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Application of logit model on Soil Conservation Practices for contribution of food Security in the case of Chencha, SNNP Region.

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Abstract

To analyze the role of soil conservation technologies to food security in the study area. Random sampling procedures were used to obtain three representative kebeles. In sample Peasant Associations of chencha district a total 270 respondents were randomly selected according to the proportion of population size. Structured and non-structured interview questions were used to collect data. Percentage, frequency, t-test for continuous variables, and chi-square test for dummy variables were used to describe explanatory variable. Logistic regression model was applied to analyze factors that influence food security. age, sex of household head, education level, farm size, extension service, total income biological and physical soil conservation practices and the fertility of the soil significantly affect the probability of being food secured. It is therefore recommended that introduction of SC technologies should also considered as they have "multiple benefits" that farmers are likely to get beside erosion control. Extension services should be improved in order to increase the rate of implementation of SC technologies. Further conclusive research be done to combine the various components of food security in order to get the conclusive impact of independent variables to food security.

Keywords: Chencha, Conservation, Food security, logistic model, Soil

1. INTRODUCTION

Ethiopia is one of the most food-insecure and famine affected countries. A large portion of the country's population has been affected by chronic and transitory food insecurity African Development Bank (2014). The situation of chronically food insecure people is becoming more and more severe. Food security situation in Ethiopia is highly linked to recurring food shortage and famine in the country, which are associated to recurrent drought. According to FAO (2018] more than 67 percent of the small family farms in Ethiopia live below the national poverty line. By using the threshold of 2,550 kilocalories (Kcal) per adult equivalent per day, 40 percent of Ethiopian households for whom their majority reside in rural parts of the country were food insecure and undernourished FAO/WFP (2010).

Land degradation, defined as a temporary or permanent decline in the productive capacity of land, or its potential for environmental management, has significantly contributed to the low yield of crops and livestock of the SNNP region. Land degradation, either natural or induced by humans, is a continuous process. It has become, however, an important concern affecting food security and the wealth of nations, and has an impact on the livelihood of almost every person on this earth. The degradation of land resources may be attributed partly to the failure of the rural population in taking due care of these resources and remaining unaware of the long-term consequences.

Food security has been a problem for people in the world. In particular developing countries, such as Ethiopia, have been facing severe version of this problem over a longer period of time. The complex interaction in the process of decision making in the context of adverse environmental conditions has made it difficult to tackle the problem in the short run (Tesfahun, F. et al., 2003).

The majority of the population of Ethiopia consists of farmers and their families reside in rural areas and whose life is almost entirely dependent on agriculture. Agriculture is the main stay of the large proportion of human population of the country, even though it is threatened by human induced land degradation and climatic factors. Traditional mixed crop livestock production system under developed and dominated by subsistence farmers, focusing on household food security (Tolera, et al, 2011).

Tolera (2011) argue out that confusion often arises over the relationship between the terms; soil erosion, soil depletion and soil or land degradation. Soil erosion refers to a loss in soil productivity due to: physical loss of topsoil, reduction in rooting area, removal of plant nutrients, and loss of water. Soil erosion is a quick process. In contrast, soil depletion means loss or decline of soil fertility due to removal of nutrients by water passing through the soil profile. The soil depletion process is less drastic and can be easily remedied through culture practices (contour terracing, artificial water way) and by adding appropriate soil amendments. Similarly, land degradation is defined as the temporary or permanent lowering of the productivity of land.

Hundreds of thousands of kilometers of structural conservation measures have been constructed over croplands in Ethiopia. However, Ministry of Agriculture, (2008) indicates that these conservation structures have not been as successful as they could be, because the farmers were not enthusiastic enough in accepting and maintaining the technology. The failure of conservation programs partly emerges from the fact that planners and implementing agencies ignore or fail to consider socio-cultural factors as key determinants of the success or failure of conservation programs (Bewket, 2007)

In Ethiopia, significant SWC activities were implemented during the 1970 and 1980s by mobilizing farmers through their peasant associations, mainly in food for work programs Bewket, (2007). This approach was criticized for its top-down approach. In many parts of the country, the current government has also been undertaking SWC through integrated and participatory watershed development approaches to improve rural livelihoods with sustainable natural resource management. In the government plan of 2006-2011, Plan for Accelerated and

Sustainable Development to End Poverty (PASDEP), one of the goals was to enhance food security through improved natural resources management MoFED, (2006). The ongoing 30-day national SWC-based watershed management campaign which started in 2010/11 and is expected to continue also indicates the motive of the government and farmers to conserve soil. This campaign mainly promotes and implements physical SWC measures such as level soil bund, level fanya juu, stone bund, etc and undertakes planting billions of seedlings every year at the national level.

Soil erosion is the main form of land degradation, caused by the interacting effects of factors, such as biophysical characteristics and socio-economic aspects. Degradation resulting from soil erosion and nutrient depletion is one of the most challenging environmental problems in Ethiopia. The Ethiopian highlands have been experiencing declining soil fertility and severe soil erosion due to intensive farming on steep and fragile land (Amsalu and de Graaff, 2006).

Recognizing land degradation as a major environmental and socio-economic problem, the government of Ethiopia has made several interventions. As a result, large areas have been converted to terraces, covered by soil bunds, closed by area closures and planted with millions of tree seedlings. Nevertheless, the achievements have fallen far below expectations. The country still loses a tremendous amount of fertile topsoil, and the threat of land degradation is broadening alarmingly (Teklu and Gezahegn, 2003).

The most important reason for limited use of SC technologies is farmers' low adoption behavior. Kessler (2006) considers SWC measures fully adopted only when their execution is sustained and fully integrated in the household's farming system. Adoption of SC measures does not automatically guarantee long-term use. For example, when SC measures have been established with considerable project assistance, not all farmers may continue using the measures. Therefore, introduction of SC technologies may not lead to sustained land rehabilitation unless the farmers proceed to final adoption.

Previous studies show that various personal, economic, socio-institutional and biophysical attributes have influential roles in farmers' decisions about the adoption of SC measures in different areas of highland Ethiopia. This relationship between attributes has not yet been studied in the Chencha watershed in the highland of Ethiopia. Appropriate understanding of these factors in the study area would assist in the formulation and implementation of the policy interventions designed to induce voluntary continued use of SWC measures.

The understanding of farmers' knowledge and their perception of factors that influence their land management practice is of paramount importance for promoting sustainable land management. It is also interesting to know if and when farmers practice what they know and perceive. Conservation agriculture achieves sustainable benefits through minimal soil disturbance (i.e., zero- or reduced tillage farming; hereafter conservation tillage), permanent soil cover, and crop rotations (Tesfaye, 2003).

Particularly in the *Chencha* highlands, different SC technologies have been promoted among farmers to control erosion. These technologies include bench terrace, soil bunds and Fanya juu bunds (made by digging a trench and moving the soil uphill to form an embankment). However, the adoption rates of these SC technologies vary considerably within the country (Kassie et al., 2009; Tefera and Sterk, 2010; Tesfaye et al., 2013; Teshome et al., 2014), largely because investments by farmers in SWC are influenced by the ecological, economic and social impacts of the SWC technologies.

In present day Ethiopia, forests are being destroyed at an alarming rate and the area covered by forests at present is only 2.4 percent compared to the estimated 40 percent initial coverage (EPA, 2006). But currently the situations of these forests are under severe pressure of deforestation for the expansion extensive agriculture and majority of forestland converted to cropland. The area having all forest potential, currently due to the decline of soil fertility, cropland productivity has been declined and as a result majority of the farmers are exposed to seasonal food shortage in the area. Therefore, it is better to conduct a research on the assessment of the role of biological and physical soil conservation practices in improving crop productivity by assessing and analyzing crop yield and soil fertility status in the study area

1.1. Statement of the Problem

In Ethiopia, food insecurity has been a serious problem for decades. Since the 1970s, a series of production failures have resulted in chronic food insecurity Kaluski et al., (2001). In the last few Decades, 4.5 million people required immediate food assistance aid. As a result, Ethiopia has been the largest recipient of food aid a (WFP, 2014). According to the Ethiopian Central Statistical Agency (2011), about 30 percent of Ethiopian population lives under poverty line. Food security is a national concern of Ethiopian government. The average per capita income of the studied households was much lower than the internationally accepted level (USD 1.25 a day). Mesfin Mensa, (2014). Regardless of their wealth rank, the community faces food shortage for six months, on average, October and May being the most critical months that challenge even the highest wealth groups while the poor have nothing to eat during these months.

Soil erosion by water is a severe and continuous ecological problem in the north-western Highlands of SNNP Region, Bekele, et al (2015). Limited knowledge of farmers to practice soil conservation technologies is one of the major causes that have resulted in accelerated soil erosion.

Although efforts by most projects made on soil and water conservation measures, little was known about the contribution of the introduced soil erosion control technologies on household food security. This study will be therefore conducted to assess the impact of the soil conservation technologies on household food security.

The natural phenomena and interference of human activities are aggravating soil degradation that needs immediate remedies to sustain cropland livestock production and productivity. Soil is the only media, which supports the germination; growth and maturity of crops in association with other life supporting systems for better yield (MOA, 2001).

However, due to high population pressure, continuous and steep slope cultivation, deforestation and with inadequate soil conservation practices, cropland productivity has been declining in the study area in which Wheat yield in year 1997 were 8quntal/ha have been reduced to 6-7quntal in year 2002, even though few farmers practiced some traditional biological and physical land management practices (MOA, 2001).

Gamogofa zone is one of the thirteen zones of the Southern Nations, Nationalities, and people's Region (SNNPR) of Ethiopia. A large part of the zone's land is exposed to severe soil erosion, land fragmentation, deforestation and land pressure. As a result, the soil becomes unable to satisfy the rapidly growing demands of population. The Chencha district of G/gofa zone has been exploited and degraded continuously. As a result, majority of rural inhabitants are suffering from food insecurity. This is mainly because of that the soil is incapable to support cultivation caused by soil erosion and its related problems. In the area, erosion problems and measures to tackle were rarely investigated.

Although structural soil conservation methods are widely represented as having significant environmental, economic, social and political benefits for both individual landholders and the wider community, adoption of such measures is commonly perceived to be slow. Consequently, severe erosion continues to affect the farmers' livelihoods. The rich top-soils have been washed off by runoff and the remaining sub-soils are exposed and generally deficient in available minerals.

Although efforts by most projects (WFP, WVE, PSNP and MERET) in southern highland, Chencha were on soil and water conservation measures, little is established about the contribution of the introduced soil erosion control technologies on household food security. But no research has been carried out that linked the soil conservation technology adoption and food security in region in general and in Chencha woreda in particular. Therefore, this researcher was investigated food security situation of the woreda using HFBM to assess their food security situation. Therefore, the study was tried to find out the inter-relationship between soil conservation technology adoption and household food security.

1.2. Objectives

The overall objective of this study is to analyze the role of soil conservation technologies to food security in Chencha highland, Ethiopia.

Specific objectives

- Assess the soil conservation practices in the study area.
- Analysis the demographic and socioeconomic factors that affect the implementation of soil conservation practices.
- Analyze the food security status of SC adopter with non-adopter households.

2. Methodology

2.1. Description of the Study Area

2.1.1. Geographical Location

This study was conducted in chencha district. Chencha district is one of the 15 districts in Gamo Gofa Zone of SNNP region of Ethiopia. Astronomical location of the district is between 37^0 29’57” to 37^0 39’ 36” East Longitude and between 6^0 8’55" and $6^0$25’30” North Longitude. It is located about 521 km south of Addis Ababa the capital of Ethiopia and 36 km away from the zonal capital of Arba Minch. The district is subdivided in to 45 rural kebeles and 5 transition towns. The district is bordered by four districts; Aribaminch Zuria in the south and southeast; Mirab Abaya in the east; Kucha in the North and Northwest; and Dita in the West.

2.1.2. Population of the Study Area

According to district Finance and Economic office estimation, in 2016, the human total population was estimated that 154,701 from this 69,842 are male and 84,859 are females implying, 54.9% of women. The household head number was male 17,621 and female 6,113 total 23,734. The district has high population number per square kilo meter which estimated 434 persons/km^2.

2.2. Research Method

2.2.1. Research Design

The study employed a mixed approach and generates both qualitative and quantitative data and utilizes cross-sectional data. It presents facts & reality about the soil conservation practice, social, economic, institutional and physical factors that affect food security at existing condition in the area of the study.

2.2.2. Methods of Data collection

The researcher used both primary and secondary data sources. The secondary source data used for this study was written documents, published researches, books and other related sources, which was obtained from the woreda agricultural development office and NGOs working on soil conservation practices and food security in the study area. Primary data were collected using semi-structured questionnaire through formal interview method. The questionnaire for household survey were included detailed inquiries about household data such as age, sex, marital status, education level, livestock holding, family size, non-farm income, perception of SCs impacts, frequency of household contact with extension agents and others.

Three group discussions were undertaken in the three Kebeles as well as discussions with experienced and knowledgeable key informants in the target areas.

2.3. Sampling Techniques

In this research, multi-stage sampling techniques was used. First, woreda was purposefully selected because of the researcher previous and current knowledge, access to get data‟s and understanding food security status of the study subjects. Secondly, the kebeles, (three sample kebeles, Kele, Elenachere and Amaran bodo) were selected by stratified random sampling technique based on agro-climatic condition. Thirdly, sample households were selected based on systematic random sampling techniques because of homogeneity in agricultural practices and settlement arrangement, identical in topography, dressing and eating styles.

Hence, Kele and elenachere were chosen from dega and Amarana bodo were chosen from moist woina dega respectively. These three rural kebeles has a total HHs head population of 900. Of which 691 were males and 209 were females. From these HHs head populations Kele had 228 males and 69 females with a total of 297 HHs head populations. While Elena chere had 246 males and 75 females with a total HHs head population of 321 and Amaran bodo had 217 males and 65 females with a total HHs head population of 282. Therefore, number of sample households head was 91 in Kele kebele, of which 70 were males and 21 were females and in Elena chere there are 98 samples HHs head of which 75 were males and 23 were females and in Amarana bodo there are 87 samples HHs head of which 67 were males and 20 were females. Totally, 276 sample households were selected from three kebeles through systematic random sampling techniques, of which 212 were males and 64 were females.

2.3.1. Sampling Size Determination

To determine the sample size of the study area, this study was use Yamane's formula (1977) (cited in Israel, 1992), with 95 confidence levels. The reason for using formula is because this kind of formula is valid for survey researchers which compose large population. Moreover, the population under investigation is homogenous in its socio-economic and geographic context and the formula enables to get manageable sample size.

$$n = \frac{N}{1 + N(e)^2} = \frac{900}{1 + 900(0.05)^2} = \frac{2700}{7.75} = 276$$

n= sample size N= total population of the sample

e= acceptable error in social science.

One group discussion was undertaken in each Kebele as well as discussions with experienced and knowledgeable key informants in the target areas. The number of participants in each group ranged from 9–11 farmers. Group discussions will be followed by an individual survey to crosscheck the information provided. FGDs were another qualitative data collection method, it was employed for those sample households who practice and do not practice SCs. One FGD was conducted in each kebele and 9–11 members will involve in each kebele. FGDs from the respondents who practices and don‟t practice SCs both male and females were involved, the religion of the discussants were orthodox and the age composition of the discussants were young and elder.

2.4. Method of Data Analysis

After we are being dead sure that the data have kept its quality, it was coded, summarized, managed and tabulated for the analysis. Data analysis was undertaken by using Descriptive and Inferential Statistics like ttest, chi-square test, frequency and percentage. Logistic regression model was employed to analyzed factors affecting food security status of households. Analysis was done using STATA version 15 software.

$$Logit\ IP(outcome)ILn\ \frac{p(outcome\ )}{1-p(outcome\ )} = \beta o + \beta 2x2 + \beta 3x3 + \cdots \varepsilon 1$$

Where, p (outcome) is the probability of occurrence of food security, 1- p (outcome) is the probability of none occurrence of food security, β_0, β_1, β_2 and β_3 estimate regression coefficient, x_1, x_2 and x_3 are explanatory variables and ε is error terms, which included in the model.

While, for this study by considering the given explanatory variables the logistic regression equation has been formulated as follows.

$$Logit\ [P(FS)] = \beta_0 + \beta_1(EXS) + \beta_2\ (IN) + \beta_3\ (DI) + \beta_4\ (SL) + \beta_4\ (SL) + \beta_5\ (CY) + \beta_6\ (SC) + \cdots + \varepsilon i$$

Were,
FS = Food security
EXS = Extension services
IN = Income
SL = Farm slope
CY = Crop yield
SC = soil conservation practices

Furthermore, data collected through key informant interviews and focus group discussions was analyzed using textual and tabular analysis. Using SPSS software for data analysis, in each sample collected from different Agro ecological zone will be compared to get the food security status of household, a modified form of a simple equation termed as Household Food Balance Model, originally adapted by Degefa (1996) from FAO Regional Food Balance Model and thenceforth used by different researchers in this field (Mesay, 2009) was used to calculate the per capita food available which is GP + GB + FA + GG) - (HL+ GU + GS +GV) Where,

NGA= Net grain available/year/household

GP= Total grain produced/year/household

GB= Total grain bought/year/household

FA= Quantity of food aid obtained/year/household

GG= Total grain obtained through gift or remittance/year/household

HL= Post harvest losses/year

GU=Quantity of grain reserved for seed/year/household

GS=Amount of grain sold/year/household

GV=Grain given to others within a year (Mesay, 2009).

The net grain available by sample households' calorie content was computed using calorie conversion table of (EHNRI, 1968). Household members were also converting to their adult equivalent. Then, the number of total calories available by each sample household was computed and divided by 365 days to get per day calorie available for household. The figure was divided to the Adult Equivalent (AE) of respective households, which finally was given the amount of calorie available per AE for each sampled household. Thus, those households greater than the minimum amount of calorie required (2100 kcal) is put under food secured otherwise not food secured (Hoddinott, 2001). The situation of household food security within soil conservation users and non-users is also seen independently.

In order to calculate rate of return to land management of crops grown by conservation practices users 2009/2010 production season, the cost of production and benefit were surveyed and calculated. Net return of per hectare is identified.

3. RESULTS AND DISCUSSION

This chapter mainly presents the findings of the study with an appropriate level of discussion. It is divided in to two sub-headings that could give a brief account of the subjects that were being investigated by the study. The first sub-heading presents descriptive analysis of sample households. The second sub-heading is econometric model that analyzes food security status of SC adopter and non-adopter households.

3.1. Descriptive statistics for socioeconomic variables in the study

A combination of different descriptive, the means and standard deviation and inferential, the t-test and X2-test, statistics for explanatory variables of sample households were performed on the household level data to inform the subsequent empirical data analysis. The descriptive and inferential results presented on Table 3 show that there was statistically significant difference between secured and insecure in terms of Age, farm size in hectare, total income.

AS discussed above there was significant difference between secured and unsecured households at 1% significant level. The observed variation in household income could be due to the fact that farmers in high altitude areas grow cash crops (Tomato, Apples) and keep dairy cattle while the farmers in low altitude mostly grow annual crops such as sweet potato, wheat and beans. Farmers in low altitude areas mainly produce food crops which are used for home consumption and little surplus for the market. This has impact on the implementation of SC practices due to the fact that income has a bearing on investment and adoption of soil conservation innovations. High income increases risk aversion behavior among farmers. These findings are in line with those of Tiffen (2003) who observed that economic factor promotes adoption of agricultural technologies. Increase in overall income may affect land use decisions taken by a farmer. High income enables farmers to expand the farm for agricultural production. The ability of the farmer to invest in agricultural production depends on the income obtained from the farm. Gebremedhin and Swinton, (2004) observed that willingness of the farmer to invest in soil improvement activities is closely associated with the overall economic profitability of farming.

Table 1 Descriptive statistics of continuous independent variables

Variable	Mean across food security status		t-test	P value
	Secured	Unsecured		
Age	43.84	46.09	1.68	0.09*
Farm size in ha.	0.28	0.22	2.01	0.04**
Total Income	2317.23	1914.14	2.75	0.006***
Farm distance in km	1.36	1.34	0.28	0.77
Family Labor	2.61	2.54	0.71	0.47
Family Size	6.89	6.79	0.46	0.64

Source: own survey, ***, **, and * indicates that at 1%, 5% & 10 significance level respectively

The descriptive and inferential statistics results presented in Table 2 show that unexpectedly 84.85% of unsecured households were male headed households and the remaining 15.15% were female headed households but from female headed households 72.32% were food secured from this observation chi2 test show that compared to female headed household's male headed households were food insecure. This suggests that the majority of the households in the study area are male headed. According to Addisu (2011) in most cases males are the ones who make major decisions such as use of income despite of the fact that women contribute significantly to agricultural production.

Regarding to education level most of food secured households were educated better compared to unsecure sample households and the test showed that there was significant difference between them. 44.44% secured and 6.21% unsecured households use physical soil conservation to curb soil erosion and this variable had significant effect on food security. There is general understanding educated farmers can easily adopt new innovations and access information and services. The study by Tesfaye et al. (2013) in southern region revealed that education influenced implementation of soil and water conservation measures. Low education level can be a barrier for agricultural development, since education normally has a significant influence on household's income strategies, land management and labor use Tadele et, al (2014). The study by Glover (2005) revealed that adoption of technologies increased with the education level of the farm household head. Johansson, et al. (2009) also observed that education correlates positively with the adoption of SC measures. It is generally agreeable that access to information sources and communication channels may increase awareness about the effects and consequences of sustainable soil conservation practices among farmers.

It was since 1980s where SWC methods introduced in the study area. These measures can be categorized into three based on the land use type in which they were applied. These are conservation measures on farmlands, conservation measures on hillsides and conservation measures on degraded lands (to rehabilitate gullies). Most of soil conservation effort made in the area was directed in controlling soil loss from cultivated fields. Many of soil and water conservation measures introduced to the area are mechanical conservation measures. These include Contour farming, water way/ cutoff drains and fanya juu. However, it is not usual to see stone bunds or stonefaced bunds due to scarcity of stone, which is attributable to geological feature of the study area. It is only in few places that terraces are constructed in the study area. The biological measures introduced in the area were grass strips, Agroforestry, and Crop rotation and area closure. According to the chi2 analysis the sample households expected that soil conservation practice will reduce soil erosion, increase soil fertility and enhances crop yield. In the study area 86.44% of food secured and 81.82% of unsecured households got extension service by this there is no significant difference in extension service.

Table 4 also describes percentage of soil conservation practice on food security. 75.23% of households who adopt SC practice were food secured only the remaining 24.77% were not adopted SC practice on their farm. 94.35% of unsecured households were not adopted SC practice which shows the advantage of SC practice to increase productivity by this to be food secured. The result indicates significant difference between secured and unsecured households.

The other part of table 4 discusses Percentage of soil conservation practice rating in the study. According to the result soil erosion control, crop productivity and fertility of the soil rating was significant by the same amount 83.33% for those households who replied positively and the remaining 16.67% replied that SC practice does not have any effect for the above three mentioned variables. This result shows there was significant difference between them.

Table 2 Descriptive statistics of Dummy/ discrete Independent Variables (chi2 test)

Percentage of food security status				
	Unsecured	Secured	Chi2	P value
Sex				
Male	84.85	27.68	5.6	0.018
Female	15.15	72.32		
Education				
No formal education	72.73	27.12		
Primary School	27.27	41.24	65.11	0.000
Secondary School	0	28.25		
Above Secondary	0	3.39		
Marital Status				
Not Married	0	4		
Married	77	127	4.03	0.258
Divorced	7	21		
Widowed	15	25		
Biological soil cons.				
Yes	66.67	96.05	44.21	0.000
No	33.33	3.95		
Physical soil				

conservation.				
Yes	6.21	44.44	58.15	0.000
No	93.79	55.56		
Expected result				
Reduced soil erosion	8.08	11.30		
Increase soil fertility	4.04	0	10.6	0.032
increase crop yield	33.33	33.33		
All	51.52	54.80		
Not used	3.03	0.56		
percentage of soil conservation practice in the study area				
food security status	Adopted	Not adopted	Chi2	P
Secured	44.44	55.56	60.71	0.00
Unsecured	5.65	94.35		
Percentage of soil conservation practice rating in the study area				
soil erosion control	yes	No	Chi2	P
Increased	83.33	68.52		
No change	16.67	31.48	6.05	0.014
Crop productivity				
Increased	83.33	68.52	6.05	0.014
No change	16.67	31.48		
Fertility				
Yes	83.33	68.52	6.05	0.014
No	16.67	31.48		

Source: own survey (2019)

Table 5 describes the difference between land ownership and slope of the land between foods secured and unsecured households. Regarding source of land most of the land was owned but there was no significant difference between the two groups. Slope is an indicator of the likelihood of erosion on the land. The slope of a plot also affects the adoption of conservation structures because the steeper the slope, the more likely the land will be exposed to erosion. Hence, it is believed that adoption of physical structures tends to be likely on steeper slopes.

Slope is an indicator of the likelihood of erosion on the land. The slope of a plot also affects the adoption of conservation structures because the steeper the slope, the more likely the land will be exposed to erosion. Hence, it is believed that adoption of physical structures tends to be likely on steeper slopes.

Table 5 indicates that out of food secured sample respondents (41.24%) of sample respondents farm plot is located steep slope “Denba gade” and about (51.41%) found in gentle “Lade gade” and the rest (7.34%) farm plot located on flat “Zuma gade” slopes. This shows that the majority of food secured sample respondent’s farm plot is found on gentle to steep slope which is susceptible to erosion. On the other hand, more than 60% of food insecured households land were located on steep slope which is highly exposed for soil erosion. Teklu and Gezahegn A, (2003) in the southern region found that the slope of a plot to be one of the factors significantly influencing the adoption of soil conservation. Their results suggest that a farmer who operates a field with steeper slope is more likely to adopt the soil conservation technology. Wagayehu and Drake (2003) also found similar results. He argued the returns from investment on steep sloped plots might be low, hence less adoption on such plots. However, in the present particular study, the result of bivariate correlations indicates that slope of a plot has been identified as a major factor that influenced farmers' adoption of soil conservation methods positively and significantly.

According to District Agriculture and Livestock Development Office report (DALDO, 2008) district has a total of 45 kebeles and all have extension workers. The study area all kebeles have extension workers. According to agriculture policy (Moa, 2005) each kebele in Ethiopia is supposed to have an extension worker. Based on the agriculture staff available in the district there is only a deficit of 3 kebeles extension workers. Different strategies should be employed to ensure that extension packages reach most farmers. There is a direct link between extension services and implementation of SC technologies. The study by (Teklu and Gezahegn A, 2004) suggests that majority of households who implemented SC measures had close contacts with extension agents. Extension services are major source of technical information for farmers. Lambin et al. (2003) observed that most of the farmers lack information and encouragement to change their traditional cultivation systems. In most cases there are gaps in knowledge and often research findings, projects and extension services fail to reach the majority. Based on the chi2 analysis there was significant difference between secured and unsecured households which implies those secured households have better extension contact relative to unsecured households.

Coping strategies used by farmers to overcome food shortages

Different coping strategies used by farmers were identified. These include Sell of animals, Off-farm employment, sell of asset, and reducing the number of meals per day.

Results in Table 6 indicate that 61.62% of unsecured and 43.5% secured households participated on Off-farm employment to supplement whatever little is obtained from their fields, whereas 32.32% of unsecured and 44.63% of secured households of households indicate that's selling of animals such as sheep, poultry and bee honey used for coping mechanism. Only 5.05% of unsecured and 9.04% secured sample households reduced the number of meals per day. Very small proportion both households forced to sell of asset and there was significant difference between the two categories in terms of coping strategy. The other important variable is months which households face series food shortage. Majority both secured and unsecured households face series food shortage for six months in the year.

Table 3 Months with series food shortage and households coping for food shortage

Coping strategy	Insecure	Secured	Chi2	Pr.value
sell of animals	32.32	44.63		
reducing meal	5.05	9.04	8.84	0.031
off-farm employments	61.62	43.50		
sell of asset	1.01	2.82		
Months with series food shortage				

3 months	25.25	29.38		
6 months	55.56	49.72		
7 months	0.00	3.95	5.04	0.28
9 months	13.13	12.43		
12 months	6.06	4.52		

Source: own survey (2019)

3.2. Econometric Analysis

Logistic regression analysis of the food security

Regression is concerned with describing and evaluating the relationship between dependent variable and independent variables on which the outcome variable depends on. Thus, this study tries to use binary logistic regression analysis to show the effect of determinant factors over food security.

Logistic regression used in study to predict a categorical (usually dichotomous) variable from a set of predictor variables to test age, sex, slope, crop yield, total income, use of soil conservation method, access extension service, use of physical conservation method, expected result, labor, livestock owner ship and access to credit with a categorical dependent variable food security, discriminant function analysis is usually employed if all of the predictors are continuous and nicely distributed; logit analysis was usually employed if all of the predictors are categorical; and logistic regression is often chosen if the predictor variables are a mix of continuous and categorical variables and/or if they are not nicely distributed (logistic regression makes no assumptions about the distributions of the predictor variables). For a logistic regression, the predicted dependent variable is a function of the probability that a particular subject will be in one of the categories.

Marginal effects after logit

y = Pr(food security status) (predict)

= 0.67816575

Table 4 Marginal effect after logistic regression of food security status

variable	dy/dx	Std.Err.	Z	P>z	[	95%	C.I.
age	-0.008	0.004	-2.170	0.030**	-0.014	-0.001	44.649
sex*	0.322	0.056	5.730	0.000***	-0.432	-0.212	0.768
slope	-0.097	0.064	-1.500	0.132	-0.223	0.029	2.424
Education	0.326	0.047	6.880	0.000	0.234	-0.421	1.879
Yield crop	0.093	0.050	1.870	0.061*	-0.190	0.004	2.899
Total income	0.030	0.000	2.200	0.028**	0.000	0.000	2172.640
Use soil cons*	0.316	0.135	-2.330	0.020**	-0.581	-0.051	0.804
Off farm*	0.021	0.087	0.240	0.808	-0.149	0.191	0.768
Access extension	0.220	0.097	2.270	0.023**	0.030	0.409	1.848
Biological SC	0.292	0.128	2.290	0.022**	0.042	0.543	1.855
Use physical SC	0.703	0.252	-2.790	0.005***	-1.196	-0.209	1.199
Credit service	0.081	0.077	1.040	0.297	-0.071	0.232	1.297
labor	0.055	0.046	1.190	0.236	-0.036	0.145	1.493
Livestock	0.045	0.041	1.070	0.283	-0.037	0.126	2.304

(*) dy/dx is for discrete change of dummy variable from 0 to 1
**** p<.01, ** p<.05, * p<.1. Source: own survey (2019)*

Age of house hold (AGEHH): Age of the household was found to be negatively associated with being food secured and statistically significant at 5%. This can be explained by the fact that older farmers' income generating potential and SC practice is less relative to youths. This implies that youths have higher personal preference which can reduce the impact of soil erosion through the implementation of long-term soil conserving structures and being food secured.

Sex of household head (SEXHH): Sex of a house hold head is one of the determinants of improved soybean adoption. As the logit model indicates sex of household head had positive and significant influence on the adoption of improved soybean variety at 1% significance level (Table 5). This shows that being male headed households have better access to information on SC variety and are more likely to be food secured than female headed households. Yenealem (2013) through his binary logit model results revealed that the adoption of improved maize variety is biased by gender, where female headed households adopt the improved varieties less.

Education (EDUCLVLHH): Having formal education improves the decision-making power of a household to engage or not in activities especial externally driven interventions. In other word, education influences farmer's decision to adopt technologies by enhancing farmer's ability to adapt to it. In this study result, education was found to affect continued use of soil and water conservation technologies positively at 1% significance level and increase the probability of being food secured by a factor of per additional year of education. The positive association shows that better educated households seem to decide to retain conservation structures better than low level of the uneducated household. This implies that education may enable farmers to easily understand and recognize the problem of soil erosion, able to change and put into practice the knowledge and skill they obtained from extension services and other sources by this they can increase yield of crops and being food secured. Study is in line with the finding of Belete (2018).

Yield of crop: From the given sample household the yield the cultivated crop significantly differs between food secured and unsecured households. There was positive association between the dependent variable food security status and this variable. Mean that when yield of the crop increases through use of improved SC practices and other factors the probability of being food secured will increase by 9.3% and it was significant at 10% significant level.

Farm income (FRMINCOM): Amount of farm income obtained within a year was one explanatory variable in this analysis. It is assumed those farmers who have more farm income more likely to be food secured than less income gainer households. It is significant estimated coefficient at 5% for this variable from the logit regression, giving evidence that shows farm income is one among the possible factors in influencing the to be food secured, ceteris paribus.

Access to extension (ACCEXN): Extension service plays a great role in enhancing awareness about SC practices and the possibility of a farmer to decide to practices SC activities. As the households get extension service, the possibility of the farmer to practice SC and to adopt new technologies increase by these farmers can produce more output and being food secured.

Agricultural extension service in the study area has been mainly given by government organization (Office of district Agriculture and Rural Development) and development agent (DAs) of the peasant association. In this study access to extension service was significantly affect to be food secured or not. Logistic regression show that the variable was 5% significant means compared to food unsecured households, if a household gets access to extension the probability of being food secured will increased by 22%.

Use of soil conservation measures (USESCMSRS): Soil conservation in Ethiopia is considered today to be of top priority, not only to maintain and improve agricultural production but also to achieve food self-sufficiency, which is the long-term objective of the agricultural development program. In this study those farmers who used SC practices are better off and food secured compared unsecured households. There was significant difference between secured and unsecured households in terms of use of SC measures and there was positive correlation between the dependent variable and this variable. The significant level was at 5%.

Biological SC (BIOLGSCM): Biological measures for soil and water conservation work by their protective impact on the vegetation cover. A dense vegetation cover prevents splash, erosion, reduces the velocity of surface runoff, facilitates accumulation of soil particles, increases surface roughness which reduces runoff and increases infiltration, the roots and organic matter stabilize the soil aggregates and increase infiltration. These effects entail a low soil erosion rate compared with an uncovered soil which shows in general a high soil erosion rate. Even cultivated crops in agricultural areas are a better protection against soil loss than uncovered soil (relatively high soil erosion rate). Thus, biological measures are an effective method of soil and water conservation, especially since they are low in cost. Due to the above advantage of biological soil conservation methods, the productivity of the soil will increase and within small plot of land farmers can get better produce and be food secured. Similar scenario was observed when farmers us this practice the probability of being food secured increased by 29.2% and logistic regression showed that it was significant at 5% significant level. The finding by Tolera (2011) revealed that traditional biological land management practices have a significant role in improving cropland and biomass productivity based on its impact on soil quality and by this increase the probability of food security.

Physical SC (PHYSCM): Physical measures are structures built for soil and water conservation. Some principles should be considered. They should aim to increase the time of concentration of runoff, thereby allowing more of it to infiltrate into the soil, divide a long slope into several short ones and thereby reducing amount and velocity of surface runoff, reduce the velocity of the surface runoff and protect against damage due to excessive runoff. These physical measures can production and productivity of small holders' farm and increase the probability being food secured. In this study like biological measures, physical measures have positive relationship with the probability of being food secured. When a household applies physical conservation methods the probability of being food secured will increased by 70.3% and it was significant by 1% significant level.

Conclusion and Recommendation

The objective of this study was to assess the implication of the soil conservation technologies on household food security. Result of descriptive and econometric analysis indicated that from socio economic variables their significant difference between secured and unsecured households on age, sex and education level of household heads. From soil conservation practices biological and physical soil conservation technologies that were implemented in the study were significantly affect to be food secure or not. From this SC practices Fanyajuu, bench terrace, water way construction, agro-forestry, tree planting, contour farming, crop rotation, inter cropping and manure application. Significant proportion of farmers implemented more than one physical soil conservation technologies and high number of the famers implemented more than one biological soil conservation technologies. This was due to the land slope and multiple benefits that farmers get apart from soil erosion control generally use of soil conservation practice had significant contribution to be food secured.

Results also indicated that effective dissemination methods such as group discussions, demonstrations and field days were used during introduction of the technologies. There was an increase in crop yields and household income following introduction of the SC technologies. Results further indicated that most farmers in the study area (64%) are food secure for most time of the year. The introduced SC technologies significantly correlated with household income, extension service, soil conservation practice and crop yields.

The major findings of the study are summarized as here under.

Farmers who practiced conservation structures were more effective in controlling soil erosion and ensuring sustainability of yield.

The study shows that majority of the farmers adopted biological and physical soil conservation practices like soil bund, fanyajuu, cut off drain and water way among the physical structures and grass strips, crop rotation, intercropping, agroforestry and compost making from biological conservation methods applied in their farm plot.

The study also found factors such as slope of the area, training, and contact with extension workers, tenure status, age, size of house hold and farm size influenced farmers to adopt these methods. This could be due to the fact that farmers whose plot is found on steep slopes have attended training and got information that are useful to make decision to adopt conservation structures.

The study also found that adopted soil conservation measures contributed in increasing farm productivity through retaining moisture content of soil and are effective in restoration of vegetation in the area. As with any agricultural production system, soil conservation also requires certain exogenous inputs to achieve more production levels.

The other problems identified include conservation structures take the scarce cultivable land out of cultivation (reduce size of land), lack of hand tools required to maintain the structures, labor constraint and some technical failures. In addition to these, farmers who perceive the structures reduce farm plot made decision not to maintain conservation structures or even remove structures completely.

Based on the study findings the following recommendations are pertinent:

Implementation of soil conservation practices/technological by the farmers should be based on farmer's conditions, knowledge and preference. This will contribute to high adoption of technologies. The soil conservation technologies should be productivity-enhancing and conservation- effective. This will result into sustainable agricultural production hence improved household income and food security.

Thus, based on the findings, the following recommendations are important and need to be considered to enjoy more benefits by addressing the constraints farmers meet in adoption of soil conservation methods.

The study found that factors such as slope of the area, training, and contact with extension workers, age, size of house hold and farm size influenced farmers to adopt these methods. When age of increases the probability of using soil conservation methods decreases. This may be due to youths have more exposure for education and have high potential to prepare physical conservation methods. Therefore, it is reasonable to recommend that adequate consideration of these variables may greatly contribute to increase the sustainable use and widespread adoption of introduced conservation structures in the study area and elsewhere in the country which might have a more or less similar physical set up. By this households who adopt SC practices may become more food secured relative to non-adopters.

The study found that cultivation expanded to all corners of the study area including to steeper and marginal parts. It is advisable to introduce appropriate land use planning in the area by giving due consideration to farmers preference.

In this study access to extension service was positively and significantly affects food security status of households. Hence, it is recommendable that extension agents have to be provided with incentives and adequate trainings that enable them fulfill their responsibilities properly. Assigning more DAs with different specialization in each Kebeles may resolve the shortfall.

Small land size influenced farmers' decision to maintain conservation structures. These farmers have to be provided with support to undertake and maintain the conservation structures. This necessitates intensification of agricultural production through the provision of appropriate support services. To realize success in this regard, agricultural research, extension and provision of farm inputs (improved seed etc) have to be combined with soil conservation activities. As hand tools are found to be a major resource constraint, better supply of such measures at implementing stage as well as ensuring access are also highly recommendable.

Action is also needed to increase farmers' awareness of the importance of conservation structures through demonstration and training. This should be an integral part of soil conservation initiatives and helps to foster positive perception and shapes the attitude of framers towards soil conservation efforts.

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