

Determinants of Rural Household Food Security in North Wollo Zone of Amhara Region, Ethiopia

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Abstract

Rural Ethiopians, who mostly depend on agriculture sector for their livelihood, have historically been characterized by food insecurity. The sector is confronted by numerous endogenous and exogenous problems, which adversely affect the food security status of rural people. This study assesses the determinants of household food security among rural households in the North Wollo Zone of Amhara Region, Ethiopia. Direct calorie intake, food consumption score, and coping strategy index were employed to measure the food security status of households. Longitudinal data on 192 households was obtained from the Ethiopia Socio-economic Survey, which was conducted by the Central Statistics Agency in collaboration with the World Bank. Descriptive statistics (such as mean, standard deviation, and percentages) and charts and frequency distribution tables were used to analyze and present the given data. A binary logit random effect model was employed to identify the determinants of food security. The results show that the percentage of food-insecure households has increased over time. Based on all food security indicators, the food security status of households decreased over the survey periods. The extent severity among food insecure households has also increased over the survey periods. The results of binary logistic random effect regression revealed that the household head's education, marital status, access to water, access to a toilet, fertilizer use, farm land size, irrigation, improved seed, tropical livestock unit, oxen ownership, and extension contact are positively and significantly correlated with the probability of being food secure, whereas family size, dependency ratio, shock, access to credit, and distance to the local market are negatively and significantly correlated. Continuous investment in education and rural development can help reduce household food insecurity.

Keywords: Coping strategy index, direct calorie intake, Ethiopia, food consumption score, food security, North Wollo, logit random effect model

1. Introduction

Food security has been a crucial topic within the broader domains of development economics and development studies. It is about ensuring that everyone has physical, economic, and social access to enough food that is safe, nourishing, and can suit their dietary needs and food choices in order to live a healthy life. International law recognizes the right to food as a fundamental human right that entitles people to adequate nutrition and the resources they need to enjoy food security over the long term (UN Office of the High Commissioner for Human Rights (OHCHR), 2010). However, the majority of the population in developing countries suffers from hunger and malnutrition. For instance, in 2021, between 702 and 828 million people experienced starvation. Since the COVID-19 pandemic outbreak, the population has increased by around 150 million, with 103 million more individuals between 2019 and 2020 and 46 million more in 2021. Likewise, the prevalence of undernourishment increased from 8.0 to 9.3 percent from 2019 to 2020, then increased at a slower rate to 9.8 percent in 2021 after being largely steady since 2015 (FAO, IFAD, UNICEF, WFP, 2022). Globally, 2.3 billion people were moderately or severely food insecure in 2021, with extreme food insecurity affecting 11.7 percent of the world's population (Ibid). In particular, hunger and malnutrition is severe, widespread, and persistent in sub-Saharan Africa. For example, in Africa, one in five persons (20.2 percent of the population) experienced hunger in 2021. Africa now has a 4.4 percentage point higher prevalence of undernourishment than it did prior to the introduction of the Sustainable Development Agenda in 2015 (Ibid).

Ethiopia is the second most populous country in sub-Saharan Africa and one of the largest countries in Africa. The highest density population distribution is found in the highlands of the north and middle of the country, with a tropical monsoon climate, characterized by wide topographic-induced disparities and highly variable rainfall. The majority of the population—more than 80%—lives in rural areas, which are still in the early phases of demographic transition and heavily reliant on smallholder agriculture as their main source of livelihood. These small farmers rely on traditional technologies and produce mostly for their own consumption. Famine vulnerability is high in Ethiopia with fast population growth, increasing pressures on land resources, increasing environmental degradation, and rising vulnerability to food shortages (World Fact Book, 2021). Drought and famine —the main drivers of both chronic and temporary

food insecurity—have plagued the nation on an ongoing basis. As a result of these circumstances, successive governments have developed rural development policies, strategies, and programs to address the problem. However, despite these programs and endeavors, Ethiopia has remained known for its poverty and food insecurity. For example, about 26 million people in the country are chronically food insecure (WFP and CSA, 2019).

Food insecurity in different parts of Ethiopia is still a serious problem and varies by ecological zone and administrative region. Amhara region has hosted the highest percentage of food insecure households (36.1 percent), followed by Afar (26.1 percent) and Tigray (24.7 percent) regions. Nearly 22.7 percent of rural households and 13.9 percent of urban households of the Amhara region are food insecure . North Wollo Zone (one of the ten zones of the Amhara Region) is among the chronically food insecurity and drought prone rural areas in the region. Most of the zone is mountainous, with steep slopes, which is not suitable for agricultural production and severely restricts the area of arable land. A survey of land shows that 47.3% of zone's land is degraded or unusable, 24% is arable land, 17.4% is shrub-land, 4.6% pastureland, 0.37% is forest land, and the remaining 6.33% is utilized for other uses . The zone suffers from repeated droughts and famines, and is actually marked as the center of the Wollo drought. Rural households are mostly confined to production of a few rain-fed crops and use traditional methods of cultivation with limited utilization of agricultural inputs. Non-farm economic activities are narrow and offer inadequate employment opportunities. Climate change (which triggered erratic rainfall), rapid population growth, land fragmentation, soil erosion, poor infrastructure (mainly road and transport facilities) are among the key problems that adversely affected agricultural production and productivity, and so food security status of the rural people. The problem of chronic food security is enormous and deep-rooted in the zone, as elsewhere in Amhara regional state that requires a systematic and in-depth studied.

A number of studies have been undertaken in different parts of Ethiopia, including Amhara region on determinants of food security. For instance, household education status, sex of household head, family size, family labor, health condition, farmland size, farm oxen, livestock ownership, off-farm income, farm implements, access to the market, farm inputs, crop diseases, access to credit, service of agricultural extension workers, and rainfall distribution are reported as the main determinants of food security (Agidew & Singh, 2018; Abafita & Kim , 2014; Arega,

2013; Tibebe; Sisay, 2017). However, to our knowledge, some of the most important determinant variables (such as aid and shocks), which could affect rural household food security are not included in the empirical models. Besides, unlike our study that used longitudinal data, the majority of the previous studies have employed cross-sectional data to identify the status and determinants of household food security. Food security is a dynamic issue. For example, a household may become food secure, chronically or temporarily food insecure during different periods of time. Longitudinal data often provides rich information on the studied variables, reveals dynamic relationships, and enables researchers to correctly measure variability and statistical effects. Moreover, detailed and systematic studies regarding the determinants of rural households' food security are scarce in the study area. This study therefore aims at filling knowledge, empirical, and methodological gaps (mentioned above) based on actual evidence concerning the status and determinants of food security in North Wollo using panel data.

This article tries to answer the following questions: what is the status of rural households' food security in the study area? What are the key determinants of households' food security in the study area? The rest of the article is structured as follows. The next section presents a brief review of related literature. Research methodology, including the specification econometric model, is presented in section three. The results and discussion are presented in Section four. The final section offers some concluding remarks and policy implications.

2. Brief review of related literature

This section presents conceptual issues, theoretical context and summary of empirical literature, and conceptual framework that guided the study.

2.1. Conceptual issues

The concept of food security has grown and changed over time. To understand and capture the issue at the individual, household, community, and national levels, various definitions of food security have been introduced and used by different scholar. The need to produce more food and to distribute it more efficiently was the main topic of concern regarding food security up to the middle of the 1970s. The concept has evolved over time to include a variety of elements that can affect malnutrition (in all its manifestations), spanning the entire food system and, in certain applications, including acknowledgement of the significant social and cultural role that food

plays. The most commonly used definition is the one that says "Food security exists when all people, at all times, have physical and economic access to sufficient, safe, and nutritious food that meets their dietary needs and food preferences for an active and healthy life" . At the household level, food security is often conceptualized as the ability of a household to guarantee all of its member's sustained access to a sufficient quantity and quality of food to live an active and healthy life . We adapt this definition given that a household is the main subject of our investigation. Generally speaking, a household is food secure when all of its members have access to food that is adequate in terms of quality, quantity, safety, and cultural acceptability and when it is not at a danger of losing such access (Yadav, 2013).

The definition of food security contains four dimensions or pillars: availability, access, utilization, and stability. Food availability is the supply side of food security and is determined by the physical presence of food in a particular country, place, or household through domestic production, import, or donation. It can be influenced by agricultural production knowledge, climate change, technologies, policies, demographic patterns, prices, etc. (Hannah, 2013). On the other hand, access to food is on the demand side of food security, which is the ability of people to obtain food through purchases, gifts, or transfers. This is determined by overall household income and employment, food prices, physical access to the market, and infrastructure availability and quality (FAO, 2006). Food utilization includes the human ability to obtain full biological benefits from food based on food safety, quality, and variety, health care, and hygiene. Food stability spans all three dimensions and exhibits variability and uncertainty in availability, access, and utilization (FAO, 2006; Thompson, Berrang-Ford, and Ford, 2010).

2.2. Empirical review

Several studies have examined determinants of household's food security in Ethiopia. Almost all of the studies have employed cross sectional survey data (see Table 1).

Table 1: An overview of some empirical studies on determinants of rural household food security in Ethiopia

Source	Study area	Purpose	Data type	Methods and food security measurement	Major results
Agidew & Singh (2018)	Amhara region, South Wollo Zone, Teleyayen sub-watershed	To evaluate the determinants of food insecurity in the rural farm households of Teleyayen sub-watershed	Cross-section	Binary Logistic Regression Household Food Balance Model (and finally Food Energy Intake)	The results of the binary logistic regression showed that the major factors that negatively affect the food security status of rural households were related to lack of farmland, poverty, recurring droughts, climate change, lack of rainfall, and land degradation.
Tsegamariam and Wakjira (2018)	Woliso Woreda, Western Ethiopia	To identify the main determinants of food insecurity rural household and its coping up mechanisms	Cross-section	Probit Model Household Calorie Intake	The study finds that ceremonial expense, livestock, dependency ratio, educational level, and pesticide use significantly affect the food insecurity status of rural households.
Tibebu and Sisay (2017)	Amhara region, North Wollo Zone	To examine the determinants of food security in North Wollo Zone	Cross-section	Logit Regression Model Household Calorie Intake	According to the study, the major determinants of food security are the age of the household head, dependency ratio, average monthly expenditure, non-farm income, family size, distance from input

					market, farmland size, number of oxen, and livestock ownership.
Mohammed (2016)	Gubalafto District of Amhara Regional State, Ethiopia	To assess the determinants of rural household food security and child nutrition	Cross-section	Logit Regression Model Direct Calorie Intake (DCI), Household Food Access Scale Indicator (HFASI), Food Consumption Score (FCS) and coping Strategy Index (CSI)	The findings revealed that the educational level of the household head, the number of livestock, agricultural technology, access to protected water, and PSNP benefits were positively and significantly correlated with the probability of being food secure, whereas household size, dependency ratio, access to credit, distance to market, and crop diversification index (as monoculture tends to be) were negatively and significantly correlated with the probability of being food secure.
Misgina (2014)	Laelaymychew Woreda of Tigray Region, Ethiopia	To assess status of household food security and its determinants	Cross-section	Logit Regression Model Household Calorie Intake	The study has shown that total cultivated land holding size, total livestock holding, total annual income per AE, and use of chemical fertilizer were positively related to food security. But the family size of the household was found to be

					negatively related.
Abafita & Kim, (2014)	Ethiopia (national level)	To examine the determinants of food security among rural households in Ethiopia	Cross-section	OLS regression and Instrumental variable (IV) Self-reported food security status and Multidimensional index generated based on Principal component Analysis	The study results show that age and education of the household head, adequacy of rain fall, livestock possession, participation in off-farm activities, soil conservation practices, and per capita consumption expenditure were strongly and positively related to household food security, while access to credit and remittance had a negative influence.
Mequanent, Birara and Tesfalem (2014)	Mana Woreda of Jimma zone, Oromia region, Ethiopia	To analyze determinants of household food security in Mana woreda of Jimma zone	Cross-section	Logit Regression Model Household Calorie Intake	The findings show that the educational status of the household head, family size, farm input use, and the number of oxen owned by households are all significant determinants of food security in the study area.
Wali and Penporn (2013)	Jigjiga District of Somali region, Ethiopia	To identify determinants of rural household food security in the	Cross-section	Logit Regression Model Household Calorie Intake	The results have shown that total household income, fertilizer use, extension service, access to credit, and veterinary service were found to have positive influences, while agro-

		Jigjiga district of Ethiopia			ecology affected the food security of the households in lowland negatively.
Mitiku, Fufa & Tadese (2012)	Shashemene district of Oromia regional state, Ethiopia	To the status and determinants of rural households' food security in Shashemene district of Oromia regional state, in Ethiopia.	Cross-section	Logit Regression Model Household Calorie Intake	The results showed that family size, cultivated land size, total farm income, off-farm income, and livestock ownership of households had a significant influence on household food security status.
Ramakrishna & Demeke (2002)	Amhara region, North Wollo Zone		Cross-section	Logit Regression Model Food balance sheet and an aggregate household food security index	The findings showed that per capita land holding, cereal production, livestock sub-sector, education, and fertilizer application are important factors in ensuring food security for households, while family size of households has influenced food insecurity positively.

As indicated in the introduction section, previous studies have relied on cross-sectional data, thus limiting more robust analysis of determinants of rural household food security. To understand the food security situation of rural households and the factors affecting their food security (which are dynamic over time) requires longitudinal (panel) data. Rural food security is not static and is not only determined by household-level factors. Rather, it is very dynamic and greatly affected by various community, physical, and environmental factors. This study, therefore, has attempted to fill this gap by using panel data.

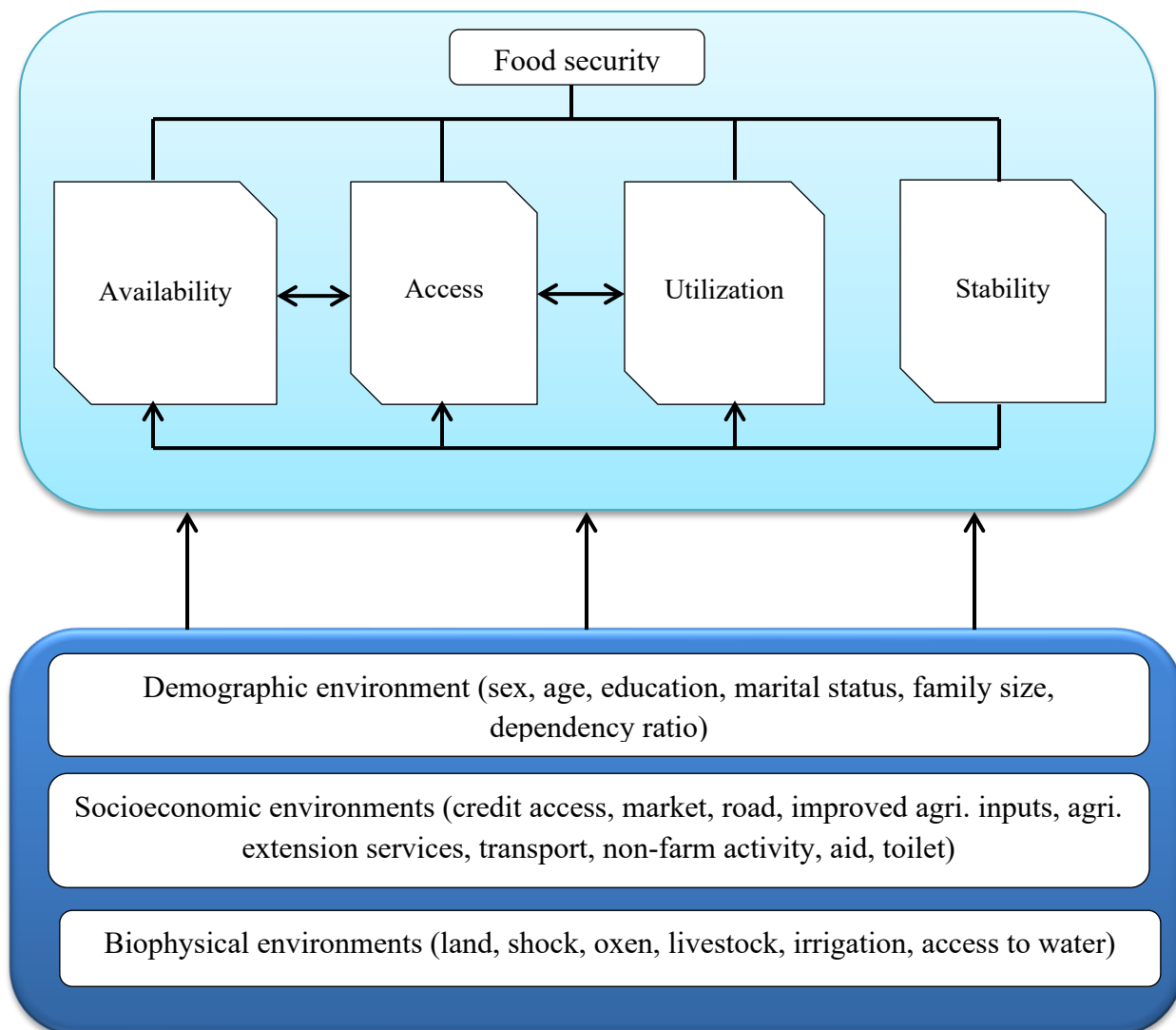
2.3. Conceptual framework

The ability of a farmer to ensure food security is influenced by a number of factors, which are rooted in demographic, socioeconomic, political, and biophysical environments (Figure 1). For example, demographic structure, ownership or access to a wide range of resources, including land ownership, farmer's income, farm size, educational attainment, credit availability, social networks, coping and adaptation techniques, and institutional (political) factors such as policies and regulatory frameworks could significantly affect food security at the household level. Household food security can also be affected by a variety of natural causes, such as hailstorms, droughts, land degradation, and changes in rainfall patterns (Khoshnodifar, 2012).

The amount of food produced, imported, exchanged; the prices of food and households; purchasing capacity; nutritional status and working capacity of families related to health care and food safety determine household food security status. The supply side of food through improved technologies results in food availability and security at national and household level. The availability of rainfall, assets owned, and the government's strategies and programs determine the availability of food. Accessibility of food, on the other hand, is not only determined by the availability of food, but also by households' purchasing capacity and the means (such as transport and markets) to acquire it. This is because food availability alone cannot bring household food security unless the distribution and purchasing capacity of households are improved. Thus, if one of the components is in short supply, the food security status of households might be affected, and households might be exposed to food insecurity. For example, FAO (1997) indicated that to achieve food security, a country must attain three basic goals: ensure adequacy of food supplies in terms of quantity, quality, and variety of food; optimize stability in the flow of supplies; and secure sustainable access to available food and nutritious supplies for all who need it. In other

words, the importance of access to food may not displace earlier concerns about adequate food availability, or even if people have money, if there is no food available at the market, people are at risk of food insecurity (Gervais et al., 2003). This showed that the three pillars were hierarchical in nature, that is, food availability being necessary but insufficient for access and access being necessary but insufficient for utilization (Webb and Rogers, 2003; Gervais, Bryson, and Freudenberger, 2003). Food stability spans all three dimensions and exhibits variability and uncertainty in availability, access, and utilization.

Figure 1: Conceptual framework



Source: own construction based on literature

In particular, external or unpredictable events or shocks (in the biophysical environment) can undermine households' livelihoods and cause them to fall into chronic and transitory food insecurity. In this regard, increasing temperatures, decreasing rainfall, and the erratic nature associated with meteorological, agricultural, and hydrological droughts affect households' food security status. Unsustainable livelihoods that damage the environment, such as deforestation, land degradation, and unprotected farming could increase local weather variability in the short-term and contribute to climate change scenarios in the long-term. Among the livelihood portfolios, traditional rain-fed agriculture is the first to be affected by climate change/variability and drought in the study area. The problem is compounded because non-farm activities that can be used as mitigation strategies for the rural poor at times of food crises are the least developed in the study area. In addition to demographic and socioeconomic factors, household educational attainment plays a critical role in mitigating climate change impacts through their skills and abilities.

3. Materials and methods

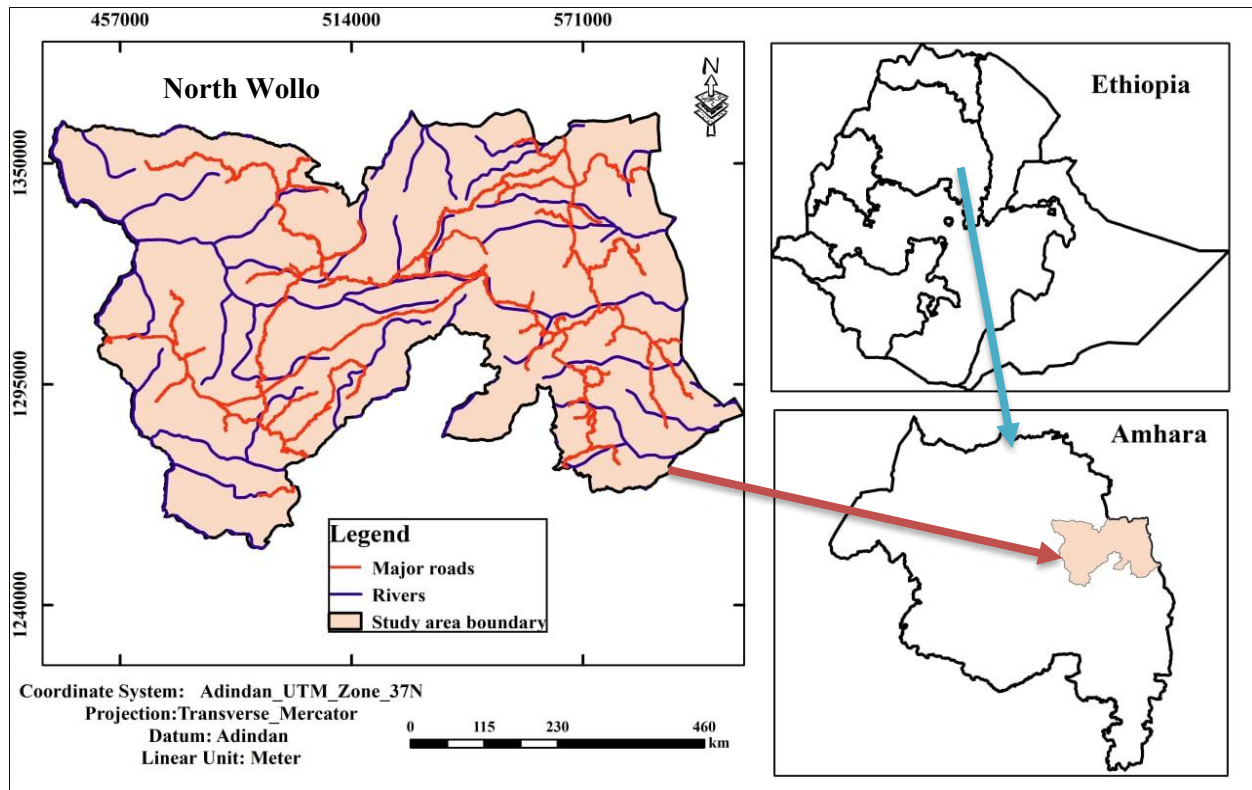
3.1. Description of the study area

The North Wollo administrative zone is one of the 12 zones of the Amhara Regional State of Ethiopia. North Wollo acquired its name after the former Wollo province was divided into north and south. It is in the northern part of the country and is geographically located at 11°50'N 39°15'E and 11.833°N 39.250°E. It is bordered on the north by Wag Hemra, on the south by South Wollo, on the east by Afar Region State, on the west by South Gondar, and on the northeast by Tigray Regional State. Part of its southern boundary is demarcated by the Mille River. The zone has an estimated area of 12,172.50 square kilometers (km), which is about 20 per cent of the region. The administrative zone has eleven *Woredas*¹. Its administrative town, Woldia, is located 380 km north-east of Bahir Dar and 521 km north of Addis Ababa. The altitude of the zone varies from 600 to 4284 meters above sea level (m.a.s.l). The North Wollo administrative zone has four agro-ecological zones, namely, lowland (Kolla) 500-1500 m.a.s.l. 38%, mid-altitude (Woina-Dega) 1500-2300 m.a.s.l is about 34%, Highland (Dega) 2300-3200 m.a.s.l is about 21%, and Wurch >3200 is about 7 % of the zone (Mohammed, 2016). According

¹ Woreda is the fourth level of government administration in Ethiopia's governance system.

to the 2007 census, the zone has a total population of 1,500,303 in a total of 355,974 households. The average person per household is 4.21. Only 10.35% of the population is urbanized.

Figure 2: Study Area



Source: Central statistics Agency, 2018.

3.2. Research method and data

Its administrative town, Woldia, is located 380 km north-east of Bahir Dar and 521 km north of Addis Ababa. The altitude of the zone varies from 600 to 4284 meters above sea level (m.a.s.l). The North Wollo administrative zone has four agro-ecological zones, namely, lowland (Kolla) 500-1500 m.a.s.l. 38%, mid-altitude (Woina-Dega) 1500-2300 m.a.s.l is about 34%, Highland (Dega) 2300-3200 m.a.s.l is about 21%, and Wurch >3200 is about 7 % of the zone (Mohammed, 2016). According to the 2007 census, the zone has a total population of 1,500,303 in a total of 355,974 households. The average person per household is 4.21. Only 10.35% of the population is urbanized.

3.3. Sampling procedures and sample size

Three-stage sampling procedures were used. In the first stage, the North Wollo zone was selected purposefully because it is one of the most food insecure zones in the region. The second stage comprises choosing sampling units or CSA enumeration areas (EAs). EAs were selected based on a probability proportional to the size of the total EAs in the region. In order to ensure a sufficient sample size in the most populous regions, quotas were set for the number of EAs in the region. And so, 16 EAs were covered in 2012, whereas 19 each were addressed in 2014 and 2016 (Table 1). In the third stage, a total of 12 households were sampled from each EA. Of these, 10 households were randomly selected from the sample of 30 agricultural sample survey (AgSS) households. AgSS households are households that are involved in farming or livestock activities. The remaining 2 households were randomly selected from all other households in the rural EA (those who were not involved in agriculture or livestock). In some EAs, there is only one or no such household, in which case fewer than two non-agricultural households were surveyed and more agricultural households were interviewed instead, so that the total number of households per EA remains the same. In all rounds, all sampled households were not addressed. Therefore, households found in all rounds were filtered from the dataset and taken as panel data. It was aimed at obtaining information about the dynamics of rural household food security status and its determinants that could not be observed in pure cross-sectional or pure time-series data. And thus, from the total of 228 surveyed rural households in the zone, 192 households that persisted in all rounds were considered for this study.

Table 1: Sample size

Study Area	Survey Year					
	2012 (wave1)		2014 (Wave2)		2016 (Wave3)	
North Wollo Zone	EA	HH	EA	HH	EA	HH
	16	192	19	228	19	228

Source: CSA and WB, panel sample survey 2012, 2014 and 2016 year.

3.4. Methods of data analysis

3.4.1. Household Food Security Measurement

As explained above, food security is a multidimensional issue which cannot be addressed by a single indicator. This article employs three indicators: Direct Calorie Intake (DCI), Food

Consumption Score (FCS), and Coping Strategy Index (CSI) to at least capture some of the dimensions (such as availability, utilization, and stability). DCI, FCS, and CSI are often used to measure food availability and utilization and vulnerability to food insecurity.

Direct Calorie Intake (DCI)

DCI often takes into account the amount of food consumption found through its own production, purchases, gifts, or assistance. These can then be converted to kilocalories using the appropriate conversion factors for comparison against household/individual energy requirements. The following steps were performed to estimate the equivalent kilocalorie consumption per adult.

- i. Total consumption of food should be determined by:

$$C_i = P_i + D_i \dots\dots\dots(3.1)$$

Where C_i = total consumption of food by households

P_i = consumption of purchased food

D_i = consumption of own production and /or donation

- ii. The different types and quantities of foods consumed by a household were converted to calories using the calorie equivalent.
- iii. The costs of children relative to adults and the extent of economies of scale are fundamental in household welfare analysis . To know the inter-personal variation in consumption, the study employed the standard approach which computes the adult equivalent household size (H_i) (Deaton, 1999; Banks and Johnson, 1998) given as:

$$H_i = (A + \gamma C)^\theta \dots\dots\dots(3.2)$$

Where A = number of adult members

C = number of children

γ = the cost of children relative to adult

θ = household economies of scale

γ and θ are parameters, each of which lies between 0 and 1. The study assigned a value of 0.5 and 0.95 for γ and θ respectively in common with comparable studies in similar contexts.

- iv. The food consumed per adult equivalent is derived by dividing the total consumption of food by adult equivalent household size.

$$Y_i = X_i / H_i \dots\dots\dots(3.3)$$

Where Y_i = total food consumed per adult equivalent units

X_i = total consumption of food

H_i = adult equivalent household size for i^{th} household

Finally, taking a threshold of 2,200 calories of recommended daily allowance per adult equivalent (R) as used by World Health Organization (WHO) and Government of Ethiopia (GoE), households who consumed greater than 2,200 calories is considered as food secure, if not, then as food insecure.

$$HFS_i = \begin{cases} 1, & Y_i \geq R \text{ (Food secure)} \\ 0, & Y_i < R \text{ (Food insecure)} \end{cases} \dots\dots\dots(3.4)$$

Where Y_i daily per capita calorie available (supply); R is the minimum recommended national standard rate of calories per person per day, which is 2,200 calorie (i.e., demand) and HFS_i food security status of the i^{th} household.

The various indices of food security (f_a) were computed using the following formula:

$$f_a = \frac{1}{n} \sum_{j=1}^q \left(\frac{R - X_i}{R} \right)^a, a = 0, 1, 2 \dots\dots\dots(3.5)$$

Where R = recommended daily allowance of calories per adult equivalent of 2,200,

X_i = consumption of household per adult equivalent,

q = number of households below the R,

n = total number of sampled households,

$\alpha = 0, 1, 2$. When we set α equal to 0, 1, and 2 we obtain f_0 , f_1 and f_2 which measures the head count /incidence, food gap and severity respectively.

Food Consumption Score (FCS)

This indicator was developed by the World Food Program (WFP). It takes into consideration the diversity, quantity, and adequacy of food consumption. It is a frequency-weighted dietary diversity score, calculated using the frequency with which a household consumed eight food groups (staples (2), pulses (3), vegetables (1), fruits (1), meat/fish/egg (4), milk (4), sugar (0.5) and oil (0.5) with a 7-day recall from the date of the survey (WFP and CSA, 2019). The frequency of food consumption should not be more than seven, which is equal to the number of the recall period. Each food consumption frequency is multiplied by its weights (given in parentheses above) and then summed to create the FCS. The score ranges from 0 to 112, "0" when a household didn't consume any food in the last 7 days, and "112" when a household consumed each food group all days for the last 7 days. In FCS, there are two types of cut-off that determine the status of food security depending on the frequency of consumption of oil and sugar in society. If consumption of oil and sugar is proportional or positively correlated with other categories of food, 21 and 35 were used as a threshold to determine the food security status. FCS below 21 is considered poor, above 35 is acceptable, and between 21 and 35 is borderline. However, this can be raised from 21 and 35 to 28 and 42 if populations, in the case of sugar and/or oil, are frequently consumed among nearly all surveyed households (WFP, 2008). In the study area, consumption of oil and sugar was not frequent in the surveyed households. Therefore, the 21 and 35 thresholds were selected to determine the status of household food security status based on FCS.

Coping Strategy Index (CSI)

When livelihoods are negatively affected by a shock or crisis, households may adopt various mechanisms (strategies) that are not adopted in normal day-to-day life, to cope with reduced or declining access to food. CSI is often used as a proxy indicator to measure household food insecurity (vulnerability to food insecurity). CSI is based on a list of behaviors (coping strategies). It combines: (i) the frequency of each strategy (how many times was each strategy adopted?); and (ii) their (severity) (how serious is each strategy?) for households reporting food consumption problems (WFP, 2012). A higher CSI indicates a worsening food insecurity situation and vice versa. This study used eight selected relevant behavioral or coping strategies based on the available secondary data specific to the study area. Households were asked about how often they used a set of eight short-term food-based coping strategies in situations in which

they did not have enough food, or money to buy food, during the one-week period prior to the interview. The information is combined into the CSI, which is a score assigned to a household that represents the frequency and severity of coping strategies employed.

First, each of the eight strategies is assigned a standard weight based on its severity. These weights are: relying on less preferred and less expensive foods (=1.0); limiting the variety of foods eaten (2.0); limiting portion size at meal times (=1.0); reducing the number of meals eaten in a day (=2.0); restricting consumption by adults for small children to eat (3.0); borrowing food or relying on help from relatives or friends (=2.0); having no food of any kind in your household (2.0); going a whole day and night without eating anything (4.0) (WFP, 2012; WFP and CSA, 2019). Household CSI values are then obtained by multiplying the number of days in the previous week. Each strategy was employed by its corresponding severity weight, and then summed together to get the totals (WFP, 2012). Based on the country's context and as internationally recommended, the total CSI score is the basis to determine and classify the level of coping into three categories: no or low coping (CSI = 0-2), medium (CSI = 3-12); and high coping (CSI ≥13) (Maxwell, 2012).

3.5. Empirical model

Our outcome variable of interest, household food security status, is a dichotomous variable which takes the value of 1 if the household is food secure and 0 otherwise. Thus, the conditional probability that a household is food secure given the X set is denoted by $p(y = 1 / X) = p_i$. the expression p_i has the form:

$$p(y_i = 1 / X) = p_i = \frac{e^{(\beta_0 + \beta_1 x_1 + \dots + \beta_p x_k)}}{1 + e^{(\beta_0 + \beta_1 x_1 + \dots + \beta_p x_k)}} = \frac{1}{1 + e^{-X\beta}} \dots \dots \dots (3.6)$$

Where p_i stands for the probability of household i being food secure, y_i is the observed food security status of household i, $\beta \sim (p + 1) \times 1$ is a vector of unknown coefficients. The logarithmic transformation of equation (3.6) yields the logit regression model which is given as:

$$\text{logit} \left(\frac{P_i}{1 - P_i} \right) = \beta_0 + \beta_1 x_1 + \dots + \beta_p x_k = X\beta \dots \dots \dots (3.7)$$

A binary logistic regression model can be fitted to longitudinal data (Chamberlain, 1980; Hsiao, 2006; Teshager, 2019). Often, our outcome variable (household food security status) depends on

unobserved factors, which may also correlate with our explanatory variable of interest. In case these overlooked variables are invariable over time, we can use panel data estimators to reliably assessment the effect of our independent variable. This study uses panel data analysis and panel data estimation to control the heterogeneity of cross-section units in households over time. Panel data estimation considers all cross-section units as heterogeneous, which helps to get an unbiased estimation. There are time invariants and household invariant variables. As Baltagi (2001) stated, compared to pure cross-section and time series, panel data estimation is better to identify and measure effects of independent variables on dependent variables, which we cannot measure using time series and cross-section data. In addition to this, panel data give more informative data, more variability, less collinearity among the variables, a greater degree of freedom, and more efficiency. It is also a better estimation method to study the duration of economic states and the “dynamics of change” over time (Baltagi, 2001). The general form of longitudinal data Binary logistic regression model for this study is:

$$y_{it} = \log\left(\frac{P_i}{1-P_i}\right) = \alpha + x'_{it}\beta + z'_i\gamma + c_i + u_{it}, \quad t = 1, 2, 3, \quad i = 1, 2, 3 \dots 192. \quad (3.8)$$

Where P_i = the probability that the household is categorized as food secured and y_{it} is the outcome of household food security status, x'_{it} is k- dimension row vector of time varying explanatory variables and z'_i is a M-dimensional row vector of time-invariant explanatory variables excluding the constant, α is the intercept, β is a K-dimensional column vector of parameters of x'_{it} , γ is a M-dimensional column vector of parameters z'_i , c_i is an household-specific effect and u_{it} is an idiosyncratic error term.

The Fixed Random (FR) model

The household-specific effect is a random variable that is uncorrelated with the explanatory variables in the random effects model. The justification behind the random effects model is that, incongruent with the fixed effects model, the variant across units is supposed to be random and unassociated with the predictor or independent variables included in the model. When we have reason to believe that differences across entities have some influence on our dependent variable, then we should use random effects. An advantage of random effects is that one can include time-invariant variables (Reyna, 2007). In the fixed effects model, these variables are absorbed by the intercept. The random effects model for this study can be written as:

$$y_{it} = \log\left(\frac{P_i}{1-P_i}\right) = a + x'_{it}\beta + z'_i\gamma + v_{it}, t=1, 2, 3, i=1, 2, 3 \dots 192. \quad (3.9)$$

Where $v_{it} = c_i + u_{it}$. Random effects assume that the error term is not correlated with the predictors, which allows for time-invariant variables to play a role as explanatory variables. In random effects, you need to specify those individual characteristics that may or may not affect the predictor variable. The problem with this is that some variables may not be available, thus leading to a bias of omitted variables in the model. RE allows generalized inferences from the data used in the model (Reyna, 2007).

The Fixed Effects (FE) Model

When using FE, we assume that something within the individual may influence or bias the predictor or outcome variables, and we need to control this. The assumption is that the error term and the predictors are causally connected. FE removes the effect of time-invariant factors so that the net effect of predictor variables on the outcome can be assessed. The household-specific effect is a random variable that can be correlated with the explanatory variables in the fixed effects model (Baltagi, 2001; Reyna, 2007). Subtracting time averages $\bar{y}_i = \frac{1}{T} \sum_t y_{it}$ from the initial model:

$$y_{it} = \log\left(\frac{P_i}{1-P_i}\right) = a + x'_{it}\beta + z'_i\gamma + c_i + u_{it}, \text{ yields the within model } \ddot{y}_{it} = \ddot{x}'_{it}\beta + \ddot{u}_{it} \text{ where } \ddot{y}_{it} = y_{it} - \bar{y}_i, \ddot{x}_{itk} = x_{itk} - \bar{x}_{it} \text{ and } \ddot{u}_{it} = u_{it} - \bar{u}_i \dots\dots\dots (3.10)$$

Another important assumption of the FE model is that those unchanging characteristics of time are unique to the individual and should not be linked to other individual characteristics. Each entity is unique. Therefore, the subject's error terms and constants (capturing individual characteristics) should not be correlated with other terms. If the error terms are correlated, then the model may not be suitable since inferences may not be correct. You may need to model that relationship (probably using a random-effects model). The Hausman test is a common tool used to evaluate the statistical significance of data. It is based on the assumption that data can be explained by a model that includes only a few explanatory variables.

Hausman-test for endogeneity

In this study, we tried to determine which model (random effect or fixed effect) to use to present the results of the regression analysis. To show the influence of variables that affect the food

security status of households, the null hypothesis is that the preferred model is random effects vs. the alternative, fixed effects. It basically tests whether the unique errors (u_i) are correlated with the regressors; the null hypothesis is that they are not.

Description and Measurement of Variables

The dependent variable for this study was household food security. Household food security status is a dichotomous variable, taking the value of 1 if the household is food secure and 0 otherwise. It was hypothesized to be a function of the independent variables summarized in Table 2.

Table 2: Summary of predictor variables and expected signs

Variable code	Description and measurements	Expected sign
SexHH	Is a dummy variable taking the value 1 if the house hold head is male, 0 otherwise	+
AgeHH	It is a continuous variable, age of household head (years)	+
EduHH	Is a dummy variable taking the value of 1 if the household heads are literate, 0 otherwise	+
Marital status HH	it is a categorical variable 1 if household head is never married, 2 if married, 3 separated, 4 divorced and 5 windowed	-
HHsize	Family size of the households in Adult Equivalent (AE)	-
Dratio	it is continuous variable number of children under 15 and older people 65+ divided by active household members	-
Access to Water	Dummy: 1 if safe water is availability within 0.5Km, otherwise 0.	+
Access to toilet	Dummy: 1 if private/shared pit is available, otherwise 0.	+
Flsize	It is continuous variable, the size of land household owned in a hectare	+
Irrigation	Dummy: if households irrigated their own consumption 1, otherwise 0	+
Fert	Dummy: assumes 1, is household uses fertilizer, 0 otherwise.	+
Imprseed	Dummy: 1 if households used improved seed during the agriculture season, 0 otherwise	+
Agrextse	It takes dummy values 1, if the household has access to agricultural service, 0 otherwise.	+
Off-farm	Dummy: 1 if income gained other than farming e.g. employment, petty trade etc. Otherwise 0.	+
Oxen	It is continuous variable, number of oxen households have in the <i>Meher</i> season.	+
TLU	It is a continuous variable, Tropical Livestock Unit, measures total number livestock's.	+

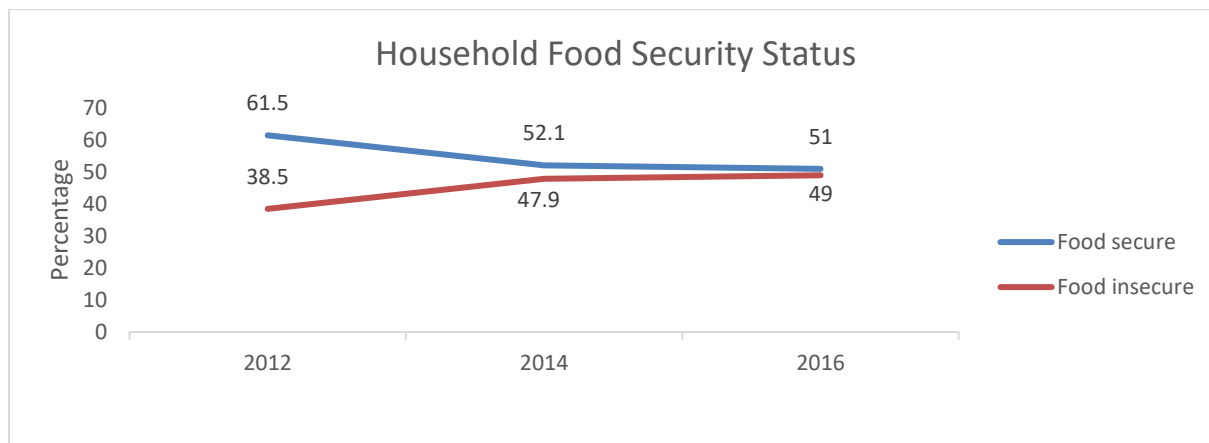
Shock	It is aggregate sum of degree of impact of shock, 1 if household affected by any shock. 0 otherwise	-
DistR	It is continuous variable, distance to the main road in kilometers	-
DistM	It is continuous variable, distance to the nearest market measured in kilometers	-
Credit	Dummy: 1 if household gain credit services. Otherwise 0.	+
Aid	Dummy: 1 if households benefit received in birr from PSNP or others through public work and direct support	+

4. Result and Discussion

4.1. Food Security Status of Rural Households

The DCI is one of the food security indicators used to capture food availability or food energy deficiency. The results indicated that 38.5%, 47.9%, and 49% of households consumed less than the minimum daily food consumption requirement of 2,200 calories during the survey time (Figure 2). This implies that the food insecurity status of rural households has increased over the survey periods in the study area.

Figure 2: Food Security Status Based on Direct Calorie Intake



Source: Author's calculation from LSMS data, 2022

Different food security decompositions/indices were estimated based on the Foster–Greer–Thorbecke (FGT) decomposition method with a threshold of 2,200 kcal per adult per day. The widely used FGT indices are count ratio, prevalence, and severity ratio. Using the 2,200-kcal threshold, the head count ratios were 0.3854, 0.4791, and 0.4892 over time, respectively (Table 3). In other words, 38.5%, 47.9%, and 49% of the sample households lived with food energy deficits or food insecurity over the survey periods. They did not consume the minimum calories

needed to stay healthy and maintain regular physical activity. However, the head count ratio does not indicate the extent of food security. It can be captured by the prevalence or gap index. In the study area, the gap index was estimated to be 0.13, 0.147, and 0.1527, respectively, which indicates the average proportionate food insecurity gap in the population over time. The gap index figure has an important implication for policymakers and development actors, since it shows how much resources are required for those food insecure households to bring them to their minimum food energy intake and become food secure. However, it does not show the extent of inequality among insecure households. The inequality among the food insecure can be captured by the square gap/severity index, which was found to be 0.061, 0.064, and 0.070, respectively, during the survey periods.

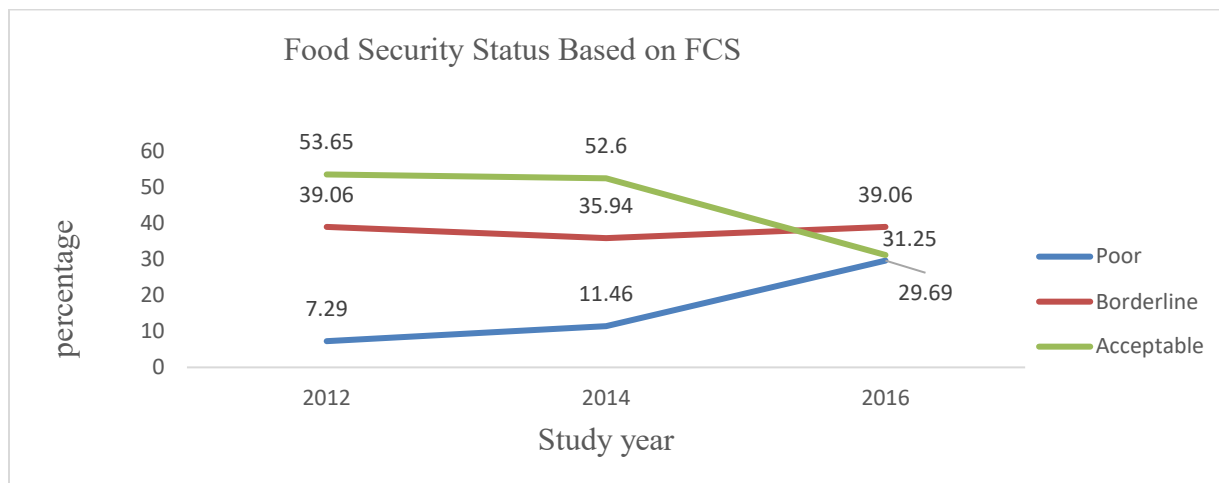
Table 3: Foster–Greer–Thorbecke (FGT) Food Security Indices

Food Security index	Below 2200 cal.		
	2012	2014	2016
Head Count	0.3854	0.4791	0.4892
Prevalence or gap	0.1258	0.1478	0.1527
Severity	0.0608	0.0638	0.0704

Source: Author's calculation from LSMS data, 2022.

Figure 3 shows the household food security situation as measured by the FCS. The results show that an acceptable consumption FCS score (greater than 35) was observed over the survey periods. However, the findings have shown that the proportion of households with an acceptable level of FCS has decreased from where it was 53.65% in 2012 to 52.6% in 2014 and 31.25% in 2016. Likewise, the proportion of households with a poor level of FCS increased from 7.29% in 2012 to 11.46% and 29.69% in 2014 and 2016. The implication of this result is that household food security status declined during the survey periods.

Figure 3: Food Security Status of households Based on Food Consumption Score (FCS)

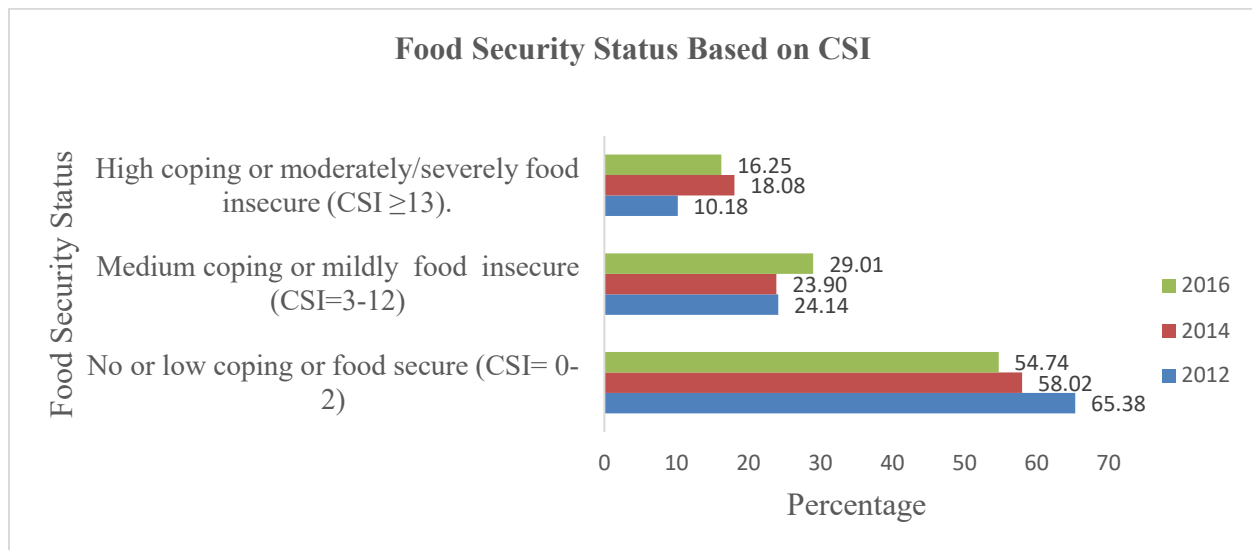


Source: Author's calculation from LSMS data, 2022.

As far as CSI is concerned, the indicator is based on the short list of 8 food-related coping strategies applied during the past 7 days prior to the survey, and the same severity weights. There are no universal thresholds for CSI. But the higher the CSI, the more severe the coping is applied by a household. However, we have adapted the classification developed by Maxwell et al. (2012) based on their study in the Tigray region of northern Ethiopia. Maxwell et al. (2012) considered a CSI score of 0 to 2 as food secure; 3 to 12 as mildly food insecure; and 13 or higher as moderately/severely food insecure. As indicated in Figure 4, the food security status of households decreased over time in the study area. For example, the proportion of food-secure households decreased from 65.38% in 2012 to 58.02% and 54.74% in 2014 and 2016. In contrast, the percentage of moderately/severely food insecure households has increased from where it was 10.18% in 2012 to 18.08% in 2014 and 16.25% in 2016 (Figure 4).

Respondents were asked to identify the months in which they faced food shortages in the past 12 months. Figure 5 presents the percentage of households that reported food shortages by month and survey time. During the survey periods, 47.50 %, 49.73%, and 56.57% of households reported that they faced food shortages for at least one month in the 12 months preceding the survey, respectively. The shortage was less severe during the first survey period with 47.50 % and more severe during the third survey period with 56.57% of households reporting food shortages.

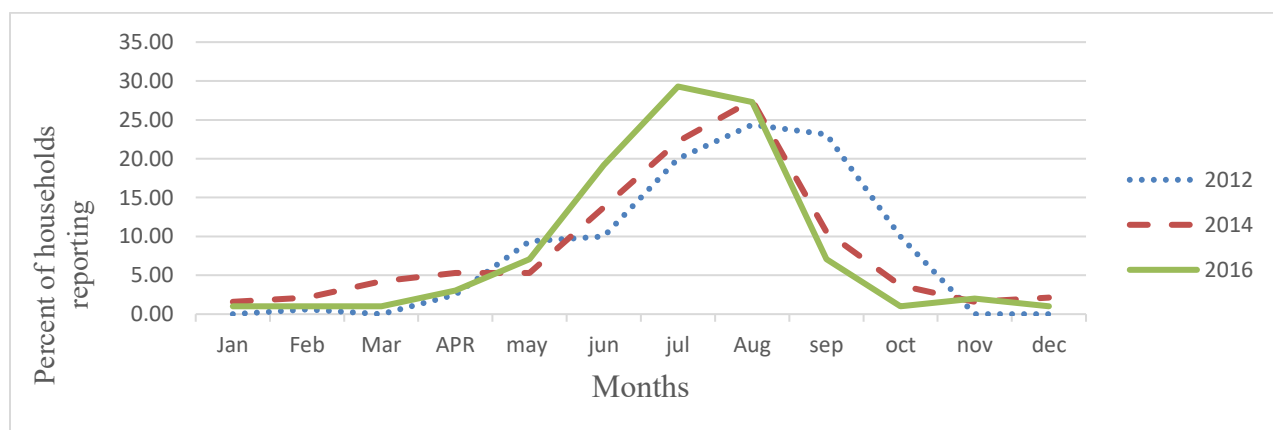
Figure 4: Food Security Status of Households Based on Coping Strategies Index (CSI)



Source: Author's calculation from LSMS data, 2022.

Considerable differences were observed in the three survey periods. In almost all survey periods, the months of June, July, August, and September were identified as slack periods for many households in the study area. For all survey periods, the critical period is from April to October.

Figure 5: Percent of households reporting food shortage by survey time



Source: Author's calculation from LSMS data, 2022.

4.2. Econometrics results

The following section presents the determinants of household food security in the North Wollo Zone. Table 5 summarizes the coefficient estimates of the model using the DCI response

variable. Tables 6 and 7 summarize estimates of the model using FCS and CSI response variables. The overall significance of the models is good in all cases (Tables 5, 6, and 7). Before estimation of the coefficients, a Hausman test was carried out to determine whether the fixed or random effect model is favored, with the null being that the preferred model is a random effect, and the alternative is a fixed effect (Green, 2008). The Hausman LM test results indicate that the probability value of chi2 is insignificant at the 5% significance level in all cases (Table 4), and so the random effect model is the most appropriate model rather than the fixed model.

Table 4: Hausman test results

Test	Indicator		
	DCI	FCS	CSI
Chi-square test value	19.98	11.90	8.74
P-value	0.5224	0.9423	0.9911

Source: own survey, 2022

The binary logistic regression results based on DCI showed that marital status, family size, dependency ratio, access to water, and irrigation were important determinants of household food security status. Household size is negatively related to the state of food security. The results indicated that larger household sizes tend to be food insecure compared to smaller household sizes. The possible explanation is that those households that depend on limited productive resources will face food insecurity because of increasing household size. The results are consistent with the results of (Misgina, 2014; Mitiku, Fufa & TadeTadese, 2012; Mequanent, Birara, and Tesfalem, 2014; Mohammed, 2016; Ramakrishna & Demeke, 2002). Likewise, the dependency ratio is negatively related to the state of food security. A higher dependency ratio is associated with a higher probability of being food insecure. The result indicates that increasing the dependency ratio of the household by one percent is associated with a decline in the odds of being food-secure by about 0.99% when reference is made to the past 7 days. The result is consistent with the findings of (Agidew & Singh, 2018; Tibebu and Sisay, 2017; and Mohammed, 2016).

As expected, access to water was found to be significant and positively related to food security in the study area. The results reveal that households' access to clean water increases the odds of being food secure by a factor of 1.07. This may be due to the fact that households who obtain drinking water from protected water sources may not be at risk of communicable diseases, which

affect the food and nutrition status of households. This finding is in line with Mohammed's (2016) findings in his Gubalafto district study. Similarly, irrigation is positively and significantly related to the probability of a household being food secure. The odds ratio in favor of food security increases by a factor of 1.401 when households irrigate their fields. Irrigation can improve crop production and productivity by enabling farmers to have access to a more reliable water supply and apply multiple crops as a result of being able to plant during the dry/lean season (WFP and CSA, 2019). This finding is consistent with that conducted by (Abonesh, Ayalneh, and Regassa, 2006) in Ada Liben District and East Shoa, Ethiopia.

Table 5: Logistic Regression Estimation for based on direct calorie intake (DCI)

KcalFS	Pooled OLS		Fixed Effect		Random Effect		RE Odds
SexHH	.054	(0.25)	-.266	(-0.89)	.054	(0.24)	1.055484
AgeHH	-.006	(-1.11)	-.002	(-0.33)	-.006	(-1.10)	0.994017
EduHH	.137	(0.70)	.14	(0.55)	.137	(0.70)	1.146828
Maritalstatus	.166***	(2.68)	.218***	(2.59)	.167***	(2.66)	1.181754
HHsize	-.077*	(-1.69)	-.126**	(-2.01)	-.078*	(-1.68)	0.924964
Dratio	-.002*	(-1.72)	-.002	(-1.23)	-.002*	(-1.71)	0.998001
WaterAcc	.068*	(1.94)	.128**	(2.26)	.069*	(1.92)	1.071436
ToilateAcc	.055	(1.01)	.157**	(2.02)	.056	(1.01)	1.057597
Flsize	.032	(1.05)	.026	(0.63)	.032	(1.05)	1.032517
Irrigation	.335*	(1.68)	.624**	(2.49)	.337*	(1.67)	1.400739
Fert	.124	(0.57)	.15	(0.53)	.125	(0.57)	1.133148
Imprseed	.166	(0.83)	.189	(0.76)	.166	(0.83)	1.180573
Agrextse	-.039	(-0.19)	.37	(1.35)	-.035	(-0.17)	0.704688
Off_Farm	.138	(0.47)	.044	(0.11)	.137	(0.46)	1.146828
Oxen	.086	(0.66)	.034	(0.19)	.086	(0.65)	1.089806
TLU	.048	(0.85)	.037	(0.48)	.049	(-0.85)	1.050220
Shock	-.17	(-0.72)	-.287	(-1.04)	-.172	(-0.72)	0.841979
Credit	-.102	(-0.42)	.151	(0.48)	-.101	(-0.41)	0.903933
Aid	.12	(0.51)	.038	(0.13)	.12	(0.51)	1.127496
DistR	-.001	(-0.47)	-.001	(-0.42)	-.001	(-0.46)	0.999000
DistM	-.005	(-0.62)	.006	(0.64)	-.005	(-0.62)	0.995012
Constant	-.374	(-0.28)			-.381	(-0.29)	0.683177
N		572		425		572	
Pseudo r-squared		0.042		0.12		-	
Chi-square		33.401		37.489		28.518	
Prob > chi2		0.042		0.015		0.056	
Akaike crit. (AIC)		797.668		315.706		799.658	
Bayesian crit. (BIC)		893.349		400.800		-	

*** p<.01, ** p<.05, * p<.1; t statistics in parentheses

Source: own survey, 2022.

As far as the estimation results based on FCS are concerned, as hypothesized, the educational status of household heads is found to be an important factor in determining household food security. As the educational status of household heads increases by one unit, the odds of a household being food secure increase by a factor of 1.83 (at $p < 0.1$) (Table 6). The result is consistent with the works of (Mohammed, 2016; Abafita & Kim, 2014; Ramakrishna & Demeke, 2002). Household size was significant and negatively related to the state of food security. Keeping other variables constant, as the number of family members increases by one, the odds of a household being food secure decrease by about 0.89 (Table 6).

The results showed that farm land size was significant and positively related to the food security status of households, suggesting the larger the land size, the better the food security status of the household. Other variables remaining constant, increasing cultivated land by one hectare increased the probability that the household was food secure by a factor of 1.136. The possible explanation was that, when cultivated land increased, households would be able to minimize their production risks or would be able to produce more, which in turn helped to reduce the food insecurity problems of their families. This result agrees with the findings of (Tibebu and Sisay, 2017; Ramakrishna & Demeke, 2002; Mitiku, Fufa & Tadesse, 2012). Correspondingly, the number of oxen owned by a household was found to be significant and had a positive relationship with the household's food security status. Other variables remained constant: an increase in the number of oxen by one increased the probability that the household was food secure by a factor of 1.579. The possible explanation was that oxen, as the most traction power in the area, helped households to produce more by themselves or to earn money by renting their oxen to others, which in turn helped households to access food. Similar results were also reported by (Mequanent, Birara and Tesfalem, 2014; Tibebu and Sisay, 2017). Access to roads, which is proxied by distance to roads, is significant and negatively related to the probability of food security as expected. That means households far from the main road are less likely to be food secure. Keeping all other factors constant, a unit increase in distance to the road in a kilometer decreases the probability of being food secure by a factor of 0.994 (at $p < 0.1$).

Table 6: Logistic Regression Estimation for based on Food Consumption Score (FCS)

FCSFS	Pooled		Fixed Effect		Random Effect		RE Odds
SexHH	.078	(0.25)	.311	(0.62)	.081	(0.26)	1.084370
AgeHH	.002	(0.25)	.007	(0.59)	.002	(0.25)	1.002002
EduHH	.599*	(1.91)	.77*	(1.81)	.605*	(1.90)	1.831252
Maritalstatus	.111	(1.29)	.078	(0.58)	.113	(1.28)	1.119663
HHsize	-.114*	(-1.67)	-.288**	(-2.51)	-.117*	(-1.65)	0.889585
Dratio	-.001	(-0.65)	0	(0.16)	-.001	(-0.64)	0.999000
WaterAcc	.046	(0.89)	.069	(0.78)	.047	(0.89)	1.599994
ToilateAcc	.027	(0.34)	-.104	(-0.77)	.026	(0.32)	1.026341
Flsize	.126***	(3.53)	.154***	(2.65)	.128***	(3.40)	1.136553
Irrigation	.04	(0.14)	.084	(0.20)	.037	(0.13)	1.037693
Fert	.328	(1.08)	.096	(0.21)	.325	(1.06)	1.384030
Imprseed	.683**	(2.54)	.294	(0.76)	.688**	(2.52)	1.989732
Agrextse	.276	(0.93)	.941*	(1.92)	.282	(0.94)	1.325778
Off_Farm	.023	(0.05)	.769	(1.16)	.03	(0.07)	1.030454
Oxen	.458**	(2.09)	.076	(0.24)	.457**	(2.07)	1.579328
TLU	.01	(0.10)	.028	(0.18)	.01	(0.10)	1.010050
Shock	-.206	(-0.67)	-.715	(-1.48)	-.212	(-0.68)	0.808964
Credit	-.184	(-0.53)	-.384	(-0.68)	-.19	(-0.54)	0.826959
Aid	.23	(0.72)	.224	(0.42)	.233	(0.72)	1.262381
DistR	-.006*	(-1.88)	-.002	(-0.33)	-.006*	(-1.87)	0.994017
DistM	-.013	(-1.29)	-.035*	(-1.92)	-.014	(-1.28)	0.986097
Constant	-1.221	(-0.68)			-1.238	(-0.68)	0.289963
N	572		234		572		
Pseudo r-squared	0.138		0.339		-		
Chi-square	69.387		58.094		49.042		
Prob > chi2	0.000		0.000		0.000		
Akaike crit. (AIC)	479.184		155.290		481.148		
Bayesian crit. (BIC)	574.865		227.851		-		

*** $p < .01$, ** $p < .05$, * $p < .1$; t statistics in parentheses

Source: Model Result based on LSMS data, 2022.

Using the CSI indicator, the study finds that sex of the household head, education status, access to toilets, fertilizer use, farm land size, tropical livestock unit, oxen ownership, extension contact, shock, and access to credit were all significant in determining the food security status of rural households. Except sex, shock, and access to credit, which have a negative relationship with food security, all other variables have a positive and significant impact on rural households' food security status, while the coefficients of the remaining variables are statistically insignificant (Table 7).

This study finds that male-headed households are more food insecure than female-headed households (unexpected result), which is illustrated by the negative relationship between sex and the food security status of households (Table 7). This could be because women are better at managing a family (using innovative and flexible coping strategies) and have a better understanding of nutrition than men. This finding is inconsistent with the findings of (Wali and Penporn, 2013; Agidew & Singh, 2018). As expected, the education status of a household head has a positive and significant relationship with food security. The possible explanation is that household head education has a significant impact on working efficiency, competency, diversifying income, adopting technologies, and becoming visionary in creating a favorable environment for dependents to be educated with the long-term goal of ensuring better living conditions than illiterate ones. Access to toilet facilities is both positive and significant. That is, keeping other variables constant, as the use of private latrines and shared toilet facilities increases by one, the probability of being food secure increases by a factor of 1.223 (Table 7). This finding is consistent with the findings of Mohammed (2016). This may be due to the household's effort to protect them from different diseases (respiratory, intestinal, etc.) that could affect their food intake and health.

Farm land size has a significant and positive relationship with the food security status of households, implying that the larger the land size, the better the household's food security status (Table 7). Application of appropriate agricultural fertilizer has paramount importance in increasing production and productivity of farming, especially in areas where the supply of land is very limited and highly prone to climate change. As expected, agricultural fertilizer has a positive and statistically significant relationship with the probability of being food secure. That means using one more additional agricultural fertilizer increases the odds-ratio of food security by a factor of 1.86. Similar results were also obtained by (Misgina, 2014; Wali, and Penporn, 2013; Ramakrishna & Demeke, 2002). Likewise, the results show that agricultural extension services positively affect food security. The possible explanation is that those households that have frequent contact with extension agents get information, technical assistance, and newly released and highly productive inputs that are critical to increasing production and productivity. This finding is in line with that of (Wali and Penporn, 2013).

Non-farm income was also found to have a significant and positive association with the household's food security status, indicating that farmers who engage in non-farm activities have

a better probability of being food secure. This could be because non-farming households have a greater disposable income and are less prone to encountering food insecurity. This finding is consistent with (Wali and Penporn, 2013; Abafita & Kim, 2014; Tibebe and Sisay, 2017; Mitiku, Fufa & Tadese, 2012). The number of oxen owned by a household has shown a statistically significant positive association with household food security. Ceteris paribus, an increase in the number of oxen owned by one household raised the odds ratio probability of food security by a factor of 3.391 (Table 7). Equally, total livestock owned by the household was found to be statistically significant and positively associated with the food security status of the household. All other things being constant, an increase in the number of livestock holdings in TLU raises the odds of a household's food security by a factor of 1.619.

Table 7: Logistic Regression Estimation for based on Coping Strategy index (CSI)

CSIFS	Pooled		Fixed Effect		Random Effect		RE Odds
SexHH	-.73**	(-2.53)	-1.247**	(-2.53)	-.73**	(-2.53)	0.481908
AgeHH	0	(0.07)	.005	(0.45)	0	(0.07)	1.000000
EduHH	1.489***	(5.92)	1.977***	(4.92)	1.489***	(5.92)	4.432661
Maritalstatus	-.005	(-0.07)	-.036	(-0.26)	-.005	(-0.07)	0.995012
HHsize	-.038	(-0.64)	-.025	(-0.27)	-.038	(-0.64)	0.962713
Dratio	0	(-0.30)	.002	(1.22)	0	(-0.30)	1.000000
WaterAcc	.048	(1.13)	.136**	(1.97)	.048	(1.13)	1.049170
ToilateAcc	.201***	(2.85)	.348***	(2.85)	.201***	(2.85)	1.222624
Flsize	.244***	(4.94)	.231***	(3.45)	.244***	(4.94)	1.276344
Irrigation	.02	(0.08)	.077	(0.20)	.02	(0.08)	1.020201
Fert	.622**	(2.20)	1.647***	(3.30)	.622**	(2.20)	1.862649
Imprseed	.376	(1.41)	.359	(0.93)	.376	(1.41)	1.456447
Agrextse	.536**	(2.04)	.561	(1.36)	.536**	(2.04)	1.709156
Off_Farm	.884**	(2.21)	1.672***	(2.67)	.884**	(2.21)	2.420562
Oxen	1.221***	(5.94)	1.446***	(4.58)	1.221***	(5.94)	3.390576
TLU	.482***	(4.81)	.621***	(4.36)	.482***	(4.81)	1.619309
Shock	-1.83***	(-5.10)	-3.098***	(-5.23)	-1.83***	(-5.10)	0.160413
Credit	-.788**	(-2.29)	-.607	(-1.14)	-.788**	(-2.29)	0.454753
Aid	.508	(1.62)	.21	(0.41)	.508	(1.62)	1.661963
DistR	-.003	(-1.35)	-.003	(-0.75)	-.003	(-1.35)	0.970445
DistM	-.012	(-1.18)	-.022	(-1.25)	-.012	(-1.18)	0.988071
Constant	-5.553***	(-3.13)			-5.553***	(-3.13)	0.003875
N	572		564		572		
Pseudo r-squared	0.372		0.682		-		
Chi-square	288.577		281.516		142.622		
Prob > chi2	0.000		0.000		0.000		
Akaike crit. (AIC)	531.510		173.327		533.510		
Bayesian crit. (BIC)	627.191		264.363		-		

*** $p < .01$, ** $p < .05$, * $p < .1$; t statistics in parentheses

Source: Model Result based on LSMS data, 2022.

As predicted, shocks have a statistically significant influence on the food security status of a household. Odds show that the probability of food security decreases by a factor of 0.16 for those households that experienced shocks. This could be explained in part by the fact that farmers may shift their labor into non-agricultural income-generating activities to compensate for what they have lost due to shocks, especially agricultural shocks, which are persistent in the study area. This finding is consistent with (WFP and CSA, 2019) description. Access to the credit is captured as a dummy variable. Unexpectedly, the coefficient of access to credit was found to be significant and negatively related to the probability of being food secure. This may be due to high indebtedness or loan default because of high interest rates, “forced credit” in the form of fertilizer or in cash without the willingness of farmers. Similar results were also reported by (Mohammed, 2016).

5. Conclusion and policy implications

This study has two main objectives: to assess household food security status and to identify determinants of rural household food security. It employed three indicators (DCI, FCS, and CSI) to capture some of the dimensions of food security. It employed descriptive and explanatory research and data analysis methods. The study finds that the food security status of rural households has decreased over survey periods in all applied food security indicators. Similarly, the gap and severity of food insecurity have also increased over study periods. The education and marital status of the household head; access to water, access to a toilet, fertilizer use, farm land size, irrigation, improved seed, tropical livestock unit, oxen ownership, and extension contact positively affect the households' food security status, whereas the sex of the household head, household size, dependency ratio, shock, access to credit, and distance to the local road increase the food insecurity status of the households in the area.

Interventions (by all development actors) should consider demographic, socio-economic, and biophysical features of the household and community to better address the problem. In particular, family planning, training and education, access to environmentally friendly agricultural technologies (irrigation, improved seeds and fertilizers), and innovative extension services need serious attention from all concerned bodies. Infrastructure (such as roads and transport facilities)

should be the focus of governmental and non-governmental organizations as well. Governments (at all levels) and lenders should properly understand the needs, livelihood activities, capacity, and context of rural households before giving loans. All development actors (government, private sector, and civil society organizations) should work in a synergic way to reduce the vulnerability of rural people to man-made (war) and natural (drought and famine) shocks and build their resilience capacity in such a way that ensures sustainable livelihoods and food security at the household and community levels.

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