Innovations

Rural households' food security status and its determinants in face of climate change and variability in Simadaworeda, Northwest Ethiopia

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Abstract
It is widely recognized that climate variability and frequent droughts resulting from El-Nino phenomenon are among the major risk factors affecting agricultural production that might contribute to hunger and food insecurity in East Africa in general and Ethiopia in particular. Food security is a serious issue around the globe, especially in developing countries including our country Ethiopia. The objectives of this study were to assess the food security status and its determinants of rural households in the face of climate change and variability among 368 randomly selected households in Simadaworeda using household survey, focus group discussion and key informant interview data collection methods. Descriptive statistics (mean and chi-square test), Core Food Security Model and binary logit econometric model were used to analyze the data.The Core Food Security Model result showed that 67.9% of the households are food insecure, while the remaining 32.1% of the sampled respondents arefood secure. The binary logitregression results revealed that farmland size, agro ecology, rainfall variability,family size,distance to market, drought tolerant seed and livestockownershipwere found to besignificantly affected household's food security. The findings indicate that majority of the households are food insecure where its improvement can be addressed through appropriate policy, institutional and technological options.The finding also demands for action to all stakeholders including the local community, government and nongovernmentorganization interventionthat needs to mainstream the issueof climate change.

Keywords: climate change, food security, households, binary regression model, Simadaworeda

1. Introduction

Climate variability and change are perhaps the most serious environmental threats to fight against food insecurity in Africa (Palau, 2015; Mekonnen*et al.,* 2021). This is because they affect food systems in several ways ranging from direct effects on crop production to changes in markets, food prices, and supply chain infrastructure (kidane*etal*., 2006; IPCC, 2007;Temesgen*etal*., 2009;Demeke*etal*., 2011;Thornton &Herrero, 2014). The dynamic forces of climate change also execrate other issues, such as deforestation, land degradation and depletion of water resources that further complicating the challenge of food security (Delgado *et al*., 2011). Almost all sectors of agriculture depend on weather and climate whose variability has meant that rural farm encounter total failure *(*Ozor*et al., 2010;* Kebede, 2016).

Food security is a growing concern, particularly under imminent climate change and variability. The World Food Summit of 1996 defined food security as existing "when all people at all times have access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life"(FAO,1996). There are three pillars which underpin food security: food availability, food accessibility and food utilization (Barrett,2005).

Food security is a serious issue around the globe, especially in developing countries.Birara*et al.(*2015*),* states by referring FAO (2014) that global hunger reduction continues and about 805 million people are estimated to be chronically undernourished in 2012-14, down more than 100 million over the last decade and 209 million lower than in 1990-92. In the same period, the prevalence of undernourishment has fallen from 18.7-11.3% globally and 23.4-13.5% for developing countries. In 2017, almost 124 million people across 51 countries and territories faced "crisis" levels of food insecurity or worse, requiring immediate emergency action to safeguard their lives and preserve their livelihoods, an increase compared to 2015 and 2016 (80 and 108 million people respectively (FAO, 2018).

Ethiopia lies within one of the most food-insecure regions in the world with a large population living subsistence production which is highly vulnerable to severe drought. The production volume of food crops as well as the per capita food production has shown tremendous decline which has been the most dominant problem of the Ethiopian economy (Girma&Menberu, 2015). In Ethiopia, climate change has far-reaching effects and presenting a unique challenge for societies, and complicates the existing development process (Hamasso, 2015). The reason for this is that the economy of the country depends largely on rain-fed agriculture and other natural resources, which are highly sensitive to climate variability through time and space (Yimam&Mohammed, 2016). Despite the great contributions of agriculture to the economy of the country, this sector is still unable to feed its people for many years because of varied socioeconomic and environmental factors, of which climate-related hazards are prominent (NMSA, 2007). According to the world food program (2010), over 7.5 million chronically food-insecure households living in 300 woredas have been focused on the Productive Safety Net Program (PSNP) to get food support for five years at the national level.

Amhara region is one of the largest regions in Ethiopia which includes 129 rural and 38 urban administrationworedasamong the existing rural woredas of the region, 64 woredas are identified as food insecure (Girma&Menberu, 2015). According to the Amhara region, food security bureau report2019 among 184 rural woredas, 70 woredas are food insecure woreda in which 1,890,935 people are supported by the Safety Net Program yearly to assure their food security.

Simada woreda is one of the foods insecure woreda of Amhara region in which among 164, 988 of rural population 20, 831(12.6%) peoples everlastingly depend on productive Safety Net Program because of chronic food security (SWAO, 2020) and by its history the woreda is considered as food aid woreda for more than 30 years.

Earlier study confirmed that climate change and variability potentially affected the underpinning pillars at different levels and disordered the link between them, dwindling their ability to deliver food security (Gregory *et al.,*2005). Studies have been undertaken to measure the extent of food security in Ethiopia (Berhanu, 2004; Gebre-Selassie, 2004;Freihiwot, 2007;Bogale&Shimeles,2009;&Kasaye, 2018). The studies on food security investigated the demographic, socio-economic and institutional factors that affect food security, but failed to address the climate factors that are believed to affect food security (Demeke*et al*., 2011). This presents an important drawback, since household food security is dictated by a host of environmental factors, together with socio-economic and institutional factors. Furthermore, a current study examining determinants of food security indicates the need to be context specific in identifying factors that influence specific investment in food security projects and programs (Beyene, 2014). The understanding of these environmental factors assists policy to enhance food security through investing on these factors and also has benefits for mainstreaming climate change issues in planning interventions that have a convincing chance of being realized that are more likely contribute to improving food security outcomes.Therefore, the objectives of this study were to assess the status of household food security and to analyze a host of climatic, demographic, socio-economic and institutional factors affecting food security of rural households in simadaworeda, northwest Ethiopia.

2 Study Area and Methods

2.1 Description of the Study Area

2.1.1 Biophysical setting

The absolute location of simadaworeda is 12°33'06" to 12°50'24" North latitude and 39°42'36" to 39°58'24" East longitude. It is bounded with Laygayntworeda in the north; EnebsieSarMidirworedain the south with, Amhara Saint and Sedie Mujaworeda in the east and Estieworeda in the west (see Figure 1). The administrative center is Wogeda; which is located at 105 kms southeast of the Zonal capital DebreTabor and found at about 205 kms away from the regional capital Bahir Dar and at 770 kms from Addis Ababa (SWA O, 2019).

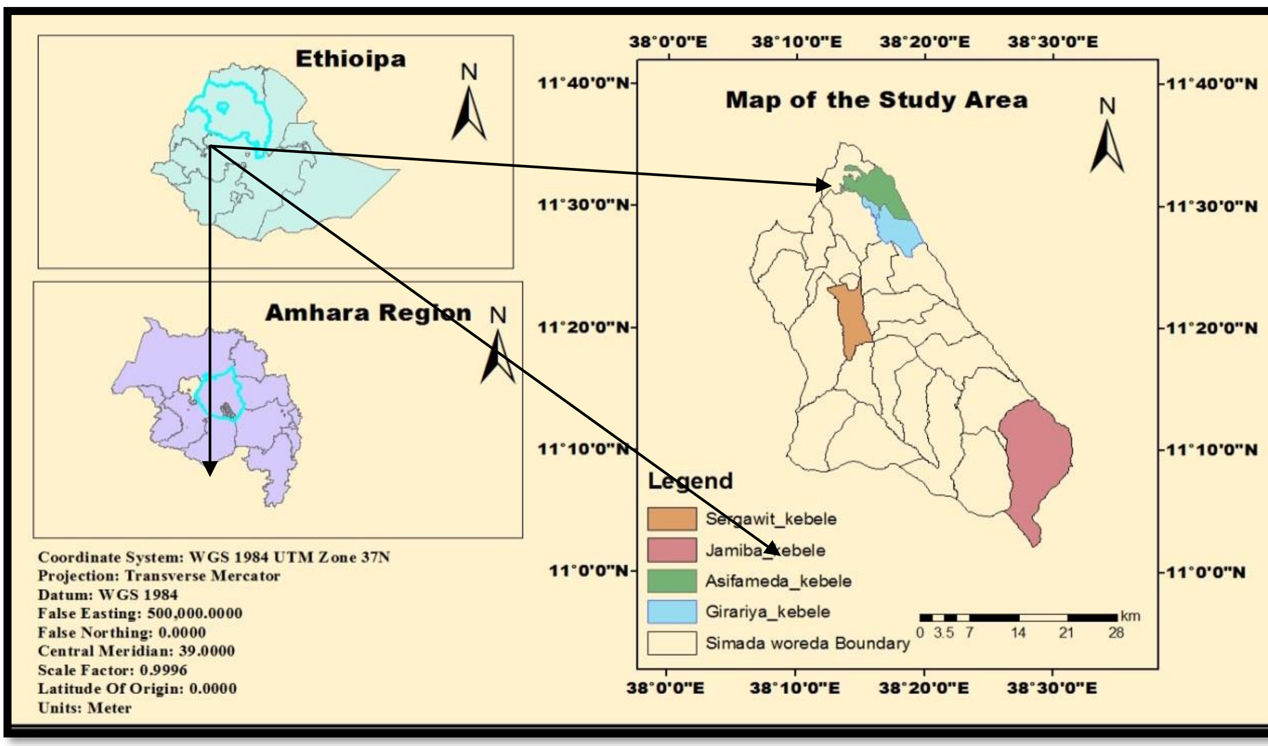

Figure 1 Map of the study area

(Source: prepared from Ethio-GIS database and CSA, 2007)

According to Simadaworeda Administration office (SWAO, 2019), the elevation of the woreda understudy ranges between 1,500 and 4,131 meters above sea level. The topography of the woreda is mostly undulating; hills and valleys extending from AbayBeshilo Gorge (1500 meter) to near to Guna Mountain summit (4131meter above sea level). Indeed, the woreda is characterized by valleys (8%), mountainous (25%), plateau/plain/ (20%), hills (42%) and others (5%). The annual mean maximum and minimum temperature of the woreda ranges from 22.7°C to 26.5°C and 5.6°C to 12.8°C respectively. The woreda has an average annual rainfall varies between 602 mm and 1455 mm (SWAO, 2019).

2.1.2 Socio-Economic Setting

According to the current Administrative structure, South Gondar Zone Administration has 18 woredasof which 13 rural and 5 urban. Simada is one of the 13 rural woredas of South Gondar Zone in Amhara Regional State, Ethiopia.

The projected total population of Simadaabout 184, 831 among the total population 164, 988(89.3%) live in rural areas while almost 19,843(10.7%) of the total population lives in urban areas (SWGCO, 2020).

Most of the people in the area are predominantly rural and the farmers are engaged in small-scale farming and subsistence with mixed agriculture.The main sources of livelihoods in the study area are crop reduction and livestock rearing. Crop cultivation and livestock production are practiced. Crop production is entirely rain-fed, except in very specific and small areas whereas vegetables are cultivated based on traditional &small-scale irrigation.

2.2 Methodology

2.2.1 Sampling procedure and Sampling size

In this study, a multi-stage sampling procedure was employed. In the first stage, the study area was selected conveniently because it helped the researcher to have ease and accessible information about the problems and status of the study area based on ease of access data.

In the second stage, among the total 26 rural kebele administration (RKA)in Simadaworeda, the four (*Sergawit and Girariya*from Woinadega, *Jamba* from Kola and *Asfameda*from Dega)) were used for this studybased on their agro-ecological characteristics, including the rainfall, soil type and topography.The kebeles were selected by using simple random sampling techniques with the consideration of probability proportion to its size. A total of 368 sample household heads was taken into consideration. In order to represent the study population, Yamane (1967) simplified formula were used at 5% level of precision.

$$n = \frac{N}{1 + N(e)^2} = \frac{4412}{1 + 4412(0.05)^2} = 368 \text{ Households}$$

Where *n*is the sample size of all selected kebeles, *e* is the level of precision (5%).

N is the total number of household heads in the four selected *kebele*

Table 1 Sample respondents of selected kebeles

Agro-ecology zone	Kebeles	Total household head	Sample household head
Dega	Asfameda	799	67
Woinadega	Sergawit	1205	100
	Girariya	439	37
Kola	Jamba	1964	164
Total		4412	368

Source: Own computation from secondary data, 2021

The sampling frame was the list of households, which was obtained from the rural kebele administrations.

2.2.2 Data types, sources and collection methods

The data required for achieving objectives of this research was both quantitative and qualitative in nature. For this purpose, both primary and secondary sources of data were used. Primary data was collected from different category of respondents; household heads, religious leaders, local representatives, kebele leaders and experts in the study area by household survey, key informant interview and discussion data collection instruments. To collect other relevant background information, secondary data was used from various sources. Secondary data was obtained from different governmental offices at various levels. Overall, both the quantitative and qualitative data of the study through questionnaire, group discussion and interview was conducted in the following ways:

Both closed and open-ended questions were prepared to generate the required primary household level data. Prior to the actual data collection, the questionnaire was pre-tested (February 2021) to ensure clarity, validity, and sequence of the question with the non-sampled respondents. The pre-testing was employed in some selected kebeles, one at each agro-ecological zone. Based on the result of pre-test, necessary adjustments were made and finally, the revised questionnaire was employed to collect data (March-April 2021) from the sampled households. To generate information at the field level, 12 enumerators who know the local language and hold diploma and first degree were recruited and trained on data collection tools and interview handling.

Data from the focus group discussion (FGD) and key informant interview (KII) were used to complement the information obtained through a household survey in order to have a better understanding status and challenges of food security. There were four FGDs held in four sample kebeles. The FGDs were composed of 6-8 participants (religious leaders, local representatives, kebele leaders, male and female household heads). A total of three individuals from four kebeles were selected as a key informant interview (KII). The KII was comprises of one religious leader, one expert with agricultural and environmental background and one kebele leader.

2.2.3 Method of data analysis

The model selection procedure employed in this study involved in two phases. The first phase was the selection of fitting model for grouping of households into food security status, and the second one was a selection of an appropriate model to determine the factors affecting food security status in the study area. The collected data from primary and secondary sources were analyzed using both quantitative and qualitative analyticaltechniques. The data were being analyzed by means, tables, graphs, percentages, frequency, and cross-tabulation, and descriptive statistics using the Statistical Package for Social Sciences (SPSS) software of version 20.

i) **Households'food balance model**

To identify the food secure and insecure households, household food balance sheet was employed. In the calculation of kilocalories intake, the amounts ofcalorie available to a household were determined through an equation termed as household food balance model (Eq. (1)), which was originally modified by Degefa (1996) from the FAO regional food balance model and later used for different studies (Eshetu,2000; Mesay, 2010).

Household food balance model is expressed as:

$$\mathrm{N}_{ij} = (\mathrm{P}_{ij} + \mathrm{B}_{ij} + \mathrm{F}_{ij} + \mathrm{R}ij) - (\mathrm{H}_{ij} + \mathrm{S}_{ij} + \mathrm{M}_{ij}) \quad (1)$$

where, N_{ij} is net food available for household i in year j; P_{ij} is total grain produced by household i in year j; B_{ij} is total grain purchased by household i in year j; F_{ij} is total grain obtained through food for work by household i in year j; Rij is total relief food received by household i in year j; H_{ij} is post-harvest losses to household i in year j; S_{ij} is total crop utilized for seed from the home by the household i in year j and $M_{ij}$is total marketed output by household i in year j.

Finally, following Degefa, food security in the current study was measured into the following four steps (Degefa, 1996). First, net food grain available for each household in kilogram (Pi) was converted into equivalent total kilocalories using conversion factors used for Ethiopia (Agren&Gibson,1996). Second, the food supply at the household level calculated in step (i) was used to calculate calories available per person per day for each household. Third, following Federal Democratic Republic of Ethiopia Food Security Strategy, 2,100 kcal calories per person per day were used as a measure of calories required (i.e., demand) to enable an adult to live a healthy and moderately active life.

Then and there, a comparison between the available (supply) and required (demand) grain food was made. Using 2100 kcal calories as cut off point, a household whose daily per capita calories available (supply) is less than his/her demand was considered as food insecure, while a household who did not experience a calorie deficit during the year under study was regarded as food secure.

ii) Binary Logit Model

In order to analyze the determinants of food security, both descriptive and econometric analyses were used. Descriptive statistics, such as chi-square test and t-test were used for dummy and continuous variables, respectively. Binary logit econometric model was used to analyze the determinants of household food security.It is commonly argued that logit and probit models are usually used to establish the relationship between household characteristics and dichotomous response variable (food security and food insecurity). The benefits of these models over the linear probability model are that the probabilities are bound between zero and one. Moreover, they best fit the non-linear relationships between the response and the explanatory variables. The model specify a functional relationship between the probabilities of being food secure to various explanatory variables.

In principle, one can substitute the probit model for logistic model, as their formulations are quite comparable; the main difference is that the logistic model has slightly flatter tails than the cumulative normal distribution, i.e., the probit curve approaches the axes more quickly than the logistic curve (Gujirati, 1995).

Therefore, the choice between the two is one of (mathematical) convenience and availability of computer programs. On this score, the logit model is generally used in preference to probit. It is also noted that the logistic distribution has got an advantage over the others in the analysis of dichotomous outcome variables, because it is extremely flexible and easily used model from the mathematical point of view and results in meaningful interpretations (Hosmer&Lemeshow,1989). Therefore, the logistic model is selected for this study, although both logit and probit models may give a similar result.

The Gujarati logit model is expressed as follows by Eq. (2) (Gujirati, 1995):

$P_i = \mathrm{E}(Y = 1/X_i\,) \; = \; \frac{1}{1+e^{-(\beta_0+\beta_1 X_i}}$(2)

For ease of exposition, Eq. (2) can be expressed as:

$$P_i \quad = \frac{1}{1+e^{-z_i}} (3)$$

Where, Zi= …….. If Pi is the probability of being food secure, then the probability of being food insecure is given by 1 – Pi, which is expressed as follows by Eq. (4):

$$1 - P_i = \frac{1}{1+e^{z_i}} \; (4)$$

Therefore, this can be written as Eq. (5):

$$\frac{P}{1-P_i} = \frac{1+e^{z_i}}{1+e^{-z_i}} = e^{z_i} (5)$$

where, $(P_i/1 - P_i)$ is simply the odds ratio in favor of food security; the ratio of the probability that the household will be food secure to the probability that it will be food insecure.

Taking the natural log of Eq. (5) above, it is possible to arrive at a log of odds ratio, which is linear not only in x, but also in the parameters.

$$L_i = Ln\left(\frac{P_i}{1-P_i}\right) = Z_i = \beta_0 + \beta_i X_i (6)$$

where, P_i is the probability of being food secure ranging from zero to one; Z_i is a function of n- explanatory variables (X_i) and is expressed as Eq. (7):

$$Z_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \ldots\ldots + \beta_n X_n (7)$$

where, β_0 is the intercept or constant term; $\beta_1, \beta_2, \beta_3, \beta_4, \ldots\ldots \beta_n$ are the slope of the equation in the model (parameters to be estimated); L_i is log of odds ratio; X_i is a vector of relevant household characteristic.

If the disturbance term (U_i) is introduced, the logit model becomes:

$$Z_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \ldots\ldots + \beta_n X_n + U_i \ (8)$$

Finally, the parameters of the model are estimated using the maximum likelihood (ML) method (Gujirati, 1995; Hosmer&Lemeshow,1989). It is noted that the ML method is a general method of estimation that is applicable to a large variety of problems (Maddala,1981). ML methods suggest choosing or estimating the value of the parameter that maximizes the logarithm of the likelihood function itself and the same result is attained. Method of ML yields value for the unknown parameters, which maximizes the probability of obtaining the observed set of data, and such a methodsis preferred when data at micro or individual level are acquired (Hosmer&Lemeshow,1989). However, there is a recognition that the OLS techniques can be used when the data set is sufficiently large and are grouped into the interval.

2. 3 Variable and working hypotheses

After the methodological procedures are clearly demarcated, it is necessary to identify the explanatory variables that can influence household food security. Consequently, review of the literature on economic theory, past research findings, experts and author's knowledge of the food security situation of the study area are used to identify the potential determinants of household food security in the study area. The dependent variable is food security, which is a dichotomous variable taking the value 1 if the household is food-secure and 0, otherwise. To dichotomize the household, the resulting average kilocalories consumed per adult equivalent (AE) per day is compared with the adequacy norm (the minimum subsistence kilocalories requirement) set by the Federal Democratic Republic of Ethiopia (FDRE) as 2,100 kcal for the country (FDRE,2002). Based on critical review of the literature, the following explanatory variables are hypothesized to have an influence on household food security:

(1) The level of education of the household head: A large body of literature noted that household heads with better educational background are assumed to have a chance to diversify household's income sources, adopt better production technologies, accept technical advice from the extension workers and can better manage their farm as compared to the illiterate ones. Educated households have a better chance of managing their farm by adopting improved practices, which in turn increases total yield. It is assumed that a literate household head often tends to adopt new skills and ideas,

which in turn have positive effects on food security (Abebaw, 2003; Bogale&Shimeles,2009; Tirfe&Hamda,2011). It is expected that the educational status of the household head and household food security have a positive association.

(2) Drought: It refers to the agricultural drought including low precipitation, dry land and decreased access to water supplies that inhibit crop and livestock production. Getachewet al. (2018) point out in their study that frequent drought and household food insecurity have positive relation. Therefore, it was expected to have positive effect on food insecurity.

(3) Farmland: Farmland size is an important determinant of household food security and it is the total area of land cultivated for food and cash crop by households, measured in hectares (Biraraet al., 2014).

(4) Household head Age: This can be used as a proxy for the experience of the household head since he/she started farming (Alem, 2007). Younger household heads were expected to have relatively poorer experiences of the socio-physical environments and farming than older household heads. Older people have relatively richer experiences of the social and physical environments and greater experience of farming activities. Older household heads are expected to have better access to land than younger heads because younger men either have to wait for land redistribution or have to share the land with their families (Haile et al., 2005; Biraraet al., 2014)

(5) Sex of the household head:female-headed households were anticipated to be more food insecure than male-headed households. Hence, sex is expected to be positively related to household food security status (Zelalem, 2014).

(6) The number of livestock: It is measured in terms of the total number of livestock holding of the farmer measured in livestock units in a household. Livestock ownership enables the households to be food secure either through the income earned or by direct consumption. Households with no or few numbers livestock were more possibility to be food insecure (Workuet al., 2014).

(7)Access to extension service:It is the provision of advice, information, and other supports to households. The advice and supports are maybe the provisions of training on the mechanisms of disease and pest control, post-harvest product management, way of preparing quality compost. Thus, it is measured in terms of accessing extension services or not. Access to extension and veterinary services was expected to have a positive impact on household food security in the study area (Hussein &Janekarnkij, 2013).

(8) Family size:It is measured in terms of the number of individuals in one family. In this study, it is a continuous variable and is assumed to have a positive association with food security and as Ejigayhu&Edris (2012) wrote household, size was found to be directly related to household food insecurity. Larger family households have a higher probability to be food insecure. This is because there will be a division of labor in a family as farm practice in the study area is labor-intensive.

(9) Access to credit service: Credit provides the opportunity to use improved agricultural technologies, and this promotes production. Accordingly, households that have an easy access to credit service have the possibility to invest in on-farm activities and improve their production. As a result, households income and food consumption pattern will improve (Bogale&Shimelis, 2009; Beyene&Muche, 2010). Therefore, it was hypothesized to have negative effect on food insecurity.

(10) Distance to the market: It is a continuous variable measured in kilometer; it will take from the residence of the household to the main market area. Closeness to the main market area creates access to additional income through off-farm/non-farm employment opportunities, easy access to agricultural information and transportation (Dorwardet al., 2003). It is thus, expected that a household located nearer to the market area has better opportunity to be food secure than a household located farther away from the market area. Therefore, it was hypothesized to have positive influence on food insecurity.

(11)Total annual income: Income determines the households' access distinguishing the food insecure and food secure households, in that those who have earned moderately larger income from different type sources could be more food secure. According to Mitikuet al. (2012) finding, farmers who have better access to different types of farm income are less likely to become food insecurity than those households who have little access. Consequently, total annual income per AE was expected to have negative effect on food insecurity.
(12)Drought-tolerant seeds: Improved seeds may withstand drought and erratic rainfall distribution when it is resistant to moisture stress. It augments agricultural productivity by increasing overall production, which in turn adds to attaining households' food security at the household level (Lipton, 2005). Hence, a household which uses improved seeds is expected to be more food secure than the non-users.
(13) Rainfall variability:Anomalies in weather have negative consequence in crop production, due to the rain fed nature of agriculture, of Ethiopia (Demekeet al., 2011). Likewise, in this study, rainfall variability is taken to be a deviation from what it supposed to be, like late start or early cessation of the cropping season as well as harvesting time rainfall. Hence, it affects the crop production and causes food shortage to the households. Kedir (2017) indicated in his study that frequent rainfall shock and household food insecurity have positive relation.
(14) Agro ecology:A study conducted by Hussein &Janekarnkij (2013) shown that agro ecology is negatively related to household food security.

Table 2 description of independent variables

Independent variable	Variable description
Educational status of HH	Dummy takes a value 1 if the household head is literate and 0, otherwise.
Household head age	Continuous
Sex of the household head	Dummy takes the value of 1 if it males 0 if its females
Total annual income	Continuous:amount of Birr households gain
Farm land	Continuous
Family size	Continuous
Drought tolerant seeds	Dummy takes a value of 1 if farmers used improved seeds and zero, otherwise.
Distance from market	Continuous variable measured in kilometer
Number of livestock	Continuous
Accesses to extension service	Dummy takes the value of 1 if there is and 0 otherwise
Credit access	Dummy takes the value of 1 if there is and 0 otherwise
Occurrence of climatic hazard (drought)	Dummy takes a value 1 if the household faced more than two drought shocks in the last ten years, which results food shortage, and 0 otherwise.
Rainfall amount, distribution& variability	Dummy takes a value of 1 if the household faced more than two rainfall shocks in the last ten years and 0, otherwise
Local agro ecology	Categorical: 1 Dega; 2 Woinadega; 3 Kolla

Source: The author's compilation

Before fitting variables into logistic regression model, variance inflation factor (VIF) and contingency coefficient (CC) were employed to check multicollinearity among continuous and dummy variables, respectively.

4. Results and Discussion

4. 1 Status of Food Security

We assessed households' food security status by minimum subsistence requirement per AE per day. Accordingly, the proportion of food secure and food insecure were 32.1% &67.9% respectively. The study indicates that the mean value of energy available for food secure and food insecure households was 2339.74kcal/AE/dayand 1640.84 kcal/AE/day, respectively.

The minimum and maximum energy available for food secure households was 2110 kcal&3560 kcal, respectively. Whereas minimum & maximum energy available for food insecure households was 950 kcal and 2090 kcal, respectively. The mean energy intake of all sample households was 1864.94kcal. The t-value confirmed that there was a significant mean between food secure and food insecured households at $p<1\%$ (see Table 5).A study conducted by Abi (2000), move toward with similar findings in low potential areas of the Amhara region. According to his study results, only 15% of farming households were able to fulfill their basic needs from agricultural activities. Nearly 30% were able to fulfill basic needs from farm and off-farm activities while about 70% of the households were not able to produce sufficient resources from any means to secure household food desires

Table 3 the association of food energy available for the households with food security status

Variables		**Food security Status**			t-value
		Food secure (n=118)	Food insecure (n=250)	Total (n=368)	
Energy available per AE per day	Maximum	3560kcal	2090 kcal	3560kcal	-5.5
	Minimum	2110kcal	950 kcal	950kcal	
	Mean	2339.74	1640.84	1864.94	
				399.84	

Note: ** Significant at 5% probability level.

Source: Household Survey (2021)

Nearly all the discussants of the FGD stated that households that generate sufficient food to feed the family throughout the year are few. They stressed that the percent of households that are food secure is less than 40%. About 88.3% of the FGD participants clarified that they have a food gap of 3 to 6 months and usually fill this gap by working different coping mechanisms including receiving food aid. The result found from the key informants' interviews is almost similar to the FGD.

4.2 Association of explanatory variables with households' food security

Tables 4 and 5 present the descriptive statistics for dummy and continuous variables that are helpful toobserve differences between food secure and foodinsecure households. The chi-square investigation shows thatgreater proportion of food secured households used drought-tolerant seeds and different livelihood options.The result further indicates that large proportions of food secure households are male-headed households,literate, accessible to extension services and credit as compared to theircounterparts. The independent t-test displays that there is a significant mean difference between foodsecure and insecure households with respect to family size, distance to market, total annual income and livestock owned.

Table 4 Association dummy variables&household food security.

Variables	Categories	Food security status				z^2-value	Significance
		Food secure (n=118)		Food insecure (n=250)			
		Freq.	%	Freq.	%		
Agro ecology	Kola	56	47.5	54	21.7	35.722***	0.000
	Woinadega	36	30.4	138	55.2		
	Dega	26	22.1	58	22.9		
Educational status	Literate	76	64.6	86	34.4	25.01***	0.000
	Illiterate	42	35.4	164	65.6		
Gender of HH	Female	10	8.5	61	24.3	20.420***	0.000
	Male	108	91.5	189	75.7		
Drought tolerant seeds	Yes	80	68.2	27	10.9	0.562^{NS}	0.453 ^{NS}
	No	38	31.8	223	89.1		
Access to extension	Yes	86	72.9	109	43.6	37.720***	0.000
	No	32	27.1	141	56.4		
Credit Access	Yes	87	73.4	87	34.8	3.341**	0.068
	No	31	26.6	163	65.2		
Occurrence of climatic hazard (drought)	Yes	32	27.4	159	63.7	20.630***	0.000
	No	86	72.6	91	36.3		
Rainfall variability	Yes	46	38.7	160	64.1	27.209***	0.000
	No	72	61.3	90	35.9		

*, *** Significant at 10% and 1%, respectively; NS: not significant; HH: household head.
Source: Household Survey (2021)

Table 5 Association of continuous variables &household food security

Variables	Food security status					
	Food secure (n=118)		Food insecure (n=250)		t-value	Significance
	Mean	SD	Mean	SD		
Age of the HH	45.75	12.257	45.70	12.878	0.039	0.969
Family size	5.77	1.902	6.09	2.137	-1.650	0.100
Farmland size	3.04	1.605	1.76	1.415	8.758***	0.000

Total annual income	4203	2005	2838	1707	7.18***	0.000
Livestock in TLU	7.98	4.805	4.61	4.472	-2.645***	0.009
Distance to market	1.55	0.795	1.79	0.993	7.455***	0.000

*** Significant at 1%; SD: standard deviation; HH: household head;TLU: tropical livestock unit
Source: Household Survey (2021)

4. 3Determinants of household's food security

A binary logit model was used to identify likely explanatory variables affecting household's food security. Before running the analysis, variables assumed to have an influence on food security were tested for multicollinearity and degree of association among variables via variance inflation factors and contingency coefficient, respectively. The test results showed that there is no multicollinearity and association problem among the variables. Among 14 variables fitted into the model,family size,agro-ecology,rainfall variability, drought-tolerant seeds, farmland size, distance to the market and livestock ownership are found to be statistically significant in determining food security of the household.Table 6 below provided the parameter estimates of the binary logit model results:

Family size is found to be negatively and significantly ($P< 0.05$) influenced to determine household food security in the study area (see Table 6), indicating that the probability of food security decreases with an increase in household size. The odds ratio revealed that in favor of the probability of being food secure decreases with increases in the family size. More specifically, the odds ratio in favor of food security, other factors being constant, decreases by a factor of 0.8345 as the family size increases by one member. The reason is that increasing household size within households whose agricultural land is less productive results in increased demand for food. This indicates larger household sizes require increased food expenditure and competition for limited resources. This creates anincompatibility between the food demand and with the existing food supply from own production and this finally end up with the household becoming food insecure. This result is consistent with a large number of empirical findings conducted in many different parts of Ethiopia and elsewhere in the world (Beyene&Muche, 2010; Obayelu, 2012; Aidoo*et al*., 2013; Zemedu&Mesfin, 2014; Gemechu*et al*., 2016).

Agro-ecology: The effect of agro-ecology can also be seen as significant where, on average, households in WoinaDega agro-ecology are more food secure compared to those in Kola agro-ecology. On the other hand, households living in Dega agro-ecology do not show significant differences on food security compared to those in Kola agro-ecology. The odds ratio in favor of food security revealed that a shift from Kola agro-ecology to WoinaDega agro-ecology increases the probability of the household being food secure by 2.5016. This may be clarified by the fact that as one moves from Kola to WoinaDega agro-ecology in the study area, the amount of rainfall increases which result in high crop production by the farming households and hence increases food security. This shows that households in areas with Kola agro-ecology need to be given special attention compared to those in WoinaDega agro-ecology.

Rainfall variability: rainfall variabilitywas positivelyand significantly impact on food security at $p<5\%$. The positiverelationship indicates that households that have experienced rainfall shock are more likely to be food insecure when it is compared to those which were not facing the rainfall shock. This is due to the fact that rainfall shock could result in crop failure that hampers the availability of food and reduce income that the households could have earned from their production. The odds ratio for this variable in favor of food security is 0.9494. This indicates that the probability of households to be food in secure increases by 0.9494, if a household was experienced to rainfall shock. The finding of this study was found consistent with what had been found by Kedir (2017).

Distance to the market: Distance to the market is found significantly and negatively related to food security in the study area. The odds ratio in favor of food security decreases by a factor of 0.6178 when the distance to the main market increased by one walking hour. The agreement on households nearer to market centers had better chances to be food secure than those who are away from market centers is due to the reason that households nearer to the market center have the probability of selling their product and purchase food from the market. The results from the FGDs held in the study area showed that households sold their livestock and livestock product to purchase food for family consumption during drought and crop failure problem. Holding other variables being constant, the odds ratio in favor of food security decreases by a factor of 0.6178, when the distance in hours of walk increases by one hour. Also, other findings confirm the result of this study (Felekeet *al*., 2005; Gemechuet *al*., 2016).

Table 6the logistic regression model results for the determinants of food security status

Variables		Odds ratio	Z-value	P-value
Agro ecology	Kola	0.7435	-1.33 NS	0.377
	Woinadega	2.5016	2.26**	0.024
	Dega	0.5385	-1.11 NS	0.266
Farm land size		1.3466	2.50**	0.013
Gender of HH		0.7132	-0.75 NS	0.452
Distance from market		0.6178	-3.01***	0.003
Access to extension		1.5349	1.43 NS	0.153
Credit access		1.0637	0.20 NS	0.839
Occurrence of climatic hazard (drought)		0.1335	0.43	0.667
Age of the HH		0.9991	-0.94	0.348
Education status of HH		0.9955	-0.11 NS	0.912
Family size		0.8345	-2.54**	0.011
Total annual income		-0.6527	-1.69	0.092*
Drought-tolerant seeds		3.5195	2.26**	0.024
Livestock in TLU		1.1061	2.71***	0.007
Rainfall variability		0.9494	2.37	0.018**
Constant		0.4447	-0.99 NS	0.324
Pseudo R^2		0.2120		
Log-likelihood function		-199.57944		
LR $chi^2(18)$		181.79		
Prob> chi^2		0.0000		
Number of observations		368		

, * Significant at 5% and 1%, respectively; NS: not significant; HH: household head.
Source: Household Survey (2021)

Drought-tolerant seeds*:*Use of drought-tolerant seeds is another variable, which was found to have a positive and significant impact on household food security (P <0.05). For example, farmers in the study area switched to drought-tolerant varieties of crops. The odds ratio for this variable in favor of food security is 3.5195. This indicates that the probability of households to be food secure increases by 3.5195, if a household has access to and uses drought-tolerant seed. This can be explained by the fact that in moisture-stressed area, due to climate change and variability, using drought-tolerant seed would reduce crop failure that in turn increase crop production.

Farm land size: the size of landholding has a significant and positive influence on household food security. This means that households with large farmsize produce more food for household consumption and for sale and have better chance to be food secure than those having relatively small size of land with the concept that the increase in agricultural output has been achieved through the expansion of cultivated land (Haile *et al*., 2005). The result discloses that the odds ratio in favor of food security increases by the factor 1.3466 when the area under cultivation is increased by 1 ha. The result of this study is in line with the finding of Bogale&Shimelis (2009); Beyene&Muche (2010) and Aidoo*et al*.(2013).

Livestock ownership: Livestock ownership affects food security as it is the backbone of the farm economy, especially in mixed farming systems. The result showed that total livestock owned by the household is found to be significant at less than 1% and positively related to food security in the study area. The odds ratio in favor of food security increases by a factor of 1.1061 when the amount of livestock owned by a household rises by one TLU. The likelyjustifications are: in addition it creates employment opportunity for the member of the family, it provides milk and milk products, and meat for direct consumption and for the market; it contribute draft power and manure for crop production; during famine and food shortage the farm households would be able to sell their own livestock and purchase food grains. The result is in line with other empirical evidence in Ethiopia (Bogale&Shimelis, 2009;Tirfe&Hamda,2011).

5. Conclusions

The sample households were categorized into food secure and food insecure groups based on kcal consumed by the households during the one year of survey date either through own harvests or purchase. The total amount of food commodity consumed by each household during the one year was converted into equivalent daily kcal per AE and then compared with recommended daily kcal per adult equivalent. Total daily food consumption per adult equivalent of less than 2100 kcal was considered as food insecure. The result of this study revealed that only 32.6%of the sample households were found to be food secure.From field observation the researcher saw that food in secured households spent much time to get some kilos of wheat grain. A binary logistic regression model was employed to estimate determinants of the probability of being food secure and insecure as a function of various household characteristics among sampled households in the study area. Seven out of 14 variables namely farm size, agro-ecological zone, rainfall variability, familysize,distance to market, drought tolerant seeds, and livestock ownershipwere found to be statistically significant with the hypothesized sign as determinants of household food security in the study area. Agriculture, in the study area, seems almost not possible to sustain the livelihood of the farming households without the contribution of livestock production. So, necessary effort should be made to improve the production and productivity of the sector. This can be done via the provision of adequate veterinary services, improved water supply points, the introduction of timely and effective artificial insemination services to improve the already existing breeds, opening sustainable and effective forage development program, provision of training for the livestock holders on how to improve their production and productivity, and improving the marketing conditions.

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