Determinants of Soil Conservation Technologies Among Small-Scale Farmers in Tanzania; Evidence from National Panel Survey

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Abstract

The adoption of Soil Conservation Technologies (SCTs) in Tanzania is very low compared to other countries in Africa with related situation. Interventions were taken by introducing soil conservation practices. However, the adoption of these practices is far below the expectation. The objective of this study was to examine the determinants ofSCTs among maize small-scale farmers in Tanzania. Secondary data from the National Panel Survey was used in this study. A binary probit regression model was employed to analyse the data. The analysis results showed that access to extension services and training as well as plot value were positively correlated at significantly level with the adoption of the introduced soil and water conservation practices. On the other hand, soil steepness influenced the adoption of soil conservation practices negatively. The finding depicts that the identified physical, socioeconomic, and institutional factors influence the adoption of SCTs so; concerned bodies should consider these influential factors to enhance farmers' adoption of soil conservation practices and promote agricultural productivity and environmental quality.

Key words: Adoption of SCTs, Soil erosion, Panel data, Binary probit model and Tanzania

JEL: Q24, Q15

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1. Introduction

Soil erosion is one of the key environmental challenges facing agricultural sector globally (World Economic Forum, 2010). In the last five decades, nearly more than one third of arable land globally was degraded by soil erosion (World Bank, 2016). Globally, more than 6 to 10 million hectares per year is lost due to soil erosion (IFAD, 2017a). Soil erosion continues to be a persistent problem at which 20-40 tons of soil is lost per hectares yearly however, the renewal rate is only 1 ton yearly (IFAD, 2016a). It has triggered nearly 85 per cent of the land worldwide to be degraded and crop production has reduced by 17 per cent(IFAD, 2017b). Africa is the most affected continent by soil erosion with more than 50 per cent of the total erosion affected population residing in the continent(FAO, 2009). IFAD, (2016b) urges that 5-6 million hectares of land yearly is being affected by soil erosion at regional level. The depletion of soil fertility is a vital factor that limits increasing rate of per capita food production for most African smallholders' farmers. The persistent decline of soil fertility led by degradation of land, poorly and low distribution of rainfall and insufficient use of improved agricultural technologies has been reported to be among the major causes of low and decreasing performance of agricultural sector in Sub-Saharan Africa (SSA).FAOSTAT, (2013) documents that by the year of 2020; the reduction of crop production due to soil erosion alone may be nearly to 16.5 per cent for the African continent as a whole and 14.5 per cent for the Sub-Saharan African, calling for a need of deliberate action.

In general, the adoption of SCTs in Tanzania is very low compared to other countries in Africa with related situation. It isestimatedthat only 12 per cent of farmers use SCTs in Tanzania, whilethe adoption rate of SCTs by smallholder farmers in Malawi is 19 percent, Botswana is 20percent, Kenya is 23percentwhile South Africa is 32percent(Odame, 2013).However due to the low adoption rate of SCTs in Tanzania, the government has made some deliberate efforts to encourage the adoption of SCTs across the country.Despite several efforts that have been conducted by the government and other conservation stakeholders in curbing the problem of land degradation, soil erosion continues to persist as a major problem contributing to the loss of soil fertility in Tanzania. The outcomes of this soil erosion are; loss of the value of land, reduction of crop yields, food deficiency and damage of several infrastructures (Shiferaw and Holden, 1998).
Several empirical studies have been carried out on technology adoption under Tanzanian context. However, nearly most of them have been addressing the agricultural technologies adoption at a regional level Magayane, (1995); Ryoba, (1996); Kalineza et al., (1999); Mbaga-Semgalawe and Folmer, (2000)Tenge et al., (2004). Available evidence displays that there is a need to address the issues of adoption of SCTs at a national level. Therefore, this study was undertaken in order of bringing this gap. The objective of this paper is to identify institutional, socioeconomic, demographic and biophysical factors which influence smallholders' farmers' decisions to adopt

SCTs in Tanzania. The specific SCTs investigated in this paper are the use of bench terraces[1] and erosion contour bunds[2]since have been proven to be effective in controlling soil erosion.

Furthermore, the key findings of this paper could provide a policy direction to the policy makers to have a clear picture on SCTs that could assist on policy reforms and implementation to Tanzania becoming a Neutral from Land Degradation (Land Degradation Neutral World) by 2030. Thus, adoption of these SCTs could assist the Government to reach its goal to reduce soil erosion by 19 tons/ha and improve land productivity of croplands on 8,462,500.5 ha by 2030 (URT, 2018). The rest of the paper is as follows.

The rest of the paper is as follows. Section 2 covers contextual framework. Review of literature and methodology in sections 3 and 4 respectively. Section 5 presents and discusses the results. Lastly, section 6 concludes the paper by providing conclusion and policy recommendations in light of the paper findings.

2. Contextual Framework

Like many other Sub-Saharan African countries, Tanzania is facing a serious problem of soil erosion which threatens agricultural production, a country whose 75 per cent of its population depends on agricultural sector as its major economic activity (URT, 2016). Agriculture sector contributes 31.7 per cent of Gross Domestic Product (GDP) and 95 per cent source of food is from smallholder farmers (NBS, 2017). Nearly 50 per cent of highlands areas in Tanzania are encountered by soil erosion whereby 25per cent of highland areas were highly eroded and 10 per cent is seriously eroded beyond land reclamation. The highland areas are reported to possess a high rate of soil erosion nearly 100t/ha/year (Majule, 2010). Due to land degradation, vast areas once fertile have been left unproductive. Soil erosion is mainly occurring in central zone that includes Dodoma, Shinyanga and Singida regions. Central zone constitutes about 25 per cent of the total are of the country and accounts over 95 per cent of the frequently cultivated land and about 60 per cent of the livestock population (Kassie et al., 2012). Soil erosion is highly occurring in cultivated lands, averaging 42 metric tons (MT) per hectare on currently cultivated lands and about 70 MT per hectare per year on formerly cultivated eroded lands (Tiwari et al., 2008). URT, (2018) noted that Tanzania loses more than 500 million MT of top soil annually by erosion at which this could have increased about 1 to 1.3 million MT of crop production to the country's harvest. In addition, poor land management techniques and misuses of natural vegetation have been observed in Tanzania. Therefore, adoption of soil conservation technologies (SCTs) is the main key component to solve these issues. Due to the effectiveness of SCTs in agriculture sector but its adoption rate to smallholders' farmers in Tanzania is quite low.

[1]**Bench terraces**: These are a series of level or virtually level strips running across the slope at vertical intervals, supported by steep banks or risers. There are two types of bench terraces, namely; Irrigation or level bench terraces: These are used where crops, such as rice, need flood irrigation and impounding water. Upland bench terraces: These are used mostly for rain-fed crops or crops which only require irrigation during the dry season. They are generally sloped for drainage. In humid regions: Use reverse sloped type. In arid or semi-arid regions: Use outward-sloped type.

[2]**Contour bunds**: It consists of building embankments across the slope of the land, following the contour as closely as possible. A series of such bunds divide the area into strips and act as barriers to the flow of water, thus reducing the amount and velocity of the runoff.

After independence in 1961 several soil conservation measures were abandoned. Hence, it led to a serious environmental and agricultural problem of land degradation (URT, 2016). In the last 1980s the government and international NGOs started to establish several projects with the aim to conserve soil fertility in different areas of the country such as Soil Erosion Control and Agroforesty Project (SECAP), Hifadhi Ardhi Dodoma (HADO) in Dodoma, Hifadhi Ardhi Shinyanga (HASHI) in Shinyanga, Hifadhi Mazingira (HIMA) in Njombe, Gairo Agroforestry and Land Use Project (GALUP) in Gairo, Soil Conservation and Agroforesty Project Arusha (SCAPA) in Arusha and Kilosa Environmental Project (KEP) in Kilosa. Also, there were several land management programmes introduced such as National Soil and Water Conservation Programme (NSWCP), Land Management and Environment Programme (LAMP), Land Husbandry Extension Programme (LAHEP) and Land Management and Natural Resources Programme (LMNRP). All these projects and programmes are monitored by Ministry of Agriculture and Food Security (MAFS), Tanzania Soil Health Consortium (TASHCO) and Tanzania Forestry Research Institute (TAFORI).

Locally, this paper is in line with several national strategies and programmes such as Kilimo Kwanza, National Strategy for Growth and Reduction of Poverty II (NSGRP II), Five Years Development Plan II/FYDP II (2015/16-2020/21) and Tanzania Development Vision (TDV) 2025. In Kilimo Kwanza, this paper reflects pillar number 8 which enhances the application of science and technology in agricultural sector. NSGRP II aims at attaining sustainable economic growth by reducing income poverty. Lastly, FYDP II follows the theme of "nurturing industrialization for economic transformation and human development" that is decisive to reach the national targeted goal at which by 2025 the nation to be in the level of middle-income country as agro-based industrialized economy. Internationally, this paper is in line with the 1992 Rio Declaration principle 22, Millennium Development Goal (MDG) 7 and Sustainable Development Goals (SDGs) 2 and 15[3]. Additionally, the paper reflects the 1996 National Agricultural Policy (NAP) and the 1997 National Environmental Policy (NEP) which agree the need to promote environmental conservation in agricultural sector.

3. Review of Literature

Asfaw and Neka, (2017) conducted a study to examine the factors influencing the adoption of soil and water conservation practices in Wereillu Woreda in Ethiopia. The study employed primary data and used binary logistic regresssion model to analyze the data. The findings of the study indicated that household head sex, education accesibility of training and extension services were positively significant associated with the farmers' decisions to adopt introduced soil and water conservation technologies. However, household head age, off-farm activity and farmlands distance from homesteads have influenced the farmers' decisions to adopt soil and water conservation techniques. Thus, the study recommended that agricultural stakeholders such as Woreida Rural and Agricultural Development Office and other concerned bodies should collaborate to promote agricultural productivity and quality of the environmnet by taking into consideration these particular influential factors.

[3]The MDG 7 accords that there is a need to promote close collaboration between local communities and the government in order to maintain environmental sustainability.
SDG 2 and 15accords that "end hunger, achieve food security and improved nutrition and promote sustainable agriculture" and the goal 15 "protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification and halt and reverse land degradation and halt biodiversity loss" respectively.

Nahayo et al. , (2016) investigated on the factors that influence the adoption of soil conservation techniques in Gatebe, Rwanda. The study adopted primary data and employed binary logistic regression model. The findings of the study revealed that age of the household head and means used by farmers to acquire farmlands were positively correlated with the adoption of soil conservation technologies. However, annual non-farm income, sex of the household head, marital status, farm land with high potential soil erosion risk, distance between farmland and the homestead, adequate labour and farmlands used inland consolidation are negatively associated with farmers' decisions to adopt soil conservation techniques. The study concluded that policy makers should make an effort to improve the farmers' awareness on soil erosion and soil conservation technologies by provision of seminars and trainings.

Kalineza et al., (1999)examined the factors that influence the adoption of soil conservation technologies in Gairo, Tanzania. The study used primary data and employed logistic regression model to analyze the collected data. The results of the study indicated that awereness of the soil degredation and conservation measures and ownership of land are positively and significant in influencing the farmers' decisions to adopt soil conservation technologies. The study recommended that land policy should be improved in order for the farmers to know their land rights since will promote the land investment by adopting soil conservation technologies. Additionally, the study emphasized the agricultural stakeholders have to promote extension services to the farmers in order to improve the soil degradation awereness.

Tadesse and Belay, (2004) conducted a study to determine the adoption of physical soil conservation techniques involving "fanyajuu" and soil bunds in Gununo, Ethiopia. The study employed primary data and used binomial logit model to detrmine the factors influencing the physical soil conservation techniques. The findings of the study showed that farm size, active members in household, ownership of plots within Soil Conservation Research Programme (SCRP), farmers' perception of soil erosion and technology characteristics have postive effect on the farmers' decisions to adopt physical soil conservation measures. On the other hand, family size and house type were negatively associated with the adoption of physical soil conservation techniques.

A positive correlation was observed between soil conservation measures and slope gradient. Whereby farmers with steep farmlands are better adopters of soil conservation techniques than who own gentle slope farmland (Aberha, 2008). Farmers with steep slope farmlands are using soil conservation techniques such as "fanyajuu" and soil bunds. The effect of steep slope farmlands and the adoption of soil conservation techniques such as terraces are found to be positively correlated (Amsalu and De Graaf, 2007). Hence, these studies encouraged the farmers to use soil conservation techniques such as terraces due to effectiveness of the soil control measures on steep slope farmlands.

Bekele and Drake, (2003) urged that farmers with poor soils or low and medium fertility are more engaged in soil conservation than those with high level of fertlilty farmlands. This is because farmers are concerned to improve the soil fertility level and productivity of the plot. Swinton and Quiroz, (2003) and Bekele, (2005) agrees that farmers who have plots suffered from gullly erosions are better adopters of soil conservation techniques since they have to conserve their plots from severe soil erosion and prevent the toatal loss of the plot land.

To bridge the gap, since most of the study mentioned above used crossectional study this study used the existing panel data in the country to investigate the determinants of Soil conservation technologies among small-scale farmers in Tanzania. Theexisting panel data in Tanzania is reach in terms of agriculture information and currently it is inwave four (4) which allows one to examine the sector dynamics and provide useful panel evidencebased policymaking decisionover time.

Notable, cross-sectional studies are likely to suffer from endogeneityproblem which make it difficult to control for unobserved heterogeneity and examine whathappens to the adoption over time. Thus, this study used the advantage of panel datain the analysis for better and more informative results.

4. Methodology

4.1 Analytical Approach of the Model

The decision either to adopt or not to adopt SCTs is termed as a binary decision which can be examined using models of binary choices. The main objective of binary choices models is to determine the probability of the economic agent (smallholder farmer) making one optimal decision rather than alternative. Hence, in this paper assumes that the smallholder farmer is considered to adopt SCTs or not.

The conceptual framework of the model analysis used in this paper is parallel to the model that Kalineza et al., (1999) and Uaiene et al., (2009)adopted to estimate the adoption of SCTs among households. The Utility maximization model acts as a basis underlying the decision making by households in Probit model. The decision of household either to adopt SCTs or not depends on utility latent index y^* which is being determined by other factors at which the higher the value rate of the index the higher the rate of household's adoption of SCTs.

The latent utility index is articulated as follows:

$$y^* = X'\beta + \varepsilon \qquad (1)$$

$X'\beta$ index is a function and ε is IID with mean 0 and unit variance.

$$y = 1 \; if \; y^* > 0 \qquad (2)$$

$$y = 0 \; if \; y^* \leq 0 \qquad (3)$$

Whereas, 0 is the threshold level or critical level of the indexy^*.

Green, (2002) provided an explanation on household choices adopting the random utility model. Describing U_{i1} as i^{th} household's indirect utility linked with the rate of adoption of SCTs and U_{i0} as i^{th} household's indirect utility linked no adoption of SCTs.

Then,

$U_{i1} = X_i'\beta_1 + \varepsilon_{i1}$ Stands for adoption of SCTs (4)

$U_{i0} = X_i'\beta_0 + \varepsilon_{i0}$ Stands for non-adoption of SCTs (5)

Since the level of utility is random then i^{th} household will choose the adoption of SCTs if and only if $U_{i1} > U_{i0}$. Then for smallholder farmer i, the probability of adoption is articulated as follows:

$$P(Y_i = 1|X) = P(U_{i1} > U_{i0}) \quad (6)$$

$$= P(X_i'\beta_1 + \varepsilon_{i1} > X_i'\beta_0 + \varepsilon_{i0}) \quad (7)$$

$$= P(\varepsilon_{i0} - \varepsilon_{i1} < X_i'\beta_1 - X_i'\beta_0) \quad (8)$$

$$= P(\varepsilon_{i0} - \varepsilon_{i1} < X_i'(\beta_1 - \beta_0)) \quad (9)$$

$$= P(\varepsilon_i < X_i'\beta) \quad (10)$$

$$= \phi(X_i'\beta) \quad (11)$$

Whereas $\phi(.)$ Signifies the cumulative distribution function (CDF) of the standard normal distribution, X' stands for vector of independent variables which describe the adoption of SCTs and β is a vector of parameters.

The model that is used in estimating the adoption of advanced SCTs by a farmer can be described as follows:

$$P(Y_i = 1|X) = \emptyset(X_i'\beta) = \int_{-\infty}^{X'\beta} \frac{1}{\sqrt{2\pi}} exp\left(^{-Z^2}/_2\right) dz \quad (12)$$

Whereas, P stands for probability that the i^{th} farmer adopted SCTs and 0 otherwise. Thus, this study is basing on the binary dependent variable which is defined whether or not a household adopted SCTs in agricultural seasons of2008-2009, 2010-2011 and 2012-2013. Three waves are used by this paper instead of four available waves because the fourth wave (2014-2015) is based on data from new households only who were not available in previous three waves.

After the parameter estimates from the Probit adoption model are attained, a regular stage is to consider the marginal effects. The parameter estimates from Probit adoption model denotes the direction of the effect of explanatory variables on the dependent variable. The estimates epitomize neither the probabilities nor the actual magnitude change instead the marginal effects are adopted to measure the expected change in probability of a particular technique chosen with respect to unit change in independent variable from the mean (Greene, 1996).

Additionally, in the aspect of linear regression model the parameters which have been estimated can also be described as marginal effects unlike in non-linear regression models/binary regression models which the estimated parameters are not described as marginal effects. However, the marginal effect of explanatory variables can be attained by derivation of the probability outcome with respect to an independent variable. Gujarati, (2004) noted that in binary regression models such as Probit and Logit models their major aim is to define the effects of explanatory variables (Xi) on the probability regression which can be shown as $Pi(Y = 1|X)$.

The latent index formulation explaining that the Probit adoption model is fascinated in the effect of each explanatory variables on y_i^* i.e. to adopt SCTs or not.

$$\text{Marginal effects} = \frac{\partial(P(TECH=1|X))}{\partial x} = \left\{\frac{dF(X'\beta)}{\propto(X'\beta)}\right\}\beta = f(X'\beta)\beta = \emptyset(X'\beta)\beta \quad (13)$$

Whereas $\phi(.)$ signifies a normal standard density which relates to the cumulative standard normal distribution, $\Phi(.)$; and X represents the explanatory variables in Probit adoption model. Therefore, the marginal effects discrete and continuous changes for binary variables will be calculated by means of explanatory variables as reference points. The estimates of marginal effects after the process of probit regression model and descriptive analysis will be done by STATA Version 14.2 Software.

Probit regression model is empirically explaining the factors influencing the adoption decisions about the SCTs among the smallholders' farmers. Probit regression model is expressed as follows;

$$P(SCT = 1) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + \beta_9 X_9 + \beta_{10} X_{10} + \beta_{11} X_{11} + \varepsilon \quad (14)$$

Where; *SCT* signifies the adoption of Soil Conservation Technology. β_0 signifies the intersect, $\beta_1 - \beta_{11}$ stands for the coefficients of the various explanatory variables and ε signifies error term. The dependent variable above in the model is having dichotomous feature involving the value of 1 for farmers adopting SCTs and 0 for farmers not adopting.

Table 1: Independent variables description and measurements used in the binary probit model for adoption of SCTs by smallholders' farmers

Variable	Description	Measurement	Anticipated
Sex (X_1)	Gender of the household head	D=1 =if male; 0=female	+
Education level (X_2)	Non-formal education level achieved by household head	D=1 if education level achieved; 0=otherwise	+
Farm Size (X_3)	Planted farm size	Acres	+/-
Age (X_4)	Age of household head	Number of years	+
Soil Type (X_5)	Soil Type on cultivated plot	Soil Ph	+/-
Soil Quality (X_6)	Soil Quality on cultivated plot	Soil Ph	+/-
Plot Value (X_7)	The Value of the cultivated plot	Tanzanian Shillings	+
Plot Steepness (X_8)	The Steepness of the cultivated plot	Farmland slope	+/-
Size (X_9)	Household size	Number of people in a household	+
Credit Inputs (X_{10})	Accessibility of agricultural inputs on credit	D=1 if a household has access to credits inputs (YES); 0=otherwise (NO)	+
Extension (X_{11})	Accessibility of extension services (particularly on land management) from the government and NGOs	D=1 if a household has access to extension services (YES); 0=otherwise (NO)	+

Source: Authors' own Computation

4.2 Data

The analysis uses the secondary National Panel Survey (NPS) data that was collected by National Bureau of Statistics (NBS) with the collaboration of World Bank. The households used in this study were interviewed in waves; first wave 2008/2009, second wave 2010/2011 and third wave 2012/2013 and are only those engaging in maize farming. Although the information of recent (fourth) wave was collected in 2014/15, it was not used for analysis in this study since majority of households was new in this wave that leads high attrition. The analysis of balanced Panel data was based on 1,509 concrete observations involving of 503 sample of households that appeared in each of the three waves 2008/2009, 2010/2011 and 2012/2013. The purpose of this is to ensure consistence traction of the same household members in three waves. The sample of panel data in this paper comprise of households from Tanzania Mainland only.

5. Results and Discussion

5.1 Descriptive Results

Table (2) reveals that the average number of people who adopted soil conservation technology is 13.9 per cent which is still small compared to other countries as it has been discussed in the introduction of this paper. Also, the sample average age of household heads was 49 years old with a minimum of 19 years and a maximum of 90 years old. World Bank, (2016) defined that a person to be regarded as adult has to be 18 years old and above. The sample mean of household size was 5 individuals per household with a minimum of 1 individual and a maximum of 35 individuals. The sample averages of households accessing the use of agricultural inputs on credit and extension services were 1.4per cent and 13.2per cent respectively.

The sample mean of farm size was 4.8 areas in acres per household which is equal to the national average that accounts 5.2 areas in acres per household compared to another study such as Selejio et al., (2018) who found that the sample size of the farm size is 6.1 areas in acres per household since the study included only maize cultivated plots. FAOSTAT, (2013) noted that smallholder farmer must own a farmland less or equal to 50 acres. The sample mean of soil type, quality and steepness of households who cultivate in their farmlands are 8.7 per cent, 9.4 per cent and 6.4 per cent respectively. The result also shows that the average level of household education level that underwent formal education is low at 28.3 percent. Furthermore, the descriptive results illustrate that value of the smallholder farmer's plot is logged with a sample mean of 12.8 at which the minimum value is 8.006 and the maximum value is 19.584 units.

Table 2: Descriptive summary statistics for independent variables

Variable	Obs	Mean	Std.Dev.	Min	Max
Adopt_SCT	1509	0.139	0.346	0	1
FarmSize	1509	4.852	5.206	0.1	50
Soil_Type	1509	0.873	0.333	0	1
SoilQuality	1509	0.943	0.232	0	1
SoilSteepness	1509	0.643	0.479	0	1
CreditInputs	1505	0.014	0.117	0	1
Accessibility of Extension services	1509	0.132	0.338	0	1
Household Head Sex	1509	0.792	0.406	0	1
Household Head Age	1509	49.993	15.215	19	90
Household Size	1509	5.619	3.007	1	35
Household Education	1509	0.283	0.451	0	1
logPlot Value	1508	12.857	1.498	8.006	19.584

Source: Authors'own computation using STATA

5.2 Econometric Analysis

The high likelihood of the given observed results indicates that the model is well specified and reliable since the classification results shows that the model is classified at 64.71 per cent since for the model to be well specified has to be above 50 per cent (Gujarati, 2004). Additionally, VIF for the independent variables is generated. For the case of this model the mean VIF is8.08 (See Table 3). When the mean VIF is below 10 the independent variables have no high correlation, hence there is no perfect correlation between variables adopted in this model (Greene, 1996).

Table 3: VIF for Independent Variables

Variable	VIF	1/VIF
logPlot value	33.96	0.0295
Soil Quality	15.18	0.0659
HouseholdHead Age	13.12	0.0762
Soil Type	7.360	0.136
Household Head Sex	5.360	0.187
Household Size	5.200	0.192
Soil Steepness	2.790	0.358
Farm Size	2.150	0.465
Household Education	1.520	0.658
Access to Extension services	1.170	0.854
Credit Inputs	1.030	0.968
Mean	**VIF**	**8.080**

Source: Authors' own computation using STATA

After carrying out essential regression diagnostic tests, then this section presents the findings of the model which shows the factors influencing small-scale farmers' decision to adopt soil conservation technologies. The findings of the probit regression models are presented in Table 4. The binary probit regression estimation in table (4) shows that the estimated values of the coefficients of the probit regression revealed that the independent variables 'soil steepness' negatively influence the adoption of SCT, 'plot value', and 'accessibility of extension services' positively and significantly influence the smallholder farmers' to adopt SCTs.

Table 4: Probit Regression Results

VARIABLES	AdoptSCT
Farm_Size	-0.00189
	(0.00803)
SoilType	0.0765
	(0.129)
SoilQuality	-0.00319
	(0.186)
SoilSteepness	-0.672***
	(0.0839)
CreditInputs	0.357
	(0.305)
Access to Extension	0.425***
	(0.113)
Household Head Sex	-0.161
	(0.109)
Household Head Age	-0.00330
	(0.00307)
Household Size	0.0155
	(0.0145)
Household Education	0.00209
	(0.0967)
logPlotValue	0.0730**
	(0.0290)
Constant	-1.581***
	(0.440)
Observations	**1,504**

Legend: Robust standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$
Source:Authors' own computation using STATA

Table 4 presents the relationship direction between dependent and explanatory variables. Additionally, in order to determine the relative effectiveness of a unit change in the value of an explanatory variable on the adoption probability, the marginal effects after probit regression method are computed. Thus, the findings are presented in Table 5.

Table 5: The Marginal Effects after Probit Regression Results

variable	dy/dx	Std.Err.	P>z
Farm size	-0.0003844	0.00163	0.813
Soil type*	0.0150099	0.02454	0.541
Soil quality*	-0.0006487	0.03786	0.986
Soil steepness*	-0.1521016	0.02031	0.000
Credit inputs*	0.0873828	0.08701	0.315
Access to Extension*	0.1023101	0.03113	0.001
Household Sex*	-0.0343774	0.02462	0.163
Household Age	-0.0006688	0.00062	0.282
Household Size	0.0031542	0.00294	0.283
Household Education*	0.0004249	0.01964	0.983
logPlot value	0.0148232	0.00586	0.011

Source: Authors'own computation using STATA
Legend: (*) dy/dx is for a discrete change of dummy variable from 0 to 1. The marginal effects for the variables which are insignificant are noted in parentheses.

Based on the findings from both Table 4 and 5 the behavior of explanatory variables is as follows: Three(3) out of eleven (11) explanatory variables in table (5) have hypothesized to influence farmers' decisions to adopt SCTs. These are plot steepness, access to extension and plot value.

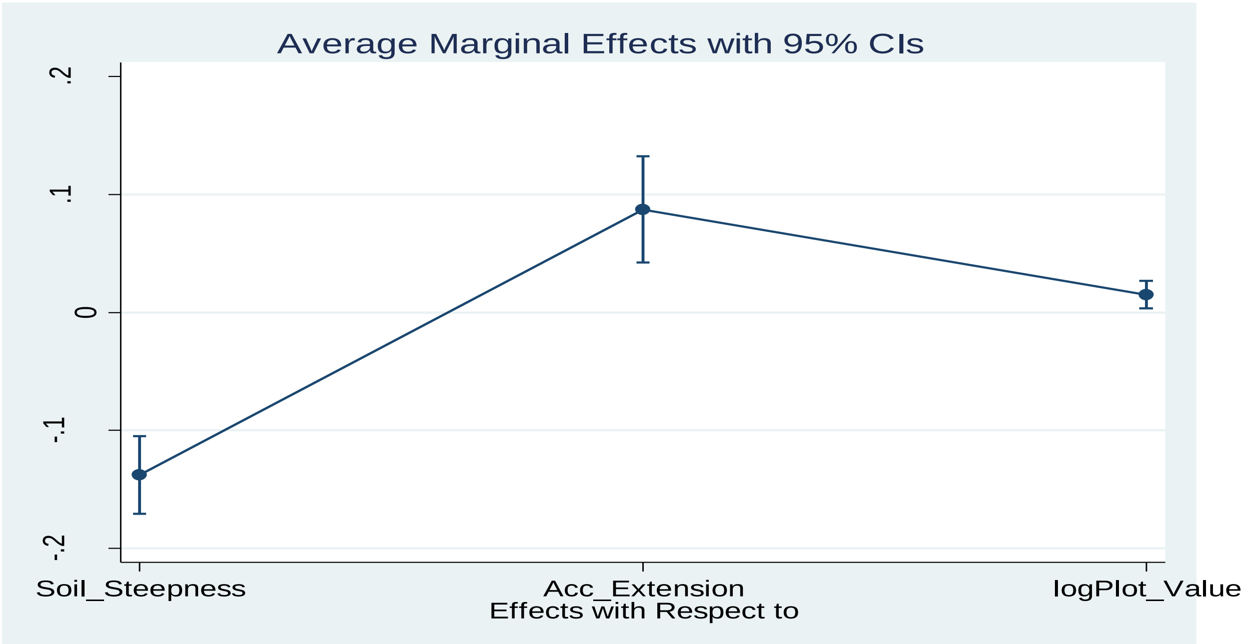
Table 5 displays plot value is positively related with the smallholder farmer's decision to adopt SCTs. Plot value is statistically significant at 0.05 per cent level with the adoption of SCTs. This implies that an increase unit of plot value owned by smallholder farmer increases the probability for a farmer to adopt SCTs by 1.4 per cent. The finding agrees with Garcia, (2001) and Foltz, (2003) who found that the value of a farm influences a farmer to adopt advanced technologies so that to maintain the farm value. This entails that the higher the value of plot is the higher the ability of a farmer to adopt SCTs in order to preserve the sustainability of environment.

Soil steepness is negatively correlated with the smallholders' farmers' decisions to adopt SCTs. Soil steepness is statistically significant at 0.1 per cent level. This implies that smallholders' farmers whose plots were flat bottomed their likelihood of adopt SCTs decrease by 15 per cent unlike steep sloped areas, since adoption of SCTs are effective to prevent total soil loss in farmlands with steep slope. The findings are supported by Okoye, (1998); Kessler, (2006); Amsalu and De Graaf, (2007); and Aberha, (2008) who showed that farmers with gentle slope their probability to adopt agricultural technologies such as terraces are much lower because their plots are friendlier to farming activities unlike steep slopes which requires soil techniques to be ready for farming activities.

Access to extension showed a positive and significant influence on the adoption of SCTs. This implies that the likelihood of smallholder farmers to adopt SCTs increase by 10.23 per cent as they keep on receiving extension services from experts. Similarly, As faw and Neka (2017) found that access to training correlated positively and significantly with the adoption of soil and water conservation practices (ß=2.001; p-value=0.020).In line with this, Sidibe, (2005);Tiwari et al. (2008); and Asafu-Adjaye, (2008) revealed that access to training has a positive insignificant correlation with the adoption of introduced soil and water conservation practices.

The above results can be summarized using a graph (margins plot) that shows the predictive margin of the independent variables on the adoption of SCTs. The graph is shown below;

Figure 1: Results of the Predictive margins on SCTs



Source: Authors'own computation using STATA

Figure 1 depicts that the likelihood predictive mean effect of the smallholder farmer situated at flat bottom plot to adopt SCTs is decreasing by 0.13 units compared to other smallholder farmer situated at steep slope and the 95 per cent confidence interval of the effect is -0.170 to -0.104. The likelihood predictive mean of the smallholder farmer who has access to agricultural extension to adopt SCTs increases by 0.8 units and the 95 per cent confidence interval of the effect is 0.042 to 0.132. Furthermore, a smallholder farmer situated at a higher plot value his/her predictive value to adopt SCTs increases by 0.01 units and the 95 per cent confidence interval of the effect is 0.003 to 0.026. Therefore, this implies that accessibility of agricultural extension and plot values have positive relationship on SCTs adoption. However, soil steepness has negative relationship on SCTs adoption.

However, the findings from table (4) which shows only the direction of the outcome variables, displays that accessibility to extension services are positive and significant towards smallholders' farmers' decisions to adopt SCTs. Additionally, table (5) shows the direction and magnitude of the outcome variables which displays that the particular variables are positive and significant towards adoption of SCTs. The direction behavior of these variables is supported by Sutcliffe, (1995); Lapar and Pandey, (1999); Sureshwaran et al., (2008) stated that farmers with non-accessibility of extension services may find it hard to adopt agricultural technologies.

6. Conclusion and policy recommendation

This paper attempted to identify significant factors, which influence the smallholders' farmers' decisions to adopt SCTs in Tanzania. The empirical results show that major factors influencing adoption of SCTs in the study area are: Plot steepness, plot value, and extension services. A vital implication of the findings presented in this paper is that involvement in soil conservation should recognize the heterogeneity in household characteristics: socio-demographic factors, institutional pattern and field production information.

Another implication of the results of this paper is the need to increase the smallholders' farmers' education level and extension services through the provision of agricultural and environmental knowledge on seminars by agricultural and environmental stakeholders. Thus, the paper recommends for joint efforts from both private and government sectors to promote and provide education services and extension services in order to enhance the soil conservation awareness among smallholders' famers especially in rural areas. Additionally, Soil conservation technologies are not limited to bench terraces and erosion control bunds only. Therefore, other studies can be done to identify the factors influencing the farmers' decisions to adopt soil conservation technologies such as vetiver grass, tree belts, water harvest bunds and drainage ditches. Also, this paper has only investigated the adoption decisions of SCTs of smallholder farmers. Hence, other studies can investigate the adoption decisions of SCTs of large-scale farmers.

In addition, this paper is grounded to the theory of maximization utility which enlightens that income and price are crucial determinants for the individual to adopt a certain technology. However, in this paper price of the SCTs adopted by a smallholder farmer and income of the smallholder farmer were not taken into consideration since the National Panel Survey Dataset had many missing values in those respective variables. Thus, the study recommends the National Panel Survey Staff should make more effort on those variables in the coming waves.

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