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RESEARCH ARTICLE

PHYSICAL SOIL AND WATER CONSERVATION STRUCTURES: ADOPTION AND CHALLENGES TO SMALLHOLDER FARMERS IN SOUTHERN ETHIOPIA

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ABSTRACT

This study was conducted in Wonago Destrict, Southern Ethiopia with the objective of assessing the response and challenges of smallholder farmers towards soil and water conservation structures. Multi-stage sampling procedure was followed to select the *kebeles*[1] and the households for the study. The data was collected from 120 randomly selected sample households from three selected rural *kebeles* using probability proportional to size sampling techniques. Structured interview schedule was developed, pre-tested and used for collecting the essential data. Focus group discussions and key informant interviews were also conducted to generate qualitative data. In addition, secondary data were collected from relevant sources to substantiate the data collected by questioner. Descriptive statistics was used to describe the nature of data by indicating the significance of the relationship between dependent variable and independent variable. Ordered logit model was used to determine the relative influence of independent variables on the dependent variable. The result of descriptive statistics revealed that out of the total sample respondents 55% were adopters and 45% of them were non-adopters. It also indicated that in the study area, livestock holding, education, sex, participation in training of physical soil and water, non-farm activity, distance of farm land from residence and slope were found to be significantly affecting adoption of physical soil and water conservation technology by farmers. The model result revealed that sex of headed household, education of headed household, participation on training of physical soil and water conservation and livestock holding were found positively and significantly affect adoption of physical soil and water conservation structures. While the distance of farm plot from residence and non-farm activity were negatively and significantly related with adoption conservation structures. Thus, consideration of those variables would help to improve adoption of physical soil and water conservation technology among farm households.

1Kebele- The lower administration unit in the Ethiopian government structure

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INTRODUCTION

Ethiopia is endowed with distinct geography that ranges from mountains and wetlands to valleys and deserts with beautiful diversity in geography, climate and biological resources (Dawit *et al*., 2010). And many policies and policy instruments have been formulated and implemented related to these important resources by different governments that reigned in this country (Zewdu, 2000). However, the overwhelming toothless and clawless policies and policy instruments employed have never saved the natural resources from vanishing. Many researchers and academicians as well as policy makers believe that in the very recent past the total land forest cover of the country has currently dropped dramatically. For instance, the reports by EFAP, (1994); Gete and Hurni, (2001) and Tadesse, (2006) reaffirm this postulate. Hence, there are several problems facing Ethiopian agriculture sector which contribute over 46% of GDP, provide 85 % to total employment, 90% to the foreign exchange earnings and provide 70 % of raw materials requirement of countries industry (ATA, 2014). One of the greatest challenges of the national economy is natural resource degradation in general and land degradation in particular that has a great effect on economies of Ethiopia. According to Kassu (2011) the most serious problem concerning country's land resource, however, is the removal of fertile topsoil by water. Loss of arable land due to soil erosion is a widespread phenomenon in the highlands, which account for about 45% of

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Ethiopia's total land area. On steep hillsides, estimated annual rate of soil erosion is about 114.59 tons /ha/year (Mushir and Kedru, 2012).

Aware of these problems, soil and water conservation technologies were implemented in many parts of Ethiopian highlands during the 1970s and 1980s. They were introduced in some degraded and food deficit areas mainly through food for work incentives. Major types of the structure that introduced were structural types and constructed on crop lands (Kappel, 1996, Woldeamlak, 2007). However, reports indicated that these conservation structures have not been adopted and sustainably used by small holder farmers as they intended because farmers were not eager enough in accepting widely and maintaining the soil conservation technology due to the top-down approach and other technical problems (Amsalu, 2007). Likewise, Woldeamlak (2007) pointed out that sustainable adoption of new technology has become a vital concern when farmers began to dismantle structures once the incentives given to farmers discontinued following change in economic policy. He argue that the cause for failures and low adoption of introduced soil and water conservation practice were attributed mainly to non-participatory nature of conservation program, inappropriate conservation technology, discontinuing incentive of food for work and problems related to individual land owner.

In the study area in response to high soil degradation due to soil erosion, deforestation and overgrazing, some soil and water conservation technologies were promoted by Ministry of Agriculture and concerned non-governmental organization to mitigate the problem and enhance or maintain the production potential of the agricultural lands. However, soil degradation is still serious due to various socio-economic, demographic, political and institutional reasons. On the other hand the failures and low adoption of introduced conservation practices reported in different literatures. Non-participatory approach to soil conservation, inappropriate technologies, discontinuity of incentives like food for-work program, and other demographic, socio-economic and institution problems related to individual community members were strongly declared as a major causes (Yeraswork, 2000; Azene, 2001; Woldeamlak, 2003).

Even though there is abundant literature (FAO, 1994; Hurni, 1988; Hurni, 1993; Berry, 2003; Woldamlak, 2003), on the magnitude and rate of soil erosion, land cover change and extent of deforestation and land degradation in general in the highlands of Ethiopia, farmers view and response to soil and water conservation structures adoption, and challenges they face is not well documented specifically in the study area. With very few exceptions, research undertaken on soil and water conservation in the southern region has not focused on the socioeconomic or institutional factors that influence how smallholder farmers manage their land. Moreover, no study has been made so far in the study area to understand farmers' perception towards physical soil and water conservation and the associated challenges.

This means that to identify successful and alternative land management techniques for diverse farming circumstances, research is needed to understand the socio-economic, demographic and institutional factors that inhibit or favor physical soil and water management practices. Therefore, this study was designed and focused on assessing the response of smallholder farmers towards soil and water conservation structure and tried to identify the factors that influence decision on the adoption of physical soil and water technologies.

1. MATERIALS AND METHODS

1.1. Description of the Study Area

The research was conducted in Wonago destrict, Southern Nations, Nationality and People's Regional State, Ethiopia (Fig. 1). The study area is situated at a distance of 375km south of Addis Ababa. The district is comprised of 17 rural kebeles and geographically located $6^{0}13'$-6^{0} 26' North latitude and 38^{0} 13'-38^{0} 24' East longitudes.

According to CSA (2007), the total population of Wonago was estimated to 147, 940 of which 70,964 are male and 76,976 are female. The total number of headed households was about 24,463 of which 3,981 are male headed and the rest 20,482 are female headed.

The altitude ranges from 1270 to 2070 masl. The study area is characterized by a bimodal rainfall distribution with a maximum between March to June (main rainy season), and a relatively minimum rainfall between August and October. The mean annual rainfall ranges from 800 to 1600 mm with mean annual temperature ranging from 11-29^{0}C. Topographically, the area constitute mountainou*s* (39%), flat land (9%) and undulating (52%). In extreme cases, the slope can extend up to 90% (SLUF, 2006). The dominant soil type of the study area is Nitisols having greater depth. The land use system in the study area is not purely crop farming, purely cattle rearing or purely forestry but an integration of these components commonly known as agroforestry practice.

1.2. The Sampling Techniques and Procedure

For this study multi-stage sampling technique was employed to select the sample farm household. At first stage, out of 17 kebeles found in wonago district, three kebeles were selected purposively due to their activities on physical soil and water conservation intervention program by different projects and actors based on the district agricultural office. At the second stage, a list of household heads in the selected kebeles was obtained from the kebele offices and development agents. In the third stage, probability proportional to size sampling technique was used to fix the number of the sample households selected from each kebeles. Finally, a simple random sampling technique was used to select 120 respondents from the three kebeles. In this study a simplified formula provided by (Yamane, 1967) were applied to determine the required sample size.

$$n = \frac{N}{1+N\,(e)^2} \quad \text{..................................... Eq-1}$$

Where: n is the sample size, N is the population size and e is the level of precision (Table 1).

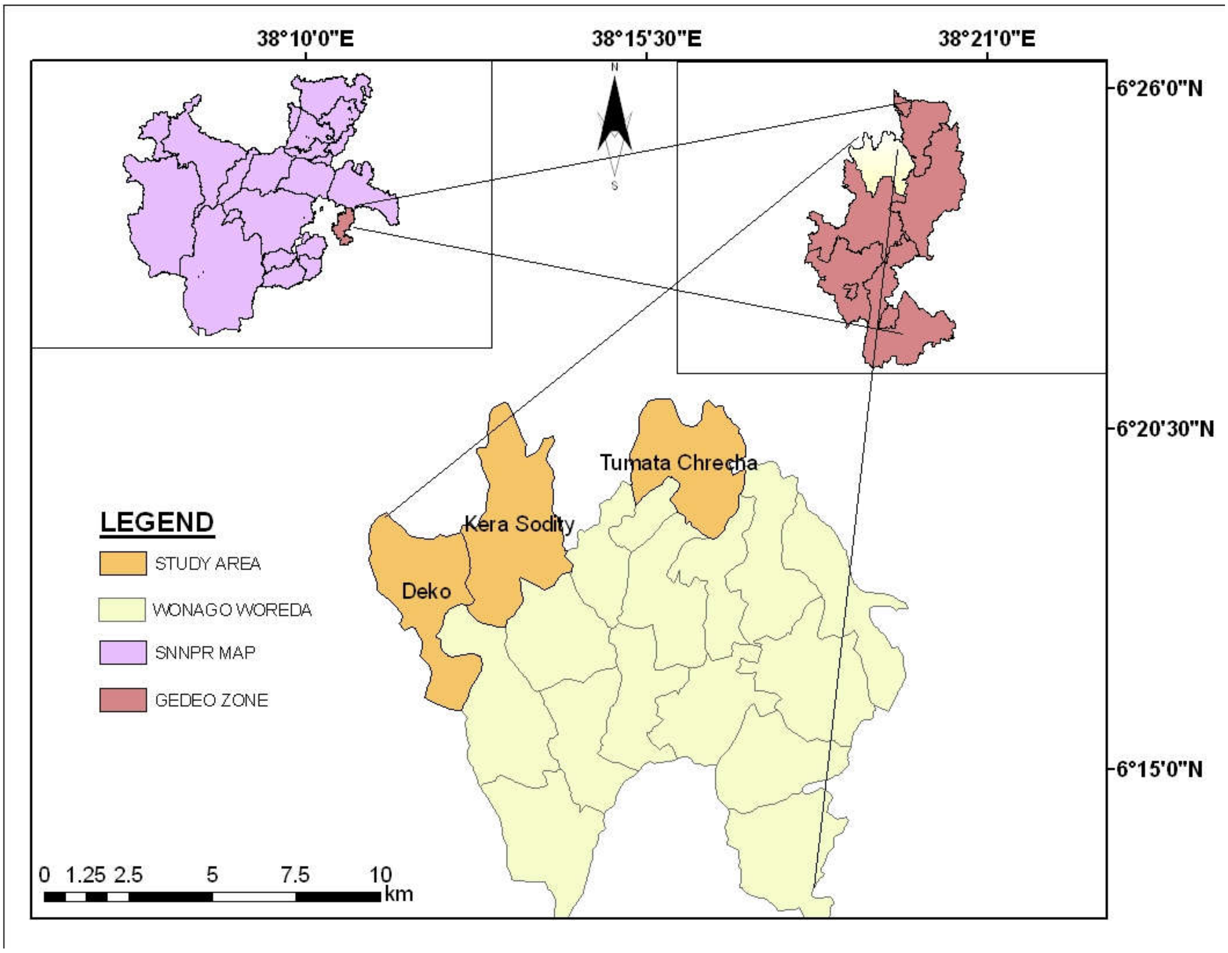

Figure 1. Map of the study area

Table 1. Distribution of Sample Respondents by Kebele in the Study Area

No.	Name of the *kebeles*	Total HHS in the *kebele*	Sample of the HHs
1	Tumata chirecha	1271	44
2	Kara soditi	1085	38
3	Dako	1110	38
Total		3466	120

1.3. The Sources and Methods of Data Collection

Both qualitative and quantitative data were collected from primary and secondary sources to obtain the necessary information. Secondary data such as description about the study area, location, topography, climate, population, soil and water conservation activities and institutional support were collected from various sources like books, internet, related journals and district agricultural and rural development office.
The primary data that were collected from 120 smallholder farmers for this research includes: household characteristics (age, education and family size), farming characteristics (farming size, source of farm plot, slope etc), land tenure issue and other related variables that are supposed to be important for the study. Before commencing the data collection by personal interview technique, pre-testing of interview schedule was made on thirty randomly selected household heads, those different from sampled household, to assess whether the target households could understand the interview questions. After pre-testing, essential amendments were made.

Focus group discussions (FGD) were conducted to collect qualitative data for the purpose of this study. A total of six focus group discussion; two focus group discussion in each *kebeles* having 8-10 household head members from both adopter and non-adopter in each group were undertaken. The discussion aimed to identify physical conservation structures introduced in the area, causes of erosion problem in the area from their experience and information on what interval they visit their farmland. A total of sixteen key informant which included extension workers, community leaders, elders and youth farmers were interviewed. The selections of key informants were selected purposively and the discussion checklists were developed in advance. The main points of discussion during informants' interviews were about accessibility of different institutional support such as: providing training on physical soil and water conservation measures; availability of labor force and farmland size) were discussed.

1.4.Methods of Data Analysis

1.4.1.Descriptive statistics

Descriptive statistics such as mean, percentage, standard deviations and frequency were used to explain demographic and socio-economic characteristics about Physical Soil and Water Conservation (PSWC) technology for the sample households. In addition chi- square and F-test (one way ANOVA) were used in this study for testing the significance of the variables using SPSS program version 16.0.

1.4.2. Econometric model

Ordered logit model: Sometimes response categories are ordered but do not form an interval scale. There is a clear ranking among the categories, but the difference among adjacent categories cannot be treated as the same. Responses like these with ordered categories cannot be easily modeled with classical regression. Ordinary linear regression is inappropriate because of the non-interval nature of the dependent variable the spacing of the outcome choices cannot be assumed to be uniform. Ordinal logit and probit models have been widely used for analyzing such data (Liao, 1994). Some polychotomous dependent variables are inherently ordered. Although the outcome is discrete, the multinomial logit or probit models would fail to account for the ordinal nature of the dependent variable (Greene, 2008). Ordered probit and logit models have come into use widely as frame-work for analyzing such responses (Zavoina and MacElvey, 1975). Hence, ordered logit model was used to assess the factors affecting adoption of physical SWC technology having four distinct categories. That is, none, low, medium and high adopter categories.

Model specification

Following Greene (2008) and Liao (1994) the functional form of ordered logit model is specified as follows:

$$y^* = \sum \beta_k \chi_k + \varepsilon. \qquad \text{.................................. \textbf{Eq 2}}$$

y* = is unobserved and thus can be thought of as the underlying tendency of an observed phenomenon. ε = we assume it follows a certain symmetric distribution with zero mean such as normal or logistic distribution. What we do observe is

$y = 1$ if $y^* \leq \mu_1$ (=0)
$y = 2$ if $\mu_1 < y^* \leq \mu_2$
$y=3$ if $\mu_2 < y^* \leq \mu_3$
$y = j$ if $\mu_{j-1} < y^*$

Where **y** is observed in **j** number of ordered categories, µs were threshold parameters separating the adjacent categories to be estimated with **βs**.

The general form for the probability that the observed y falls into category j and the **µs** and the **βs** are to be estimated with an ordinal logit model is

$$\Pr ob(y = j) = 1 - L\left(\mu_{J-1} - \sum_{k=1}^{k} \beta_k \chi_k\right) \qquad \text{..............\textbf{Eq 3}}$$

Where L represents cumulative logistic distribution

So the above ordinal logit model was used and treated against potential variables that are assumed to determine farmers decision on the adoption of PSWC technologies. All analysis was done after the coded responses to the questions entered in to the computer and the final analysis was done using STATA software.

Test for multi-collinearity problem

Multicollinearity test: Before executing the econometric model, all the hypothesized explanatory variables were checked for the existence of multicollinearity problem. The problem of multicollinearity may arise due to a linear relationship among explanatory variables. Multicollinearity problem might cause the estimated regression coefficients to have wrong sign, smaller t-ratios for many of the variables in the regression and high R^2 value. Besides, it causes large variance and standard error with a wide confidence interval. Hence, it is quite difficult to estimate accurately the effect of each variable. Different methods are often suggested to detect the existence of multicollinearity problem. Among them variance inflation factor (VIF) technique was employed in the present study to detect the existence of multicollinearity in continuous explanatory variables and contingency coefficient (CC) for dummy variables (Gujarati, 1995).

According to **Gujarati (1995)**, VIF (Xi) can be defined as

$$\textbf{VIF}\ (\mathbf{X_i}) = \frac{1}{\left(1 - R_i^{\,2}\right)} \qquad \text{............................... \textbf{Eq 4}}$$

Where: $R_i^{\,2}$ is the multiple correlation coefficients between $\mathbf{X_i}$ and other explanatory variables.

Selected continuous explanatory variables, (X_i) were regressed on all other continuous explanatory variables, and the coefficient of determination ($R_i^{\,2}$) was constructed for each case. The larger the value of $R_i^{\,2}$ results in higher value of VIF (X_i) which causing higher collinearity between variables. For continuous variables, as a rule of thumb, value of VIF greater than 10, are often taken as a signal for the existence of multicollinearity problem in the model (if the value of $R_i^{\,2}$ is 1, it would result in higher VIF (∞) and cause perfect multicollinearity between the variables).

In the same line, the contingency coefficient (CC) was computed for dummy variables from chi-square (χ^2) value to detect the problem of multicollinearity (the degree of association between dummy variables). According to Healy (1984) as cited in Paulos (2002), the dummy variables are said to be collinear if the value of contingency is greater than 0.75.

$$\textbf{C.C} = \sqrt{\frac{\chi^2}{n + \chi^2}} \qquad \text{................................. \textbf{Eq 5}}$$

Where: C.C is contingency coefficient, n= is sample size, χ^2 = is chi-square values.

1.4.3.Definition of Variables and Hypothesis

Dependent variables of the model

The dependent variable in this study is adoption index (AI) that indicates respondent farmer's adoption and intensity of use of selected (improved[1]) PSWC technologies. Such technologies include terrace, soil bund and cut-off drain.

Improved terrace: This is physical structure constructed on steep slope along contour as determined and designed by development agent or district soil and water conservation (SWC) structure expert to control runoff, allow sufficient time for percolation and maintains fertility of soil. They also filter sediment and remove excess water.

Improved soil bund: These are embankments constructed from soil along contour with water collection channel or basin at its upper side as determined and designed by SWC experts. They are constructed to control runoff and erosion from cultivated land by reducing the slope length of the field with ultimately reduces and stops velocity of runoff.

Improved cut-off drain: These are structures dug across the slope based on the design made by development agent or district SWC structures expert by taking different parameters in to consideration (slope and contour) to prevent loss of seeds from plot, fertilizers, manures and soil due to water flowing on to the plot from uphill.

Adoption index is one of the techniques used in the case of adoption study of multiple practices and measures adoption and intensity of use of improved technologies with reference to the optimum possible level without taking time into consideration. This variable is of proportional type, and therefore will be of censored from 0 to 100, as the proportion of land treated for soil erosion out of the total land that demand such a treatment. Accordingly, AI which shows to what extent small holder farmers have adopted the improved PSWC structures which were determined and designed by development agent/ district experts was calculated using the following formula

$$Ali = \frac{Numberof \quad PSWC \quad practice \quad adopted}{Numberof \quad PSWC \quad practice \quad applicable} \text{ ……. Eq 6}$$

Where, Ali = adoption index of the i^{th} farmer where, i = 1, 2, 3…n, & n = total number of respondent

Note that for this study non-adopters are defined as those farmers who did not construct any improved PSWC structures regardless of traditional[2] conservation measures on their farm for the past three years, and adopters are those farmers who have constructed improved PSWC structures (structures determined and designed by experts) on their farm. Thus, non-adopters are given the AI score of zero while adopters can get AI score ranging from greater than zero. To keep adopters in to this interval of AI score, for those farmers who were found using the conservation practices below or above some acceptable range were considered as full adopters of that specific recommendation. On the basis of AI, adopters were classified in to three categories, low, medium, and high adopter while non-adopters were kept as non-adopter category. Therefore, a total of four adopter categories were considered in this study.

Independent (explanatory) variables: Are variables that are expected to influence the probability of occurrence of the above mentioned dependent variables.

Household's Demographic Characteristics

Household Head Age (AGEHHS): it is a continuous variable, refers to the age of household head in years. Seid (2009) indicate that age is negatively related to farmers' conservation decision. On the contrary, Aklilu and Graaff (2006) stated that, the longer, the farming experience, related to the older farmers, is expected to have a positive effect on the conservation decision. Hence, it is hypothesized that age and adoption of conservation structures to be positively or negatively correlated.

Sex of household heads (SEXHHS): this is dummy variable which takes a value of 1 if the household head is male and 0 if it is female which influence adoption of technologies. Tesfaye (2006) found that male headed household has better access to information than female headed household because they have freedom of mobility and participation in different meetings. Hence male headed households are expected to adopt introduced improved technologies better than female headed households. Therefore male headed household was hypothesized to positively influence adoption of PSWC structures.

Family Size (FAMSIZ): This is the number of the household in terms of man equivalent. The influence of the household size may have significant effect on the conservation practice. As maintaining soil conservation structures is labor intensive, if house hold labor is the only source of labor, households with larger household size make decision to retain structures (Tesfaye, 2009). Contrary to this, the negative effect of larger family size household is draw labor away from investment in conservation for search of food for survival (Abera, 2003). Therefore based on this argument, the household size influences adoption of PSWC practice negatively or positively.

Education of the Household Head (EDUCHH): This is dummy variable, which takes a value of 1 if the household is literate and 0 otherwise. It is expected that small holder farmers with a better educational attainment perceived the problem of soil erosion better and make decision to adopt conservation structures (Techane, 2002). So, it was hypothesized to have positive relationship with adoption of PSWC practice.

[1] Improved physical soil and water refer to practices built as determined and designed by experts, taking different parameters such as slope and contour in to consideration.

[2]The traditional SWC methods refer to practices built upon farmers' indigenous knowledge and experience.

Institutional variables

Land acquisition (LNDAN): this is dummy variables which indicate the means by which a small holder farmer accessed land (rented or own). If the farmer gets the land from kebele or parents it gives 1 but if get through rented or sharing crops it gives 0. Farmers that rent land have short term planning compared to those who have their own land hence they may not interest about the benefit that obtained on the long term from conservation structures (Mesfin, 2006). Based on this, it is hypothesized that source of land (own land) is correlated to adoption decision positively.

Participation on SWC Training (PARTRING): it is dummy variables representing whether a farmers has attended SWC trainings or not. Farmers, who attend trainings, can have the required information and understand the problem of soil erosion very well. Farmers who have access to training are expected to adopt the structures more than those who haven't get access to training. That means access to training has positive influence on adopting SWC structures (Kebede, 2006).

Distance of Farm Land from Residence (DISFRES): this is a categorical variable that represents how much far the parcel is situated from the residence according to a number of farmers which is measured in minutes. According to Fikru (2009) and Jabessa (2008) resident distance was negatively and significantly influenced the adoption and intensity of adoption of different agricultural innovations.

Land characteristics

Slope of the land (SLOPLND): it refers to the slope of the plot as perceived by the farmers and grouped in to flat (1), gentle slope (2), moderate slope (3) and steep slope (4). Erosion is more serious on steeper plots than on flat plots. Farmers that have farm plots on steeper location are more likely to use conservation measures than farmers on flat areas. Prior research found out that slope of a plot is positively and significantly related to decision on use of PSWC measures (Paulos *et al*., 2004). Hence, slope of a plot is expected to be positively related to farmers' decision to use conservation measures.

Economic variables

Non-farm activity (NONFRAT): this is a dummy variable representing whether the household was involved in non-farm activities or not. Being involved in non-farm activities compete out resource required to construct and maintain conservation structures. Hence, negative association is expected between involvement in non-farm activities and decision to adopt conservation structures (Habtamu, 2006). Thus, non-farm activity is hypothesized to influences the adoption of PSWC technology negatively.

Farm Size (FARMSIZ): this is a total area of land a household cultivates measured in hectare. Farmers having large farm size can bear risk of loss of cultivation land from conservation structures and therefore expected to influence adoption of structures positively (Mahilet, 2013). On contrary to this, farmers having large farm size lack labor power to construct the conservation structures in all of his/her land. So farm size influences the adoption of structures negatively (Endrias, 2003). Therefore, the researcher expects farm size to influence the adoption technology positively or negatively.

Livestock holding (TLU): This variable refers to the total number of livestock owned by the sample households and were measured in TLU. Previous studies came up with mixed result and in this study small holder farmers' decision to retain conservation structures may go either way. In rural context, livestock holding is an important indicator of household's wealth position. Livestock ownership of a household influences the adoption of improved conservation technologies differently by different people across different areas. In most cases, livestock holding has positive contribution to household's adoption of technologies. This is evident from many of the past adoption studies which have reported positive effect of livestock (Zelalem, 2007 and Dereje, 2008). Contrary to the above findings, Mesfin (2006) reported that livestock holding influenced negatively the farm level adoption of farmers' participation on SWC activity. His explanation for this reason is that livestock are generally considered a symbol of wealth and farmers with large livestock herd sizes tend to focus more on their livestock operations and pay less attention to their land conservation. Thus, this variable is expected to positively or negatively affect the adoption of PSWC structure.

Social variable

Organization membership (ORMSHP): Paul (2011) proved that potential of social capital to internalize economic externalities and help the adoption of conservation practice. Action by one farmer to reduce water or wind erosion may benefit neighboring field by slowing the rate of water or wind movement across those lands. Thus membership in local organization is hypothesized positively influence the probability of adoption of soil conservation structures.

2. RESULTS AND DISCUSSION

2.1.1.Current status and extent of adoption

In this study the condition for 'adopter's' scale is defined in terms of continual sustenance of certain proportion or volume of constructed soil structures. As indicated in Table 3, out the total sampled respondent 55% were adopter and 45% of the households were non-adopter of PSWC technology. The AI scores were divided into four classes whereby, the non-adopters, the low, the medium and the high adopters' index were arranged as 0, 0.01-0.33, 0.34-0.66 and 0.67-1.00, respectively. The actual AI scores ranges from 0 to1. AI score of 0 point implies non-adoption of the overall improved PSWC measures .01- 1 implies adopting the introduced technology at lower, medium and relatively higher level. There is significant difference (F=1.0344) among the AI score of the four adoption categories at less than 1% significance level which indicates variation in the level of adoption among the sample headed household.

Table 2. Summary for Independent Variables, Measurement Scales and the Hypothesized Relationships

Variables	Description of variables	Type	Unit of measurement and expected sign
AGEHHS	Household head age	Continuous	Number of years (- or +)
SEXHHS	Sex of household head	Dummy	1 if the household head is male and 0 otherwise (+)
FAMSIZ	Family size	Continuous	No of household in man equivalent (+ or -)
EDUCHHS	Education of the household head	Dummy	1, if literate; 0, otherwise (+)
SLOPLND	Slope of the land	categorical	1, if flat; 2, if gently sloping; 3, if moderately sloping; 4, if steep slope (+)
LNDAN	Land acquisition	Dummy	1, if owned; 0, otherwise (+).
PARTRING	Participation on SWC training	Dummy	1, if yes; 0, otherwise (+)
FARMSIZ	Farm size	Continuous	Hectare (+ or -)
TLU	Livestock holding	Continuous	Number of livestock in TLU (+ or -)
NONFAT	Non-farm activity	Dummy	1, if involve in non-farm activity; 0, otherwise (-)
DISFRES	Distance of farm from residence	Categorical	1, if less than 15minute; 2, if 15-30 minute;3, if more than 30 minute (-)
ORMSHP	Organization membership	Dummy	1,if yes; 0, otherwise (+)

Table 3. The Distribution of the Respondents by Adoption Categories

Adoption category	Number	%	Adoption index rate	Mean adoption index	SD	F-value
Non-adopter	54	45	0.00	0.0000	0.0000	1.0344***
Low adopter	28	23.3	0.01-0.33	0.2946	0.10394	
Medium adopter	23	19.2	0.34-0.66	0.7043	0.11748	
High adopter	15	12.5	0.67-1.00	1.0000	0.0000	
Total	120	100	0-1	0.3288	0.37197	

*** Statistically significant at 1% level of significance

Table 4. Adoption Intensity of Household by Sex and the Marital Status

Description	Adopter category in %				Total	Chi-square
	Non adopter	Low adopter	Medium adopter	High adopter		
Sex						
Male	42.5	20	15.8	10	88.3	3.633**
Female	2.5	3.3	3.3	2.5	11.7	
Marital status						
Married	42.5	22.5	17.5	12.7	95	
Single	1.7	0	0	0	1.7	6.996
Divorced	0.8	0	0.8	0	1.7	
Widowed	0	0.8	0.8	0	1.7	

** Statistically significant at 5% level of significance

Table 5. The Farmers' Adoption Intensity by the Educational Status

Education	Adopter category in %				Total	Chi-square
	Non adopter	Low adopter	Medium adopter	High adopter		
Literate	11.7	15	18.3	21.7	66.7	21.900***
Illiterate	23.3	8.3	0.8	0.8	33.3	

*** Statistically significant at 1% level of significance

The mean AI scores of non-adopters, low, medium and high adopters groups, which are 0, 0.294, 0.704, and 1.00, respectively. One way analysis of variance revealed that there is significant mean difference (F=1.0344) among the AI scores in the four adopter categories at less than 1% significance level. This indicates the variation in level of adoption of PSWC structures among sample farmers.

2.1.2.Demographic characteristics sample households

Sex of the household head (SEXHHS): from the total interviewed households, 11.7% were female headed and 88.3% were male headed households. This clearly shows the existing gap between male headed and female headed households in terms of participation in SWC activity. The chi-square test also shows a statistically significant difference among the groups in terms of their sex at 5% significant level and this implies that male headed households are more likely adopter of PSWC than female headed households (Table 4).

Educational status of the household head (EDUCHH): the educational status of the household head is one of the influencing factors for the technology adoption in a given society. As indicated in Table 5 medium and high adopters had better level of educational achievement than non and low adopters, this implying the significant role of education in adoption of SWC technology. Out of the total non and low adopters about 23.3% and 8.3% of them were illiterate and remaining 11.7% and 15% of them were literate. And the chi-square test for education level of the adopter groups was found to be statistically significant difference at 1% probability level. This hints that educational statuses of the households' heads do positively affect the adoption of PSWC technologies.

Age of the household head (AGEHHS): Age structure of the sample household shows that the average age of non, low, medium and high adopter of the categories of the households were 44.0, 44.2, 42.4 and 44.1 respectively. The mean age difference among the groups is found to be statistically insignificant (Table 6).

Family size (FAMSIZ): In the study area**,** the average family size in terms of man equivalent of sample households is 3.8 persons. The average family size for none, low, medium and high adopters of PSWC technology were 4.0, 3.6, 4.0 and 3.1 in man equivalent respectively. The F-value result shows that there is no a statistical significant difference between the four groups in terms of this variable (Table 6).

2.1.3. Economic variables

Farm size (FARMSIZ): The total farm size owned by households is taken as proxy to economic status. The survey results showed that the average size of total farm size holding by the sample household is about 1.12 ha. High adopters of PSWC technology households owned, on the average, 1.20 ha of total farm size while the corresponding figures for the non adopters households was 0.94 ha. The mean difference among the adopter categories is found to be statistically insignificant (Table 7).

activities in which sample households were participating. When a farmers and family members are more involved in non-farm activities, the question of time spent on their farm land will be limited and hence the family is discouraged from being involved in construction and maintenance of SWC measures. Out of the total households interviewed 60.8% had participated in non-farm activities while 39.2% were did not. Among the households who participated in non-farm activities, none, low, medium and high adopters accounted about 23.3%, 15.8 %, 13.3% and 8.3% respectively. The results of chi-square test indicated that participation of the household head in non-farm activities had significant difference (x^2 = 2.814) among the groups at 10% level of significance (Table 8). The results of this study are similar with the findings of Almaz (2008).

2.1.4.Institutional variables

Training of SWC measures (PARTRING): Training is one of the important techniques which can help to introduce certain new technology.

Table 6. The Farmers' Adoption Intensity by Age and Family Size

Description	Adoption categories in %								Total		F-value
	Non-adopter		Low adopter		Medium adopter		High adopter				
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
Age	44.0	12.88	44.2	13.16	42.4	11.18	44.1	16.46	43.76	12.98	0.104
Family size	4.0	2.02	3.6	1.41	4.0	1.88	3.1	1.85	3.8	1.85	1.058

Table 7. The Distribution of Respondent by Farm Size and TLU

Description	Adoption categories in %								Total		F-value
	Non-adopter		Low adopter		Medium adopter		High adopter				
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
Farm size	0.94	0.71	1.29	0.96	1.29	1.11	1.20	1.08	1.12	0.91	1.370
TLU	0.89	1.12	1.36	2.39	1.87	2.02	1.61	1.60	1.28	1.75	2.014*

* Statistically significant at 10% level of significance

Table 8. The Distribution of Households by Participation on Non-Farm Activity

Non- farm activity	Adopter category in %				Total	Chi-square
	Non adopter	Low adopter	Medium adopter	High adopter		
Participation						
Yes	23.3	15.8	13.3	8.3	60.8	2.814*
No	21.7	7.5	5.8	4.2	39.2	

* Statistically significant at 10% level of significance

Livestock ownership (TLU): The maximum and minimum livestock holding in the study area were 10.89 TLU and 0 TLU respectively. The test of mean variance using one-way ANOVA showed that there was significant mean difference (F=2.014) among adoption categories at 10% level of significant (Table 7). Regarding relationship of livestock holding with adoption, many adoption studies so far conducted have also reported similar results. To mention some, for instance, Yishak (2005) and Rahmeto (2007) have found that livestock holding has positive and significant influence on adoption of improved conservation technologies.

Non-farm activity (NONFRAT): During slack periods, many farmers earn additional income by engaging in various nonfarm activities. This is in turn to increases their financial position to command over the new inputs. In the study area, carpenter, daily labour and other activities were some of the non-farm

It is also the most important means through which farmers get agricultural information. During the key informant interview they raised different points about the benefit of training to built their confidence and initiate them to have better understanding about PSWC measures. The result of farmers' participation in different training in relation to PSWC practice is presented in Table 9 which highlights that about 42.5 % of sampled farmers have attended training related to PSWC technology while 57.5% did not obtain training on the PSWC technology. The result of chi-square test revealed that participation on training of PSWC was significant at 1% level of significance.

Land acquisition (LNDAN): with regards to source of land, out of the total household surveyed 30.8% and 25.8% of the sample household obtained land from *kebele* and from their parent respectively, while the rest 43.3% obtained it through sharing crops and renting. From the total high adopter 2.5%

and 3.3% of them got land from kebele and parents respectively and the rest 6.7% obtained the land by sharing crops and renting. The chi-square result is indicating that there is no statistical significance difference among the four categories in terms of land acquisition (Table 10).

Distance of farm land from residence (DISFRES): During the FGD, it was indicated that farmers having land far from their residence usually don't visit their cultivation field except during harvesting and planting season. During slack season, livestock roam (travel) on the field freely and destroy conservation structures. Farmers remove such bunds during plowing season. Hence, farmlands situated far from the residence suffer from destruction of conservation structures and enhanced erosion. Out of the total sample household 20.8% and 27.5% were far from their farm land, which takes less than 15 minute and 15 to 30 minute respectively and the rest 51.7% were far away more than 30 minutes on foot. The average walking time by sample respondents is found to be significant difference among adopter categories (χ^2 = 13.898) at 5% level of significance (Table 10).

respectively. From the total high adopter respondents around 5.8% of the farmers had steeply sloping land and the rest 5% of them had moderate slope. The result of chi-square test indicated that the slope of land holding had statistically significant difference ((χ2= 14.128) among the adoption categories at 10% significance level (Table 11).

4.1.6. Social variable

Organizational membership (ORMSHP): Social participation is expected to have an indirect influence on adoption behavior to the farmers. It links an individual to the larger society and exposes them to a variety of information. This exposure makes them positively predisposed towards innovative ideas and practices. Out of the total sample household heads 30% of them participated in different organizational membership while the rest (70%) of them were not involved in any organizational membership. The chi-square result shows the existence of statistically insignificant difference between the adoption categories with respect to organizational membership (Table 12).

Table 9. The Distribution of Households by Training of SWC

Description	Adopter category in %				Total	Chi-square
	Non adopter	Low adopter	Medium adopter	High adopter		
Training on SWC						
Yes	11.7	15	8.3	7.5	42.5	13.397***
No	33.3	8.3	10.8	5	57.5	

*** Statistically significant at 1% level of significance

Table 10. Households Distribution by Land Acquisition and Farm Distance from Residence

Description	Adopter category in %				Total	Chi-square
	Non adopter	Low adopter	Medium adopter	High adopter		
Land acquisition						
From Kebele	11.7	6.7	10	2.5	30.8	7.374
From parent	14.2	5.8	2.5	3.3	25.8	
Sharing crops & rent	19.2	10.8	6.7	6.7	43.3	
Distance of farm land from residence						
< 15 minutes	8.3	2.5	4.2	5.8	20.8	13.898**
15-30 minutes	9.2	7.5	5.8	5	27.5	
>30 minutes	27.5	13.3	9.2	1.7	51.7	

** Statistically significant at 5% level of significance

Table 11. The Distribution of Household by Slop of the Land

Slop of land	Adopter category in %				Total	Chi-square
	Non adopter	Low adopter	Medium adopter	High adopter		
Flat	8.3	0.8	0.8	0	10	14.128*
Gently sloping	5.8	1.7	0.8	1.7	10	
Moderately sloping	14.2	5	6.7	5	30.8	
Steeply sloping	16.7	15.8	10.8	5.8	49.2	

* Statistically significant at 10% level of significance

2.1.5.Land characteristics

Slope of the land holding (SLOPLND): Usually problem of erosion is so sever in steep slope in high rainfall areas. This idea raised during FGD also elaborates the effect of the slope of the land as one of the major erosion problem in the area. Therefore most farmers obliged to undergo different conservation methods in order to cultivate and harvest their crops. Out of the total household surveyed 49.2% and 30.8% of the sample household had steeply and moderately sloping land

Table 12. Households Distribution by Organizational Membership

Organizational membership	Adopter category in %				Total	Chi-square
	Non adopter	Low adopter	Medium adopter	High adopter		
Yes	16.7	6.7	2.5	4.2	30	4.529
No	28.3	16.7	16.7	8.3	70	

2.2. Econometric Model Results

This section presents ordered logit econometric model results on the factors affecting adoption of PSWC technology. Prior to the estimation of the model parameters, it is crucial to look in to the problem of multicollinearity or association among explanatory variables. To this end, the Variance Inflation Factor (VIF) was used to check multicollinearity among continuous explanatory variables. The values of VIF for the explanatory variables were less than 10; which are obviously the indicators for the absence of multicollinearity. Likewise, the degree of association among dummy variables was measured with contingency coefficient test. The value of contingency coefficient result is found to be very low (<0.75). Both result shows that multicollinearity was not a serious problem (Table 13 and Table 14).

Finally, a set of 12 explanatory variables (4 continuous and 8 discrete) were included in the logistic analysis. Out of the twelve hypothesized variables, six variables such that sex (SEXHHS), education status (EDUHHS), participation of training on SWC (PARTRING), tropical livestock unit (TLU), non-farm activity (NONFRAT), distance from residence (DISFRES) were found to have significant effect on the adoption of PSWC technology (Table 14). Following this, variables that are found to be significant are presented and discussed below.

literate. The finding of Tesfaye and Debebe (2013) support the result whereby indicated a positive association between literacy level and intensity of adoption PSWC measures.

Tropical Livestock unit (TLU): Consistent with a priori expectations, livestock holding was measured in tropical livestock unit (TLU) and was found to be positively and significantly influence adoption of PSWC at 10% level of significance. This result shows that the farmers with large number of tropical livestock units are more likely to adopt PSWC technology than those who own small number of TLUs. The positive association between adoption and number of TLU indicated that large size of livestock creates better opportunity to earn more income. The income generated from livestock helps the farmers to invest in PSWC technology. Other things held constant, the odds ratio 1.303 for number of TLU shows that, as the number livestock units increases by one TLU, the odds ratio in favor of adopting PSWC technology increases by a factor of 1.303. Mulugeta and Karl (2010) study also draws the same conclusion based on the study conducted on assessment of integrated SWC measures on key soil properties.

Table 13. Contingency Coefficient of Dummy Explanatory Variables

	Sex	Eduhh	Sloplnd	Sorlnd	Parting	Nonfrat	Disfres	Ormshp
SEX	1.0							
EDUHHS	.037	1.00						
SLOPLND	.052	.133	1.00					
SORLND	.049	.131	.017	1.00				
PARTING	.052	.389	.292	.067	1.00			
NONFRAT	.134	.024	.026	.047	.017	1.00		
DISFRES	.058	.200	.033	.187	.250	.133	1.00	
ORMSHP	.015	.228	.009	.111	.389	.237	.336	1.00

Table 14. Summary of Results of Continuous Independent Variables

Variables	Mean across adopter category				1/VIF	F-value
	Non adopter	Low adopter	Medium adopter	High adopter		
AGEHHS	44.0	44.2	42.4	44.1	0.71	0.104
FAMSIZ	4.0	3.6	4.0	3.1	0.95	1.058
FARMSIZ	0.94	1.29	1.29	1.20	0.66	1.37
TLU	0.89	1.36	1.87	1.61	0.70	2.014*

* Statistically significant at 10% level of significance

Sex of the household head (SEXHHS): This variable was found to influence adoption of PSWC technology positively and significantly at 5% level of significant. This implies that being female household head lacks the adoption and intensity of uses of PSWC technology in the same probability level. This may be because of labor intensive nature of soil conservation could not match with multi role of female in farm households. The result is in agreement with the findings of earlier researchers (Teshome *et al*., 2012).

Education level (EDUHHS): This variable took positive sign and it is significant at 1% probability level. This is related to the fact that heads of households with better educational status are more in a position to recognize the advantage of PSWC technology and to demonstrate to take part in it, consequently. The odds ratio of 4.647 for education implies that keeping the influence of other factors constant, the decision to adopt PSWC structures is increasing by a factor of 4.647 as the households

Participation on training of SWC (PARTRING): Participation on training related to PSWC activity was positively and significantly influences the adoption of PSWC technology and it was found to be statistically significant at less than 1% significance level. Training about PSWC measures is one of the major sources of information to adopt new technology. Moreover, taking training widens the household's knowledge with regard to attribute, practices and characteristics of all aspects of new technologies (PSWC in our case). The odds ratio of 11.234 for participation on training shows that the frequency of farmers' participation in PSWC increases the odds ratio in favor of adoption of PSWC technology by 11.234. The result clearly shows the importance of participation in training in the adoption of new technologies. Participation of farmers in training relate to PSWC would facilitate access to credit, access to extension information and access to market. This is in line with the study conducted by (Kebede *et al.*, 2013). Thus, any attempt to be made in scaling up of PSWC technology, need to focus on improving the skill of the communities through training.

Distance of farm land from residence (DISFRES): In this study, distance from residence of the farmers affected the extent of adoption of PSWC negatively and significantly at 1% level of significance. This implies that farmers whose residing was located far off from their farm land, the probability of adopting conservation measures was less as compared to the farmers who had their farms at a close proximity from their residence. The odds ratio 0.312 implies that the odds of a farmer, who were near their farm land adopted conservation measures by 0.32 folds than the odds farmers that had farm land far from residence. This indicated that farmers had farm land far from residence failed to retain conservation structure with less follow up of the structure because of the far distances from farm land. The focus group discussion result held with key informants also explained the distance of the farm land affects adoption because conservation structure needs strict follow up to fully development of the structure. This study is in line with Waga and Jermias (2013). In the same line, Gebresenbet (2008) in his study on the determinants of adoption and intensity of use of improved SWC practice in *Sodo* district found that distance of residence from farm land had negative and significant relationship with adoption.

Non-farm activity (NONFRAT): Non-farm activity affects farmers' extent of adoption of PSWC measures negatively and significantly at 5% level of significant. This implies that the farmers who were engaged in non-farm activities have less time to adopt SWC measures because they spend more of their time for non-agricultural activities. The odds ratio shows, the farmer who participate in nonfarm activity were adopt PSWC technology by 0.2883 less than the farmers who were not involved in nonfarm activity. Mushir and Kedru (2012); and Almaz (2008) come with the same result of negative association between adoption of conservation measures and involvement in non-farm activities.

Table 15. The Ordinal Logit Model Results for the Factors Affecting Adoption of PSWC Technology

Variables used	Coefficient	Z -value	Odds ratio
Age	-0.0059928	-0.30	1.006011
Sex	1.353648	2.48**	2.0582964
Family size	0.1655394	1.33	0.8474365
Education	1.536174	3.05***	4.646775
Land acquisition	0.1962075	0.46	1.216779
Distance from residence	-1.152053	-2.63***	0.3159872
TLU	0.2649272	1.86*	1.303336
Farm size	0.4315895	1.65	1.539703
Non -farm activity	-1.058919	-2.38**	0.2883253
Organizational membership	0.3213034	0.66	0.7252032
Participation on SWC training	2.418959	4.67***	11.23416
Slope of the land	0.0789467	0.14	1.082147
Number of observation=120, Pro>chi2=0.0000, Pseudo R^2 =0.2553, Log likelihood= -113.9743			
*** 1% ** 5% and * 10% significant levels			

3.SUMMERY AND RECOMMENDATION

3.1. Summery

Soil erosion is a threat to the economic development of Ethiopia as it affects the agricultural sector of the country significantly. At the face of increased dependency on the agricultural sector for economic development, sustained use of the land resource has become very important. This study was conducted with the general objective to identify the determinants of adoption and extent of use of physical soil and water conservation technology at household level in Wonago district*,* Southern Ethiopia. The study focused on identifying types of conservation structures implemented in the area, assess the current status of adoption, and to identify factors which affects households' adoption behavior.

Physical Soil and water conservation technology considered in the area consisted of total farm land covered by different types of physical soil and water conservation structures. Based on the extent of adoption of such structure types, adoption index was calculated for each respondent. Based on their adoption index, respondents were grouped in to four adopter categories across which factors hypothesized to be responsible for such variation were assessed.

Descriptive statistics was used to explain the demographic and socio economic characteristics of the sample households. The chi-squared (χ^2) and F-value results showed that none, low, medium and high adopter categories households differed statistically and significantly from each other in sex of households, educational status, distance from residence, non-farm activity, tropical livestock unit, participation on training of soil water conservation and slope of the land.

Ordered logistic regression model was employed to identify determinants of households' adoption of physical soil and water conservation. The model result revealed that sex of household, educational status; tropical livestock unit and participation on training of soil water conservation are found to be positively and significantly related to households adoption of the technology while distance from farm residence and non-farm activity are negatively influences decision to adopt physical soil and water conservation technology.

5.2. Recommendations

The result of the study revealed that farmers' decision to use physical soil and water conservation practice is influenced by multiple factors such as demographic, institutional and economic factors. Considering the essence of these factors might contribute to design appropriate strategies to attain approach and technical change in sustainable natural resource conservation process in the study area under similar conditions. Based on the main findings of the study, the following recommendations were drawn.

1. Involvement in non-farm activities is the most significant factor that influences farmers' decision to retain conservation structures negatively. This is due to the fact that farmers who are involved in non-farm activities lack the required resources (mainly labor and time) to maintain and retain conservation structures. Therefore, such farmers need awareness creation to allocate their time and labor force and they can make decision to invest on both activities by government and nongovernmental organization.

2. Training is found to influence farmers' decision to adopt conservation structures positively and significantly. Because training could help in building the confidence of farmers to develop trust on soil and water conservation technology. Therefore, it is crucial that extension workers and other institutions working on soil water conservation should consider the issue of sensitizing about soil water conservation technology. Particularly, farmers training centers should be given due attention to strengthen its institutional capacity.
3. Adoption and variations in the level of adoption of soil and water conservation among the households were found to be influenced by different factors among these, sex difference is one of the prevailing factors. As a result, female-headed households are less adopter of physical soil conservation technology than male headed households. This might be due to lack of access to information sources. Therefore, enhance participation of women and awareness creation should be done both by governmental and non-governmental organizations about the multipurpose of soil water conservation measures to expand the technology more effectively.
4. The study revealed that education status of household head positively and significantly affects farmers' decision to adopt physical soil and water conservation technology. As a result, more educated household heads are in the better position to adopt the new technology. Therefore, enhance the educational status of the farmers through adult education.

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