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The Effect of Farmers' Participation in Soil and Water Conservation Practices in Their Household Food Security Together with Other Determinant Factors in Farta Woreda, South Gondar Zone, Amhara National Regional State, Ethiopia

Delelegn Adugna[1]* Dr. Daregot Birhanu[2] Hailu Menale[3]
1.Amhara National Regional State Bureau of Agriculture
2.Department of Economics, Bahir Dar University
3.Guna Tana Integrated Field Research and Development Center, Debre Tabor University

Abstract
The objective of this study was to examine the impacts of soil and water conservation activities on household food security status together with other factors in Farta woreda, South Gondar Zone. In this study a two stage sampling procedure was employed to select 6 sample kebeles out of 41 and 381 sample households out of 8230 in the sampled kabala's using simple random sampling. The primary data were collected using pre-tested structured questionnaire. Categorization of households in to food secure and insecure was done based on the cost of 2200 kcal per day per adult which was determined to be 1985 birr per year per adult person as food poverty line for Ethiopia. The result revealed that only 35.67% of sample households participated in soil and water conservation activities voluntarily and about 70.34% and 29.66% of sample households were food insecure and secure groups respectively with the average 21 percent food gap for insecure households. Descriptive statistics and binary logistic regression model was employed to identify rural household food security status. The result of binary logit model revealed variables such as participation index, age, family size, education level, off-farm income, farm income, size of cultivated land, soil fertility problem, ox ownership and dependence ratio were found to be significant determinants of rural household food security status. Thus development partners should made effort to increase farmers' participation in soil and water conservation and activities should be done in integrated way to maintain the food security level of households. Moreover attention should be given to those factors that were found to affect both farmers' participation and households' food security status in the study area.
Keywords: Participation, Soil and Water Conservation, Food Security, Binary Logistic Regression

1 Introduction

The economic performance and development prospects of many developing countries like Ethiopia are largely dependent on Agricultural crop production (Doppler, 2004). Sustainable increases in crop production are critical for achieving food security for growing populations in such developing countries. However, according to Doppler (2004) soil erosion is a problem for such developing countries and soil degradation declines agricultural productivity (IFPRI, 1997) cited in Slaymaker 2002. This is due to inappropriate resource management practices.

Soil degradation and poor water management are serious problem throughout Africa for the development of agriculture. Inappropriate farming practices result in soil erosion, a loss of soil organic matter and declining fertility and capacity to retain water. The results are unreliable yield and chronic water shortage due to lack of sufficient ground water recharge (FAO 2008). The negative effects of soil degradation processes on agricultural production, rural incomes, food consumption and even national wealth are evident in many areas, most notably in Sub-Saharan Africa (IFPRI, 1997) cited in Slaymaker 2002. All most all of sub–Saran Africa needs to increase production on food and this needs will become more urgent during at least the next twenty five years (FAO, 2001). Mitigation of degradation processes and restoration of soil productivity through the promotion of sustainable use of soil and water resources is thus a priority concern in respect of achieving both food security and wider poverty reduction objectives (Slaymaker 2002).

About 40% of the world's agricultural land is seriously degraded, where 80% of this degradation is caused by soil erosion (Graaff *et al.* 2009). Land degradation in Ethiopia accounts for 8% of the global total (Tekalign, 2008). The most serious problem is the removal of fertile topsoil by water in the highlands where, 85% of the human and 77% of livestock population is living and agriculture is intensive (Gete, 2000). The annual costs of land degradation in Ethiopia are estimated to be 2-3% of agricultural GDP (ESIF-SLM, 2010). According to FAO/WFP 2005, more than 2 million ha of Ethiopia's highlands have been degraded beyond rehabilitation, and an additional 14 million hectares severely degraded, which is reflected in cereal yield reduction averaging less than 1.2 tons per hectare in most of the highlands. As a result of this extensive land degradation, soil productivity has been negatively affected agricultural production. The low productivity of agricultural sector coupled with rapid population growth aggravated the problem of household food insecurity. Food insecurity and sluggish growth in agricultural production, accelerated by increasing population pressure and soil degradation characterized the Ethiopian agriculture (Million and Belay, 2004) cited in Mesfin *et al.* 2012.

Soil loss in Amhara region is estimated to be 58% of the total soil loss in the country and this has resulted in a reduction in agricultural productivity of 2 to 3% per year (Tesfahun and Osman, 2003). For example during the 2009 Meher the productivity of barely for Amhara (13.07 Qtl/Ha) which was lower than the national average (15.5 Qtl/Ha). Due to low household land size, high population density, and low soil fertility and agricultural productivity, Amhara has the highest number of chronically food insecure and low income people in Ethiopia (FOA and WFP, 2009). According to the 2007 census, 23.3% of Ethiopia's average population lives in Amhara, while 31.1% of Ethiopia's low income and food insecure resides in the region (CSA, 2007).

For subsistence farmers the consequence of land degradation is direct "less food with more effort." As a producer soil degradation leads to "lower yield with more efforts" so either less food or less income. As a consumer, they can buy it if they have money (Frits Penning and David, 2002). Degradation may also leads increasing cost of living and to higher food price so household food security is also affected in the second case. But at global and national level the effect may not be seen. In this case the focus is on the sufficient food for all people in the world and the nation respectively. But in household food security, the focus is on the ability of household to purchase or produce food they need for healthy and active life, disposable income is crucial. Food security has always a component of production, access and utilization (Frits Penning and David, 2002). Erosion problem has also effects on environmental degradation and future food production and calls attention of successful approaches to reduce the problem and improve food security (Frits Penning and David, 2002). To enhance productivity of land and to improve food security integrated and holistic soil and water management is required (FAO 2001). Yenealem et.al (2013) also indicated that agricultural countries like Ethiopia, soil and water conservation is a crucial in improving livelihood of the rural farm households and the approaches to more productive and sustainable system must be holistic in terms of farmers' involvement and other stakeholders. Successful and sustainable production has been developed where farmers were actively participated in soil and water conservation activities (FAO 2001). Farmers participation means "with farmers" design and implement interventions strategies should occur together all stakeholders (Frits Penning and David, 2002).

Despite the growing policy interest and increasing efforts made by the government in monitoring soil losses, changes in vegetative cover and changes in depth of water tables, farmers' participation on soil and water conservation is low and soil and water degradation becomes major causes for food insecurity and vulnerability in Ethiopia (Barrett *et al.* 2002 and Berhanu *et al*. 2009). According to UN 2010 report, Ethiopia face a food security situation and it is a least developed country ranked 171 out of 182 countries in the UNDP human development index for 2009.

2 Methodology

2.1 Description of the Study Area

The study was conducted in Farta woreda, South Gondar Zone, Ethiopia which located between $11^0$32'- $12^0$03' latitude and $37^0$31'- $38^0$43' longitude. It has a total area of 1117.88 km^2 (111788 hectare) which is divided into 41 local administration called Kebela. The topography of the study area varies from place to place and there are significant differences in altitude gradient which can be even observed in a short distance which range from 1900 to 4113 meters above sea level (FWOA, 2013). According to FWOA, 2013 the study area has two agro climatic zones: Dega which covers about 44% of the area with an altitude of more than 2300 m.a.s.l. and Woinadega ranging between 1900–2300 m.a.s.l and encompasses about 56% of the area. The topography and terrains of the wereda consists of 45% gentle slope, 29% flat and 26% steeply sloped. The area has mean annual temperature of 15.5^0c and it has unimodal rainfall pattern with mean annual rainfall of 1570 mm (FWOA, 2013).

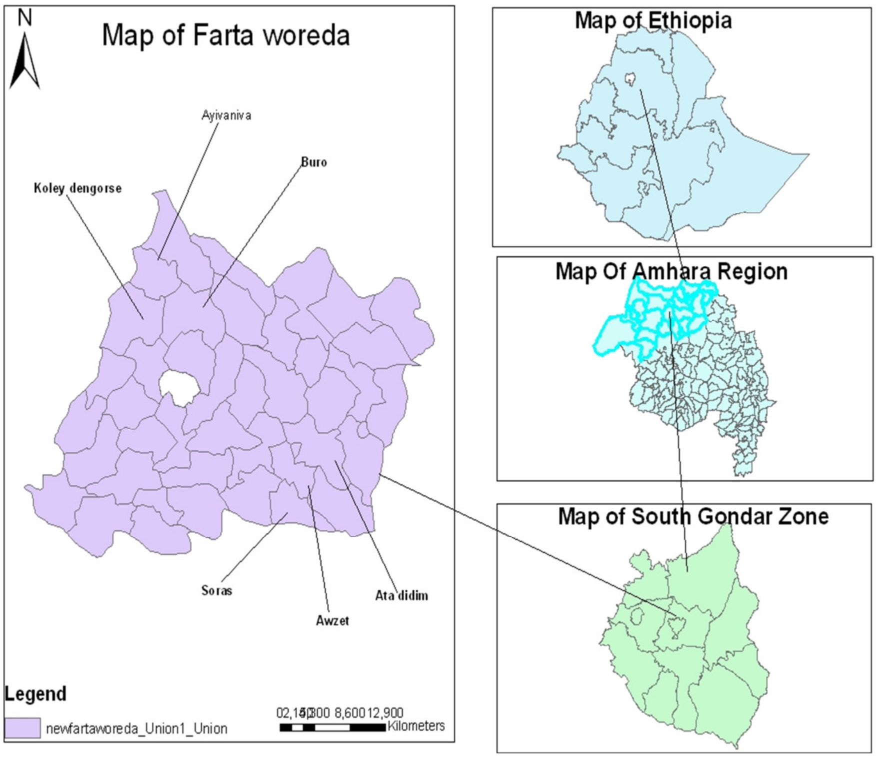

Figure 1. Map of the Study Area

2.2 Data collection technique

For this study quantitative and qualitative data were collected from primary and secondary sources. Primary data was collected from sample households using structured questionnaire. The structured survey questionnaire was pre-tested before the actual data collection and some adjustments were made after the pre-test based on the results. Five enumerators who can speak the local language were trained on the techniques of data collection, including how they should approach farmers, conduct the interview, and convince the respondent to give relevant information on sensitive economic and social issues. Continuous assistance was made by the researchers to correct possible errors at the field and more than half of the data were collected by the researchers. The survey was conducted from the mid March to the early April 2014.

A two stage sampling procedure was employed to take sample household. In the first stage, 3 kebeles from highland and 3 kebeles from mid-altitude were selected randomly and then, three hundred eighty one representative farmer households were randomly selected from selected kebeles using probability proportional to sample size sampling techniques. The list of household heads in each kebeles was used to make random selection of the sample household farmers. The random was started at household number 5 and the next households were selected at random interval of 22 by chance from each kebele.

According FWOA, 2013, total household size of the sample kebeles (6 kebeles) is 8230. To decide the sample size of this study a "simplified formula for proportions" which was provided by Yamane (1967:886) cited in Endalamaw, 2013 was used.

This formula is: $\boldsymbol{n} = \frac{N}{1+\mathrm{N}(e)^2}$

Where:

n = statistically acceptable sample size
N = total household size of the sample kebeles i.e 8230
E = level of precision (error level) at 95% confidence level (0.05)

2.3 Measuring participation of farmers' in SWC activities

Activities of SWC such as bunds, cut-off-drains and waterway, check dam construction, plantation on physical conservation structures and area closure that expected to increase productivity and reduce food insecurity were considered to assess the extent of farmers' participation towards the technology. Farmers' participation level in soil and water conservation was given a value as participation index formula. Participation index of individual farmer was calculated using formula provided by (Badal, et al. 2006) as.

$$\mathbf{PI_j} = \frac{\sum_j^N \mathbf{x_j}}{\mathbf{N}}$$

Where,
PI_j = Participation Index for the i^{th} farmer
X_j= 1, 2, 3- - N activities used to indicate the participation of i^{th} farmer in SWC
N = Total number of activities taken to indicate participation level (bunds, cut-off-drains and waterway, heck dam construction, plantation on physical conservation structures, area closure etc.)

2.4 Methods of Data Analysis

2.4.1 Analytical econometric model selection

When the dependent variable is binary (0, 1), OLS regression technique produces parameter estimates that are inefficient and heteroscedastic error structure. As a result, testing hypothesis and construction of confidence interval becomes inaccurate and misleading (Aldrich and Nelson, 1984) cited in Hlina 2005.

Similarly, a linear probability model may generate predicted value outside 0 - 1 interval which violates the basic tenets of probability. It also creates a problem of non- normality of the disturbance term (Ui), hetroscdasticity of Ui, possibility of ŷ lying outside the 0-1 range and the generally lower R^2 values. As result hypothesis testing and constructing confidence interval become inaccurate and misleading and moreover the predicted values (ŷ) lies outside 0-1 range and violate the basic tenets of probability (Gujarati, 2004). To alleviate these problems and produce relevant outcomes, the most widely used qualitative response models are the logit and probit models (Amemaya, 1981) cited in Hilina 2005.

The logit and probit are the possible alternative models and have been widely used for a binary response variable which give qualitatively similar results. However, logit model extremely flexible and easily used model from mathematical point of view and results in meaningful interpretation than probit model. (Gujarati, 2004) Therefore in this study binary logistic regression model was employed to analyze both factors that affect farmers' participation in SWC activities and of rural households in Farta woreda.

2.4.2 Binary logistic regression model

Binary logistic model was used to identify factors that affect farmers' participation in SWC activities and the determinants of rural households' food security and to assess their relative importance in determining the probability of being in a food secure situation and (participant in SWC activities) at household level. The analysis of the logistic regression model was showed that changing an independent variable alters the probability that a given individual becomes food secure or (participant in SWC activities), and was helped to predict the probability of achieving food security (be participant in SWC activities).

Following Gujarati (2004), the functional form of logit model was specified as follows:

$$P_i = \frac{1}{1+e^{-Zi}} \text{ --- (1)}$$

Where, P_i, is the probability that a given household be food secure or (participant in SWC activities).
Zi: is a function of n- explanatory variables (x) and expressed as:

$$Z_i = \beta_o + \beta_1 X_{i1} + \beta_2 X_{i2} + \cdots + \beta_n X_{in} \text{ .... (2)}$$

Where:
Bo: is the intercept.
B1, B2,… Bn , are coefficients of the equation in the model.
The slopes tell how the log-odd in favor of household is food secure or (participant in SWC activities) as independent variables change.
Pi is not only non-linear in X but also in the Bi's, which can be written as:

$$pi = \frac{1}{1+e^{-(\beta_o+\beta_1 X_{i1}+\beta_2 X_{i2}+\cdots\beta_n X_{in})}} \text{ ....(3)}$$

The probability that a given household be food insecure or (non participant) is expressed by:

$$1-P_i = \frac{1}{1+e^{Z_i}} \text{ .... (4)}$$

Therefore, taking the ratio of the probability household is food secure to food insecure or (participant to nonparticipant in SWC activities) can be written as:

$$\frac{P_i}{1-P_i} = \frac{1 + e^{Z_i}}{1 + e^{-Z_i}} = e^{Z_i} \text{ .... (5)}$$

Now $\frac{P_i}{1-P_i}$ is simply the odds ratio in favor of food secure to food insecure or (participant to nonparticipant). However, the relationship between the probability of i^{th} household being food secure or (participant in SWC activities) and the independent variables is not linear. In order to make meaningful interpretation, the probability of i^{th} household being food secure or (participant in SWC activities) should to be written as linear combinations of explanatory variables. This was computed by taking natural log of equation 5 and we got

$$L_i = \ln\frac{P_i}{1-p_i} = Z_i = \beta_o + \beta_1 X_{i1} + \beta_2 X_{i2} + \cdots \beta_n X_{in} \text{ .... (6)}$$

Where, Li is log of the odds ratio, which is linear not only in X, but also in the parameters (the relationship between the probability of i^{th} household being food secure or (participant in SWC activities) and his/her

characteristics are linear now).
Thus, if the stochastic disturbance term (Ui) is introduced, the logit model becomes:
$Z_i = \beta_O + \beta_1 X_{i1} + \beta_2 X_{i2} + \cdots \beta_n X_{in} + U_i$ .... (7)
In reality, the significant explanatory variables do not all have the same level of effect on the probability of farmers' participation in SWC activities and food security status. The relative effect of the significant explanatory variables can be measured by examining marginal effect, defined as the rate change in probabilities that would result from a unit change in the value of explanatory variable which can be computed using the following formula provided by (Gujirati, 2004)
$\frac{dP}{dX} = P(1-P)\beta_i$..8
But after the logistic regression, STATA command 'mfx' gives the value of marginal effect of each explanatory variable on the dependent variable and the interpretation of the significance variables in this study was based on marginal effect. In this study, the above econometric model was used to measure and analyze both factors that affect both farmers' participation in SWC activities and the determinants of rural households' food security status.

2.4.3 Parameter estimation in logistic regression model

The logistic regression model cannot be estimated by the usual ordinary least square method because to apply OLS we must know the value of the dependent variable in (Pi / 1 - Pi), which obviously not known and more over the methods of OLS doesn't make any assumptions about the probabilistic nature of the disturbance term. If there is data on individual observations the method of maximum likelihood can be used to estimate the coefficients of the equation (Gujarati, 2004). Therefore, in this study the maximum likelihood estimation method was used to estimate the coefficients of parameters of the two models. In line with this, descriptive statistics, such as mean, standard deviation, frequency, percentage, and chi-square test were employed to analyze data. Moreover STATA version 11.0 was employed for the analysis of the two econometric models.

2.5 Logistic Regression Diagnostics

To make valid the analysis, assessments of the following logistic regression model assumptions were made.

2.5.1 Multicolinearity test

One of the assumptions of logistic regression model is that the independent variables are not linear combinations of each other. When this assumption violates that is when there is either an exact or approximately exact linear relationship among the independent variables, and it makes hard to get coefficient estimates with small standard error (Gujarati, 2004). Thus prior to the estimation of the logistic regression model, the explanatory variables were checked for the existence of multi-co-linearity.

The existence of multi-co-linearity among the continuous explanatory variables was checked using variance inflation factor (VIF). Following Gujarati (2004), VIF is defined as:

$$\mathrm{VIF}(X_j) = \frac{1}{(1 - R_j^2)}$$

Where:
Xj = the j^{th} quantitative explanatory variable regressed on the other quantitative explanatory variables.
R^2j = the coefficient of determination when the variable Xj regressed on the remaining explanatory variables. As a rule of thumb, if the VIF of a variable exceeds 10 that variable is said to be highly collinear and it can be concluded that multi-co-linearity is a problem (Gujarati, 2004).
Multi-co-linearity problem among discrete variables was detected using coefficient of contingency (*CC*) calculated from chi-square. It is related to by the following formula as:

$$CC = \sqrt{\frac{x^2}{N + x^2}}$$

Where:
x^2 = Chi-square random variable and
N = is total sample size.
Contingency Coefficient (CC) ranges from 0 to 1. As rule of thumb, CC values less than 0.5 assumes weak association between discrete variables and indicates no severe multi-co-linearity.

2.5.2 Specification error test

The other assumption of logistic regression model is that the logit of dependent variable is a linear combination of the independent variables. When this assumption violates, there is a specification error in the model. This indicates that either the logit function is incorrect and/or all relevant variables are not included in the model. In this study the STATA command 'linktest' was used to detect a specification error of the model. This test is issued after the logit or logistic command and uses linear predicted value (_hat) and linear predicted value square (_hatsq) as a predictor for model specification error. As a rule of thumb to have no model specification error, the value of linear predictor (_hat) should be significant and that of the value of linear predictor square (_hatsq) should be insignificant in the linktest result. STATA output of logistic regression model gives the value of (_hat) and (_hatsq).

2.5.3 Goodness-of-fit of the model

The goodness of fit of a model measures how well the model describes the response variable. Assessing goodness of fit involves investigating how close values are predicted by the model with that of observed values (Bewick et al., 2005) cited in (Teshager, 2012). Conventional measure of goodness of fit, $R^{2,}$ is not meaningful in binary regressed model but similar measures to R^2 called pseudo R^2 are available (Gugirati 2004). As a rule of thumb, if pseudo $R^2 > 0.2$ the model describes the response variable well.

Another alternative approach to test the significance of a number of explanatory variables is likelihood ratio test (LR). It tests the null hypothesis that all slop coefficients are simultaneously equal to zero (Gugirati 2004). Therefore, the likelihood-ratio test statistic is given by:

$$LR = -2(\ln L_0 - \ln L_1)$$

Where, L_0 , is the likelihood function of the null model and, $L_{1,}$ is the likelihood function of the full model. Under the null hypothesis, LR statistics follows the x^2 distribution with degree of freedom equals to the number of explanatory variables and hence if LR exceeds $x^2(\alpha)$ we reject the null hypothesis and conclude that at least one of the independent variables is significantly related with household food security or (participation in SWC activities). But STATA output of logistic regression gives the value of the log likelihood chi-square and pseudo R-square for the model and conclusion was made based on their values.

3 Result and Discussion

Table.11: Distribution of participation index of sample households in SWC activities

Participation index	Frequency	Percent	
0	187	49.08	
0.2	65	17.06	
0.4	23	6.04	
0.6	65	17.06	
0.8	34	8.92	
1	7	1.84	
Total	381	100	
Mean = .2503937	Std. Dev. = .3015418	Min = 0	Max = 1

Source: Own survey in March 2014

Participation index of the sample households revealed that the indices lie between 0 and 1. The zero indexes indicate no participation in SWC activities and one index indicates households participated in all the soil and water conservation activities. About 49.08 percent of the respondents did not participate in any of the soil and water conservation activities, only 1.8 percent of them were did all the SWC activities. Participation index 0.2. 0.4, 0.6 and 0.8 indicates the participation of households in one, two, three and four SWC activities respectively. The overall mean of participation index of sample households was found to be 0.25 with standard deviation of 0.302.

3.1 Relationship of food security with participation index of household's in SWC activities

Table 16: Associations between HH food security and participation index in SWC (n = 381)

Variables	Description	Insecure(268) percent	Secure(113) Percent	Total (381) Percent	Pearson chi2 Value
Participation of HHs express Index	0	67.9	4.42	49.08	
	0.2	20.89	7.96	17.06	
	0.4	2.98	13.27	6.04	
	0.6	3.36	49.56	17.06	
	0.8	4	20.35	8.92	215.8166
	1	0.8	4.42	1.84	(Pr =0.000)

Source: Own survey in March 2014

Integrated works of bunds, cut-off-drains and waterway, check dam construction, plantation on physical conservation structures and area closure on farm land expected to improve productivity of the land and thereby food security status of households. According to above (Table 16) among food insecure sub groups, 67.9 percent of them were found to be nonparticipants in soil and water conservation activities. In other words out of 187 none participant sample households in SWC activities**,** 97.3 percent (182) of them were found to be food insecure. Among food secure sub groups, none participants were only 4.42 percent. In other words out of 187 none participated households in SWC activities, only 2.7 percent of them were found to be food secured. Again the result revealed that food insecure group were accounted 20.89 percent and food secure group were accounted

7.96 percent from participation index of 0.2. Similarly food insecure group were accounted 3.36 percent and food secure group were accounted 49.56 percent from participation index of 0.6. This result implies that when participation index increases, the percentage proportion of the probability of the households to be food secure increases. The Pearson chi^2 statistics also indicated that participation index and household food security have positive relationship and statistically significant at 1 percent significance level. This result was in agreement with hypothesis made in this study that a higher participation index of farmers in SWC activities has positive implication on food security status. Thus a household with more participation index is likely to being food secured than household with low participation index (Table 16).

3.2 Econometric Analysis of the Role of Farmers' Participation in SWC Activities Together with Other Determinants on Rural HHs' Food Security

Binary logistic regression model was used to investigate the role of farmers' participation in soil and water conservation activities together with other demographic and socio-economic determinants of food security status of rural household of Farta Woreda. Logistic regression model was preferred because it results in a meaningful interpretation, it is mathematically flexible and easily used distribution and it requires fewer assumptions (Hosmer and Lemeshow, 1989) cited in Teshager 2012. Farmers' participation level in SWC activities which was expressed in index was entered into the model together with other fourteen determinant factors which were expected to influence rural household food security based on information from the related literature and the researcher's personal knowledge regarding the study area.

Table 25: Logistic regression estimates of the role of farmers' participation in SWC activities together with other determinants on rural HHs food security

					No. of obs.	=	381
					LR chi2(15)	=	293.85
				Log	Likelihood	=	-84.7021
					Prob. > chi2	=	0.000
					Pseudo R2	=	0.6343
FOODSC	Coef.	Std. Err.	Z	P>z	[95% Conf.	Interval]	dy/dx
PISWC	5.180339	0.805246	6.43	0.000***	3.602087	6.758592	0.607955
AGE	0.041533	0.020121	2.06	0.039**	0.002097	0.080969	0.004874
FAS	-0.75114	0.172553	-4.35	0.000***	-1.08934	-0.41294	-0.088153
EDU	0.537864	0.241823	2.22	0.026**	0.0639	1.011827	0.063123
OI	0.000262	0.000116	2.25	0.024**	3.42E-05	0.000489	3.07E-05
UAI	0.324288	0.579237	0.56	0.576	-0.811	1.459573	0.036329
TLU	0.005393	0.179816	0.03	0.976	-0.34704	0.357826	0.000633
FI	0.000334	0.000111	3.01	0.003***	0.000117	0.000552	3.92E-05
CFL	1.52398	0.796189	1.91	0.056*	-0.03652	3.084481	0.178852
SFP	-1.10195	0.44306	-2.49	0.013**	-1.97033	-0.23357	-0.15143
DIS	-0.00735	0.080184	-0.09	0.927	-0.1645	0.149812	-0.000862
CRD	0.439288	0.44553	0.99	0.324	-0.43393	1.312509	0.054145
EXC	0.147843	0.123164	1.2	0.23	-0.09355	0.38924	0.017351
OX	0.860215	0.298011	2.89	0.004***	0.276125	1.444306	0.100953
DIR	-0.72704	0.34142	-2.13	0.033**	-1.39621	-0.05787	-0.085325
_cons	-3.78924	1.417495	-2.67	0.008	-6.56748	-1.011	-------

***, **and * indicates significance at 1, 5 and 10 percent level respectively.
Source: Own survey in March 2014.

Ten out of fifteen explanatory variables which were hypothesized to affect food security of rural households of Farta Woreda were found to be statistically significant in logistic regression result. These variables includes participation of household heads' in SWC activities that expressed in index, age of the HH head, family size of the household, education level of the household head, off-farm income of the head, farm income of the household, size of cultivated farm land, soil fertility problem, ox ownership and dependence ratio in the households. Five variables such as usage of agricultural input, livestock ownership, distance to market center, credit usage and extension contact found to be insignificant but they took the expected sign in the model (Table 25).

Before the actual implementation of the above model, logistic regression diagnostics of the model was also considered here. This includes multicolinearity test, specification error test and goodness-of-fit.

To check whether explanatory variables are perfectly correlated with each other or not, value of variance inflating factor for continuous variables and coefficient of contingency for discreet variables was computed using STATA version-11 software. The result showed us that there was no high multi-co-linearity problem between the continuous variables as well as discreet variables. The value of variance inflation factor (VIF) for all continuous variables individually were less than 1.77 with mean of 1.36 (Table 26) and the contingency coefficient for individual discreet variables were less than 0.5 (Table 27). Therefore we can identify the independent effect of the explanatory variables on the rural household food security status in the study area.

Table 26: Variance inflation factors for continuous variables for the determinants of HH food security

Variables	VIF	1/VIF
Livestock	1.76	0.568261
Cultivated farm land	1.75	0.571369
Farm income	1.59	0.630007
Family size	1.36	0.736153
Extension contact	1.31	0.764991
Age the HH head	1.3	0.768068
Education level	1.21	0.827055
O-farm income	1.16	0.860073
Distance to market	1.11	0.90185
Dependence ratio	1.08	0.923413
mean VIF	1.36	

Source: Own survey in March 2014.

Table 27: Contingency coefficient for discrete variables for the determinants of HH food security

Variables	PISWC	UAI	SFP	CRD	OX
PISWC	1				
UAI	0.353	1			
SFP	-0.2476	-0.1492	1		
CRD	0.0775	0.1572	0.0733	1	
OX	0.3165	0.1161	-0.1954	0.1182	1

Source: Own survey in March 2014.

Specification error was also checked for the model roles of farmers' participation in SWC activities together with other determinant factors on rural household food security with command linktest using STATA version-11 software. The linear predicted value (–hat) was found to be significant at one percent significance level (p-value = 0.000) and linear predicted value square (–hatsq) found to be insignificant (with p-value = 0.125). The result tells us that in this model there was no omitted relevant variable(s), the link function was correctly specified and the logit of food security was a linear combination of the explanatory variables (Table 28 below).

Table 28: Result of link test command for model specification diagnosis

		Number of obs	=	381		
		LR chi2(2)	=	296.06		
		Prob > chi2	=	0.000		
		Pseudo R2	=	0.6391		
		Log likelihood	=	-83.599		
FOODSC	Coef.	Std. Err.	z	P>z	[95%Conf.	Interval]
_hat	0.9778	0.1038924	9.41	0.000	0.774174	1.181425
_hatsq	-0.0559	0.0364055	-1.54	0.125	-0.12725	0.015454
_cons	0.201348	0.2451137	0.82	0.411	-0.27907	0.681762

*** indicates significance at 1 percent level.

Source: Own survey in March 2014.

3.2.1 Goodness-of-fit of the model of the determinants rural household food security also checked.

As we can showed in (Table 25) the value of pseudo $\mathbf{R^2}$ found to be **0.6343** which is greater than **0.2**. Thus we can conclude that the independent variables describe rural household food security status well in the model. Similarly the value of likelihood ratio test statistic found to be **(LR) = 293.85** in the estimates of logistic regression (Table 25) which is distributed as chi-square with degree of freedom df = **15** and the tabulated value of chi-square at five percent significance level found to be $x^2_{0.05}(15)$ = **24.9958** in the table. Thus, since value of **LR** exceeds value of $x^2(15)$, we rejected the null hypothesis and conclude that at least one of the independent variables is significantly related with rural household food security status at five percent significance level.

After checking the healthiness of the model, econometric result interpretation of significant variables for the determinants of rural household food security were presented as showed bellow.

Participation of the HH in soil and water conservation activities (PISWC): This variable which was measured in participation index has been found to be positively related with rural household food security status and the relationship was significant at 1% probability level. The result indicated that the probability of the household being food secure will increases with an increase in the participation index of the household in soil and water conservation activities. It is in agreement with the hypothesis made in this research. As the logistic regression result indicated, holding other independent variables which were entered in to the model constant, as a household head participation index in SWC activities increase by one unit, the probability of household to be food secure will increase by 60.8 percent(table 25). The possible justification for this result may be that as the household's level of participation increase (participating in integrated SWC activities), fertility of the soil will improve and this intern will enhance crop productivity of the land. Moreover when the household participation index increase, vegetative cover of their land will improve and this again may create alternative means for fodder sources for the livestock and income from livestock production increase. Similarly when the fertility of the land improved through conservation activities, fertilizer demand of the land reduces and households' expense for fertilizer will be low. This implies that when participation index of the household in SWC activities increase, its cumulative effect leads to food security and livelihood improvement of the household.

Age of the household head (AGE): Age of the household head and rural food security have positive association in the study area as expected. The variable was found to be significant at five percent probability level with coefficient of 0.041533. The logistic regression result revealed that probability of the household to be food secure increases as the age of the household head increases. The marginal effect 0.004874 for age of household head implies that, holding other explanatory variables in the model constant, the probability of the household being food secure increases by 0.49 percent as age increases by one year. The possible reason for this result may be as the age of the household head increases, he/she can acquire more knowledge, skills and experiences of production enhancement and livelihood support activities and endowed with more assets. Moreover as age of household head increase options of making food available from off-farm opportunities also may increase.

Family size of the household (FAS): In the study area family size has been identified to have a negative effect on rural household food security status as expected in the hypothesis. The negative sign of coefficient of the variable implying that large family size lead to households to be food insecure. According to the estimation result, the variable was statistically significant at one percent probability level which implies that, other independent variables remains constant in the model, the probability of the household to be food secure decrease by 8.8 percent as family size increase by one person. The possible reason for this result may be as family size increases demand for food will also increase. But cultivable land size in the study area is very low as a result the household cannot supply the demanded amount of food by producing on his/her small cultivable land. This may leads to food insecurity as family size increases.

Education level of the household head (EDU): Education level of the household head was found to statistically significant at five percent probability level and positively related with rural household food security status in the study area. This implies that household becomes more likely to be food secure with an increasing educational attainment of the head. As the logistic regression result indicated, holding other independent variables which were entered in to the model constant, as a household's education level increase by one unit, the probability of household to be food secure will increase by 6.3 percent. The justification of this result may be due to the fact that better educated household heads can enhance production by improving his/her land productivity through participating in integrated SWC activities and accepting technical advice from experts about modern agricultural production. Moreover educated households can diversify his/her income sources than illiterate ones.

Off-farm income (OI): Off-farm activities have important role in improving food security by increasing employment and income generating opportunity of the farmers. As the model output showed, the variable was found to be statistically significant at five percent probability level and there was a positive relationship between off-farm income of the household and food security status in the study area. Holding other independent variables constant in logistic regression model, increase in off-farm income of the household by one hundred Ethiopian birr, the probability of household to be food secure will increase by 0.3 percent. The justification of this result may be due to the fact that off- farm activities may create additional job opportunities especially for poor households and youths and increase their limited income which leads to improvement of food security.

Farm income of the household (FI): Farm income which earned from crop and livestock production was found to statistically significant at one percent probability level and positively related with rural household food security status. The positive sign of the coefficient of farm income indicates that, holding other independent variables constant in the model, increase in farm income of the household by one hundred Ethiopian birr will lead to increment of the probability of household food security by 0.39 percent in the study area. The justification of this result may be due the fact that crops and livestock (cattle, sheep and goats) are the major sources of food and cash income for rural households. This implies that households who have these farm income sources will be more likely to be food secure than those households who do not have these source of farm income.

Cultivated farm land (CFL): The size of cultivated land the household owned was found to be statistically significant at ten percent probability level and positively related to household's food security status in the study area. This implying that household heads who have smaller cultivated farm land size are more likely to be food insecure than those having bigger cultivated farm land size. The results of the logistic regression model showed that holding other independent variables which were included in the model constant, an increase in cultivated land of the household head by one hectare, will increases the probability of the household food security by 17.88 percent. The reason for this finding may be that as cultivated land size of the household's increase, crop production of household increase and again if crop production of household increase, the probability of the household's being food secure will also increase. Similarly as crop production increases, households will have a chance to get fodder for livestock from crop residue which is again important to increase income from livestock production and enhance food security of the household.

Soil fertility problem (SFP): As priori expectation, soil fertility problem have a negative effect on rural household food security status and was found to be statistically significant at five percent probability level. The negative slop coefficient of the variable implies that households who face soil fertility problem are more likely to be food insecure than those who don't face soil fertility problem. The result of the logistic regression model showed that holding other independent variables which were included in the model constant, the probability of the household who face soil fertility problem being food secure decrease by 15.14 percent than a household who does not face soil fertility problem. The justification for this finding may be that as the household faces soil infertility problem, his/her crop production will decrease which leads to food insecurity.

Number of Oxen owned (OX): oxen are playing a significance role to plough the land for cultivation purpose in the study area. According to logistic regression result, oxen ownership found to be statistically significant at one percent probability level and positively related to household food security status. This implies that household who owned oxen have better chance to be food secure than those who don't own. According to the estimation result obtained from the model, holding other independent variables which were included in the model constant, the probability of the household being food secure increases by 10.1 percent as ox ownership of the household increase by one extra ox. The possible justification for this result may be as the household owns oxen, he/she can prepare his/her cultivable farm land properly and timely and can get better yield of crops. Again better crop yield leads to improvement of food security status of the household.

Dependency ratio of the household (DIR): As expected, dependency ratio of the household has negative influence on the households' food security status in the study area. The variable found to be statistically significant at five percent probability level. The results of the binary logistic regression model implied that an increase in inactive labor force of the household head by one person, will decreases the probability of the household being food secure by 8.3 percent holding other independent variables which were included in the logistic regression model constant. The possible explanation for this result may be that inactive labor force may not contribute labor for agricultural production and for other activities but they increase the demand of food with in the household and this intern increase the probability the household to be food insecure.

4 Conclusion

The descriptive result of this study showed that majority of sample households (70.34 percent) facing food insecurity and it can be conclude that the woreda is food insecure. The food security status of the sample households is influenced positively by farmers' participation in SWC activities, age of households' head, education level, ox ownership, cultivated farm land, off-farm income and farm income. On the other hand it is influenced negatively by family size, soil infertility problem and dependence ratio.

The marginal effect of farmers' participation index in SWC activities on rural household food security was positive and higher than other significant variables. Therefore it can be conclude that farmers' participation in soil and water conservation activities has key role to enhance food security status of the household in the study area.

The negative marginal effect of soil infertility problem on rural household food security status was higher than other negative determinant variables. Therefore it can be conclude that it is the key factor which leads to food insecurity in the study area as showed in logistic regression output.

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