either left-censored, right-censored or both left-censored and right-censored, where the lower and/or upper limit of the dependent variable can be any number.

The two limit Tobit model can be specified as:

$$y_i^* = \beta x_i + \varepsilon_i$$

Where y_i^* is a latent variable(unobserved for values smaller than 0 and greater than 1) representing specialization or diversification index; x_i is a vector of explanatory variables; β is a vector of unknown parameters to be estimated; and ε_i is a disturbance term (unobserved factors).

Denoting y_i(crop diversification index) as the observed dependent variable the two limit Tobit model can be specified as:

$$y_i = \begin{cases} 0 \;\; if y_i^* \leq 0 \\ y^* \;\; if \; 0 < y_i^* < 1 \\ 1 \;\; if y_i^* > 1 \end{cases}$$

Unlike traditional regression coefficients, the Tobit coefficients (β coefficents) cannot be interpreted directly as estimates of the magnitude of the marginal effects of changes in the explanatory variables on the expected value of the dependent variable. In a Tobit equation, marginal effect includes both the influence of the explanatory variable (x_i) on the probability of crop diversification as well as its intensity (y_i). More explicitly, the marginal effect takes into consideration that a change in an explanatory variable will affect simultaneously the number of sample farmers diversifying their production and the extent of diversification.

Definition of Variables

Dependent Variable: the dependent variable used in the Tobit model is crop diversification measured by crop diversification index (CDI). The index spans a continues range from 0 to 1; the value of the index for a completely specialized farm producing one crop is 0 where as a completely diversified farm has an index of 1.

Explanatory Variables:

The following are expected to be the explanatory variables that determine the dependent variable, crop diversification. The choice of these variables is based on a review of the literature on the topic.

Sex of the household head: This is a dummy variable (that takes a value of 1 if the household head is male and 0 if female). Access to resources such as land is an important indicator of welfare among rural farm households and is especially critical for women with no use rights over a parcel of land. The inequality that exists in accessing and having resources between males and females determines how each household will respond to diversification. Women's low economic position, e.g. lack of ox and skill to plough may influence their decisions to grow less number of varieties. Hence, male headed households are more likely to diversify (Fetien et al. 2009).

Age of the household head: Age is a continuous variable (a variable that takes on any value between its minimum value and its maximum value), and is one of the factors that affect production decisions on the part of the farmer. Elderly farmers look at farming as just a way of life, whereas young farmers may be more inclined to look at farming as a business opportunity in order to financially support their families (FAO, 2012). In this study, it is expected that elderly farmers will not diversify, while younger farmers will seek to diversify. Therefore, it was expected that this variable negatively associated with crop diversification.

Household Size: The size of the household was expected to be positively related with crop diversification. The larger the household size, the more likely that it will be able to diversify so as to increase its food production levels. In addition, this variable could also show the availability of labor in the household. Previous studies also support this hypothesis (Kiru, 2014).

Level of Education of household head: It is argued that educated people can understand agricultural instructions easily and are better able to apply skills imparted to them, unlike the uneducated. It was expected that this variable will positively influence crop diversification. Previous findings by Ibrahim et al. (2009) indicated a positive relationship between education level and crop diversification.

Farm size: This is a continuous variable referring to the total area of arable farmland that a farmer owns measured in hectares. The amount of land a farmer has available plays a crucial role in determining how many crops a farmer can produce. Previous findings show that crop diversification is associated with larger farms (Benin *et al*., 2004, Fetien *et al*., 2009). Therefore, it is expected that the variable will be positively associated with crop diversification as larger land sizes encourage the household to cultivate more crops.

Ownership of Oxen: this refers to the number of oxen owned by the household and is a continuous variable. Ownership oxen is critical in the Ethiopian traditional and small holder farming. Oxen constitute the main source of animal power for agricultural work. The larger the number of oxen the household owns, the more the level of crop diversification will be. As a result, it was expected that this variable will be positively associated with crop diversification.

Fertilizer use: Fertilizer is an important input because without it, most crops in the northern Ethiopia do not produce well due to the low fertility of the soil. As a result, fertilizer usage by farmers on their crops has continued being an essential practice to enhance their crop production. Kiru (2014) showed that the quantities of fertilizer obtained by farmers are positively associated with crop diversification. Thus, this variable is expected to positively influence crop diversification.

Distance to the Market: Distance to the market from the residence is an indicator of physical access to markets and organized trade, as well as proximity to economic resources. The nearer to the market the farmer is, the easier it becomes for him or her to diversify and to take produce to market. Studies on diversification highlight the importance of proximity to main roads and markets for development of other farm enterprises (Benin *et al*., 2004). However, in some instances, farmers located farther away from markets or main roads, are found to diversify in

order to meet their broad subsistence and nutritional needs (Kankwamba*et al*., 2012). Hence, the nature of the association of this variable with crop diversification is indeterminate and could be negatively or positively associated.

Number of extension contacts: the larger the number of contacts a farmer has with extension agents, the more he/she is likely to engage in production large number of crops. It is a continuous variable measured the number of contact made during a year. It was expected that this variable has positive association with crop diversification. Fetien *et al*. (2009) found that number of extension contacts has a positive effect on crop diversification.

Number of farm plots: this refers to the number of farm plots the household owns. This is a continuous variable expected to positively influence crop diversification. Benin *et al*. (2004) and Wondimagegn *et al*. (2011) found positive relationship between numbers of plots owned and crop diversification.

Summary of the explanatory variables that are assumed to affect crop diversification in the study area are summarized in Table 2, below.

Table 2. Summary of Explanatory Variables for the Tobit Model

Explanatory Variable	Type	Expected sign
Sex of household head (1=male; 0= female)	Dummy	+
Age of household head (in years)	Continuous	-
Household size (number)	Continuous	+
Level of education (0=illitrate;1=adult education;2=primary;3=secondary)	Dummy	+
Farm size (in hectares)	Continuous	+
Ownership of oxen (number)	Continuous	+
Fertilizer use (1=yes; 0=no)	Dummy	+
Distance to the market (in minutes)	Continuous	+ /-
Number of extension contact	Continuous	+
Number of farm plots	Continuous	+

Note: (+) sign indicate as the predictor variable increase the crop diversification increase. (-) sign the inverse relationship between the predictors and the crop diversification.

CHAPTER FOUR: RESULTS AND DISCUSSION

This chapter presents results of the study and discusses the results by giving due emphasis on purpose of the research objectives. This chapter is divided into four sections. The first section deals with the socio-economic characteristics of the sample households. The second section describes the crop diversification status of the sample households while the third section describes the food security status of the sample households. The fourth section presents the nexus between crop diversification and household food security. The final section presents and discusses the determinants of crop diversification using the Tobit regression.

4.1. Socio-economic Characteristics of the Sampled Households

The socio-economic characteristics of the sample households are presented in Tables3and 4. The results of the descriptive statistics indicate that the 75% of the sample households are male-headed and 25% of them are female headed. Majority of the sample households (70.44%) are illiterate. About a quarter of the sample households (25.12%) have completed primary education and very few households have completed secondary education (Table 3).

Table 3.Summary statistics of the sample households (categorical variables)

Variable	Freq.	Percent
Sex of household head		
Male	153	24.63
Female	50	75.37
Educational Level of household head		
Illiterate	143	70.44
Adult education	4	1.97
Primary	51	25.12
Secondary	5	2.46
Fertilizer use		
Yes	141	69.46
No	62	30.54
Irrigation use		
Yes	100	49.26
No	103	50.74

Source: Survey result

As indicated in Table 3, the result of the descriptive statistics shows that about 69% of the sample households have used fertilized and about 31% of them did not use fertilizer implying lower level of fertilize use in the study area. About 49% of the households use irrigation and the majority (51%) of them did not have access to irrigation facilities.

The socio-economic profiles of the sample households for the continuous variables are presented in Table 4.

Age of the sample households ranges from 24 years to 65 years. The result of the descriptive statistics also revealed that the average age of the household heads in the study area is 45 years implying longer farming experience of the household heads (Table 4).

Table 4. Summary statistics of the sample households (continuous variables)

Variable	Variable description	Mean	Std. Dev.	Min	Max
hdds	Household Dietary Diversity Score (0-12)	6.12	1.76	2	10
hfias	Household Food Insecurity Access Scale (0-27)	8.39	4.63	0	22
CDI index	Crop Diversification Index ($0 \leq CDI \leq 1$)	0.53	0.25	0	0.87
agehh	Age of the household head	44.98	8.29	24	65
hhsize	Household size	5.42	2.00	1	11
landsize	Farm land size owned by the household	0.95	0.52	0.13	5.25
oxen	Number of oxen owned	1.75	1.00	0	5
dist_min	Distance to the market (measured in minutes)	44.44	31.54	1	120
plot_num	No of farm plots owned by the household	2.99	0.99	1	6
Ext_con	Number of extension contacts made	3.50	0.70	1	4

Source: Survey result

Family size in the study area ranges from one person to eleven persons with an average of 5 persons per household.

The average land holding in the study area is 0.95 hectares which is less than the national average of 1.53 hectares. The land holding size in the study area ranges from 0.13 hectares to 5.25 hectares. The number of plots owned by the sample households' rages from one plot to six plots with an average of about 3 plots.

The descriptive statistics revealed that the number of oxen owned by the sample households rages from 0 to 5 with an average of 2 oxen. The result also shows that sample households had made, on average, 3.5 contacts with extension agents. Some household's contacted extension agents once in year while the maximum number of contacts made is 4 times a year. Households

in the study area expected to travel about 45 minutes to reach the nearest market. The descriptive statistics also revealed that the maximum hours/minutes required to reach the nearest market place is about 120 minutes (2 hours).

As indicated in Table 4, the dietary diversity of the sample households ranges from 2 to 10 food groups and the mean dietary diversity of the sample households is 6.12 food groups. The result of the descriptive statistics also shows that the CDI of the sample households rages from 0 to 0.87 with a mean index of 0.53. Mean HFIAS score of the sample households is 8.39 and the maximum HFIAS score of the sample households is 22.

4.2. Crop Diversification Status of the Sample Households

This section presents the type and number of crops grown by the sample households and the levels of crop diversification of the sample households as measured by the crop diversification index.

4.2.1. Types and Number of Crops Grown and Harvested

The major crops grown and harvested by the sample households are presented in Figure 3.Both cereal and vegetables crops are grown in the study area. The major cereal crops grown by the sample households in the study area are wheat, barely, *teff* and sorghum in their order of importance. As indicated in Figure 3, wheat is the main cereal crop grown by about 187 households followed by barely and *teff* which are produced by 164 and 101 households respectively. About 11 households have grown maize. Cowpea, *Nug* and *Guaya* are also produced in the study area though very few households produce them.

Onion, tomato, cabbage and pepper are among the most important vegetables grown and harvested by the sample households in the study area. For instance, as indicated in Figure 3, onion and tomato have been produced by about 32 and 29 households respectively.

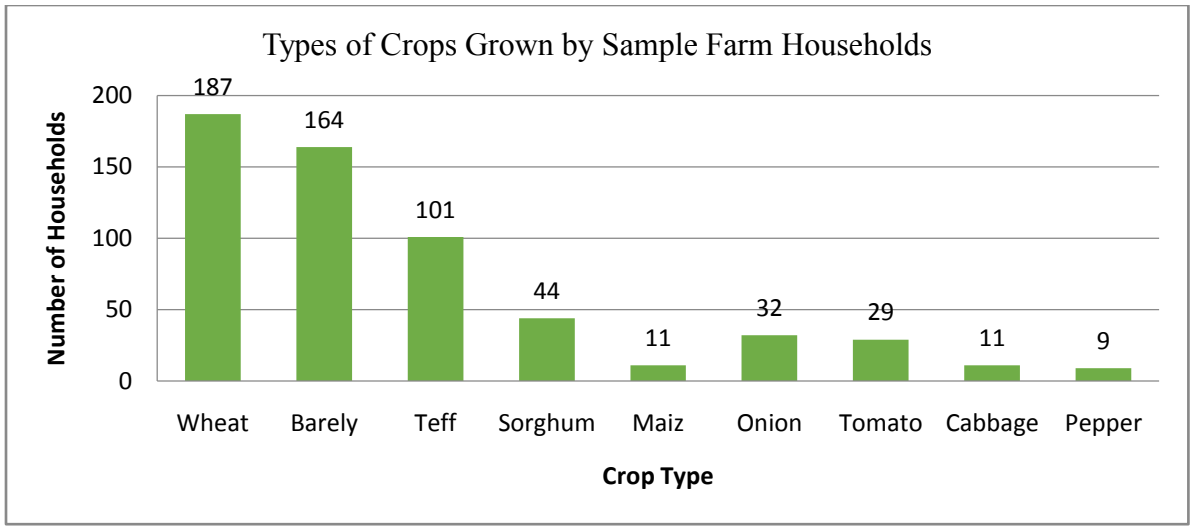

Figure 3: Types of Crops Grown by the Sampled Farm Households

As shown in Table 5, the number of crops grown by the sample households rages from one to eight crops with an average of 3 crops. About 15% and 25% of the sample households produced one and two types of crops respectively. The majority of the sample households (32%) produced three types of crops while only 3% of the sample households produce more than 5 types of crops. A significant number of the sample households (71%) has grown and harvested less than four types of crops.

Table 5. Number of Crops Grown and Harvested by the Sample Households

Number of Crops	Number of Households	Percentage (%)
1	30	14.78
2	50	24.63
3	65	32.02
4	29	14.29
5	23	11.33
6	3	1.48
7	2	0.99
8	1	0.49
Total	203	100

Source: Survey Data by Author

4.2.2. Crop Diversification Index of Sample Households

In order to determine the status of the sample households with respect to their crop diversification, crop diversification index (CDI) was calculated using the Simpson Index of Diversification. These indexes were then categorized into five levels of crop diversification.

The results of the levels of crop diversification of the sample households are presented in Figure 4.About 23% of the sample households are with low and very low level of crop diversification while 20% of the sample households have moderate level of crop diversification. The majority of the households (46%) are with high level of crop diversification. only 11% of the sample households have more than 0.75 level of index implying the highest level of diversification.

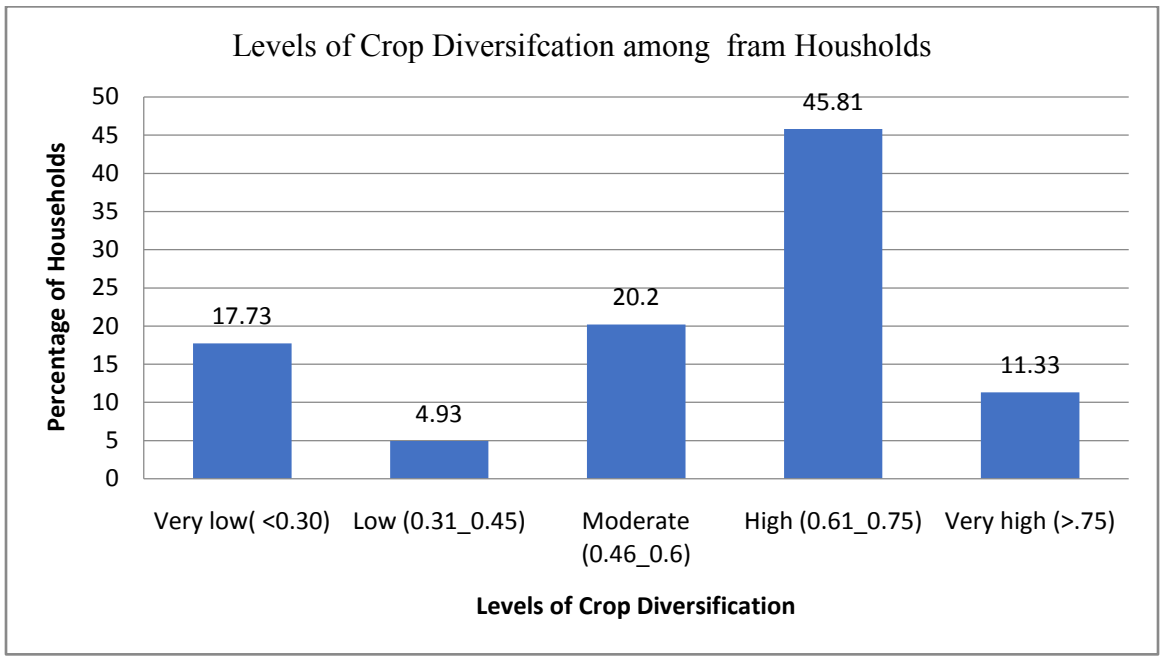

Figure 4. Levels of Crop Diversification of the Sampled Farm Households

The sample households were also asked the type of crop diversification they are practicing. As indicated in the Table 6, about 97% of the sample households who grow two or more crops are practicing crop rotation whereas only 2 % of them practice in intercropping. This implies that most of the farm households practice crop rotation as diversification in the study area.

Table 6. Types of Crop Diversification Practiced by Sample Households

Type of Diversification	Number of Households	Percentage (%)
Intercropping	4	2.31
Crop Rotation	167	96.53
Both	2	1.16
Total	173	100

Source: Survey Data by Author

The sample households were also asked the reasons for diversifying their cropping activities. Crop diversification reduces risk of crop failure was their most important reason followed by improves food security. Crop diversification increases income from sale of crops was the third most important reason for diversifying cropping activities. The last important reason forwarded by the respondents was it improves nutrition. Lack of land, irrigation facilities and lack of labor were among the most important reasons of the respondents for not growing more crops.

4.3.Socio-economic Characteristics and Crop Diversification Index (CDI)

Given the focus of the study is on crop diversification, it is really important linking the socio-economic characteristics of the sample households with respect to their level of crop diversification. Accordingly, the socio-economic characteristics are classified as demographic, resource ownership and institutional characteristics and discussed separately in the following sections.

4.3.1. Demographic Characteristics and CDI

The demographic characteristics of the sample households include sex, level education, age and family size which are summarized in Table 7.

Sex of household head and CDI

As indicated in Table 7, female headed households have mean CDI of 0.311 whereas the male headed households have mean CDI of 0.59. This implies that male headed households have higher level of crop diversification. T-test was conducted to assess if the mean difference in CDI between male headed and female headed households has statistical significance. The result shows that, the mean difference in CDI between male headed and female headed is statistically significant (t= -7.83) at less than 1% probability level.

Education level of household head and CDI

For ease of analysis, the education level of sample households was categorized as illiterate and literate (adult education, primary and secondary education). Household heads with some level of literacy including adult education, primary and secondary education has higher CDI (0.58) whereas illiterate households have lower CDI (0.5). T-test was conducted to assess if the difference is significant. The result shows that, the mean difference in CDI between literateand illiterate is not statistically significant (t= 1.92) (Table 7).

Table 7. Demographic characteristics of the sample households by level of crop diversification

Variable	Obs	CDI (Mean)	Std. Dev.	Pr(|T| > |t|)	t-test
Sex of household head					
Female	50	0.311	0.197	0	-7.83*
Male	153	0.594	0.286		
Educational Level of household head					
Literate	60	0.578	0.233	0.0557	1.92
Illiterate	143	0.503	0.259		
Age of household head in years					
Young Age (24-45)	103	0.441	0.282	0	-5.10*
Older Age (46 -65)	100	0.612	0.185		
Household size (number)					
Small family Size (1-6)	149	0.478922	0.267	0	-4.52*
Large family size (7-11)	54	0.65267	0.147		

Source: Survey result * Significant at p<0.1

Age of household head and CDI

To analyze the continuous socio-economic variables such as age and family size with respect to the crop diversification index which is also a continuous variable, quintiles have been calculated. This helps to categorize and group the continuous variables. The quintile classified age of the households' heads in to two age groups as indicated in Table 7.

The sample households classified under the young age group had a mean CDI of 0.44 whereas households under the old age classification had a mean CDI of 0.61 implying that old age households have higher level of crop diversification. Test was run to assess if the difference in mean CDI is significant with respect to the two groups. The result shows that, the mean

difference in CDI between young and old age groups is statistically significant (t= -5.10) at less than 1% probability level(Table 7). This could be due to the fact that old age farmers have more agricultural experience.

Household size and CDI

As indicated in Table 7, households with larger family size had higher CDI (0.65) compared to households with lower household member had lower CDI (CDI=0.48). This could be due to the fact that large family size have better availability of labour to engage in crop diversification.

4.3.2. Households Resource Endowment and CDI

The households resource endowments considered in this study are number of oxen owned, farm land size and number of plots owned by the sample households. These are the households resource endowments assumed to affect crop diversification practices.

Number of oxen owned and CDI

Ownership of oxen is critical in traditional smallholder farming. Figure 5 shows the number of oxen owned by sample households and their respective average CDI. Households who do not own an ox have a very low level of CDI (0.24). However, households own 5 oxen had the highest level of diversification index (0.82). On the other hand, households who own a pair oxen have a mean CDI of 0.58.

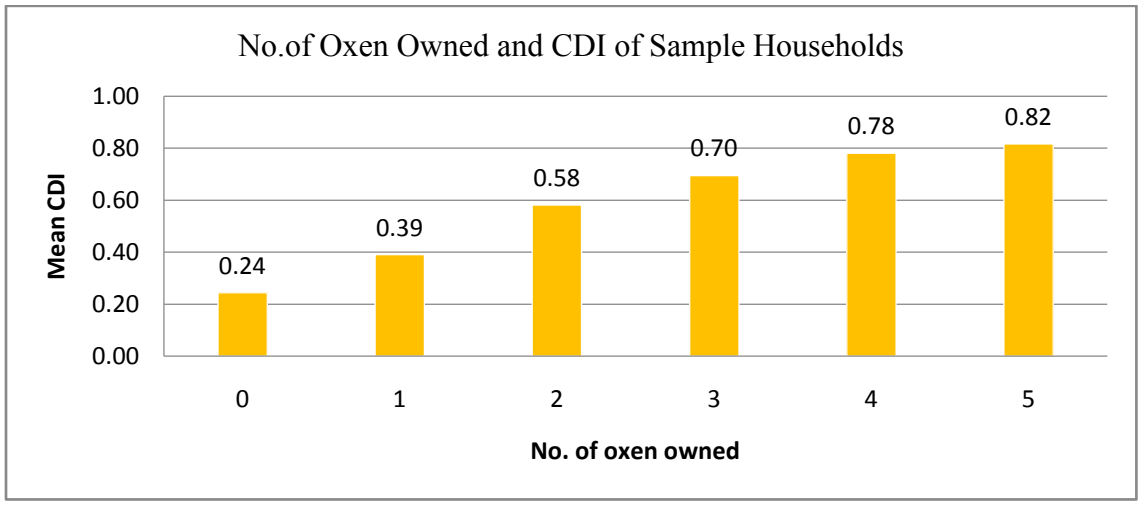

Figure 5. No. of oxen owned and CDI of the Sampled Farm Households

From Figure 5, it can be concluded that the higher the number of oxen owned by households, the higher is the crop diversification index implying that ownership of oxen is critical for farm households to diversify their cropping activities.

Further analysis was made on the number of households owned by the sample households using the quintile classification. As indicated in Table 8, the quintile classified the households with respect to ownership of oxen as households who own two oxen and less and households who own more than 2 oxen. Households who own two or less oxen have a lower CDI mean (0.48) while those households who own three or more oxen have higher level of CDI (0.71). T-test was run to assess if there is significant statistical difference between the two groups. The result, shows that there is significant statistical difference between the two groups at less than 1% probability level.

Farm land size and CDI

The result of the descriptive statistics shows that households own large farm size had higher crop diversification index. The mean CDI for households with large farm land and household with relatively small farm land is 0.69 and 0.46 respectively. The result of the t-test also shows that there is statistically significant (t=-6.38) difference between households with large family size and households with small land size with respect to their level of crop diversification. This implies that households with large farm land are able to grown many crops.

Table 8. Resource endowment of the sample households by level of crop diversification

Variable	Obs	CDI (Mean)	Std. Dev.	Pr(|T| > |t|)	t-test
Number of oxen owned					
Smaller No. of oxen (0-2)	164	0.48	0.26	0	-5.20*
More No. of oxen (3-5)	39	0.71	0.1		
Farm land size owned (in hectar)					
Small land size (0.13-1.24)	144	0.46	0.25	0	-6.38*
Large land size (1.25-5.25)	59	0.69	0.14		
Number of plots owned					
Lower no. of plots (1-3)	134	0.44	0.26	0	-7.63*
More no. of plots (4-6)	69	0.69	0.11		

Source: Survey result * Significant at p<0.1

Number of plots and CDI

The result of the descriptive statists reveals that households who have many plots lands are in better position to diversity their cropping activities compared to households with one or few plot of lands. Household who have four or more plots of farm land have higher CDI (0.69) while households with fever number of plot land had lower mean CDI (0.44). The result of the t-test also shows that the difference is statistically significant at 1% probability level (Table 8). The reason could be due the fact that households with many plots are able to grow different crops in different plots.

4.3.3. Households Access to Institutional Services and CDI

The institutional services include in this study are fertilizer use, irrigation facilities, number of extension contacts and distance to the market. The sample households' access to institutional services are summarized in Table 9.

Fertilizer Use and CDI

The sample households were also compared with respect to fertilizer use. The result of the descriptive statistics shows that households who used fertilizer had higher CDI (0.56) compared to households who did not use fertilizer. The crop diversification index of the non-users of fertilizer is 0.44. The result of the t-test analysis shows that the difference in mean CDI of the fertilizer users and non-users is statistically significant (t=-3.34) at probability level of less than 1% (Table 9).

Irrigation Use and CDI

The sample households were also compared with respect to irrigation use and its implication for crop diversification. The result of the descriptive statistics, as indicted in Table 9, shows that households who had access to irrigation facilities have higher level of crop diversification (CDI=0.63) while households with no access to irrigation have lower level of diversification with mean CDI of 0.42. The result of the t-test also shows that the difference in mean CDI of the irrigation users and non-users is statistically significant (t=-6.53) at less than 1% probability level. This implies that availability of irrigation facilities encourages farmers to diversify their

cropping activities especially that of vegetable production. Most of the households who grow vegetables have irrigation facilitates.

Table 9. Access to institutional service of the sample households by level of crop diversification

Variable	Obs	CDI (Mean)	Std. Dev.	Pr(|T| > |t|)	t-test
Fertilizer use					
No	62	0.435	0.29	0.001	-3.34*
Yes	143	0.561	0.224		
Irrigation use					
No	103	0.419	0.289	0	-6.53*
Yes	100	0.63	0.144		
Distance to the market (in minutes)					
Fewer travel time (1-40)	107	0.597	0.238	0	4.66*
More travel time (41-120)	95	0.439	0.242		
Number of extension contacts made/year					
Lower no. of contacts (1-4 times)	81	0.439	0.264	0.4399	-0.77
More no. of contacts (more than 4 times	117	0.692	0.106		

Source: Survey result * Significant at p<0.1

Distance to the Market and CDI

The result of the descriptive statistics shows that households with shorter travel time to reach the nearest market had higher CDI (0.6) while households who travel more than 40 minutes to reach the nearest market had lower CDI (0.42). The t-test also showed that the difference between the two groups with respect to their level of crop diversification is statistically significant at less than 1% probability level (Table 9). This in turn implies that the better market access the household has, the higher probability of the household to diversify cropping activities. The result is in line with the information that the FGD discussants revealed. They revealed that households who grow many crops especially vegetable growers are facing market access problem. One of the focus group discussants said that:

> "*Though we are producing tomatoes and onion, we are really suffering from getting market for our produce; our tomatoes were spoiled; and we regretted our decision to produce vegetables*."

Number of extension contacts and CDI

As depicted in Table 9, households with many extension contacts had higher CDI compared to those households with few extension contacts. The result of the t-test was not statistically significant this could be due the fact that extension agents provide same information for all farm households irrespective of the number of contacts they made. This could be due to the fact that the existing extension services provided focus mainly on increasing production and productivity of the existing crops.

4.4. Food Security Status of the Sample Households

One of the objectives of the study was to assess the food security status of the sample households. The Households Food Insecurity Access Scale (HFIAS) and Households Dietary Diversity Score (HDDS) were used to measure the food security status of the sample households.

HFIAS scores of the sample households is presented in Figures 6. The sample households were categorized into four levels food security/insecurity based on their HFIAS scores. About 33% of the sample households are food secure whereas about 18% of the sample households are severely food insecure. Figure 6 also shows that about 29% of the sample households are under the category of moderately food insecure and about 21% of the sample households are mildly food insecure. It can be concluded that majority of the sample households (67%) in the study area are food insecure (Figure 6).

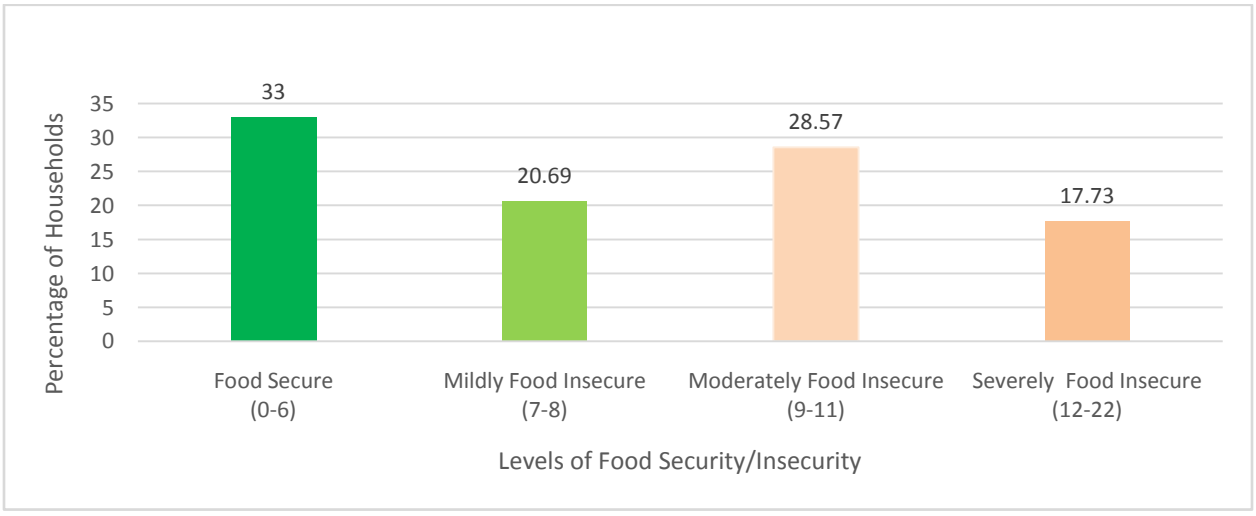

Figure 6. Distribution of the Sample households based on Households Food Insecurity Access Scale (HFIAS)

The mean HFIAS scores of the sample households is indicated in Figure 7. The food secured households have mean HFIAS score of 3.49 whereas the severely food insecure households have as high as 15.47 HFIAS score. Mildly food insecure and moderately food insecure households have a mean HFIAS score of 7.38 and 10.4 respectively (Figure 7).

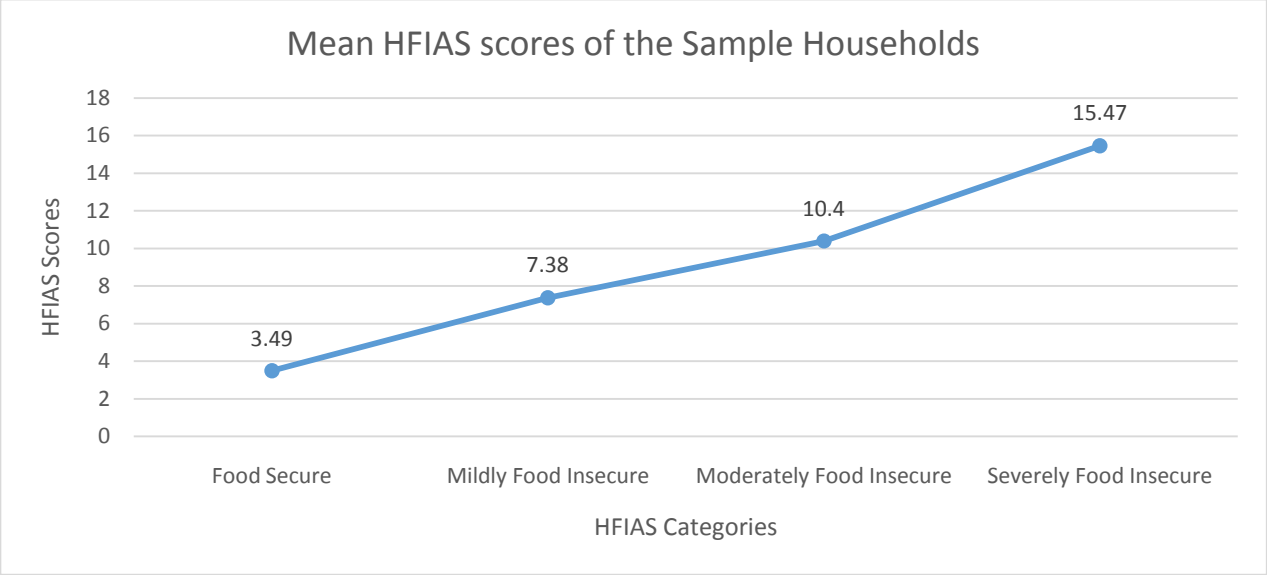

Figure 7. Mean HFIAS scores of sample households based on categories

As can be seen in Figure 7, as the level of food insecurity increases, HFIAS score increases implying that the level of food insecurity of households is worsening.

The other indicator of food security status of households used in this study is the HDDS. The HDDS of the sample households is presented in Figure 8.

The sample households were categorized in to three categories on the basis of the number of food groups they consumed. The sample households were asked if they have consumed or not the 16 food groups. Then, the food groups were categorized in to 12 food groups. The HDDS were calculated. The HDDS were then categorized into three categories of low dietary diversity, medium dietary and high dietary. The low dietary diversity score includes households who consumed up to four food groups; medium dietary diversity includes households who have consumed 5-7 food groups and the high dietary diversity score included those households who consumed 8-12 food groups.

Figure 8 shows the HDDS of the sample households. 25% of the sample households were under the category of high dietary diversity score i.e., consumed 8-12 food groups whereas about 18% of the sample households are with the lowest dietary diversity score. More than half of the sample households (57%) were under the medium dietary diversity score.

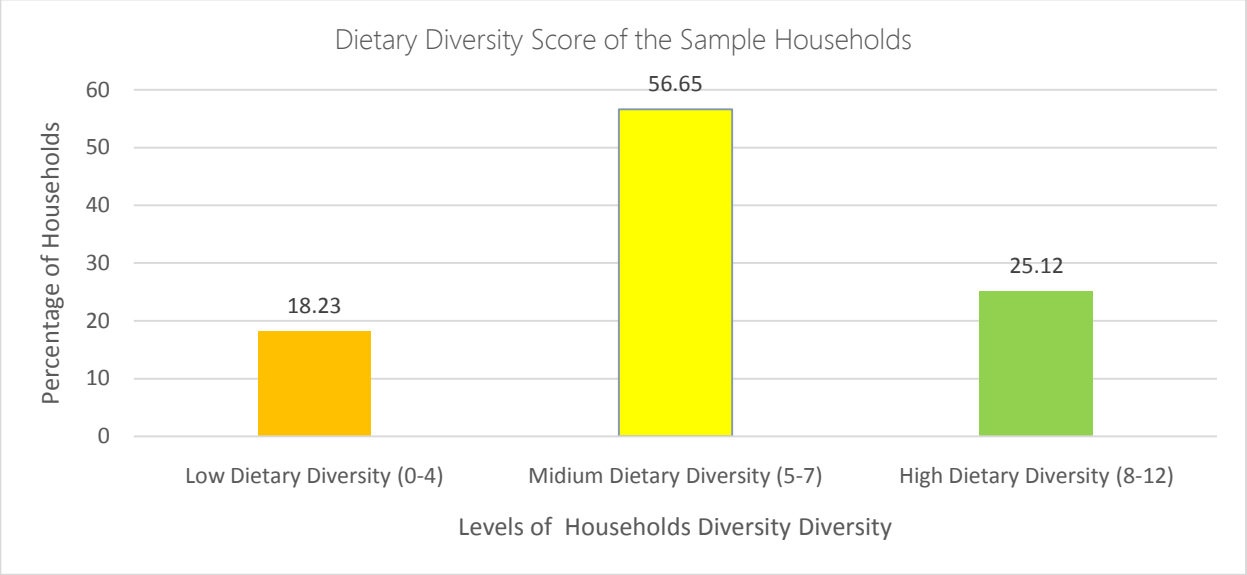

Figure 8. Distribution of Sample Households based on Dietary Diversity Scores

The mean dietary diversity score of the sample households is indicated in Table 10. The mean dietary diversity score of the households with the low level of dietary diversity is 3.78. Households with high dietary diversity score head a mean HDDS of 8.61 where as those households with medium dietary diversity had a mean HDDS of 5.77. The mean HDDS of all the sample households was 6.12 with standard deviation of 1.76.

Table 10. Mean HDDS of the sample Households

Levels of HDDS	No. of Food Groups	Mean HDDS	Std. Dev.
Low Dietary Diversity	0-4	3.78	0.47
Medium Dietary Diversity	5-7	5.77	0.78
High Dietary Diversity	8-12	8.61	0.60
Total		6.12	1.76

Source: Survey Data by Author

4.5. Relationship between Food Security Status and Crop Diversification

This sub-section presents and discusses the relationship of the food security status of the sample households and the number of crops grown. It also discusses the food security status and the crop diversification as measured by crop diversification index. The food security and crop diversification status of the sample households have already been determined in the previous the sections.

4.5.1. Food Security Status and Number of Crops Grown

This sub-section tries to relate the food security status of the sample households as measured by HDDS and HFIAS scores and the number of crops grown.

Figure 9 shows that households who have grown only one crop had an average HDDS score of 5.2 where as those households who have grown eight crops had an average HDDS of 10. Households who have grown four, five and six crops had an average HDDS of 7.03, 7 and 7.09.

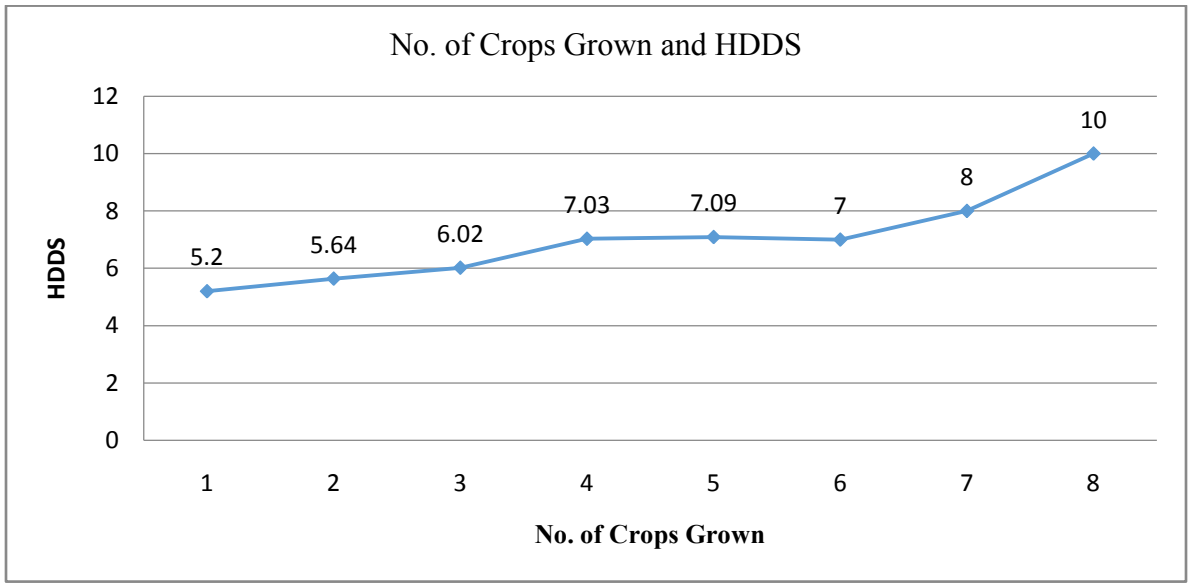

Figure 9. Number of Crops and HDDS Score of the Sample Households

The overall distribution shows that as number of crops grown by households increase, the HDDS also increase implying that number of crops grown and HDDS have positive relationship. Households growing many crops were more likely to be food secure.

This also consistent with the responses from the FGD. One of the FGD discussant said that:

'*Previously we were considering that vegetables such as tomato and cabbages are the foods eaten by urban dwellers. But, now we have realized the benefits of these vegetables and we started growing and consuming these items'*. This shows that households in the study area are considering the production of vegetables in addition to the cereal production.

As shown in Figure 10, households who have grown only one crop had an average HFIAS score of 11 whereas households who have grown eight crops had a 0 HFIAS score. Households who had grown 2 crops had an average HFIAS score of 9.12. As the number of crops grown by the sample household's increase from one to four crops, the HFIAS score declines accordingly. But those households who had 5 crops had an average HFIAS score of 7.48 which slightly higher.

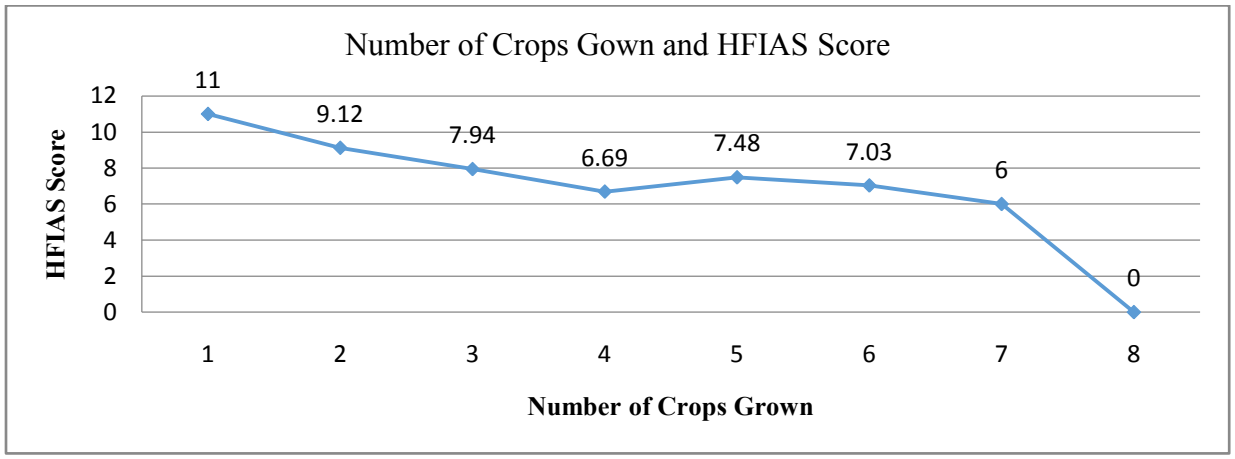

Figure 10. Number of Crops and HFIAS Score of the Sample Households

In general, we can say that the number of crops grown and HFIAS score have negative relationship implying that as the number of crops grown increases, the level of food insecurity of the sample households' declines. Households which have relatively higher number of crop grown per season are less likely to face severe food insecurity.

The two measures of food security portray almost same trend with the number of crops grown by the sample households. The next section tries to link the food security status of the sample households and the crop diversification index- which is the measure of crop diversification status of sample households.

4.5.2. Food Security Status and Crop Diversification Index

This sub-section presents the relationship among the food security status and crop diversification with respect to the sample households. Pearson Correlation coefficients was calculated to see the correlation of the food security status indicators (HDDS and HFIAS) and crop diversification index (CDI). Table 11 gives the overview of the Pearson's correlation coefficients for the continuous variables.

Table 11. Pearson Correlation coefficients for the continuous variables

	CDI	HDDS	HFIAS
CDI	1	0.33	-0.25
HDDS	0.33	1	-0.75
HFIAS	-0.25	-0.75	1

As indicated in Table 11, HDDS score is positively correlated with CDI and negatively correlated with HFIAS. As the food security status increases, HFIAS decreases. The HFIAS score is negatively correlated with CDI and HDDS. Higher HFIAS score means the household is more food insecure while higher CDI means higher crop diversification and higher HDDS scores indicate better food security status of the households. All correlations were significant at 0.01 level. Using correlation analysis, it was examined that the HFIAS score is negatively correlated with crop diversification and HDDS. This implies that HFIAS score decrease as food security increases increase in HDDS.

The distribution of sample households on the basis of their HDDS and CDI and HFIAs and CDI is indicated in Figures 11 and 12 respectively.

As indicated in Figure 11, households with very low crop diversification index score had lower HDDS (5.43); households with low crop diversification index had mean HDDS of 5.64. On the other hand sample households with very high crop diversification index had the highest mean HDDS of 7.2. This implies that crop diversification improves household food security as measured by HDDS. In general, Figure 11 shows that as the level of crop diversification increases, the number of food groups consumed by the sample households' increase.

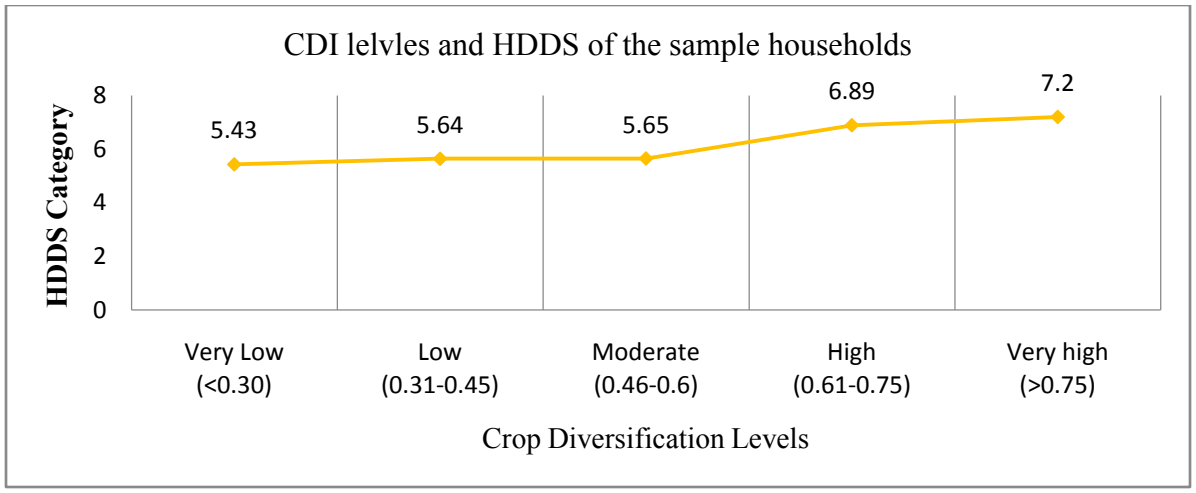

Figure 11. Crop Diversification Index and HDDS Score of the Sample Households

Figure 12, shows that households with very low level of crop diversification had the highest HFIAS score whereas households with the highest level of crop diversification had the lowest level of HFIAS score. This implies that crop diversification improves the level of food security of households.

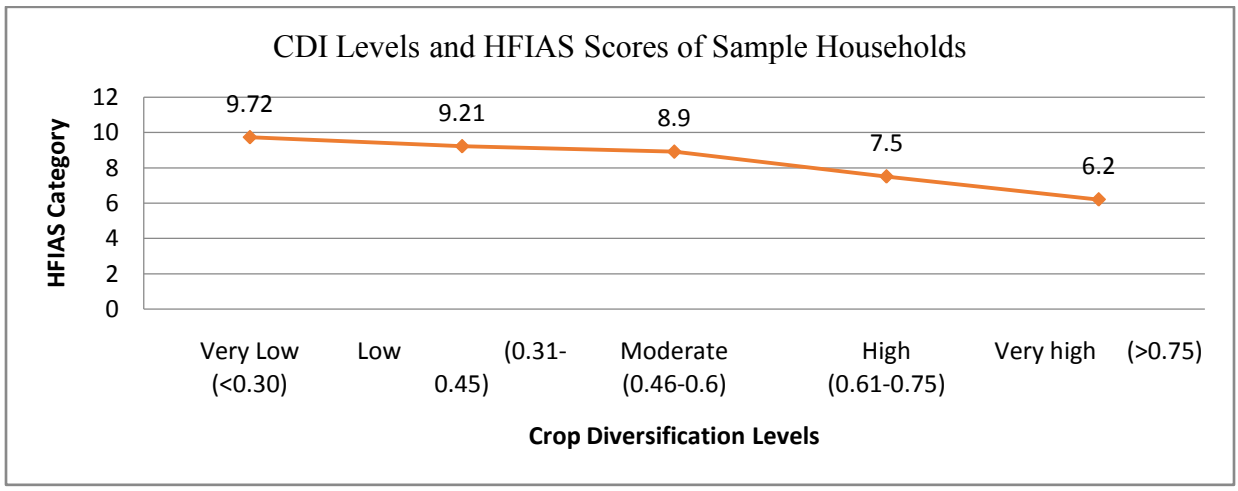

Figure 12. Crop Diversification Index and HFIAS Score of the Sample Households

From the above results, it can be concluded that food security status of farm households can be improved through crop diversification and therefore farmers should be stimulated to more diversify the different crops.

4.6. The Role of Crop Diversification to Household Food Security

This section presents and discusses the influence of crop diversification on household food security status. The variables we have here are the crop diversification index (CDI), the households dietary diversity score (HDDS) and the Households Food Insecurity Access Scale (HFIAS) calculated in the previous sections. The dependent variables, here HDDS and HFIAS are continues variables, and the independent variable is also continues variables. The researcher want to determine if CDI has an influence on either HDDS or HFIAS or both. Together with the CDI, other socio-economic variables have also been used in the ordinary least square (OLS) regression.

The results of the OLS regions are shown in Table 12. The result of the regression shows that crop diversification as measured by the CDI index has a positive and significant influence on HDDS. Household size, ownership of oxen, and distance from the market were also found the main factors that influence HDDS. These are discussed in detail below.

Crop Diversification

The coefficient of CDI is significant at 5% and shows a positive impact on household dietary diversity score. Households with higher crop diversification index are more likely to have diversity in terms of food crops that can be consumed within the household thus justifying the positive relationship. This implies crop diversification improves household food security as measured by dietary diversity in the study area. On the other hand, crop diversification has a negative influence on HFIAS score of the sample households though it is not significant. The negative influence implies that households with higher crop diversification intensities are less food insecure as compared to those with low levels of crop diversification. Hence, farmers who intensify crop diversification are better off than their counterparts as diversification is positively related to dietary diversity and negatively related to food insecurity mainly due to the benefits of crop diversification.

These results are consistent with the recent studies conducted by Mango *et al.* (2018). In their study of the role of crop diversification in improving household food security in Malawi, they found that crop diversification improves food security as measured by food consumption score and household food insecurity access scale. John *et al*. (2015) in their study of food and nutrition

implication of crop diversification in Malawi found that crop diversification has an important positive effect on households' food security as measured by households' dietary diversity. Another study by Makate *et al.* (2016) also found that crop diversification has a positive impact on household food security in Zimbabwe.

Mugendi, (2013) also indicated that crop diversification also has a direct effect on food availability and nutrition besides improving productivity, increasing production and income stability. This is mainly because crop diversification will improve yields, bring crop yield stability and also that crop insurance effect since if one crop fails the farmer can depend on the other crop.

Household size

The result of the OLS regression indicted that household size has a negative and significant relationship with the dietary diversity score of the sample households. It is significant at 10% probability level. Family size affects household food consumption with regard to the number of consumers. This is, because, large family size exerts more pressure on household food consumption and causes the available dietary energy of household to decrease. Studies conducted by Degefa (2002), and Arega (2014) revealed that, household food availability declines with increase in household size.

Ownership Oxen

Owning draught power obtained from farm oxen highly influences the production capacity of farm households in traditional agriculture like Ethiopia. The result of the regression analysis shows that ownership oxen positively and significantly (at 10% level of significance) influences households dietary diversity (Table 12). This result is consistent with other similar studies. Mesay (2009) in his study of the causes of rural household food insecurity in Kuyu district found that number of oxen owned by a household has strong association with availability of food grains in the household. Degye *et al*. (2012) in their study of does crop diversification improve household food security in rural Ethiopia found that ownership of livestock positively affect the dietary diversity of farm households. Mango *et al.* (2018) also found that cattle ownership enhances households' food consumption.

Table 12. OLS regression result of the effect of crop diversification on HDDS and HFIAS

	(1)	(2)
VARIABLES	HDDS	HFIAS
cdi	1.327*	-1.800
	(0.699)	(2.004)
sexhh	-0.167	-0.427
	(0.382)	(1.026)
agehh	-0.0170	0.0154
	(0.0153)	(0.0431)
hhsize	-0.188***	0.163
	(0.0638)	(0.192)
Adult education	-0.628	1.714
	(0.572)	(1.736)
Primary education	-0.0425	0.132
	(0.260)	(0.721)
Secondary education	-0.413	-0.377
	(0.394)	(1.389)
landsize	0.0729	-0.440
	(0.270)	(0.846)
oxen	0.577***	-0.747*
	(0.151)	(0.436)
dist_min	-0.00882**	0.0134
	(0.00438)	(0.0118)
Constant	6.679***	9.203***
	(0.747)	(2.110)
Observations	203	203
R-squared	0.206	0.084

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

Distance to the Market

Market distance refers to the number of kilometers farmers have to travel to reach the next marketplace to sell their produce. The result of the OLS analysis shows that distance to the market has a negative and significant effect on HDDS of the households. This variable is significant at 10% probability level (Table 12). Farmers who live near to the market places are more to diversity their crop activities thereby improve their dietary diversity.

4.7. Determinants of Crop Diversification

The result of the Tobit model which analyzed the determinants of crop diversification in the study area is summarized in Table 13.

Multicollnearity was checked using variance inflation factor. The calculated VIF values are all less than 10 (the cut-off point) which indicated that multicollnearity is not a serious problem.

Since Tobit model has a probit component and its results are sensitive to the assumption of homoscedasticity, a robust standard error Tobit regression was run.

The result of the Tobit model shows that level of education of the household head, number of oxen owned, distance to the market and number of plots owned were found to be the main factors that affect crop diversification in the study area (Table 13). Each of the significant variables is explained below.

Education of Household Head

The level of education the household head attained positively and significantly affected crop diversification of the sample households. This is significant at 10% probability level (Table 13). This could be due to the fact that more educated farmers are able to easily understand the benefits and opportunities of crop diversification. This result is consistent with other similar studies. Ame *et al*. (2016) in their study of assessment of household food security through crop diversification found that level education of the household positively and significantly affect crop diversification in Myanmar. John *et al*. (2015) in their assessment of food and nutrition implication of crop diversification in Malawi found that literacy of household head positively affects crop diversification.

Number of Oxen Owned

Ownership oxen is critical in the Ethiopian traditional and small holder farming. Oxen constitute the main source of animal power for agricultural work. The result of the Tobit analysis shows that ownership of oxen has a positive and significant effect on crop diversification in the study area. This implies that an increase in the number of oxen owned by smallholder farmers increased the likelihood of diversifying their crop production. The result of the study is in conformity with the findings of John *et al*. (2015). In their assessment of food and nutrition

implication of crop diversification in Malawi found that ownership of oxen positively and significantly affects crop diversification. This result is also consistent with the results of Feiten *et al*. (2009) who also found that crop diversification is positively related to livestock ownership.

Table 13. Tobit regression estimates of factors influencing crop diversification

	(1)
VARIABLES	Factors affecting crop diversity
sexhh	0.0274
	(0.0490)
agehh	0.00173
	(0.00203)
hhsize	0.00776
	(0.00796)
Adult education	0.106***
	(0.0270)
Primary education	0.0565**
	(0.0284)
Secondary education	0.0745
	(0.110)
landsize	0.0497
	(0.0426)
oxen	0.0748***
	(0.0186)
fertilizer	-0.0172
	(0.0421)
dist_min	-0.00144***
	(0.000470)
irrigation	0.0450
	(0.0367)
plot_num	0.0615***
	(0.0208)
ext_cont	0.0784
	(0.0648)
Constant	-0.0197
	(0.102)
Observations	203
R-squared	0.562

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

Distance to the market

Distance to the market is an indicator of physical access to markets and organized trade, as well as proximity to economic resources. The nearer to the market the farmer is, the easier it becomes for him or her to diversify and to take produce to market. The result of Tobit analysis shows that distance to the market is negatively associated with crop diversification. It is significant at 5% probability level (Table 13). This implies that farm households living very far from the market centers are found with lower diversification of their cropping activities. The reason could be due to the fact that farmers could find difficulty of selling their produce especially in the case of vegetable producers. Benin *et al.* (2004) confirmed the importance of proximity to main roads and markets for development of other farm enterprises or crop diversification. Degye*et al.* (2012) also found that distance to them main road has a negative effect on crop diversification of smallholder farmers in Ethiopia. This result is in contradiction with the findings of Kankwamba *et al*. (2012). In their study of determinants and spatiotemporal dimensions of crop diversification in Malawi, they found that farmers located farther away from markets or main roads, are found to diversify in order to meet their broad subsistence and nutritional needs.

Number of plots owned

The number of plots a farmer has plays a crucial role in determining how many crops a farmer can produce. The result of the Tobit analysis indicated that number of plots owned by the household has a positive and significant impact on crop diversification. The positive coefficient for the number of farm plots operated by a household indicates that households with more number of farm plots are more likely to diversify by growing different crops on each plot of land. This variable is significant at 10%probability level (Table 13).The result of the study is in line with the finding of Berhanu and Moti (2010) who found land fragmentation to be most important determinant of crop diversification. It is also consistent with the findings of Wondimagegn *et al.* (2011) who found number of plots owned by farmers has a positive and significant effect on crop diversification in eastern Ethiopia.

CHAPTER FIVE: SUMMARY, CONCLUSION AND RECOMMENDATION

This section presents the summary of the main findings, concluding remarks and policy recommendation.

5.1. Summary and Conclusion

This study assessed the role of crop diversification to household food security in Enderta woreda. It also identified the factors that influence crop diversification in the study area. Household dietary diversity score and household food insecurity access scale were used as a proxy to measure food security. OLS regression was used to assess the impact of crop diversification on households' food security and Tobit model was used to identify the determinants of crop diversification. Crop diversification index was calculated to measure the crop diversification status of the sample households.

The study revealed that majority (67%) of the sample households are food insecure as measured by the household food insecurity access scale. The study identified that as the number of crop grown by a household increase, their dietary diversity increases where as their level of food insecurity decreases with an increase in number of crops. There is a positive relationship between the number of crop grown and the dietary diversity. This implies that the larger the number of crops grown and harvested by households, the better is their food security status as measured by the dietary diversity score. On the other hand, there is a negative relationship between the number of crops grown and the households' food insecurity access scale implying that as the number of crops gown increase, the level of food insecurity declines.

The result of the OLS regression showed that crop diversification has a positive and strong impact on households' food security as measured by the household dietary diversity score (HDDS). The OLS result also showed that crop diversification has a negative influence on HFIAS implying that as the level of crop diversification increase, the probability that a household become food insecure declines. Farming households with more than one crop grown tend to be more secure in terms of food supplies and income and hence are able to cater for the food requirement of their households. Crop diversification hence improves food security through improving food stocks in terms of quantity and variety and also in improving income through

sale of crop produced from a variety of grown crop species which then is used to further improve consumption patterns.

In addition, the result of the OLS regression showed that number of oxen owned positively influences HDDS but negatively influence HFIAS. This implies that as the number of oxen owned by households increase, the dietary diversity score increase and their level of food insecurity declines. The OLS regression result also showed that family size and distance to the market negatively and strongly influence HDDS while these variables influence HFIAS positively. This indicates that as the number of household members and distance to the market increase, the level of food insecurity of households increase. The results suggest that ownership of oxen, distance to the market and family size are crucial factors for food security in the study area.

From the results, it can be concluded that crop diversification among other factors is a viable option in smallholder farming that can contribute significantly to household food security. This is mainly because crop diversification improves food access and availability for the household. Crop diversification benefits the farmer mainly in the sense that cultivating several crop species helps to manage both production risks, which in the end ensures more food options for the household and income through market participation from the surpluses.

The result of Tobit model showed that level of education of the household head, number of oxen owned and number of plots owned are main factors that determine crop diversification in the study area. The result also showed that distance to the market has a negative and strong effect on crop diversification in the study area.

Education of the household head has a positive and significant effect on crop diversification. The result showed that farmers who had adult literacy and who completed primary education are found with higher probability of crop diversification. This implies that household heads knowledge is crucial factor for farmers to practice in crop diversification.

In addition to the result of the Tobit model on market distance, the focus group discussants also reported that availability of market highly affects their decision to grown more crops especially vegetables. Farmers who produce vegetables like tomato, onion and cabbage are suffering from lack of market and this discourage them to grow more crops.

It can be concluded that education of the household head, number of oxen and plots owned and access to the market are the crucial factors that affect crop diversification in Enderta woreda.

5.2. Recommendation

Based on the findings of the study, the following recommendations are suggested to promote crop diversification and improve food security.

The result of the study indicates that food security status of households can be enhanced through crop diversification i.e., increasing the number of crops gown. This suggest that the government need to intensify promotion of crop diversification in smallholder farming, especially to those currently less diversified to improve the food security status of the rural people. The nutrition sensitive agricultural strategy clearly specified the importance of production of diversified foods to improve smallholder farmers' nutritional status. Therefore, attention should be given for the proper implementation of the strategy and crop diversification for food security can be incorporated into the existing extension services.

The result of the study also showed that ownership of oxen determines both crop diversification and household food security.If the government is committed to improve farm household food security, attention should be given to the resource base of smallholder farmers. Therefore, strategies need to be devised to address draft power (oxen) needs of smallholder farmers as it is key in smallholder farming. For instance, the government in collaboration with the microfinance institutions can work possibility for offering small loans with low interest rates without collateral to smallholder farmers.

The result of this study also suggests that distance to the market affects crop diversification activities of small holder farmers. Access to markets can play positive role in enhancing crop diversification among farmers. Therefore, access to market, especially to farm households who produce vegetables, need to be given attention. For instance farmers who grow vegetables can be linked to large hotels and supermarkets in nearby towns and regional market centers.

The number of plots owned by the farm households positively affects crop diversification. As it is difficult to provide additional farm plots to the small holder farmers, strategies need to be designed to encourage farmers to use their backyard gardening to produce vegetables so as to improve food and security.

A positive relationship between levels of education the household head attained and crop diversification was also found. Households who had at least adult education were found with high crop diversification practices. Hence, attention should also be given to smallholder farming households' access to education. This could be through expanding at least adult education at kebele levels.

References

Alison, K. B. (2010). Crop Diversification and Technology Adoption: The Role of Market Isolation in Ethiopia. M Sc Thesis, Montana State University, Bozeman, Montana.

Ame, C., Aung T., and Stijn S. (2016). Assessment of Food Security through Crop Diversification in Natmauk Township, Magway Region, Myanmar. University of Natural Resources and Life Sciences, Boku, Viena, Australia.

AndrzejC., KatarzynaS. (2015). Specialization and diversification of agricultural production in the light of sustainable development, Journal of International Studies, Vol. 8, No 2, pp. 63-73. DOI: 10.14254/2071-8330.2015/8-2/6

AregaBazezew (2012). Determining food security indicators at household level in drought prone areas of the Amhara region of Ethiopia: The case of Lay Gaint district. Ethiopian Journal of Environmental Studies and Management. 5 (4), 422-434.

Ashfaq, M., Hassan. S., Naseer, M. Z. Baig, I. A. &Asma, J. (2008). Factors affecting farm diversification in rice-wheat. Pakistan Journal of Agricultural Science, 45(3), 91 – 94.

AschalewFeleke (2006). Determinants and dimensions of household food insecurity in Dre- Dawa, Ethiopia. M.Sc. Thesis Presented to Alamaya University, Alamaya.

Ayalneh, B and A. Shimelis (2009). Household level determinants of food insecurity in rural areas of Dire Dawa, Eastern Ethiopia. African Journal of Food, Agriculture, Nutrition and Development (AJFAND Online 9 (9): 1914-1926

Barrett, C.B., and Lentz, E.C. 2009. "Food Insecurity." In The International Studies Compendium Project. Oxford, UK: Wiley-Blackwell Publishing.

Behrman, J.R. 1996. "The Impact of Health and Nutrition on Education." The World Bank Research Observer 11 (1) (February 1): 23–37

Benin, S., Smale, M., Gebremedhin, B., Pender, J., &Ehui, S. (2004). The Determinants of Cereal Crop Diversity on Farms in the Ethiopian Highlands. Contributed paper for the 25th International Conference of Agricultural Economists. Durban, South Africa

Berhanu G. &Moti J. (2010). Market Orientation, Diversification and Market Participation of Smallholders: Evidence from Ethiopia, World Food System - A Contribution from Europe, Tropentag, Zurich. International Livestock Research Institute (ILRI), Improving Productivity and Market Success (IPMS) Project, Ethiopia.

Bittinger, A. (2010). Crop Diversification and Technology Adoption: The Role of Market Isolation in Ethiopia. An MSc Thesis Submitted to Montana State University, Bozeman, Montana.

Chanyalew, D., Adenew, B., & Mellor, J. (2010). *Ethiopia's agricultural sector policy and investment framework (PIF) 2010-2020.* Addis Ababa: Minisry of Agriculture and Rural Developement

Clements, R., J. Haggar, A. Quezada, and J. Torres (2011). Technologies for Climate Change Adaptation – Agriculture Sector. X. Zhu (Ed.). UNEP Risø Centre, Roskilde, 2011, available at http://tech-action.org/

Clifton, M.,Rongchang W., Marshall and Nelson M. (2016). Crop diversification and livelihoods of smallholder farmers in Zimbabwe: adaptive management for environmental change. SpringerPlus (2016) 5:1135. DOI 10.1186/s40064-016-2802-4

CSA. (2007). Central statistical authority population estimates (Volume I), CSA, Addis Ababa, Ethiopia.

Coates J, Swindale A, Bilinsky P. (2007). Household Food Insecurity Access Scale (HFIAS) for measurement of household food access: indicator guide. Version 3. Washington, DC: Food and Nutrition Technical Assistance Project, Academy for Educational Development.

Coyle, B. T. (1992). Risk aversion and price risk in duality models of production: a linear mean-variance approach. American Journal of Agricultural Economics 74:849-859

DegefaTolossa (2002). Household Seasonal Food Insecurity in Oromiya Zone, Ethiopia: Causes. Social Science Research Report Series, No.26: OSSREA, Ethiopia, Addis Ababa.

Degye G., Belay K., and Mengistu K. (2012). Does Crop Diversification Enhance Household Food Security? Evidence from Rural Ethiopia. Science and Education Development Institute. Volume 2 (11) Nov.: 503 - 515, 2012

Dohrmann, J.A., and Thorat, S. 2007. "Right to Food, Food Security and Discrimination in the Indian Context." ASIEN (January): 9–31

Emrys, E. H., and P.Ngau, (1991). Rural Urban Relations, Household Income Diversification and Agricultural Productivity. In Development and Change, 22, 519-545. http://dx.doi.org/10.1111/j.1467-7660.1991.tb00424.x

Ellis, F. (2000). Rural Livelihoods and Diversity in Developing Countries. Oxford: Oxford University Press.

FAO. (2011). The State of Food and Agriculture 2010-2011. Women in agriculture: Closing the gender gap for development. Rome: FAO.

FAO. (2012). Sustainable Crop Production Intensification. Twenty-third Session. Rome, Italy.

FAO. (1996). Rome Declaration on World Food Security and World Food Summit Plan of Action. World Food Summit 13-17 November 1996. Rome.

Fetien A, Bjornstad, A, Smale M (2009). Measuring on farm diversity and determinants of barley diversity in Tigray, northern Ethiopia. MEJS. 1, (2): pp. 44-66.

Gauchan D, Smale M, Maxted N, Cole M, Sthapi BR, Jarvis D, Upadhyay MP (2005). Socioeconomic and agro-ecological determinants of conserving diversity on-farm: The case of rice genetic resources in Nepal. J. Nepal Agric. Res. 6 : pp. 89-98.

Gedlom G. (2008). The Role of Food for Work to Cooperatives on Household Food Security in EndertaWoreda, Tigray, Ethiopia. MSc Thesis submitted to Faculty of Dryland Agriculture and Natural Resources, MekelleUnivesiry

Goshu, D., Kassa, B., & Ketema, M. (2013). Measuring diet quantity and quality dimensions of food security in rural Ethiopia. *Journal of Development and Agricultural Economics*.

Glenn D., Israel (1992). Determining Sample Size. University of Florida, IFAS Extension

Guush B., Mehari H., and Tassew W. (2015). Childhood Shocks, Saftety nets and Cognitive Skills: panel data evidence from rural Ethiopia. Ethiopia Strategy Suppr Program/IFPRI, working paper 73.

Heitzmann, K., Canagarajah, R.S., and Siegel, P.B. 2002. Guidelines for Assessing the Sources of Risk and VulnerabilityNo. 0218. Social Protection Discussion Paper. Washington: World Bank

Hadleya, C., Linzerb, D.A., Tefera, B., Abebe, G., Fasil, T. and D. Lindstrome, (2011). Household capacities, vulnerabilities and food Insecurity: shifts in food insecurity in urban and rural Ethiopia during the 2008 food crisis. Social Science & Medicine 73: 1534-1542.

Hailu, M. (2012). Causes of Household Food Insecurity in Rural BosetWoreda: Causes, Extent and Coping Mechanisms to Food Insecurity. Lap Lambert Academic Publishing.

Hoddinott, J. 2012. "Agriculture, Health, and Nutrition: Toward Conceptualizing the Linkages." In Reshaping Agriculture for Nutrition and Health. IFPRI.

Ibrahim, H., Rahman, S., Envulus, E., &Oyewole, S. (2009). Income and crop diversification among farming households in the rural area of North Central Nigeria. Journal of Tropical Agriculture, Food, Environment, and Extension, 8(2), 84-89.

Immink, M.D.C., & Alarcon, J.A. (1991). Household food security, nutrition, and crop diversification among smallholder farmers in the highlands of Guatemala. Ecology of Food and Nutrition 25 (4).

Michler, Jeffrey & Josephson, Anna. (2017). Specialization versus Diversification: Agricultural Diversity and Poverty Persistence in Ethiopia. World Development. 89. 214-26.

Jones, A.D., Shrinivas, A., &Bezner-Kerr, R. (2014). Farm production diversity is associated with greater household dietary diversity in Malawi: Findings from nationally representative data. Food Policy, 46, 1-12

John M., Henry K., and Karl P. (2015). Food and Nutrition Security Implications of Crop Diversification in Malawi's Farm Households.

John H., and Yisehac, Y. (2002). Dietary Diversity as a Food Security Indicator. Food and Nutrition Technical Assistance Project, Academy for Educational Development, Washington, D.C.

Joshi P. (2005). Crop diversification in India: nature, pattern and drivers. In: New Delhi India: Asian Development Bank Krupinsky JM, Bailey KL, McMullen MP, Gossen BD, Turkington TK (2002) Managing plant disease risk in diversified cropping systems. Agron J 94:198–209

Joshi, P.K., Gulati, A., Birthal, P.s., &Twari, A. (2004). Agricultural diversification in South Asia: patterns, determinants and policy implications. Economic and Political weekly, 39 (24), 2457-2467.

Kankwamba, H., Mapila, A. T. J. M., &Pauw, K. (2012). Determinants and spatiotemporal dimensions of crop diversification in Malawi. Lilongwe: International Food Policy Research Institute.

Kibrom T. Sibhatu, Vijesh V. Krishna, and MatinQaim (2015). Production diversity and dietary diversity in smallholder farm households. Department of Agricultural Economics and Rural Development, Georg-August-University of Goettingen, 37073 Goettingen, Germany.

KiruSichoongwe (2014). Determinants and Extent of Crop Diversification among Smallholder Farmers in Southern Zambia. A Thesis Submitted to the Faculty of Development Studies in Partial Fulfilment for

the Requirements for A Master of Science Degree in Agricultural and Applied Economics, Bunda College of Agriculture, University of Malawi, Malawi.

Kumar, U. D., &Chattopadhyay, M. (2010). Crop Diversification by Poor peasants and Role of Infrastructure: Evidence from West Bengal. Journal of Development and Agricultural Economics, 2(10), 340-350.

Lin B. (2011). Resilience in agriculture through crop diversification: adaptive management for environmental change. Bioscience 61:183–193

Lorenzo Pellegrini& Luca Tasciotti (2014) Crop diversification, dietary diversity and agricultural income: empirical evidence from eight developing countries, Canadian Journal of Development Studies/Revue canadienned'études du développement, 35:2, 211-227, DOI: 10.1080/02255189.2014.898580

Luo, R., Shi, Y., Zhang, L., Zhang, H., Miller, G., Medina, A., and Rozelle, S. 2012. "The Limits of Health and Nutrition Education: Evidence from Three Randomized-Controlled Trials in Rural China." CESifo Economic Studies 58 (2) (April 27): 385–404

Magaña‐lemus D, Ishdorj A, Iii CPR, Lara‐álvarez J. (2016). Determinants of household food insecurity in Mexico. Agric Food Econ. https ://doi. org/10.1186/s4010 0‐016‐0054‐9

Makate C, Wang R, Makate M, Mango N. (2016). Crop diversification and livelihoods of smallholder farmers in Zimbabwe: adaptive management for environmental change. SpringerPlus.;5(1):1–18. https://doi. org/10.1186/s40064-016-2802-4.

Maxwell, S. & Smith, M. 1992. Household food security; a conceptual review. In S. Maxwell & T.R. Frankenberger, eds. Household Food Security: Concepts, Indicators, Measurements: A Technical Review. New York and Rome: UNICEF and IFAD

Maxwell, S.(1996). Food security: a post-modern perspective. Food Policy. 21 (2): 155-170.

Maxwell,D,R. Caldwell and M.Langworthy(2008) 'Measuring Food Insecurity: Can an Indicator Based on Localized Coping Behaviors be Used to Compare Across Contexts?', Food Policy 33(6)533-540.

MessayMulugeta (2009). Causes of Rural Household Food Insecurity: A Case FromKuyu District, Central Ethiopia. Journal of Sustainable Development in Africa 11 (4). Clarion University of Pennsylvania, Clarion, Pennsylvania

MeskeremAbi and DegefaTolossa (2015). Household Food Security Status and Its Determinants in GirarJarsoWoreda, North Shewa Zone of Oromia Region, Ethiopia. Journal of Sustainable Development in Africa (Volume 17, No.7, 2015). Clarion University of Pennsylvania, Clarion, Pennsylvania.

MugendiNjeru, E. (2013). Crop diversification: A potential strategy to mitigate food insecurity by smallholders in sub-Saharan Africa. Journal of Agriculture, Food Systems, and Community Development, 3(4), 63–69. http://dx.doi.org/10.5304/jafscd.2013.034.006

Nelson Mango, N., Clifton, M., Mapemba, L.andSopo, M. (2018). The role of crop diversification in improving household food security in central Malawi. Agriculture & Food Security. A*griculture & Food Security*20187:7. https://doi.org/10.1186/s40066-018-0160-x

Niehof, A. (2004). The significance of diversification for rural livelihood systems, Food Policy, 29 (4):321–338.

Pieters, H., Guariso, A and Vandeplas, A. (2013). Conceptual framework for the analysis of the determinants of food and nutrition security. LICOS - Centre for Institutions and Economic Performance & Department of Economics, KU Leuven, Belgium

Rahman S (2008). Determinants of crop choices by Bangladeshi farmers: A bivariate Probit analysis. Asian J. Agric. Devt. 1,(5): pp. 29-42.

Samuel, G., 2004. Food Insecurity and Poverty in Ethiopia: Evidence and Lessons from Wollo. Ethiopian Economics Association (EEA)/Ethiopian Economic Policy Research Institute (EEEPRI), Working Paper No. 3/2004, Addis Ababa, Ethiopia

Seid N, Seebens H (2008). The impact of location on crop choice and rural livelihood: Evidences from villages in northern Ethiopia. ZEF Discussion Papers 123, Bonn. pp. 1-27

Shiferaw T. Feleke, Richard L. Kilmer, Christina H. Gladwin (2004). Determinants of food security in Southern Ethiopia at the household level. Food and Resource Economics Department, Institute of Food and Agricultural Sciences, University of Florida, Gainesville, Florida.

Shoffner AV, Tooker JF (2012). The potential of genotypically diverse cultivar mixtures to moderate aphid populations in wheat (Triticumaestivum L.). Arthropod Plant Interact 7:33–43

Swades P. and K. Shyamal (2012). Implications of the methods of agricultural diversification in reference with malda district: drawback and rationale. International Journal of Food, Agriculture and Veterinary Sciences 2 (2) :97105 http://www.cibtech.org/jfav.htm.

Swindale A. &Bilinsky, P. (2006). Household dietary diversity score (HDDS) for measurement of household food access: indicator guide, Version 2. Food and Nutrition Technical Assistance Project, Academy for Educational Development, Washington, D.C

Tagel G. (2012). Food Security Policy: Does It Work? Does It Help? PhD Desseration, Faculty of Geo-Information Science and Earth Observation, University of Twente, the Netherlands.

Torheim, L.E., Ouattara, F., Diarra, M.M., Thiam, F.D., Barikmo, I., Hatloy. A., &Oshaug, A. (2004). Nutrient Adequacy and dietary diversity in rural Mali: association and determinants. European Journal of Nutrition, 58, 594-604.

USAID (2006). The Livelihoods Atlas for Ethiopia: The Livelihoods Integration unit.

Webb. P, Jennifer Coates,J., Frongillo E.,Rogers,B.,Swindale, A. and Bilinsky, P. (2006). Measuring Household Food Insecurity: Why It's So Important and Yet So Difficult to Do? *The Journal of Nutrition*, Volume 136, Issue 5. https://doi.org/10.1093/jn/136.5.1404S

Windle J, Rolfe J (2005). Diversification choices in agriculture: A choice modeling case study of sugarcane growers. Australian J. Agric. Res. Econ. 49,(1): pp. 63-74.

Wondimagegn, M., Bekabil, F. and H. Jema, (2011). Pattern, trend and determinants of crop diversification: empirical evidence from smallholders in Eastern Ethiopia. Journal of Economics and Sustainable Development 2(8): ISSN 2222-2855.

Annex 1: Household Questionnaire

This questionnaire is prepared with the aim of collecting data for a study focusing on "**The Role of*Crop Diversification to Household Food Security in EndertaWoreda, Tigray***." It is designed to get information from households in selected kebeles of Endertaw*oreda* in Tigray Regional State.

You are kindly requested to provide accurate and reliable information for the reliability of the final document that will be produced based on the information you provide. It is expected to serve for academic purpose to the partial fulfillment of the requirement for a Master of Science (MSc) Degree in Food Security from Addis Ababa University.

The researcher wants to assure you that the information you provide will be kept confidentially.

Name of Kebele/*Tabia*: _____ Kebele ID: [___ ___]

Household ID: [___ ___ ___ ___] Enumerator ID: [___ ___]

Date of Interview: _____/_____/2017

Demographic Characteristics of Households

1. Age of household head in completed years. [__ __] years

2. Sex of household head 00=female 01= male [__ __]

3. Has the household head attended school? 00=No 01=Yes [__ __]

4. What was the highest grade that the household head completed? [__ __]

00=None 01=Primary education 02=Secondary education 03=vocational

04=University 05=Adult literacy

5. Household size. Enter the total number of household members. [__ __]

6. Age group of the household members:

Children under 5 years [__ __] Age of 15 to 65 years [__ __]

Above 5 and below 15 years [__ __] Above 65 years [__ __]

Land owned

7. In the last 12 months/agricultural year, has your household owned, borrowed or rented any agricultural land? 00= No 01= Yes [__ __]

8. Number of plots owned by the household [__ __]

9. What is the total area/size of agricultural land you owned? [___ ___ ___. __ __]

Land ID	**Land Type**	**10. Size** If more than one plot, ask for the sum of all plots.	**11.** Units of land area Use **Code box #1**	**12.** What proportion of the land was irrigated in the last dry season? 01=Less than half 02=Half 03=More than half 04=All 05=No land was irrigated in dry season
1	Owned	[__ __ __.__ __]	[__ __]	[__ __]
2	Borrowed	[__ __ __.__ __]	[__ __]	[__ __]
3	Rented-in	[__ __ __.__ __]	[__ __]	[__ __]
4	Sharecropped-in	[__ __ __.__ __]	[__ __]	[__ __]

Agricultural land allocated for various crops

13. Did you allocate your agricultural land for various cropping purposes? [__ __]

00= No 01=Yes

14. If your answer for question No. 13, above, is 'yes", what type of diversification do you practice? 01=intercropping 02= crop rotation 03=both [__ __]

15. If you answer for question No. 13, above, is 'yes', indicate your agricultural land allocated to the various crops in the last agricultural year.

CROP	Important crops grown and harvested in the last agricultural year. Use **Code-Box #2**	Area allocated in local units in last agricultural year.	Local units for land area/plots Use **Code-box 1**
Crop 01	[__ __]	[__ __ __]	[__ __]
Crop 02	[__ __]	[__ __ __]	[__ __]
Crop 03	[__ __]	[__ __ __]	[__ __]
Crop 04	[__ __]	[__ __ __]	[__ __]

Crop 05	[__ __]	[__ __ __]	[__ __]
Crop 06	[__ __]	[__ __ __]	[__ __]
Crop 07	[__ __]	[__ __ __]	[__ __]
Crop 08	[__ __]	[__ __ __]	[__ __]
Crop 09	[__ __]	[__ __ __]	[__ __]
Crop 10	[__ __]	[__ __ __]	[__ __]

16. Reasons for diversifying cropping activities?

Reasons for diversifying	00=No 01=Yes
Reduces risk of crop failure	[__ __]
Improves food security	[__ __]
Improves nutrition	[__ __]
Increase income from sale of various crops	[__ __]
Others (specify)_____	[__ __]

17. If your answer for question no. 13, above is 'No', what are the major reasons for not diversifying your cropping activities?

Reasons for not diversifying	00=No 01=Yes
Lack of land	[__ __]
Lack of labor	[__ __]
No irrigation facilities	[__ __]
Fear of crop failure	[__ __]
Lack of market	[__ __]
Others (specify)_____	[__ __]

18. How do you evaluate the trend on your crop diversification practice over the last five years? 01=Increasing 02= Decreasing 03=Constant/no change [__ __] 04=Do not practice in diversification

19. If your answer for Question No. 18, above, is decreasing, what are the major reasons?

1) _____
2) _____
3) _____
4) _____

20. If your answer for Question No.18 is increasing, what are the major reasons?

1) _____
2) _____
3) _____
4) _____

Crops grown and harvested

	21.	**22.**	**23.**	**24.**	**25.**
CROP	Important crops grown and harvested in the last agricultural year Enter code from **Code-Box #2**	What is the total quantity of this crop harvested in the last agricultural year? In local units	Local unit used Use **Code-Box #3**	What is the amount consumed from the total harvest of this crop produced in the last agricultural year?	What is the amount of crop sold in the last agricultural year?
Crop 01	[__ __]	[_____]	[__ __]	[_____]	[_____]
Crop 02	[__ __]	[_____]	[__ __]	[_____]	[_____]
Crop 03	[__ __]	[_____]	[__ __]	[_____]	[_____]
Crop 04	[__ __]	[_____]	[__ __]	[_____]	[_____]
Crop 05	[__ __]	[_____]	[__ __]	[_____]	[_____]
Crop 06	[__ __]	[_____]	[__ __]	[_____]	[_____]
Crop 07	[__ __]	[_____]	[__ __]	[_____]	[_____]
Crop 08	[__ __]	[_____]	[__ __]	[_____]	[_____]
Crop 09	[__ __]	[_____]	[__ __]	[_____]	[_____]
Crop 10	[__ __]	[_____]	[__ __]	[_____]	[_____]

Code Box 2: Local Crop names

01=Teff	11=Berbere/pepper	21=Chick peas	40=Avocado
02= Barely	12=Sweet Potatoes	22=Cow peas	41=Mango
03=Maize	13=Potato	23=Horse bean	42=Banana
04=Wheat	14=Tomato	24=Lentiles	43=Orange
05=Sorghum	15=Onion	25=Nueg	44=Pineapple
06=Zengada	16=Cabbage	26=Haricot bean	45=Coffee
07=Oats	17=Garlic	27=Seasame	46=Chat
08=Guaya	18=Carrot	28=Boloke/Adenguare	47=Gesho
09=	19=Selata	29=Groundnuts	48=Ginger
10=	20=Pumpkin	30=Nuts	49=Others

Livestock Ownership

S/No	**Type of Livestock**	**26.** How many of the following animals did the household owned <u>in the last 12 months</u>? 00=None ► Skip to next row	**27.** How many of the following animals does the household <u>currently</u> own? 00=None ► Skip to next row
	Milk animals		
1	Cow	[__ __]	[__ __ __]
2	Calves	[__ __]	[__ __ __]
3	Heifer	[__ __]	[__ __ __]
	Plough or Draught animals		
4	Oxen	[__ __]	[__ __ __]
5	Donkey/horse/mule	[__ __]	[__ __ __]
6	Bull Calf/Young bull	[__ __]	[__ __ __]
7	Camel	[__ __]	[__ __ __]
	Small Ruminants		
8	Sheep	[__ __]	[__ __ __]
9	Goat	[__ __]	[__ __ __]
10	Poultry	[__ __]	[__ __ __]
11	Others (specify)	[__ __]	[__ __ __]

Labor and Off-farm Activities

28. Do you face labor shortage in your farming activities? 00= Yes 01= No [__ __]

29. If "yes" for Question no 28, what measures do you take?

01=Hire labor 02=use traditional labor exchange like debbo 03= Use relatives [__ __]

04=others (specify) _____

30. Do you have another occupation other than farming? 00= N0 01= Yes [__ __]

31. If "yes" for Question 30, in which non-farm activities are you involved?

01=Wage labor 02=petty trade 03=handcraft [__ __]

04=Others (specify) _____

32. Annual income earned from off-farm activity in Ethiopian Birr. [__ __ __]

33. Did the off farm income help you to diversify your cropping activities?

00=No 01=Yes [__ __]

PSNP participation

34. Are you beneficiary of Productive Safety Net Program (Direct cash transfer)?

00= No 01= Yes [__ __]

35. Are you beneficiary of Productive Safety Net Program (public works)?

00= No 01= Yes [__ __]

36. Do you think that participating in the public works program affect crop diversification activities? 00= No 01= Yes [__ __]

37. If 'yes' for Question No. 36, how?

_____

Farm Implements

Items	**38.** Did you own the following in the last agricultural year? 00=No 01=Yes	**39.** Do you have these currently? 00=No 01=Yes
01=Agricultural tools (e.g. sickle, shovels)	[__ __]	[__ __]
02=Cart/ wheelbarrow	[__ __]	[__ __]
03=Pesticide sprayer	[__ __]	[__ __]
04=Plough	[__ __]	[__ __]
05=Working pump (motor or engine)	[__ __]	[__ __]
06=Thresher	[__ __]	[__ __]
07=Tractor	[__ __]	[__ __]

Irrigation and Fertilizer Utilization

40. Have you used any irrigation in the last agricultural year? 00=No 01=Yes [__ __]

41. If 'yes' for Question 40, above, what proportion of land was under irrigation?

01=Less than half 02=Half 03=More than half 04=All [__ __]

05=No land was irrigated

42. If 'No' for question 40, what was the reason for not using irrigation? [__ __]

01=lack of access to irrigation facilities 02=lack of labor 03=sufficient rain

04=others (specify) _____

43. Have you used fertilizer in the last agricultural year? 00=No 01=Yes	**44.** Amount of fertilizer used in Kg?	**45.** Reasons for not using fertilizer 01=higher price 02=plot do not need fertilizer 03=others (specify)_____
[__ __]	[___ ___ ___]	[__ __]

46. Where do you sell your products?

01=Local markets 02=town market 03= farm gate 04= Cooperatives [__ __]

05= others (specify) _____

47. What is the distance from your home to the market center (woreda) in hours? [__ __ __]

48. What mode of transport do you use from home to market center?

01=donkey/mule 02= track/vehicle 03=carts 04=others (specify)_____ [__ __]

49. Did you encounter problem of where to sell your agricultural products?

00=No 01=Yes [__ __]

Access to information and extension services

Item	**50.** Did you own the following in the last agricultural year? 00=No 01=Yes	**51.** Do you, have this item currently?00=No 01=Yes
01=working radio	[__ __]	[__ __]
02=television	[__ __]	[__ __]
03=mobile	[__ __]	[__ __]

52. Did you make contacts with DAs in the last agricultural year? 00= No 01= Yes[__ __]

53. If 'yes' for Q.52, how many contacts did you make with the DAs in the last agricultural year?

01= Once 02= Twice 03= Four times 04= frequently [__ __]

FOOD SECURITY (HFIAS)

SAY: Now I am going to ask you some questions about the food you eat at home. This should be asked for someone who is responsible in food preparation in the household i.e, usually mothers.

Q.0	Which of the following statements best describes the food situation at your home in the last four weeks? **FIELDWORKER:** Read the alternatives 01=We always eat enough of what we want 02=We eat enough but not always what we would like 03=We sometimes do not eat enough 04=We frequently do not eat enough	[__ __]

SAY: Now I am going to ask you some more specific questions about the food the family eats and problems that some people experience. Please always answer on behalf of **all household members** and think about the last four weeks.

Q.1	In the past four weeks, did you **ever worry** that your household would run out of food before you get money to buy or could acquire more? 00=No ► Skip to Q.2 01=Yes	[__ __]
Q.1a	How often did this happen? 01 = Rarely (once or twice in the past four weeks) 02 = Sometimes (three times to ten times in the past four weeks) 03 = Often (more than ten times in the past four weeks)	[__ __]
Q.2	In the past four weeks, were you or any household member not able to eat the **kinds of foods you want** because of lack of money/resources? (For example, no meat, no vegetable, no fruit) 00=No ► Skip to Q.3 01=Yes	[__ __]
Q.2a	How often did this happen? 01 = Rarely (once or twice in the past four weeks) 02 = Sometimes (three times to ten times in the past four weeks) 03 = Often (more than ten times in the past four weeks)	[__ __]
Q.3	In the past four weeks, did you or any household member have to eat a **limited variety of foods** due to a lack of money/resources? (For example, only injera and 'shirowot' no vegetables or meat) 00=No ► Skip to Q.6 01=Yes	[__ __]
Q.3a	How often did this happen? 01 = Rarely (once or twice in the past four weeks) 02 = Sometimes (three times to ten times in the past four weeks) 03 = Often (more than ten times in the past four weeks)	[__ __]
Q.4	In the past four weeks, did you or any household member have to eat some **foods that you really did not want to eat** because of a lack of money to obtain other types of food? (For example, wild foods such as '*hamli*', immature crops, discarded food such as '*dirkosh*') 00=No ► Skip to Q.5 01=Yes	[__ __]
Q.4a	How often did this happen? 01 = Rarely (once or twice in the past four weeks) 02 = Sometimes (three times to ten times in the past four weeks) 03 = Often (more than ten times in the past four weeks)	[__ __]

Q.5	In the past four weeks, did you or any household member have to **eat less (portion size) meal** than you wanted because there was not enough food? 00=No ► Skip to Q.6 01=Yes	[__ __]
Q.5a	How often did this happen? 01 = Rarely (once or twice in the past four weeks) 02 = Sometimes (three times to ten times in the past four weeks) 03 = Often (more than ten times in the past four weeks)	[__ __]
Q.6	In the past four weeks, did you or any household member have **reduce the number of meals eaten** a day because there was not enough food? (For example skip breakfast or lunch) 00=No ► Skip to Q.7 01=Yes	[__ __]
Q.6a	How often did this happen? 01 = Rarely (once or twice in the past four weeks) 02 = Sometimes (three times to ten times in the past four weeks) 03 = Often (more than ten times in the past four weeks)	[__ __]
Q.7	In the past four weeks, was there ever **no food to eat** in your household because of lack of money/resources to get food? 00=No ► Skip to Q.8 01=Yes	[__ __]
Q.7a	How often did this happen? 01 = Rarely (once or twice in the past four weeks) 02 = Sometimes (three times to ten times in the past four weeks) 03 = Often (more than ten times in the past four weeks)	[__ __]
Q.8	In the past four weeks, did you or any household member **go to sleep at night hungry** because there was not enough food? 00=No ► Skip to Q.9 01=Yes	[__ __]
Q.8a	How often did this happen? 01 = Rarely (once or twice in the past four weeks) 02 = Sometimes (three times to ten times in the past four weeks) 03 = Often (more than ten times in the past four weeks)	[__ __]
Q.9	In the past four weeks, did you or any household member go a **whole day and night without eating** anything because there was not enough food? 00=No (questionnaire is finished) 01=Yes	[__ __]
Q.9a	How often did this happen? 01 = Rarely (once or twice in the past four weeks) 02 = Sometimes (three times to ten times in the past four weeks) 03 = Often (more than ten times in the past four weeks)	[__ __]

FIELDWORKER: Ask the following question ONLY for those whose answered Q.8=01 OR Q.9=01.

Q.10	Were the children in the household also affected? 00=No 01=Yes	[__ __]

Food Security (Household Dietary Diversity)

Say: Now I would like to ask you about the types of foods that you or anyone else in your household ate yesterday during the day and at night

Q.1	During the previous 24-hour period did you or any household member consume any of the following? (Include food you ate at home)	00=No 01=Yes
1	Any *injera*, or any other foods made from teff, millet, sorghum, maize, rice, or wheat?	[__ __]
2	Any pumpkin, carrots, squash, red or orange sweet potatoes?	[__ __]
3	Any potatoes, yams, taro, cassava or any other foods made from starchy roots or tubers?	[__ __]
4	Any dark, green, leafy vegetables such as cassava leaves, bean leaves, spinach, pepper leaves, taro leaves, and amaranth leaves?	[__ __]
5	Any other vegetables (onions, cabbage, tomatoes)?	[__ __]
6	Any ripe mangoes, ripe papayas?	[__ __]
7	Any other fruits (citrus fruit, bananas, cactus)?	[__ __]
8	Any liver, kidney, heart, or other organ meats?	[__ __]
9	Any other meat (beef, goat, lamb, chicken)?	[__ __]
10	Any eggs?	[__ __]
11	Any fresh or dried fish?	[__ __]
12	Any foods made from legumes such as beans, peas, lentils, or nuts?	[__ __]
13	Any cheese, yogurt, milk or other milk products?	[__ __]
14	Any foods made with oil, fat, or butter?	[__ __]
15	Any sugar, honey, sweets, sugary sweet drinks?	[__ __]
16	Any spices (black pepper, salt),condiments (sauces/awaze), coffee, tea, alcoholic beverages	[__ __]

Q2. Did you or anyone in your household eat anything (meal or snack) outside home yesterday?

00=No 01=Yes 77=NK [__ __]

Primary source of food procurement

Q.3	What is the primary source for obtaining the following?	01= Own production 02= Purchased 03= Borrowed 04= Food aid 05=gift from friends or relatives
1	Cereals (teff, sorghum, maize, or wheat)	[__ __]
2	Vegetables	[__ __]
3	Fruits	[__ __]

Q4. Do you think that crop diversification improves household food security?

00=No 01=Yes [__ __]

Q5. Do you think that crop diversification improves household nutrition security?

00=No 01=Yes [__ __]

Annex 2: Check list for FGD and Key Informants

Guidelines for Focus Group Discussions (FGDs)

1. What is the land holding situation of farmers in your kebele/*tabia*, example, average farm size, trend, e.t.c?
2. Is the land holding size a limiting factor for crop diversification?
3. Is labour shortage problem in the locality for farming activities?
4. What are the major crops grown in this locality?
    - Cereals, vegetables, fruits, etc.
5. What is the crop diversification practice (intercropping, crop rotation, etc.) in this locality?
6. Why farmers diversify their cropping activities?
7. What are the market related problems in your locality?
8. Do the existing market problems hinder you from production new varieties such as vegetables?
9. Do farmers in your locality devote most of their time to off-farm activities?
10. Do you get sufficient service from development agents (DAs)?
11. How do you evaluate the visit of DAs in your farm activities?
12. What are the major farm implements necessary?
13. Do you think that crop diversification improves household food security? How?
14. Do you think that crop diversification improves household nutritional security?
15. What are the major factors that hinder crop diversification activities in this locality?

Check lists for Key Informants Discussions (Woreda Experts)

1. Educational Background _____Qualifications_____
2. Role/responsibility _____

Farm Land

3. What is the average farm land size (in hectares) in the woreda?
4. How do you express the association between land size and crop diversification?
5. Do you think that the existing land holding size encourages crop diversification in the woreda?
6. What are the major crops (cereals, vegetables, fruits, etc) grown in this woreda?

Household Size

7. What is the average house hold size in the kebeles?
8. Are off-farm activities available in the localities?
9. Is labour shortage a problem for farmers to diversify their cropping activities?

Irrigation and Fertilizer utilization

10. What is the irrigation potential of the woreda?
11. Do you think that availability of irrigation facilities encourage crop diversification?
12. What is the fertilizer utilization practice of farmers in the woreda?

Livestock

13. Do you think that livestock holding affect crop diversification? How?

Market Access

14. Where do farmers sell their products?
15. Is there problem of market access for produces such as vegetables?
16. What is the average distance of the kebeles from the market center of the woreda?
17. Do you think that market access has an effect crop diversification practice?
18. Are there strategies related to crop diversification (or specialization) in the woreda? Which one is encouraged by the WOARD?
19. What are the major constraints for crop diversification in the woreda?
20. What do you suggest to increase crop diversification practice (such as production of vegetables) of farmers in the woreda?

Food Security

21. What is the level of food security in the woreda?
22. How do you measure food security in the woreda?
23. Do you think that crop diversification improves household food and nutrition security?
24. What do you suggest to increase the crop diversification practice of farmers in the woreda?

Check lists for Key Informants Discussions (Development Agents)

1. Educational Background _____Qualifications_____
2. Role/responsibility _____

Farm Land

3. What is the average farm land size (in hectares) in the *kebele/tabia*?
4. How do you express the association between land size and crop diversification?
5. Do you think that the existing land holding size encourages crop diversification in this community?
6. What are the major crops (cereals, vegetables, fruits, etc) grown in this *kebele/tabia*?

Household Size

7. What is the average house hold size in the *kebele/tabia*?
8. Are off-farm activities available in the localities?
9. Is labour shortage a problem for farmers to diversify their cropping activities?

Irrigation and Fertilizer utilization

10. What is the irrigation potential of the *kebele/tabia*?
11. Do farmers have access to irrigation facilities?
12. Do you think that availability of irrigation facilities encourage crop diversification?
13. What is the fertilizer utilization practice of farmers in the *kebele/tabia*?

Livestock

14. Do you think that livestock holding affect crop diversification? How?

Market Access

15. Where do farmers sell their products?
16. Is there problem of market access for produces such as vegetables?
17. What is the average distance of this *kebele* from the market center of the woreda or nearest town?
18. Do you think that market access has an effect crop diversification practice?

19. Are there strategies related to crop diversification (or specialization) in the *kebele*? Which one is encouraged by the woreda?
20. What are the major constraints for crop diversification in the *kebele*?
21. What do you suggest to increase crop diversification practice (such as production of vegetables) of farmers in the *kebele*?

Food Security

22. What is the level of food security in the *kebele*?
23. How do you measure food security in the *kebele*?
24. Do you think that crop diversification improves household food and nutrition security?
25. What do you suggest to increase the crop diversification practice of farmers in the *kebele*?

Annex 3: Variance Inflation Factor

Variable	VIF	1/VIF
oxen	2.16	0.463864
cdi	2.11	0.474907
sexhh	2.06	0.486243
landsize	1.63	0.614995
hhsize	1.58	0.634476
agehh	1.41	0.706787
dist_min	1.28	0.780931
educationhh3	1.15	0.866836
educationhh4	1.13	0.882902
educationhh2	1.03	0.973737
Mean VIF	1.55	