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Determinant Factors of Food Security among Households in Northern Ethiopia: An Application of Binary Logistic Regression Model

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Abstract

Food security is a situation of having, at all times, both physical and economic access to sufficient food to meet dietary needs for a productive and healthy life. Food security is presently a critical social issue that needs immediate attention from policymakers and other decision-makers. This study aimed to identify the determinant factors of food security of households in East Gojjam zone. A cross-sectional study design was conducted, and the study units were selected using a systematic random sampling technique through a multistage cluster sampling technique. The multivariable binary logistic regression model was employed to identify the determinant factors of food security among households. Among the households considered in this study, about 25.6% were found to be food secure. Food security was significantly associated with the source of access to energy, landholding size in a hectare, the loan from financial institutions, practice of irrigation, tropical livestock unit (TLU) (livestock possession), slope of agricultural land, and district at 5% level of significance in the study area. A low proportion of food security among households was observed and important determinant factors of food security have been explicitly identified. Therefore, the stockholders concerned, particularly the agricultural office, should intervene to promote food security among households through the expansion of irrigation systems to increase agricultural yields; and the practice of agroforestry (cohesive livestock and agricultural products) should be implemented in community.Initiatives for nutrition education in the community should be implemented to increase the use of foods, so that people are conscious of the variety of foods their bodies need to maintain good health.

Keywords: Binary logistic regression model • Food security • Household

Abbreviations: AIC: Akaike's Information Criterion; BIC: Bayesian Information Criterion; CFSM: Core Food Security Module; TLU: Tropical Livestock Unit; ROC: Receiver Operating Characteristic; USDA: United State Department of Agriculture

Introduction

Food security exists when all people at all times have physical, social, and economic access to sufficient, safe, and nutritious food to meet their dietary needs and food preferences for an active and healthy life. On the contrary, *food insecurity* is a situation in which limited or uncertain availability of nutritionally adequate and safe foods or limited or uncertain ability to acquire acceptable foods in socially acceptable ways [1-3]. It also combines low food intake, unpredictable food exposure, and susceptibility to a subsistence strategy that provides enough food in good times but is not immune to shocks [4].

Globally, the number of people suffering from chronic food deprivation has grown from about 804 million in 2016 to nearly 821 million in 2017. Throughout Africa, overall food insecurity (moderate or severe) is much greater than in any other part of the world.Of a total of 2 billion people worldwide suffering from food insecurity, 1.04 billion (52%) are in Asia; 676 million (34%) are in Africa, and 188 million (9%) are in Latin America. In 2018, acute malnutrition or wasting affected 49.5 million children under five [5,6]. The 2030 Sustainable Development Agenda sets out a transformative vision acknowledging that our climate is evolving, bringing with it new problems that need to be addressed if we are to live in a climate without poverty, food insecurity and malnutrition in all of its forms. Yet more than 820 million people are still hungry in the world today, demonstrating the daunting challenge of meeting the Zero Hunger goal by 2030. In almost all sub-regions of Africa, and to a lesser degree, in Latin America and Western Asia, hunger is rising. The significant development in South Asia in the last five years, but the prevalence of undernourishment in this sub-region remains the highest in Asia. 2 billion people worldwide face moderate to extreme food insecurity, and 17.2% (1.3 billion people) of the world's population has suffered significant food insecurity [7,8].

Today, the world faces a potential food security crisis due to a growing population and a lack of secure supply of safe, nutritious, and sustainable high-quality food with lower inputs and other environmental changes and diminishing resources in the light of global climate change [9,10]. Given some development, most countries are not on track to achieve the goal of eradicating poverty and hunger, and increasing population growth makes it much more difficult to tackle hunger.And realizing food security requires that: sufficient quantities of adequate food are regularly available, individuals have adequate incomes or other resources to purchase or exchange for food, food is adequately prepared and stored, and individuals have sound knowledge of nutrition and childcare that they make good use of, and access to adequate health and sanitation services [8,11].

Ethiopia has made important development gains over the past two decades, by reducing poverty and expanding investments in basic social services. In the face of several efforts made in Ethiopia so far to improve the overall *food insecurity*, it is still a major problem since a long time ago [12]. In 2017, the food security scenario in Ethiopia worsened significantly. The estimated food insecure population risen from 5.6 million in December 2016 to 8.5 million in August 2017, with extended drought, conflict, insecurity, and crop disease among the primary drivers [13]. The government of Ethiopia has a long-term strategy of agricultural development-led industrialization continues to address the country's food insecurity and is complemented by Ethiopia's Food Security Programme, which includes the Productive Safety Net Programme, the Household Asset Building Programme and others designed to ease households out of food insecurity [14]. Therefore,

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it is crucial to identify the determinant of food security at the household level using a household-based cross-sectional study to design appropriate strategies that can help reduce the problem. Therefore, this study tries to identify the determinant factors of food security in the East Gojjam zone, northern Ethiopia using a binary logistic regression model.

Data and Methodology

Study area and study design

This study was conducted in East Gojjam zone on two arbitrarily selected districts namely Machakel and ShebelBerenta. In this study, a cross-sectional survey was carried out to investigate the degree of food insecurity and it's determinants in which the study population consisted of all households in the study area at the survey time.

Source of data: Primary data was used for this study. Data were collected by using a structured interviewer-administered questionnaire, in the fall of March 2017. The questionnaire covered a range of topics including 18 items core food security module (CFSM) question series, socioeconomic, demographic, and related characteristics of households.

Variables Under the study: In this study, food security is measured at the household level and it refers to certain, sufficient, or acceptable availability, access, or utilization of food. The response variable for this study was the food security status of households with a binary outcome (with a status of food secure and food insecure). The household is classified into one of the food security status based on the household's scale score on the food security scale using the set of CFSM indicator questions adopted from the united state department of agriculture (USDA). This measure is the standard measure of food insecurity and is now used to measure food security in virtually all national, state, and local surveys. The independent variable (predictors) for this study includes different socio-economic, demographic, environmental, and institutional characteristics of the household, and those were adopted from previous literature and based on the economic theory and assumed to affect the food security status of households were considered [15-20].

Sampling technique and sample size: Multistage cluster sampling (two-stage cluster sampling) was employed. Primarily, East Gojjam zone was classified based on geographical or administrative characteristics into different clusters (districts), among those clusters two districts were randomly selected. Secondly, the district was classified into Keble's and some of the Keble's were selected using a simple random sampling technique (lottery method) from each district. Lastly, households that are the smallest study unit in this study were selected using a systematic sampling technique. Besides, a total of 504 households (sample size) were considered for this study.

Statistical Methodology

Since the dependent variable food security status of households (food secure, food insecure) is a dichotomous (binary) multivariable binary logistic regression model was used as a tool to identify the determinant factors of food security among households. The binary logistic regression model empowers one to select the predictive model for dichotomous dependent variables. It describes the relationship between a dichotomous response variable and a set of explanatory variables (predictors) [21-23].

For this study, the binary logistic regression model was used to scrutinize the predictors on the probability of the response variables (food security)(Y_{ij}) , and Y_{ij}takes a values 1 if the households had a better score on the food security scale using the set of CFSM indicator (food secure) and 0 other wises. Let us denote the proportion of success (food secure) by $p(Y_i = 1) = \pi_j$, and the proportion of failure (food insecure) by $p(Y_{ij} = 1) = 1 - \pi_j$ with the assumption of Y_i~ Bernoulli (π_i). Besides, $\mathbf{X}_{nx(k+1)}$ denote the single level binary logistic regression data design matrix of k predictor, for the response variables food security status and $\beta_{(k+1)x1}$ bea vector of unknown coefficients of the covariates and intercept and given as:

$$X = \begin{bmatrix} 1 & x_{11} & x_{12} & \dots & x_{1k} \\ 1 & x_{21} & x_{22} & \dots & X_{2k} \\ \vdots & \dots & \dots & \dots & \vdots \\ 1 & x_{n1} & x_{n2} & \dots & x_{nk} \end{bmatrix} \quad \beta = \begin{bmatrix} \beta_o \\ \beta_1 \\ \vdots \\ \beta_k \end{bmatrix} \quad [1]$$

Considering the descriptions given in equation 1, the logistic regression function can be defined as:

$$\pi_i = \frac{\exp(\beta_o + \beta_1 X_{i1} + \beta_2 X_{i2} + \dots + \beta_k X_k)}{1 + \exp(\beta_o + \beta_1 X_{i1} + \beta_2 X_{i2} + \dots + \beta_k X_k)} = \frac{\exp(X_i'\beta)}{1 + \exp(X_i'\beta)} \quad [2]$$

Whereπ_ii=1,2, ...,n is the i^{th} probability of households become food secure given a set of predictors ($\mathbf{X}$). Then, after algebraic manipulation, the multivariable logistic regression model can be written as in terms of an odds ratio (equation 3) and logit link (equation 4) for *i*=1, 2,..., k as [23]:

$$\theta = \frac{P(y = 1/X)}{1 - p(y = 1/X)} = \exp(\beta_o + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_k X_k) = \exp(X_i'\beta) \quad [3]$$

$$\log\left(\frac{P(y = 1/X)}{1 - p(y = 1/X)}\right) = \log\left(\frac{\pi_i}{1 - \pi_i}\right) = \beta_o + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_k X_k = X_i'\beta \quad [4]$$

Parameter Estimation and Goodness of fit test

The logistic regression model uses maximum likelihood estimation (MLE) to estimate the unknown coefficients (parameters) that are included in the model. Hence, in this study the maximum likelihood estimation technique to estimate the unknown parameters of the model was employed. The likelihood ratio (G^2) test (log-likelihood test) was used to assess the overall fit of the fitted logistic regression model. And the Hosmer-Lemeshow test(atest procedure that is formulated under the null hypothesis that the model fits the data well, and the alternative is that the model does not fit) was employed. Lastly, the Wald test was used to test the significance of individual logistic regression coefficients for each predictor. Besides, Akaike's information criterion (AIC) and Bayesian information criterion (BIC) were considered as the model selection criteria.

Results

Descriptive statistics

In this study, a total of 504 households were considered from two districts, namely Machakel and ShebelBerenta. The food security status of the households in this study was determined using the 18-item Core Food Security Module (CFSM) question series designed by USDA, which is recognized as the standard measure of food insecurity in virtually all national, state and local survey. From a total of 504 households, 375 (74.4%, 95% CI: 70.39, 78.04) were food insecure, and 129(25.6%, 95% CI: 21.96, 29.6) were food secure (Table 1).

The proportion of food security shows a variation across administrative units (districts) in this study. Among 241 households considered in shebelBerenta district, 143(59.3%) are food insecure, and of 263 households in Machakel district, 232(88.32%) are food insecure. Nearly three-fourth of household heads (74%) in terms of both genders had food insecure status. Among 405 married households, only one-fourth (24.9%) of them are food secure. Of 87 illiterate heads of households, 72(82.8%) are food insecure;

Table 1. Distribution of households via food security status in the study area.

Food security status	Frequency	Percent (95%: CI)
Food insecure	375	74.40 [70.39,78.04]
Food secure	129	25.60 [21.96, 29.60]

and among 63 elementary completed household heads, 32(50.8%) of them are food secure. From 344 households from WoinaDega agro-ecological zone, only 64(18.6%) of them are food secure. Of the households who had an agricultural land with normal (level) slope 39 (52.7%) of them are food secure. And from 398 households who had private land ownership, 103(25.9%) are food secure (Table 2).

Model specification

In this study, the binary logistic regression model was employed to identify the determinant factors of food security by incorporating a set of predictors associated with the dependent variable. To appropriately address all factors that are alleged to affect the status of food security, different previous food security-related pieces of literature were well carefully perceived.

Univariate analysis

The response (outcome) variable for this study was food security status (food secure, food insecure) of households, and the explanatory variables considered in this study were district, age of head of households, the gender of head of households, marital status of head of households, education status of head of households, agro-ecological zone, family size, land size, monthly income, monthly expenditure, tropical livestock unit (TLU), land ownership status, access or source lighting, soil fertility, access for the toilet, training by agricultural profession, source of drinking water, use of farm input (fertilizer), Plot slope (steepness), irrigation practice, use of the improved seed, loan access, and saving practice based on different kinds of literature.

Before building a multivariable binary logistic regression model to identify the determinant factors of food security univariate fit for each explanatory variable was performed (Table 3). As a result, explanatory variables that appear to be important in a univariate analysis at a 20% level of significance were fitted together by a multivariable binary logistic regression model.

Among the set of predictors considered in the univariate analysis in Table 3: district, education status of head of households, land size, TLU, access or source lighting, soil fertility, source of drinking water, plot slope (steepness), irrigation practice, use of the improved seed, loan access, and saving practice appear to be important in a univariate analysis at 20% level of significance.

Multivariable analysis

Variables that showed an association with the outcome variable at P-value ($P < 0.2$) in the univariate analysis were entered into the final multivariable analysis. Adjusted Odds ratio (AOR) along with a 95% confidence interval was estimated to identify the determinant factors of food security and P-value < 0.05 was used to declare the statistical significance of each predictor in the multivariable analysis. The multivariable binary logistic regression model with the logit link function was fitted for the explanatory variables that appear to be important at univariate analysis with food security status (Table 4).

The likelihood ratio test statistic has a chi-square distribution with degrees of freedom are obtained by differencing the number of parameters included in both models. The null hypothesis for this test statistic is that all the coefficients in the logistic regression model except the constant are zero. When the likelihoodratio test statistic is significant, at least one of the predictors is significantly related to the response variable [21]. In this study, the full multivariable binary logistic regression model was compared to the null model (only intercept model) using the likelihood ratio test (LRT) which tests whether the current model predicts better than the intercept only model. The value of the likelihood ratio chi-square statistic is LR (21)=143.75 with $p \leq 0.001$ implies that the full model predicts the data better than the intercept only model (Table 5). To check the goodness of fit the Hosmer and Lemeshow test was conducted on the multivariable binary logistic regression model. As shown from Table 5, the Hosmer and Lemeshow test of the fitted model are insignificant (chi (8)=5.691, P-value=0.0623) showing that the multivariable binary logit model fit the data well. Besides, the full model had a minimum information criterion (AIC=473.57, BIC=566.47) as compared with the null (intercept only) model (Table 5).

Besides, a receiver operating characteristic (ROC) curve was plotted to illustrate the diagnostic ability or accuracy of a binary classifier system as its discrimination threshold is varied. The ROC curve is created by plotting the true positive rate against the false-positive rate at various threshold settings [24-26]. As shown in Figure 1, the area under the ROC curve is 0.824 shows that a moderate accuracy was observed, as an area between 0.7 and 0.9 indicates moderate accuracy [24].

The results displayed in Table 4, the multivariable binary logistic regression, that provides the estimated coefficients, standard errors, p-values, adjusted odds ratio, and their 95% confidence intervals of the

Table 2. Demographic and related characteristics of households by food security status in the study area.

Characteristics		Food insecure		Food secure		Total
		Frequency	%	Frequency	%	
District	ShebelBerenta	143	59.30%	98	40.70%	241
	Machakel	232	88.20%	31	11.80%	263
Gender of Head of HHs	male	301	74.30%	104	25.70%	405
	female	74	74.70%	25	25.30%	99
	Married	304	75.10%	101	24.90%	405
Marital status of Head of HHs	single	19	79.20%	5	20.80%	24
	Divorced	21	77.80%	6	22.20%	27
	widowed	31	64.60%	17	35.40%	48
Education status of Head of HHs	Illiterate	72	82.80%	15	17.20%	87
	Read and write	258	78.70%	70	21.30%	328
	Elementary completed	31	49.20%	32	50.80%	63
	High school and above	14	53.80%	12	46.20%	26
Agroecological zone	kola	45	71.40%	18	28.60%	63
	WoinaDega	280	81.40%	64	18.60%	344
	Dega	50	51.50%	47	48.50%	97
slope of land	level	35	47.30%	39	52.70%	74
	medium	307	79.30%	80	20.70%	387
	Gentle slope	33	76.70%	10	23.30%	43
land ownership	private	295	74.10%	103	25.90%	398
	Rented	67	77.90%	19	22.10%	86
	Collaborated	13	65.00%	7	35.00%	20

Table 3. Univariate analysis of the determinants of food security among households in East Gojjam Zone, 2017.

Predictors	Coef.	Std. Err.	Z	P>z	[95% Conf. Interval] for		AOR	[95% Conf. Interval]	
District (Ref.: ShebelBerenta)									
Machakel	-1.484	0.3394882	-4.37	0.000	-2.149964	-0.81919	0.226598	0.116488	0.440787
Education status for the head of household (Ref.: Illiterate)									
Read and write	-0.099	0.3712105	-0.27	0.789	-0.8271168	0.6280018	0.905238	0.437308	1.873862
Elementary comp.	0.571	0.4500323	1.27	0.204	-0.3107503	1.453344	1.770562	0.732897	4.277394
High school+	0.513	0.5661746	0.91	0.365	-0.5963683	1.622995	1.670818	0.550808	5.068249
Land size (hec.)	0.437	0.1306163	3.35	0.001	0.1815689	0.6935755	1.548942	1.199097	2.000857
The slope of agricultural land (Ref.: Normal slope)									
Medium	-0.760	0.3311309	-2.3	0.022	-1.409506	-0.111496	0.467432	0.244264	0.894494
Gentle slope	-0.960	0.5415121	-1.77	0.076	-2.021459	0.1012291	0.382849	0.132462	1.10653
Source lighting (energy source) (Ref.: Kerosene)									
Private generator	0.915	0.5884847	1.56	0.12	-0.2381255	2.068692	2.497483	0.788104	7.914466
Solar panels	0.693	0.3301115	2.1	0.036	0.0461368	1.34015	1.999993	1.047218	3.819617
Government elect.	1.422	0.6042366	2.35	0.019	0.2379081	2.606472	4.146191	1.268593	13.55116
Other	0.527	0.3525154	1.5	0.135	-0.1635347	1.2183	1.694492	0.849137	3.381436
Soil fertility of agricultural land (Ref.: infertile)									
Medium	0.004	0.5590684	0.01	0.994	-1.091203	1.100304	1.004561	0.335812	3.00508
Fertile	0.831	0.7307519	1.14	0.255	-0.6007596	2.263735	2.296733	0.548395	9.618949
Saving habit of household head (Ref.: Yes)									
No	0.051	0.3131923	0.16	0.87	-0.5626777	0.6650134	1.0525	0.569682	1.944517
Have you taken a loan, for the last 12 months (loan status) (Ref.: Yes)									
No	-0.764	0.3512766	-2.18	0.029	-1.453339	-0.076359	0.465404	0.233788	0.926483
Source of drinking water (Ref.: Pipe)									
Pond	-0.256	0.6062232	-0.42	0.673	-1.444314	0.9320374	0.774035	0.235908	2.539678
River	-0.457	0.3465539	-1.32	0.187	-1.136818	0.2216485	0.63281	0.320838	1.248133
other	-0.539	0.7182121	-0.75	0.452	-1.94766	0.8676793	0.582754	0.142607	2.381378
Irrigation practice (Ref.: No)									
Yes	1.828	0.5694972	3.21	0.001	0.7123152	2.944703	6.2246	2.038706	19.00502
Do you use improved seed (Ref.: Yes)									
No	0.576	0.3728994	1.55	0.122	-0.1544	1.307339	1.779744	0.856929	3.696324
TLU	0.186	0.0592793	3.14	0.002	0.0696565	0.302027	1.204232	1.07214	1.352598
cons	-2.818	0.9405664	-3	0.003	-4.66232	-0.97536	0.059675	0.009445	0.377054

Table 4. Multivariable analysis (parameter and odds ratio estimates) of the determinants of food security among households in East Gojjam Zone, 2017.

Predictors	Coef.	Std. Err.	Z	P>z	[95% Conf. Interval] for		AOR	[95% Conf. Interval]	
District (Ref.: ShebelBerenta)									
Machakel	-1.484	0.3394882	-4.37	0.000	-2.149964	-0.81919	0.226598	0.116488	0.440787
Education status for the head of household (Ref.: Illiterate)									
Read and write	-0.099	0.3712105	-0.27	0.789	-0.8271168	0.6280018	0.905238	0.437308	1.873862
Elementary comp.	0.571	0.4500323	1.27	0.204	-0.3107503	1.453344	1.770562	0.732897	4.277394
High school+	0.513	0.5661746	0.91	0.365	-0.5963683	1.622995	1.670818	0.550808	5.068249
Land size (hec.)	0.437	0.1306163	3.35	0.001	0.1815689	0.6935755	1.548942	1.199097	2.000857
The slope of agricultural land (Ref.: Normal slope)									
Medium	-0.760	0.3311309	-2.3	0.022	-1.409506	-0.111496	0.467432	0.244264	0.894494
Gentle slope	-0.960	0.5415121	-1.77	0.076	-2.021459	0.1012291	0.382849	0.132462	1.10653
Source lighting (energy source) (Ref.: Kerosene)									
Private generator	0.915	0.5884847	1.56	0.12	-0.2381255	2.068692	2.497483	0.788104	7.914466
Solar panels	0.693	0.3301115	2.1	0.036	0.0461368	1.34015	1.999993	1.047218	3.819617
Government elect.	1.422	0.6042366	2.35	0.019	0.2379081	2.606472	4.146191	1.268593	13.55116
Other	0.527	0.3525154	1.5	0.135	-0.1635347	1.2183	1.694492	0.849137	3.381436
Soil fertility of agricultural land (Ref.: infertile)									
Medium	0.004	0.5590684	0.01	0.994	-1.091203	1.100304	1.004561	0.335812	3.00508
Fertile	0.831	0.7307519	1.14	0.255	-0.6007596	2.263735	2.296733	0.548395	9.618949
Saving habit of household head (Ref.: Yes)									
No	0.051	0.3131923	0.16	0.87	-0.5626777	0.6650134	1.0525	0.569682	1.944517
Have you taken a loan, for the last 12 months (loan status) (Ref.: Yes)									
No	-0.764	0.3512766	-2.18	0.029	-1.453339	-0.076359	0.465404	0.233788	0.926483
Source of drinking water (Ref.: Pipe)									

Pond	-0.256	0.6062232	-0.42	0.673	-1.444314	0.9320374	0.774035	0.235908	2.539678
River	-0.457	0.3465539	-1.32	0.187	-1.136818	0.2216485	0.63281	0.320838	1.248133
other	-0.539	0.7182121	-0.75	0.452	-1.94766	0.8676793	0.582754	0.142607	2.381378
Irrigation practice (Ref.: No)									
Yes	1.828	0.5694972	3.21	0.001	0.7123152	2.944703	6.2246	2.038706	19.00502
Do you use improved seed (Ref.: Yes)									
No	0.576	0.3728994	1.55	0.122	-0.1544	1.307339	1.779744	0.856929	3.696324
TLU	0.186	0.0592793	3.14	0.002	0.0696565	0.302027	1.204232	1.07214	1.352598
cons	-2.818	0.9405664	-3	0.003	-4.66232	-0.97536	0.059675	0.009445	0.377054

Table 5. Akaike's information criterion and Bayesian information criterion for the null and full model.

Model	Obs	ll(null)	ll(model)	df	Information criterion		Likelihood ratio test		HLT	
					AIC	BIC	LR chi²	Prob> chi²	Chi²	Prob> chi²
Null model	504	-286.665	-286.665	1	575.3308	579.5533				
Full model*	504	-286.665	-214.789	22	473.5792	566.4759	143.75	0	5.691	0.0623

'*' Indicates the fitted multivariable binary logistic regression model with a set of predictors, HLT: Hosmer and Lemeshow Test.

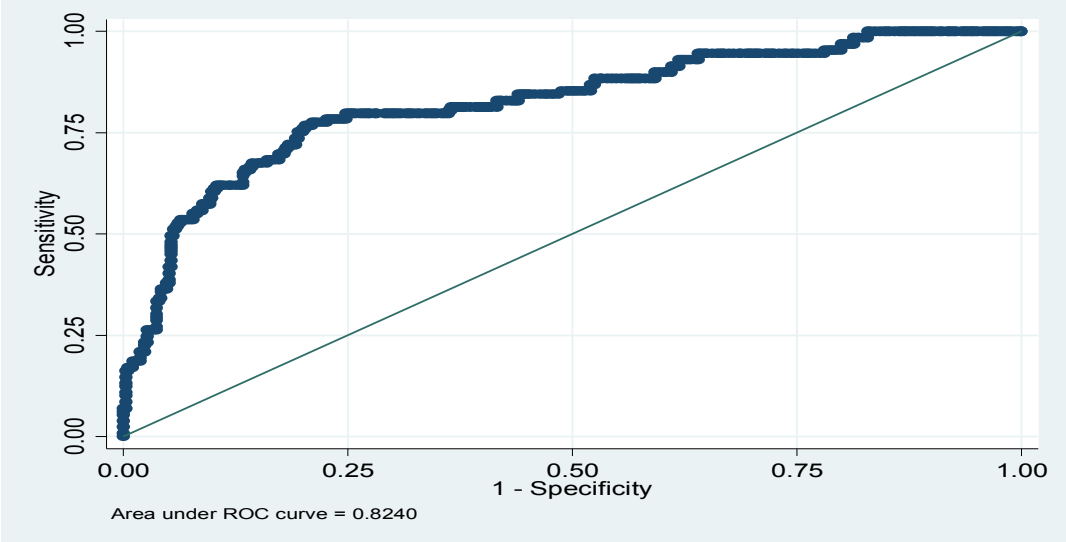

Figure 1. The ROC curve plot of the sensitivity versus 1-specificity of a diagnostic test.

explanatory variables. The importance or effect of each predictor in the outcome variables is interpreted as the log odds of the response variable being food secure as opposed to food insecure. The result of multivariable binary logistic regression analysis showed that district, landholding size (in hec.), slope (steepness) of agricultural land, source of access to energy (source lighting), loan status, irrigation practice, and TLU were found to be important predictors for food security among households in the study area, at 5% level of significance.

Households from Machakel district were 0.226 times less likely to be food secure than those of households from Shebelberenta district (AOR=0.226, 95%CI: 0.116, 0.441). For one unit increase in the landholding size in a hectare of the household, the odds of being food secure would be increased by 54.8% (AOR=1.548, 95%CI: 1.199, 2.001), given that all of the other variables in the model are held constant. Households who had an agricultural land with a medium slope (moderately sloped) were 0.467 less likely to be food secure than households who had normal slope (level or flat) agricultural land (AOR=0.467, 95%CI: 0.224, 0.894) (Table 4).

Households who use the solar panel as a source of access to energy were 1.999 times more likely to be food secure than those households who use kerosene as a source of access to energy (AOR=1.999, 95%CI: 1.047, 3.819). Likewise, Households who use government electricity as a source of access to energy were 4.146 times more likely to be food secure than those households who use kerosene as a source of access to energy (AOR=4.146, 95%CI: 1.268, 13.551). Households who don't take a loan from any financial institutions were about 0.465 times less likely (AOR=0.465, 95%CI: 0.234, 0.926) to be food secure than those households who take a loan from financial institutions in the previous 12 months before the survey time. Households that practice irrigation to produce different agricultural commodities were 6.224 more likely (AOR=6.224, 95%CI: 2.039, 19.005) to be food secure than households that do not practice irrigation. Similarly, for one unit increase in the TLU of the household, the odds of being food secure would be increased by 20.4% (AOR=1.204, 95%CI: 1.072, 1.353) (Table 4).

Discussion

In this study, a low proportion of food security 25.6% (nearly one-fourth of the respondents) among households were observed in the study area. This may be because households were unable to produce satisfactory agricultural products due to poor soil fertility and degraded land nature. And also the commonly grown agricultural products in the study area had low power in generating income (not exportable commodities). Therefore, an intervention related to food security programs should be highly implemented and advocated in the study areas to change the living standard of the communities.

In this study, landholding size in a hectare of the household was found to be a significant determinant of household food security. For one unit increase in the landholding size in a hectare of the household, the

odds of being food secure would be increased by 54.8% (AOR=1.548, 95%CI: 1.199, 2.001), given that all of the other variables in the model are held constant. This finding is consistent with the study results testified from the Oromia region of Ethiopia [27]. This possible reason may be that households who had enough plot of land can fully cover their needed food by producing commodities with a low expense. As land is a scarce natural resource for the rural households (below 2 hec/household) in Ethiopia, this study inspires the practice of agroforestry (mixed farming system: assimilated elements of both livestock and crop cultivation) to amend the living standard of the households.

The geographical or administrative unit (district) was found to be a statistically significant determinant for household food security. Households from Machakel district were 0.226 times less likely to be food secure than those of households from Shebelberenta district (AOR=0.226, 95%CI: 0.116, 0.441). Households belonging to machakel district were less likely to be food secure as compared to households belonging to Shebelberenta district. The possible variation may be due to low and poor potential land for farm and off-farm activities to fulfill their basic needs in machakel district than Shebelberenta district. Besides, agricultural lands in machakel district are highly degraded, and this situation largely reduces the fertility of the soil. This study encourages the government and concerned bodies to pay attention to afforestation and contour programs to recover the degraded land.

Similarly, the sloping nature of the agricultural land was found to be another important factor for food security. Households who had an agricultural land with a medium slope (moderately sloped) were 0.467 less likely to be food secure than households who had normal slope (level or flat) agricultural land (AOR=0.467, 95%CI: 0.224, 0.894). This may be due to the fact that moderately sloped lands are highly vulnerable for soil erosion (a major threat to development in most economies of the world) and unable to hold up their fertility nature that makes the agricultural land less productive. This result is consistent with the study done in South Africa and Himalayas by [28,29].

Livestock ownership (in tropical livestock unit (TLU)) was found to be a statistically significant determinant for household food security. Keeping the effect of other predictors constant, for one unit increase in the TLU of the household, the odds of being food secure would be increased 20.4% (AOR=1.204, 95%CI: 1.072, 1.353). This implies that large livestock ownership positively contributes to household food security. This may be due to the fact that livestock serves as a way of wealth accumulation, and they may serve to alleviate the vulnerability of households during crop failures and other disasters. This result is consistent with the previous studies conducted in different parts of Ethiopia, particularly the central Zone of Tigrai and Borana Zone of Oromia regional state [15,18,30].

More importantly, irrigation practice was another significant determinant factor of household food security. Households that practice irrigation to produce different agricultural commodities were 6.224 more likely (AOR=6.224, 95%CI: 2.039, 19.005) to be food secure than households that do not practice irrigation. The possible reason for this may be enhanced water supervision and use are fundamental to lifts or improve food production in terms of quantity and variety with accumulative agricultural yields. This study is consistent with other studies [31,32] which argued that proficient use of available irrigation water is a chief alarm to improve food security. Therefore, this study motivates the stakeholders to work on communities in developing irrigation systems to increase agricultural yields, in developing sustainable new food sources through practices like fish farming, through garden projects with agricultural micro-enterprises, and nutrition education initiatives.

Likewise, the source of access to energy was found to be a statistically significant determinant of household food security. The present study found that households who use the solar panel as a source of access to energy were 1.999 times more likely to be food secure than those households who use kerosene as a source of access to energy (AOR=1.999, 95%CI: 1.047, 3.819). And also households who use government electricity as a source of access to energy were 4.146 times more likely to be food secure than those households who use kerosene as a source of access to energy (AOR=4.146, 95%CI: 1.268, 13.551). The possible explanation for this variation might be access to energy in the form of renewable energy (solar panel, and government electric) needs low cost for obtaining the service from the user side, easy to use for cooking food, and also they may have high media exposure to access information on various issues from various platforms using energy as compared with other means of access to energy. This result is in line with the studies conducted in Pakistan, argued that households with electricity connections were less probable to be food insecure than those who do not have electricity connection [33].

Access for loans from a financial institution for the past 12 months was found to be another determinant factor for household's food security. Households who don't take a loan from any financial institutions were about 0.465 times less likely (AOR=0.465, 95%CI: 0.234, 0.926) to be food secure than those households who take a loan from financial institutions in the previous 12 months before the survey time. The possible explanation could be that households who take a loan from a financial institution may not use for productive use (they may expense the loan on non-profitable items/goods), and the use of poor business plan to get the credit service. This result is consistent with the studies done in Ethiopia argued that households who have access to credit sources were likely to be less food secure[18].

Conclusion

A low proportion of food security among households was observed in the study area. Among the set of predictors considered the source of access to energy, landholding size in a hectare, access for a loan from financial institutions, the practice of irrigation, tropical livestock unit (TLU) (livestock possession), slope of agricultural land, and district were found to be a statistically significant determinant of food security. As a result, collaborative efforts by different stockholders should be organized to improve the food security status of households. The agricultural office should intervene to promote food security among households via developing irrigation systems for better agricultural products and agroforestry practice (cohesive livestock and agriculture products) should be promoted in the community. Besides, the health office and agricultural office jointly should work on the establishment of garden projects (agricultural production site with a variety and mixed products) and promoting nutrition education initiatives for improving food utilization-making awareness on the variety of foods their bodies need to maintain good health.s.

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