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Determinants of adoption of sustainable land management practice choices among smallholder farmers in Abay Basin of Oromia, Ethiopia

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Land degradation mainly caused by soil erosion, and shades an ominous threat to the livelihood development prospects of Ethiopian smallholder farmers. In response to this, the government of Ethiopia introduced a Sustainable Land Management Program (hereafter referred as 'SLM'), even though the adoption by smallholder farmers has been low. This study aims to analyze the factors that influence the adoption of SLM practices choices using primary data collected from 200 smallholder farmers. Both descriptive statistics and Multivariate Probit model were applied. The multivariate probit model revealed that the main factors that positively and significantly influenced the decision of farmers to use these SLM practices are the household size, livestock holding size, amount of total income, level of education, the slope of farm plot, extension services and use of credit, the status of soil erosion hazard. However, distance to the nearest market had a negative and significant effect on adoption of SLM practices choices in the study area. The study recommended that the regional and local government should design various specific programs to resolve the constraints for scaling up and adopting the SLM practices through facilitating additional income-earning activities, encouraging the use of labor-saving technologies, promoting modern livestock production system, increasing farmers' literacy level, promoting soil conservation techniques, widening the rural microfinance intuition services and establishing near market information provision center in the study area.

Key words: Smallholder farmers, adoption, Sustainable Land Management (SLM), multivariate Probit, Abay Basin.

INTRODUCTION

Land threatens the overall economy of Ethiopia. Particularly, the agricultural sector which is a source of 45% of the country's GDP and 85% of employment is highly vulnerable to the problem of land degradation (Gebrelibanos and Abdi, 2012; MoFED, 2013). Based on this, the creation of conducive atmosphere for better

performance of the agricultural sector is not only an important and realistic option to improve food security status of Ethiopians but also a means to improve their standard of living. However, recently due to changes in watersheds in general and land degradation in particular which resulted from a range of natural and anthropogenic

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factors, the agricultural sector has been challenged and the extent of fertile land available for this sector is decreasing; this can reduce productivity, household's food security, and aggravate poverty in degraded areas of the country (MoA, 2012; Teklewold and Kohlin, 2011; Gebrelibanos and Abdi, 2012).

On the other hand, Woldeamlak (2003), Mushir and Kedru (2012), Abebaw et al. (2011), FAO (2012), Befikadu and Frank (2015) argued that land management practices in Ethiopia have fallen far below expectations and land degradation mainly caused by erosion remains widespread in the country. They further argued that the adoption rate of conservation practices by farmers remains limited and still the country is losing a tremendous amount of fertile top soil, and the threat of land degradation is broadening alarmingly. In view of this, the Ethiopian Government and other developmental partners have introduced an extensive mechanical and biological watershed conservation schemes in various parts of the country over the last decades particularly after the famine of the 1970s (Emily and Fanaye, 2012; Binyam and Desale, 2014).

Despite such positive efforts on land conservation in the country, success of these conservation practices has remained controversial among the researchers and policymakers. Most researchers argued against the success of many land conservation efforts of the country. For instance, empirical studies by Abebaw et al. (2011), Befikadu and Frank (2015) argued that land and water management practices in Ethiopia have fallen far below expectations and land degradation mainly caused by erosion remains widespread in the country. Other recent empirical studies in Ethiopia such as Haftu et al. (2019), Senbetie et al. (2017), Paulos and Belay (2017), Tesfaye (2017) and Schmidt and Tadesse (2018) examined the SLM technology practices choices and their implication on land degradation in the different parts of the country. They argued that the adoption rate of SLM practices by farmers remains limited and still the country is losing a tremendous amount of fertile topsoil. On the contrary, the measures of the choices of SLM technology practices are not sufficient to successfully alleviate the higher rates of land degradation and thereby wisely use and conserve soil and water resources in the country. But also, identifying its determinants and designing sustainable strategies to redress the prevalence of serious land degradation enhances farm productivity, and the food security statuses of smallholder farmers are critical. Hence, this study provides insights into smallholder farmers' adoptions option, and factors influencing choice of SLM practices in the Abay Basin of Oromyia, Ethiopia.

MATERIALS AND METHODS

Description of study area

The study conducted in Abay Basin which is found in Oromyia

National Regional State of Ethiopia. Oromyia is one of the nine regional states in the Federal Democratic Republic of Ethiopia. Geographically, the region is located in the central part of Ethiopia extending from 3°20′N to 10°35′N and from 34°05′E to 43°11′E with a total land area of 353,690 km^2. It constitutes about 31.15% of the total land size of the country which makes it the largest of all the regions in Ethiopia. Oromyia region's topography consists of a high and rugged central plateau and the peripheral lowlands. Elevations in the region range from less than 500 to over 4300 m above sea level (masl). The highlands (>1500 masl) constitute about 48% of the region's total area while areas between 1000 to 1500 masl constitute 38%. The highlands are home to more than 80% of the total human population and 70% of the livestock population of the region and account for over 90% of the cropland. Almost 90% of the region's economic activities are concentrated in the highlands (BoFED, 2008) (Figure 1).

Data types, source and methods of collections

Both qualitative and quantitative data types were collected using primary and secondary data sources. The data from primary source were collected from sampled farm household heads using structured questionnaire, key interview and focus group discussion while secondary data were collected from various published documents.

Sampling design

A multi-stage sampling technique was used to randomly select 200 households from three districts. In the first stage, out of the four districts implementing SLM program in the western highlands of Jimma zone of Oromiya National Regional State; the three districts namely Omonada, Sigmo and Sokoru were randomly selected. In the second stage, out of 10 SLM program kebeles (Small administrative unit) found in the selected district, a total of 6 *Kebeles* were proportionally and randomly taken. In the third stage, the total lists of households in the six selected SLM program kebeles were stratified into upstream and downstream land users. Finally, from the selected rural Kebeles, households were selected using a probability proportional sampling method. Hence, the data were generated through a survey of 200 households. The study applied Cochran (1997) statistical formula to determine the representative sample size with 95% confidence interval and 5% level of precision.

Methods of data analysis

Data analysis was carried out using descriptive statistics and econometric model. Descriptive statistical techniques such as measure central tendency, measures dispersion and chi-square testes are used while, multivariate Probit model applied and detail justification and specification are provided below.

Different empirical studies argued that farmers usually consider a set of possible technologies and select the one that they assume will have the best results and the highest utility; hence, the choice and adoption decision is inherently multivariate (Marenya and Barrett, 2007; Nhemachena and Hassan, 2007; Yu et al., 2008; Kassie et al., 2009). However, most previous studies of conservation technology adoption decision assume a single technology without considering the possible correlation/interdependence between different technologies, thereby masking the reality that decision makers are often faced by a set of choices (Yu et al., 2008). In general, when technologies are correlated, univariate modeling excludes useful information contained in the interdependence and adoption decision analysis. A single technology approach may, therefore, underestimate or over-estimate the influence of factors
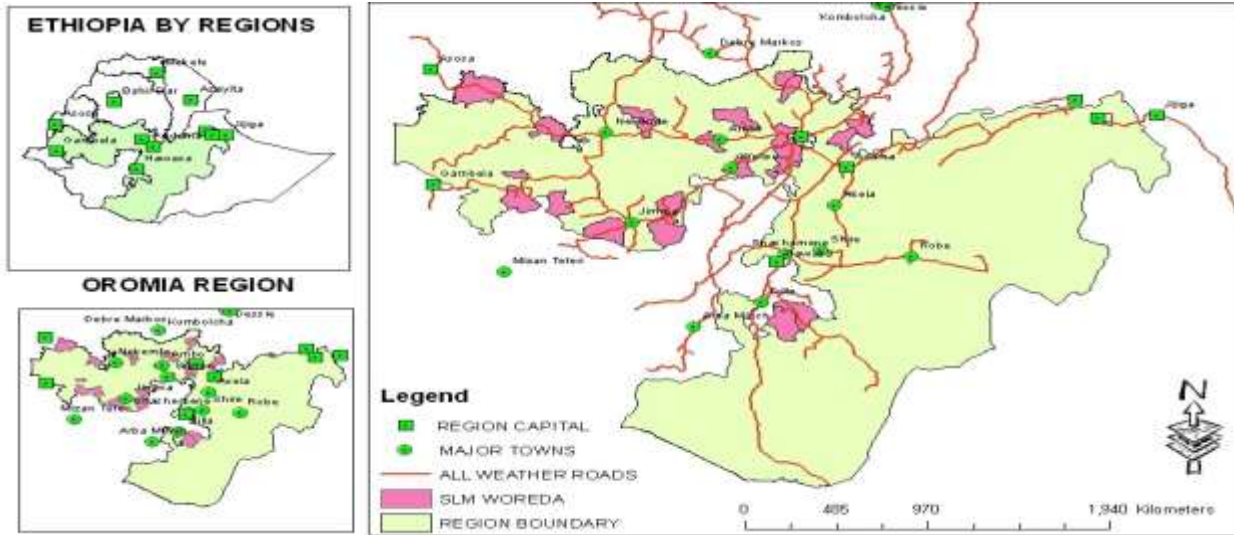
Figure 1. SLM Project implemented districts in Oromia region of Ethiopia.
Source: BoFED (2008).

on the farmers' choice decision. In general, univariate models ignore the potential correlation among unobserved disturbances in the adoption equations as well as the relationships between adoptions of different rainwater management technologies, because farmers may consider some combination of conservation as complementary and/or competing. Failure to capture such interdependence will lead to biased and inaccurate estimates (Kassie et al., 2012).

As a result, to solve the stated problems of using univariate approaches, methods such as the bivariate or multivariate probit (Amsalu and de Graaff, 2007; Dorfman, 1996) and multinomial logit (Bekele and Drake, 2003; Ersado et al., 2004) for multiple choice problems have been recommended in the analysis of farmer adoption decisions. However, using the multinomial logit model to determine the probabilities of choosing conservation options, it is assumed that the stochastic components are independently and identically distributed (IID) with an extreme value distribution (McFadden, 1974; Ben-Akiva and Lerman, 1985). Besides, there are several limitations of using MLM model to identify the determining factors of WTP and WTA. The most severe of these, is the Independence from Irrelevant Alternatives (IIA) property, based on the assumption that the error terms are independent across alternatives, individuals, choice sets which states that a change in the attributes of one alternative changes the probabilities of the other alternatives in proportion. This substitution pattern may not be realistic in all settings. Again the model fails to capture differences in tastes that cannot be linked to observed characteristics and mis-prediction arises (Hensher et al., 2005). In addition, Independence of Irrelevant Alternatives (IIA) seems to be restrictive in many empirical applications and the parameter estimates from the MNL model are biased if IIA assumption is violated. The coefficients of all attributes are assumed to be the same for all respondents in a choice experiment of MNL, whereas in reality there may be substantial variability in how people respond to attributes. Moreover, MNL does not take into consideration correlations within each respondent's series of choices. To overcome the problem of MNL model, therefore, using Multivariate Probit (MVP) Model can be appropriate. Attributes of various adaptation strategies are assumed to have influence over the choice made by farmers. In this study, a MVP model is adopted because it accommodates both

correlations and heteroskedasticity that may exist in the model (Cappellari and Stephen 2003; Greene, 2008). In the light of this, this study applied MVP model to analyze the farmer's decision to adopt SLM practices choices.

The dependent variable in the empirical estimation for this study is the choice of an adaptation option from the set of SLM practices of the study area. These practices are broadly classified into soil fertility management methods (use of organic and inorganic fertilizer and crop-rotation techniques), and soil erosion control methods (terrace, soil-bund and tree-planting techniques). The covariates include demographic, socio-economic, farming, farm specific, institutional, market and infrastructure characteristics. Following Cappellari and Stephen (2003), the multivariate probit econometric approach for this study is characterized by a set of *m* binary dependent variables y_{im} such that:

$$Y_{im}^* = \beta_m' X_{im} + \varepsilon_{im}, \text{ m = 1, ...4 (adoption of SLM practices choices),} \tag{1}$$

$$Y_{im} = 1 \text{ if } Y_{im}^* > 0 \text{ and 0 otherwise} \tag{2}$$

Where $\varepsilon_{im}, m = 1,....,4$ are error terms distributed as multivariate normal, each with a mean of zero, and unitary variance. The estimation is based on the observed binary discrete variables Y_{im} that indicate whether or not h^{th} farm household has chosen and adopted a particular SLM practices technology choices (denoted by 1 for adoption and zero for non-adoption). The status of adoption is assumed to be influenced by various observed characteristics (X_{im}). The unobserved characteristics are captured by the error term denoted by ε_{im} while β_m is a parameter to be estimated.

In line with this, it can be assumed that SLM practices considered in this study are interdependent, implying that the choice of one SLM is likely to influence (positively or negatively) the choice of another conservations, hence the error terms (ε_{im}, m = 1... 4) in Equation 1 are distributed as multivariate with zero mean and variance 1. The off-diagonal elements in the covariance matrix represent the unobserved correlation between the stochastic

Table 1. Summary of variables, descriptive statistics, measurements, and their hypotheses.

Variable	Measurements	Descriptive statistics	Hypothesis
		Mean (Std)/ Freq (%)	SLM practices
Demographic characteristics			
Age	Years	43.27 (9.35)	+
Sex	Male/Female	187 (93.5)	+
Household size	Adult equivalent	7.45 (2.62)	+
Socio-economic characteristics			
Education level	Years	1.66 (0.76)	+
Off-farm income	Dummy	175 (87.5)	+/-
Annual income	Birr	18,130.75 (21194.01)	+/-
Farming and farm specific characteristics			
Farming experience	Years	3.74 (3.07)	-
Farm size	Hectare	1.66 (1.06)	+
Livestock size	Number	3.16 (1.13)	+/-
Soil erosion hazard	Yes/No	74 (37.00)	+
Slope of farm plot	Yes/No	110 (39.48)	+
Institutional, market and infrastructure characteristics			
Distance to near market center	Kilometer	6.83 (6.43)	-
Frequency of extension contact	Number	9.14 (15.19)	+
Use of credit	Yes/No	56 (28.00)	+
Distance to weather road	Kilometer	4.1 (7.07)	-

Source: Own Survey (2020).

components of the mth type of SLM practices. This assumption means that Equation 2 gives a MVP model that jointly represents decisions to adopt a particular SLM practices. This specification with non-zero off-diagonal elements allows for correlation across the error terms of several latent equations, which represent unobserved characteristics that affect choice of alternative SLM practices. The explanatory variables, measurement, descriptive statistics and their hypothesis used in the study are summarized in Table 1.

RESULTS AND DISCUSSION

Descriptive statistics results

Sustainable land management practices

The uses of SLM practices are the key factors to preserve, enhance, and sustain the productive capacity of land in agriculture (Singh et al., 2018). SLM practices mitigate soil fertility loss, soil erosion, and wastage of water via controlling water run-off, evaporation and infiltration of water (Liniger et al., 2011). In order to reduce the ongoing land degradation across watersheds thereby improving the ecosystem and livelihoods of farmers, the government of Ethiopia implemented the SLM program in six regions of the country since 2012 (Schmidt and Tadesse, 2018). SLM practices enabled

smallholder farmers to be resilient for climate change, use wisely and conserve resources (soil and water), and thereby enhance their food security situations. Among the six regions where SLMP was implemented Oromiya region is one and western Oromiya is among it. Because of this, farmers in the study areas were assessed to what extent they adopted SLM practices implemented by the government, the challenges they are facing at plot and household levels, their WTP for sustaining this intervention and its welfare impact in the study area. In this study, the various SLM practices implemented in the study area are categorized into two major groups. The first group is the soil fertility management methods which include the use of organic and inorganic/farmyard fertilizer, crop-rotation, zero-tillage and fallowing techniques. The second group is the soil erosion control and water conservation methods which include the use of terrace, soil and stone-bunds, check-dam, fanyajuu, tree-planting, agro-frosty, grace strips, irrigation and water harvesting practices. The results on farmers' use of SLM practices during the 2015/16 cropping season are presented in Table 2.

Soil fertility management practices: Restoring the fertility of the land through applying appropriate soil fertility management practices has positive implication for the improvements in productivity of farmland and entails

Table 2. Classification of sustainable land management practices.

Types of SLM practices	Total		Land strata		χ^2-value
	Freq	**%**	**Downstream (83)**	**Upstream (117)**	
Soil fertility management methods					
Organic and/or inorganic fertilizers	183	91.5	80	102	3.27*
Crop rotation	168	84	81	87	0.70
Fallowing	6	8	2	4	1.79
Zero tillage	7	3.5	1	6	3.70***
Soil erosion control and water conservation methods					
Check-dam	10	5	4	6	0.42
Drainage	29	14.5	19	10	3.74*
Fanyajuu	5	2.5	0	5	5.13**
Soil-bund	178	89	82	96	5.53**
Stone-bund	26	13	13	13	2.05
Terrace	91	45.5	47	43	0.49
Agro-forestry	23	11.5	10	13	2.05
Grace strips	19	9.5	9	10	1.63
Tree planting	115	57.5	53	62	1.26
Water harvesting	10	5	5	5	0.00
Irrigation	28	14	19	9	3.27*

Note: ***, ** and * means significant at the 1%, 5% and 10% probability levels, respectively
Source: Computed from survey data, (2020).

the improvement of livelihoods of people. In this regard, farmers in the study areas were assessed regarding their explicabilities of these practices for enhancing the productive capacity of their farmland. These include the use of organic and inorganic fertilizer (91.5%) and use of crop rotation (84%), use of both short and long term (8%), and zero tillage (3.5%). Moreover, the use of zero tillage and organic and/or inorganic fertilisers were found to be significantly different between upper and downstream users at 1 and 10% level of significance. This implies that most farmers in the studied districts had kept the fertility of their land by applying some selected soil fertility management practices.

Erosion control and water conservation methods: Erosion and inappropriate conservation of water causes substantial degradation of land in the study area. In view of this, the result presented in Table 2 shows sampled farmers have adopted the use of erosion control and water conservation methods; soil-bund (89%), stone-bund (13%), terraces (45.5%), drainage (14.5%), check-dam (5%), tree planting (57.5%), agro-forestry (11.5%), grace strips (9.5%), irrigation (14%), and water harvesting (5%). Moreover, the use of drainage, irrigation, fanyajuu, and soil-bund were found to be significantly different between upper and downstream users at five and ten percent level of significance. This implies that good efforts were made by the farmers for implementing soil erosion and water conservation methods on the upper stream.

Model result on adoption of sustainable land management practices choices

This section examines the farmers' decisions to adopt the main SLM practices for preserving, maintaining and sustaining productivity of the capacity of land in the study areas. These practices include; soil fertility management methods (use of organic and inorganic fertilizer and crop-rotation techniques), and soil erosion control methods (terrace, soil-bund and tree-planting techniques). Table 3 presents the maximum likelihood estimation result of MVP model on factors influencing adoption of SLM practices among smallholder farmers.

The Wald test χ^2 (70) is 123.5 and statistically significant at 1% levels, indicating that the MVP model fits the data reasonably well. The null hypothesis that there is no correlation between residual of five equations $(\rho_{21} = \rho_{31} = \rho_{41} = \rho_{51} = \rho_{32} = \rho_{42} = \rho_{52} = \rho_{43} = \rho_{53} = \rho_{54} = 0)$ is strongly rejected at one percent level of significance. This implies that the decisions to adopt soil fertility management methods are not strictly independent from the decision to adopt soil erosion control methods. Hence, the use of a MVP model is well justified than Univariate Probit model. This result verifies that separate estimation of the choice decisions of these SLM practices is biased, and the decisions to choose the five SLM practices are interdependent decisions. There are differences in the adoption of SLM practices behavior

Table 3. Multivariate Probit simulation results of the adoption of SLM practices.

Variables	Coefficients (Equations)				
	Fertilizer (1)	Crop-rotation (2)	Terrace (3)	Soil-bund (4)	Tree planting (5)
Sex	0.20	-0.29	-0.15	0.06	0.02
Age	-0.02	0.01	0.01	0.20	-0.01
Household size	-0.10	0.14***	|0.10 **	-0.01	0.04
Education	1.20**	0.09	0.04	0.15*	0.14
Farm size	-0.10	0.01**	0.03	0.15	0.05
Slope of farm plot	2.10***	-0.33	1.60 ***	0.16	0.72**
Income	-0.08	-0.01	0.21**	-0.01	-0.10
Off farm income	-0.88	-0.12	-0.34	0.41	0.02
Livestock	0.20***	-0.01	0.05	0.09*	0.01
Distance to market	-0.11**	-0.01*	-0.06***	-0.03**	-0.03
Distance to road	-1.37	0.01	-.0 13	-0.02	1.25
Use of credit	0.26**	-0.04	-0.09	0.15*	0.02
Extension contact	0.14**	0.02	0.06	0.33	0.03***
Soil erosion hazard	0.13	0.18	0.15	1.07**	0.34
Constant	-1.65***	-0.59	-4.62***	0.13*	1.52 ***
Predicted probability	46.9%	29%	13.5%	15.6%	10.5%
Joint probability of success %			0.078		
$\hat{\rho}_{21}$			0.05		
$\hat{\rho}_{31}$			-1.34		
$\hat{\rho}_{41}$			-0.22		
$\hat{\rho}_{51}$			-0.33		
$\hat{\rho}_{32}$			0.69 ***		
$\hat{\rho}_{42}$			0.77***		
$\hat{\rho}_{52}$			0.12		
$\hat{\rho}_{43}$			0.33 **		
$\hat{\rho}_{53}$			0.34**		
$\hat{\rho}_{54}$			0.04		
Log likelihood			-395.42		
Wald χ^2 (70)			123.51***		
Likelihood ratio test of rho, Pr > $\chi^2(10)$			57.05 ***		

Note: ***, ** and * indicate the level of significance at 1, 5 and 10%, respectively.
Source: Modal result (2020).

among smallholder farmers, which are reflected in the correlation of the error term matrix. Separately

considered, the ρ values (ρ_{ij}) indicate the degree of correlation between each pair of dependent variables. The $\hat{\rho}_{32}$ (correlation between the choice for terrace and crop-rotation SLM practices), $\hat{\rho}_{42}$ (correlation between the choice for soil bund and crop-rotation SLM practices) positively and significantly correlated at 1% level of significance, respectively. Similarly, $\hat{\rho}_{43}$ (correlation between the choice for soil band and terrace SLM practices), and $\hat{\rho}_{53}$ (correlation between tree-planting and terrace SLM practices) are positively and significantly interdependent at 5% statistical significant levels, respectively. The positive result suggests that the decisions to adopt soil fertility and erosion control methods are complimentary and farmers implement multiple SLM practice at a time in the study areas.

The simulated maximum likelihood (SML) estimation of marginal success probability for each SLM practices result shows that, the probability that farmers choose the use of organic and inorganic fertilizer, crop-rotation, terrace, soil-bund, and tree-planting SLM practices was 46.9, 29, 13.5, 15.6 and 10.5%, respectively. This indicates the likelihood of choosing tree-planting is relatively low (10.5%) as compared to the probability of choosing organic and inorganic fertilizer (46.9%), the crop-rotation (29%), soil-bund (15.6%), and terrace 13.5%. This implies that the use of organic fertilizer and inorganic fertilize is the most likely chosen SLM practice by farmers. This might be due to the scarcity of land size in the study area. Moreover, the joint probabilities of success or failure of choosing five SLM practices suggest that the likelihood of households to jointly choose the five practices is low 7. 8%, suggesting farmers are more likely to fail to jointly choose the five SLM practices at a time.

The simulation results show that eight explanatory variables have a significant effect on soil fertility management methods (use of organic and inorganic fertilizer and crop rotation). The size of household, level of education, the size of livestock holding, land size, frequency of extension contact, the slope of farm plot and use of credit have a significant positive influence; whereas the distance to the near market center has a significant negative influence. In addition, the status of adoption of soil erosion control methods (terrace and soil-bund) positively and significantly was influenced by household size, level of education, the size of livestock holding, slope of farm plot, amount of income and frequency of extension contact, whereas the distance to near market center has a significant negative influence.

Household size has positive and significant effect on the likelihood of adoption of soil fertility management and soil erosion control methods (crop-rotation and terrace) SLM practices at one and five level of significances, implying that the likelihood of adoption increases with the size of the family members. This is due to the fact that

SLM practices require more labor force to undertake various specific activities of soil fertility management methods. The relationship between family size and watershed adoption practices was reported to have a similar positive result by previous studies in Ethiopia (Gebrelibanos and Abdi, 2012; Haftu et al., 2019).

The level of education of household has positively and significantly affected the likelihood of adoption of soil fertility management and soil erosion control methods (organic and inorganic fertilizer and soil-bund) of SLM practices at five and ten percent level of significances. This implies that the likelihood of adoption increases with the level of education of the household head. This is probably because educated household head better understand the benefit of adopting soil fertility management and soil erosion control methods of SLM practices. The study by Senbetie et al. (2017), Tesfaye and Brouwer (2016) and Yitayal (2004) also obtained a similar result in their respective studies on the relationship between the level of education and the decision to adopt soil conservation technology in Ethiopia.

Farm size has a positive significant effect on the adoption of crop-rotation as SLM practice at five percent level of significance. The positive effect of farm size suggests that farmers with relatively large farms better implement crop-rotation farming than small farms. This is because farmers who own large farmland produce more agricultural output for sale and hence earn adequate farm income so that they are interested to invest in soil erosion control methods. This result agrees with our hypothesis formulated regarding the relationship between adoption of SLM practice and landholding size of the household. Habtamu (2009), Befekadu and Frank (2015), Senbetie et al. (2017) and Tesfaye and Brouwer (2016) also found a similar result in their respective studies. However, the study by Haftu et al. (2019) found out a negative relationship between farm size and adoption of indigenous conservation practices in the Tigray region of Ethiopia.

Keeping the other variables in the model constant, the slope of the farm plot has a positive and significant influence on the likelihood of adopting organic and/or inorganic fertilizers, terrace, and tree-planting as SLM practices at 1 and 5% level of significances, respectively. The result implies that owners of sloppy plots are more likely to adopt SLM practices as compared to households with a less slopped plot. Plots that are characterized by a steeper slope are endowed with more runoff water and hence more likely to adopt soil erosion control methods. This result is consistent with the studies by Wagayehu (2003) and Haftu et al. (2019) who found that gentle slope plots have a significant positive effect on the adoption of various SLM technologies. The total income from farming has a positive and significant effect on the adoption of terrace SLM practices at a five percent level of significance. The result implies that the likelihood of

adoption of erosion control method of SLM practices increases with those household heads who earn more farm income from various activities including crop and livestock production, non-farm income as well as remittance. This result might be due to the fact that farmers who earn adequate income might hire the required labour force to implement various soil erosion control methods of SLM practices.

The number of livestock size has a positive and significant effect on adoption of organic and inorganic fertilizer and soil bund SLM practices at one and ten percent level of significances. This implies that the likelihood of adoption of soil fertility management and erosion control methods of SLM practices increase with the number of livestock size owned by households. In other words, farmers who own more livestock are more likely to adopt these SLM practices than those with less number of livestock. This result might be due to the fact that farmers who own relatively more livestock size make use of animal manure as a source of inorganic fertilizer. Besides the income obtained from the sale of livestock could be used for organic fertilizer purchase and hiring of the labor force to undertake various activities of soil erosion control methods. This finding is consistent with Tesfaye and Brouwer (2016) and Senbetie et al. (2017) studies in Ethiopia.

Distance from the nearest market centre to farmer residence has a negative and significant effect on the likelihood of adopting crop-rotation, organic and inorganic fertilizer, soil-bund and terrace SLM practices at one, five and ten percents level of significances. This shows that farmers who are far away from the nearest market centers are less likely to adopt SLM practices than those who are located near market centers. The possible explanation for this result is that the further the farmers' houses from the nearest market centre, the less likely for them to adopt SLM practices due to lack of motivation to supply agriculture produce to market than farmers closer to the center. This finding is also confirmed by Paulos and Belay (2017) in Dabus Sub-basin of northern Ethiopia. The use of credit has a positive and significant effect on the adoption of organic and inorganic fertilizer and soil-bund SLM practices at five and ten percent level of significance, respectively. This implies that household heads who use credit are more likely to adopt the soil fertility management and soil erosion control methods of SLM practices than those who do not. This might be due to the fact that credit rectifies the possible finance constraints and thereby provides more access to the adoption of SLM practices. This result is consistent with Deressa et al. (2009) and Haftu et al. (2019) in their respective studies.

The number of extension contacts per cropping season has a positive and significant effect on the likelihood of adopting organic and inorganic fertilizer, and tree-planting SLM practices at five and ten percent levels of significance, respectively. This shows that farmers with more extension contacts are more likely to be adopters of soil fertility management and erosion control methods to protect their land from degradation than those with fewer contacts during the cropping seasons. This result is consistent with the studies by Haftu et al. (2019), Senbetie et al. (2017) and Wagayehu (2003) they found that the frequency of extension contact has a significant positive effect on the adoption of land conservation technologies in their respective studies in Ethiopia.

Finally, the perception of erosion hazard has a positive and significant effect on adoption of soil bund SLM practices at five percent levels of significance. This implies that farmers who perceive soil erosion problem and its adverse effects on the productive capacity of farming land are more likely to adopt the soil fertility management SLM practices than others. Consistent with this, Paulos and Belay (2017) found perception of erosion hazard has a positive effect on adoption of land conservation technologies.

CONCLUSION AND RECOMMENDATIONS

The study examined the factors influencing adoption of SLM practices choices (such as the use of organic and inorganic fertilizer, crop-rotation, terrace, soil-bund and tree-planting) to preserve, enhance and sustain the productive capacity of farm land using Multivariate Probit model. The main factors that positively and significantly influenced adoption of SLM practices choices are the household size, livestock holding size, amount of total income, level of education, the slope of farm plot, extension services and amount of credit, the status of soil erosion hazard. However, distance to the nearest market had a negative significant effect on adoption of SLM practices choices in the study area. Based on the finding, the study recommended the local and regional government should design specific programs of solving the constrains and thereby scale up and foster adoption of SLM practices. This can be done by enhancing the literacy level of farmers via strengthening the existing formal and informal education programs, facilitating additional income-earning opportunities, encouraging participation of farmers on various off/non-farm income-earning activities, encouraging the use of labor-saving technologies, promoting the use of soil conservation methods, promoting modern livestock production system via adopting modern livestock breeds, providing advance loan through strengthening the services of rural microfinance, credit and saving intuitions, establishing market information provision center, and strengthening the existing provision of extension services, providing short and long-term training for development workers in the study area.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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