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Full Length Research Paper

Factors affecting adoption of soil and water conservation practices in the case of Damota watershed, Wolaita zone, Southern, Ethiopia

Belete Limani Kerse

Wolaita Sodo University, Ethiopia. Corresponding author. E-mail: belelima127@gmail.com

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The main objective of the study was to determine and examine factors influencing the adoption of soil and water conservation technologies for integrated watershed management and planning in the Damota catchment in Wolaita Zone, Southern Ethiopia. The selection of the study area was based on the fact that a great deal of integrated watershed based conservation works are being undertaken. Hence, Damota watershed has a wider experience in the activities of watershed based soil and water conservation. Both purposive and simple random sampling techniques were applied to select sample kebeles and representative households respectively. A total of 148 respondents were interviewed to generate primary data. The interview schedule was pre-tasted for the collection of the essential quantitative and qualitative data for the study. 11 explanatory variables were used for the binary logit model, out of which 8 were found to be significant to affect farmers' adoption. Thus, education and perception of erosion as problem at 10% significant level positively; family size, land size and slope at 5% significant level and sex were found affecting the tendency a household to adopt conservation structures positively while participation in non-farm activities and proximity of farm from the residence were found influencing at 5% significant level negatively a household tendency to practice conservation structures. Hence, to the scope of the research finding, it is utmost important to consider the factors that were found being influencing the tendency of household adoption. Moreover, strategy which focus on enhancing the willingness and ability of farmers should be adopted, strengthen learning opportunities through facilitating the establishment of farmers training center and strengthen extension.

Key words: Watershed management technologies, Adoption, Binary logit, Damota Watershed

Introduction

A global assessment of human-induced soil degradation indicated that globally about 560 million hectares (36% of total) of farmlands had degraded at an annual rate of 5 to 6 million hectares (Scherr, 1999). Soil erosion is the main form of land degradation, caused by the interacting effects of factors, such as biophysical characteristics and socio-economic aspects. Land degradation in the form of general loss of productivity and was pervasive problem in Ethiopia especially prior to the 1980's when there was no clear defined government policy on natural resource management (Alemeneh, 2003). The degradation was known for its nutrient depletion and the most challenging environmental problems in the country (Amsalu and De Graaff, 2007).

In Ethiopia as reaction to the 1970s famine, different natural resource management initiatives through community mobilization have been piloted. Thus, since then massive soil conservation and afforestation programs have been implemented to reduce the major problems of soil erosion (Hurni, 1990). Considerable public resources have been mobilized to develop soil and water conservation technologies and promote its usage by farmers. Massive dissemination of soil and water conservation technologies have been under taken throughout the country which includes, structural methods, such as soil and stone bunds; agronomic practices, grass strip and agro-forestry techniques and water harvesting options such as tied ridges and pond construction (Shiferaw *et al* ., 2007).

However, disseminating different structures and attempting bringing lasting panacea to continuous land degradation particularly soil erosion was not straight forward. Thus, soil conservation has been carried out with limited success. There is less-willingness of farmers to adopt and maintain the extensively introduced practices of soil conservation. Moreover, according to Woldeamlak (2007), many soil and water conservation structures were not tailed to their site appropriateness specifically, policy related issues like land tenure were not considered. Despite these challenges, soil and water conservation remained a vital technique to the achievement of food security, poverty reduction and environmental sustainability in the country.

This study was focused on community based soil and water conservation practices in the Damota watershed of Wolaita Zone due to severe soil erosion caused by low adoption behavior of local farmers and improper management of watersheds. The government, with concerned bodies is introducing the practice of integrated watershed management through soil and water conservation but most farmers were not willing to adopt the new introduced soil and water conservation practices. Moreover, previous studies conducted were unable to fish out the influencing factor that hider the active involvement of the local people in the soil and water conservation activities in their locality. Thus, this is the point of departure for the originality of the study in the light site in specifying problems.

METHODOLOGY

Study area description

The study was conducted around Mount Damota which is geographically located between 6.4^0 and 6.9^0N latitude, and 37.4^0 and 37.8^0 E longitude. Mount Damota is found in Wolaita Zone of the Southern Nations, Nationalities and People's Region (SNNPR). It is about 390km away from Addis Ababa the capital city of Ethiopia and about 5-15km from the Zonal town Sodo which is bordered by Damote Gale, Sodo Zuria and Boloso Sore Woredas of the Zone (WZARDD, 2009). The Mount Damota catchment covers 13 kebeles from which five kebels including Damot waja, Waraza Lasho, Gurumu Woyde, Kokate Marachare and Dalbo Wogene are in Sodo Zuria Woreda; Kunasa Fulasa, Damot Boloso, Woshi Gale, Wandara Gale, Shasha Gale and Akabilo are in Damot Gale whereas Gurumo Koysha kebele is in Boloso Sore Woreda. Furthermore, the target watershed is found in Damot waja, wraza lasho and washi gale kebeles as shown in figure 1. As it is indicated in Damota Mountain Development Program base line data report of 2009, the population of the three Woredas (Damot Gale, Sodo Zuriya and Boloso Sore) is 320,133, 306,072 and 368,590 respectively and the average family size of Damot gale 5.1, Sodo Zuria 5.1 and Boloso Sore 4.8. Population density of Damot Gale, Sodo Zuria and Boloso Sore is 781, 600 and 678 people per square kilometer respectively. This figure shows that the area is the most densely populated area in the country.

Methods of Data Collection and Analysis

For conducting study two main data sources were used. Primary and secondary sources were used. Thus, primary data were collected through field observation, focus group discussion, key informant interview and household survey. The household survey was used to collect qualitative data type of the research. Before conducting the questionnaire survey, drafting questionnaire was given considerable attention in order to develop understandable, unambiguous and well-targeted questionnaires by avoiding confusing and incomprehensible terms which can erode the confidence of the respondents. Testing of the questionnaire was done in the actual study area in order to cross check the relevance of its contents. The **secondary data** were collected by reviewing of the available project documents, reports and research papers. This helped to identify the existing knowledge gap needed to be filled through research. A total of 148 households were selected using random sampling procedures that are resident of the treated watershed.

Method of data analysis

Prior to subjecting the data collected through households' questionnaire survey to statistical analysis, organization and coding were made carefully. Then, the arranged data were analyzed using SPSS statistical software version 20.0. For the analysis, descriptive statistics such as frequency, means, and standard deviation, test of significance, correlation and chi-square test were used step by step. However, the descriptive statistics were unable to indicate the direction and the magnitude of the association that exist between variables. Moreover, these tools were found insufficient to determine the influence of explanatory variables. Therefore, to analyze the factors affecting farmers' adoption of SWC practices, binary logit model was used.

Model specification

As it is mentioned above for the analysis of the data collected, binary logistic regression model was used. According to Neupane *et al.* (2002), this model is popular

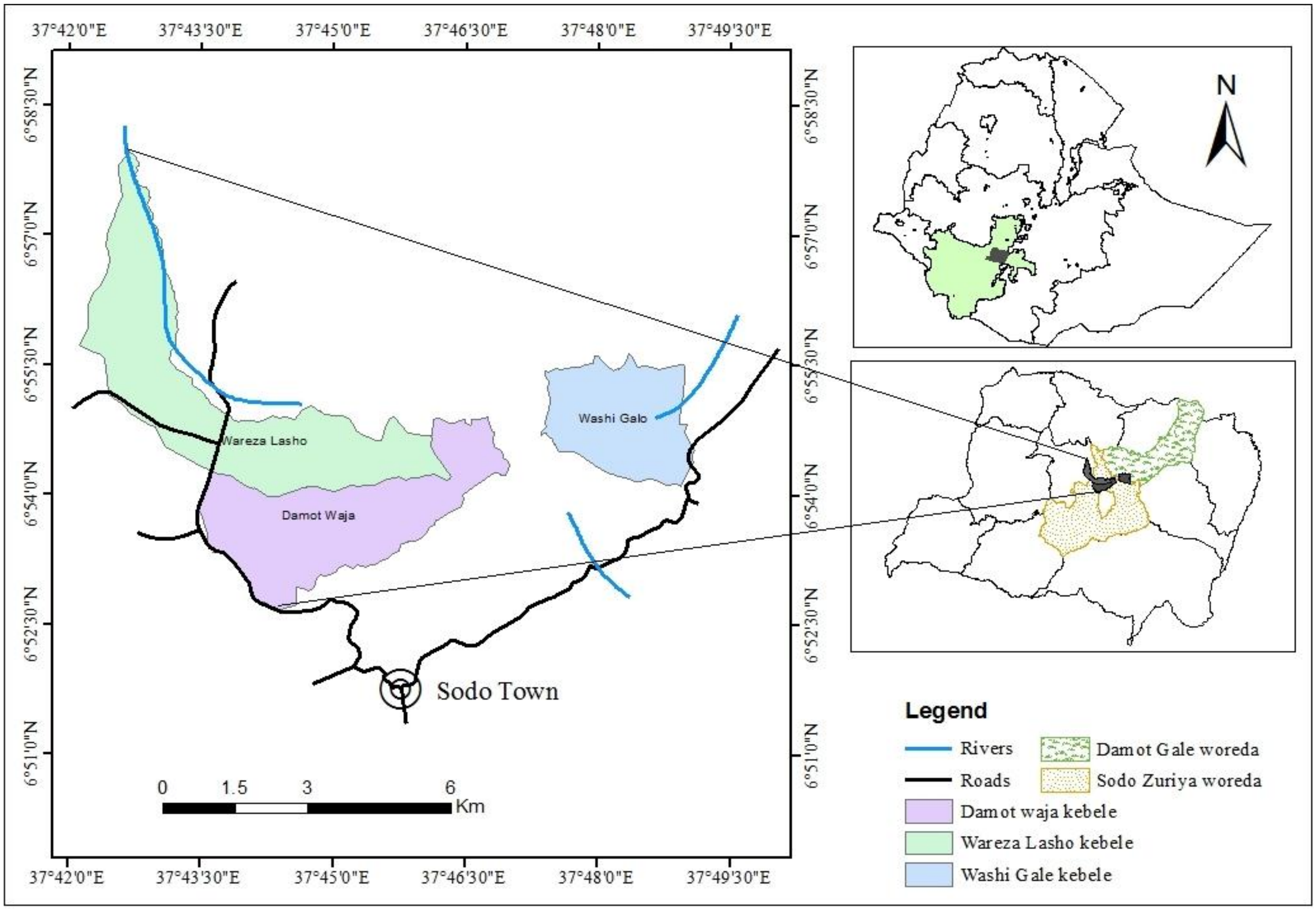

Figure 1. Map of the study sub watershed

statistical techniques in which the probability of a dichotomous outcome such as adoption or non-adoption is related to a set of explanatory variables that are hypothesized to influence the outcome. Therefore, to determine farmers' choice to adopt soil and water conservation strategies or not to adopt the model was selected hoping that it could reflect the observed status of continued use of soil conserving structures on any particular farm household. Furthermore, according to Tabachnick and Fidell (2007); binary logistic regression is said to be useful since it has a capacity to analyze a mix of all types of independent variables like continuous, discrete and dichotomous.

During model specification procedure Gujarati (2004), the logistic regression model characterizing adoption or not by the sample households is used as follow:

$$P_i = \frac{e^{Z_i}}{1 + e^{Z_i}} \quad (2)$$

Where Pi is the probability of being producer for the ith household and Zi is a set of socioeconomic factors affecting participation (Xi) and the disturbance term (Ui) expressed as:

$$Z_i = \beta_0 + \sum_{i=1}^{n} \beta_i X_i + U_i \quad (1)$$

Where β_0 is the intercept, β_i are the slope parameters in the model and n is the number of explanatory variables.

Dependent variable

Independent (explanatory) variables

A dependent variable is a variable that is said to be affected or explained by another variable. In this study, farmers' adoption is treated as a dichotomous dependent variable, i.e. it takes the value of 1 if the farmer is practicing soil and water conservation measures and 0

Table 1. Definition of variables used in the model

Explanatory Variables as coded in the model	Description	Expected sign	Previous studies on influence of each variables
AGEHH	Age of the household head	Negative	Maskey *et al*. (2003); Yitayal (2004)
FAMSIZE	Number of children in the household	positive or negative	Bekele and Holden (1998)
RSEX	Sex of the household head; 1 if male and 0 otherwise	Positively	Asfaw and Assefa (2004)
EDUHH	Education level 0f a household (illiterate=1, literate= 0)	Positive	Engel *et al*. (2005); Maddison (2006)
PERCEPTN	Awareness of soil erosion as a problem;1 if farmer had perceived erosion as a problem, 0 otherwise	Positive	Shiferaw and Holden (1998)
EXTCON	Extension contact: 1 if the farmer gets extension contact, 0 otherwise	Positive	Nhemachena (2009)
NOFARAC	Participation in non-farm activities; O, if participate; 1, otherwise	Negative	Birhanu and Swinton (2003)
LANDSIZE	the size of the farm in hectares	Positively	Aklilu and Jan De (2006)
DIST	Proximity of farm from the residence; 1 if the distance to be far 0 otherwise	Negatively	Phiri (2009)
SLOPE	Slope of the plot; 1 if steep and 0 otherwise	Positively	Wagayehu (2003)
TENUR	If the farmer feels that the land belongs to him/her at le least in his/her lifetime; 0 otherwise.	Positively	Mulugeta *et al*. (2001); Girma (2001)

otherwise. Brief explanation the independent variables with their source are presented in Table 1.

RESULTS AND DISCUSSION

Descriptive results on Profile and possession of respondents

For questionnaire survey, 148 households were selected randomly 79.7% were male while 20.3% were female. Almost all the sampled households (99.3%) in the intervention area were married. Furthermore, 39.8%, 56.8 % and 3.4% of respondents in intervention area were found being lliterate, can read and write, and 9-10 grades respectively. The minimum and maximum age of the interviewed respondents range from 27 and 76 years with average age of 44.55. While the average family size of the sampled households was found being 5.00 with range of 1 to 12 family. The mean land holding size of the surveyed households was 0.639 hectares with minimum and maximum land size of 0.625 and 2.000 hectares.

The view of the local people on determents of the adoption of SWC

As the result in the table 2 below shows the willingness of the local people to adopt SWC structures as influenced by the appropriateness of the technologies to the site condition, shortage of farm land, distance from their residences area, steepness of the site, awareness about the problem of soil erosion as well as its controlling measures, and non-cooperativeness of the local people for working in collaboratively with each other and external agents in decreasing order. The study is line with (Abay and Asefa , 2004). Other limiting factors like being as shelter for pests and rates, difficult to till, need much labor, difficult to implement, reduce farm size were mentioned in Simeneh (2015).

Determinants of the local people's adoption of SWC

Pretest result of multicolinearity

Prior to undertaking the binary logistic regression analysis, existence of multicollinearity was checked. According to Gujarati (2004) multicollinearity among the continuous variables can make difficult to untangle the separate effects of the independent variables on the dependent variable. This in turn will hinder to derive estimators of parameter coefficient and make statistical inference difficult. Therefore, the problems of multicillinearity were tested by computing Variance Inflation Factor (VIF). Then, if

Table 2: Some factors influencing the local people adoption of SWC

Possible determinants	Frequency	Percent (%)
Appropriateness of technologies	140	94.59
Slope of the farm	124	83.78
Shortage of land	128	86.49
Distance	126	85.14
Awareness and training	120	81.08
Non co-operative neighbors	110	74.32

Table 3. VIF of continuous explanatory variables

Variable	Variance inflation factors
AGE	2.76
FAMSIZE	3.44
LANDSIZE	2.35

Table 4. Contingency coefficient for dummy variables

	EDU	SEX	TENUR	EXTECON	SLOPE	DIST	PRERASPR	WEALTH
EDU	1.000	0.232	0.429	0.156	0.106	0.152	0.03	0.082
SEX		1.000	0.231	0.026	0.024	0.022	0.139	0.137
TENUR			1.000	0.05	0.098	0.012	0.265	0.085
EXTECON				1.000	0.166	0.051	0.132	0.156
SLOPE					1.000	0.301	0.473	0.172
DIST						1.000	0.174	0.122
PRERASPR							1.000	0.109
WEALTH								1.000

the value of VIF is greater than 10, it is an indicator for the presence of multicollinearity problem among the variables. The result of VIF in the below table 3 shows that there is no multicolinearity problem among the variables since there is no variable which resulted VIF greater than 10.

Besides VIF, it is very crucial to check the existence of multicolinearity among dummy variables. According to Mesfin (2005) , for dummy variables if the value of contingency coefficient is greater than 0.75, the variable is said to be collinear. Thus, contingency coefficient (cc) analysis was made to detect the presence of association between dummy variable. The output of the pair-wise correlation coefficients of the predictor variables, show that there is no problem of collinearity (Table 4).

The Binary logistics analysis result

The logistic regression result reveals that among the hypothesized explanatory variables included in the model, family size, non-farm activities, land holding size, distance from their residence and slope of the site were found affecting the dependent variable at 5% significant level, whereas education and perceiving erosion as problem influencing at 10 % significant level. Moreover, sex of the surveyed households was found determining the adoption of soil and water conservation while age, extension, and land tenure have not shown significance relationship as shown below. Therefore, the discussion of each variable in the light of other scholars' is presented following the tabulated result of binary logistic regression (Table 5).

Age of the household

Age of the household was found to be positively associated with continuous use of conservation structures and statistically insignificant with retention of conservation structures. This can be explained by the fact that older farmers have relatively old age experience with problems of soil erosion and its impact in reduction of their crop products compared to youths. This implies that older farmers have higher personal preference which can reduce the impact of soil erosion through the implementation of long term soil conserving structures. Thus, this has been suggested to influences farmers' attitude towards the technology and the problem.

However, the finding of Long (2003) and; Wagayehu (2003) oppose this suggestion. According to these scholars soil conservation requires longer period and puts land out of production. Furthermore, older farmers lack labor required to maintain conservation structures installed. Hence, these situations affect farmers' attitude negatively on soil conservation structures.

Sex of the household

As hypothesized, being maleness significantly and positively influencing the tendency of a household to implement soil and water conservation practices at 1% significant level. Thus, the male-headed households were more likely to implement conservation structures than female headed households. A unit change from being headed by a female household to male increases the probability of adopting soil and water conservation technologies by 18.256 odd factors. The possible reasons for these results are male households are better exposed to modern SWC technologies and have more power to make adoption decision than female households.

This result is in line with the argument that male-headed households are often considered to be more likely to get information about new technologies and take risky businesses than female-headed households (Abay and Asefa, 2004). However, this result contradicts the findings of Apata *et al.* (2009) who argued that sex has no statistically significant relationship with the implementation tendency of household to implement different soil and water conservation structure strategies. Nhemachena and Hassan (2008) have found that female headed households were more likely to take up technologies adaptation methods than male in assessing determinants of African farmers' categories for adapting to climate change.

Family size

As the result in binary logistic regression showed family size is statically significantly at 5% level. It was positively related with adoption rate of soil and water conservation practices. The coefficient value in table 5 indicates that other factor held constant when family labour increases by one unit the interest increases by 6.626. This positive impact may be due to the laborious nature of conservation work which needs more labor force. Hence, the household who has more family size is favorable to supply more labour. This is consistent with the study of Apata *et al*. (2009) which revealed that a household with large family size is desirable to supply family labour to implement labour intensive field works.

In contrary to this study Yohannes (2001), large family size is not a decisive factor for adoption of SWC structures on a household farm whether single, large or small families. They do their adoption in a way that does not demand a great deal of labour at one time or the other, but rather extends the work over a number of months. Similarly, Bekele and Drake (2003) argued that households with larger family size are likely to face food scarcity. Consequently, they try to maximize short-term benefits and would be less interested in soil conservation measures whose benefits can be reaped in the long run also found similar results.

Education

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 10% significance level and increase the probability of use by a factor of 4.01 peradditional 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. Study is in line with the finding of Long (2003). However, the study made by Bekele (1998) in Ethiopia showed education is negatively related to the desire and capacity of adopting soil and water conservation structures.

Perception of soil erosion as a problem

Farmers' perception of soil erosion problem affects the adoption of soil conservation measures positively and significantly. The implication is that farmers who feel that their farmlands are prone to soil erosion are more likely to adopt physical soil conservation measures more likely than those who do not perceive the problem of soil erosion. The odds ratio 3.363 implies that the odds of a farmer who perceived soil erosion better to adopt conservation structure was 3.363 times the odds of farmers that did not perceive. It affects the decision of farmers by shaping opinion of farmers with regard to the conservation of the resource. Thus, perception of soil erosion is a necessary condition for adoption of soil conserving technologies. The previous studies like Amsal and De Graaff (2006) also supported the above finding.

Extension service

Access to extension service of head of the household has no significant association but it has shown positive

Table 5. The Maximum likelihood estimates of the binomial logit model

Variables	Estimated Coefficient(B)	(S.E)	Wald Statistics	Sig. Level	Exp (B) (Odds ratio)
AGEHH	0.161	0.159	1.217	0.293	1.06
SEX	3.008	1.003	10.649	0.002***	18.256
FAMSIZE	1.984	0.863	6.299	0.014**	6.626
EDU	1.471	0.844	3.549	0.063*	4.01
PRERASPR	1.29	0.82	2.868	0.096*	3.363
EXTCON	0.736	0.824	0.879	0.380	1.98
NOFARAC	-1.214	0.769	4.151	0.033**	0.376
LANDSIZE	0.219	0.717	0.142	0.031**	1.225
DIST	-0.984	0.603	5.038	0.025**	0.445
SLOPE	1.72	0.794	5.641	0.018**	5.111
TENUR	0.065	0.824	0.114	0.940	1.066
CONSTANT	-0.301	2.32	0.145	0.741	0.773

*, ** and *** significant at 10%, 5%, and 1% probability level.
Omnibus Tests of model coefficients: Chi-square=66.030***, Sig 0.000,
-2log likelihood = 78.358
Percentage of correct prediction = 72.4

relationship with tendency of adopting soil and water conservation. Extension contacts play a great role in raising awareness about technology including farmer's adoption. By doing so the increased awareness would enhance farmers' interest on conservation technology. Therefore, extension contact was hypothesized to positively influence farmer adoption. Nemachena (2009) reported after conducting a comprehensive survey of agricultural households across 11 African countries revealed that better access to extension have strong and positive influence on adaptation to climate change. This implies that farmers who have access to extension services are more likely to be aware of climatic conditions as well as the knowledge of various management practices. Similarly, Fatuase and Apata *et al.* (2009) indicated that the extension agents do enlighten farmers on what time of the year (period) that a particular crop could be best grown as a result of variation in weather conditions.

Non –farm activities

As hypothesized, engaging in non-farming activities discourages a household not to participate in soil and water conservation activities. Thus, non-farm activities influence farmer's continuous use of soil and water conservation technologies negatively and significantly at less than 5% probability. It decreases the probability of using SWC technologies by a factor of 0.376. This could probably be the chance of a household for alternative income generation. Therefore, rather than focusing on measures that might enhance the productivity of their farm they tend to participate in non-farm activities. Thus, the involvement in non-farm jobs is common in the study area. Some are engaged in handicrafts, daily labor work, selling of firewood, small scale trading and brewing local beverages. Similarly, Bryceson (1999) reported that in most African countries, the majority of farm families derive their livelihoods not only from crop and livestock production but also from a range of activities outside of agriculture.

Land size

The size of farm land was found to be positively associated with continuous use of conservation structures and statistically insignificant. The positive coefficient implies that farmers with relatively larger holdings had higher probability to apply conservation technologies. This can be attributed to the fact that conservation structures occupy part of the productive land and farmers with larger farm size can afford retaining structures compared to those with relatively lower farm size. Amsalu and De Graaff (2006) similarly found that farmers who have a larger farm are more likely to invest in soil conservation measures because they have the funds to do so. This result is also inconsistent with the finding of who reported a negative relationship between size of holdings and the probability of continuous use of soil conserving structures. The studies explained this might be due to the labor-intensive nature of constructing soil conservation structures.

Distance

As hypothesized during variable description, distance between a farm plot and residence of a household influence their motivation to implement soil and water conservation negatively. The coefficient of distance of a farm was found being negative as shown in Table 5. The possible reason could be farmers with plot of land that are far to the soil erosion prone area and technologies implementation site have showed unwillingness to adopt SWC structures. In other word, it implies that longer walking distance between farm land and residential area was related to a reduced adoption of soil and water conservation practices. This is because the time and energy farmers spend to reach farm plots is lesser for nearer farm plots than distant farm plots and also the closer the plot is to the residence area the closer supervision and attention it will get from family. Similar result was found by Amsalu (2006), analysis of factors influencing adoption of soil and water conservation technologies in Ngacium sub-catchment of Kenya. Moreover, Simneh (2015) revealed the factors as this paper showed.

Slope

Slope of a farm plot has been found statistically significant and positively correlated with continued use of structures at less than 5% probability level. This implies that slope of a land influences the adoption of soil and water conservation technologies positively. As stated in the hypothesis, a household inclines implementation of soil and water conservation structures as he or she owns very steep land which could probably be exposed to soil erosion. Commonly as slope is an indicator of soil and water loss from farmland, farmers cultivating steep slope fields perceive the threat of soil loss. This implies that households farming steep land are more likely to adopt conservation structures than less steep lands. Additionally, the slope of land affects farmers' decision by influencing the productivity of their cultivated land and significance of soil erosion through reducing the availability of fertile farm land. This study is in line with the findings of Birhanu and Swinton (2003); and Amsalu (2006).

Tenure security

Land tenure is about the characteristics of tenure security in the study area which is linked with property rights. Farmers can freely invest on their farms on soil and water conservation structures. Even though it is not statistically significant, tenure is positively related to the adoption of soil and water conservation structures. Thus, the result of the marginal effect shows that tenure security significantly increases the likelihood of implementing soil and water conservation structures. Conversely, Yohannes (200) revealed that tenure insecurity had in Southern Ethiopia no negative effect on long-term investment. This difference could be explained by the differences in socio-economic and land redistribution experiences between Amhara and Southern regions.

CONCLUSION AND RECOMMENDATION

From this study it is possible to conclude that soil erosion is the main form of land degradation, caused by the interacting effects of factors, such as biophysical characteristics and socio economic aspects. To overcome this serious problem, different initiatives focusing on soil and water conservation have been undertaken in Ethiopia. However, disseminating different structures and attempting to bring lasting panacea to continuous land degradation particularly by soil erosion was not straight forward. Thus, as the finding of this study indicted there was less-willingness of farmers to adopt and maintain the extensively introduced practices of soil and water conservation. This is due to the fact that the tendency of a household to practice structure was found being influenced by education, perception erosion as problem, family size, land size, slope, sex, participation in non-farm activities and proximity of farm from the residence. Hence, to the scope of the research finding, it is utmost important to consider the factors that were found influencing the tendency of household adoption. Moreover, strategy which focus on enhancing the willingness and ability of farmers should be adopted, strengthen learning opportunities through facilitating the establishment of farmers training center and strengthen extension contact.

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