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Soil and water conservation practices: economic and environmental effects in Ethiopia

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Efforts towards soil and water conservation (SWC) goal were started since the mid-1970s and 80s to alleviate both the problems of erosion and low crop yield of Ethiopia. The data were collected through structured questionnaire via face to face interview with 120 sampled household (HH) from Karasodity and Deko villages of Wenago district. The data were analyzed using descriptive statistics and the Heckman two-step econometric estimation procedure. Family size, frequency of extension services, training, and types of SWC practices showed significance and positive relationship with environmental effectiveness (EP) of SWC practices. Access of input, age of the household head, livestock holding and land size were positively related with, and frequency of extension services, access of credit and total land to labor ratio were negatively related with effectiveness of SWC practices on economic level of household (ELHH). Total benefit of SWC practices showed negative relationship with ELHH and statistically significant at p<0.01. It indicated the fact that the benefits from investing in SWC practices accrue over time. There should be work to demonstrate the profitability through providing technical support, access to credit, and provision of efficiently working tools needed for the construction and maintenance of SWC practices.

Key words: Soil and water conservation (SWC), environmental, economic, effectiveness, Heckman

INTRODUCTION

Land degradation remains one of the biggest environmental problems worldwide, threatening both developed and developing countries and it has been a major global agenda because of its adverse impact on environment and food security and the quality of life (Slegers, 2008). Land degradation, poverty and food insecurity are pervasive and interconnected problems in Ethiopia (Holden and Shiferaw, 2004). Land degradation due to soil erosion and nutrient depletion is considered as the main problem constraining the development of the agricultural sector in Ethiopia (Amsalu and de Graaff, 2007; Tefera and Sterk, 2010).

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Since degradation of land has real economic, social, and human costs with substantial impacts on national economies, it also directly threatens the long-term growth of agricultural productivity, food security, and the quality of life, particularly in developing countries (Shiferaw et al., 2009). The problem is very serious particularly in steep lands where rain fed agriculture constitutes the main livelihood of the people (Hurni, 1988; Shiferaw and Holden, 2001). Recent studies in Ethiopia also indicated that land degradation is a dominant process at the bottom land of the watersheds where there is a saturated soil, in this part of the watershed the soil will be easily removed by sheet and rill erosion and the formation of gullies (Tebebu et al., 2010; Tilahun et al., 2013; Ayele et al, 2015)

Despite the severity of the problem, it is only very recently, in the past three decades, that land conservation has received policy attention in the country (Amsalu and de Graaff, 2007). Soil and water conservation (SWC) in Ethiopia is closely related to the improvement and conservation of biophysical environment, and ensuring sustainable development in agricultural sector and its economy at large (Abera, 2003). In Ethiopia, efforts towards this conservation goal were started since the mid-1970s and 80s (Bekele and Drake, 2003; Shiferaw and Holden, 1998). Since then, different soil and water conserving practices with a variety of approaches have been underway (Adugnaw and Desalew, 2013). The focus was conserving soil, rainwater and vegetation effectively for productive uses, harvesting surplus water, rehabilitating and reclaim marginal lands through appropriate conservation measures and mix of trees, shrubs and grasses based on land potential (Lakew et al., 2005). Effective SWC practices, including physical and biological, are of substantial benefit for attaining and sustaining food security in smallholder farming, through the successful rehabilitation and management of natural resources (Kebede et al., 2013).

Recognizing the threat of land degradation and benefits of SWC practices, the government of Ethiopia is promoting SWC technologies for improving agricultural productivity, household food security and rural livelihoods (Shiferaw and Holden, 1998; Amsalu, 2006, Teshome et al., 2016). The continued use of SWC seemed mainly determined by the actual economic profitability and environmental benefits, and determinant factors for effectiveness.

The positive effects of soil and water conservation (SWC) occur through time and practicing of SWC technologies depends on the ability of the technologies to improve economic and environmental benefits. While there is a bulk of information regarding the adoption of SWC practices, little information is documented on the economic and environmental benefits of the various SWC practices implemented in the study area. The evaluation of the effectiveness of these SWC practices that are alleged to enhance productivity is very important in order to evaluate their performance in reducing land degradation and rehabilitating the land (Yitayal and Adam, 2014). Evaluating the impact of past efforts and proper understanding of the improvement in the livelihood of smallholder farmers" is essential to draw lessons and improve the efficiency of the SWC practices. Therefore, the main objective of the study was to evaluate the environmental and economic effectiveness of SWC practices in Wenago district, Southern Ethiopia.

METHODOLOGICAL APPROACH

Description of the study area

The research was conducted in Wenago district, Gedeo Zone, Southern Ethiopia, located at 375 km South of Addis Ababa, the capital of Ethiopia (Figure 1). The District is sub divided into 17 administrative rural kebeles (villages) (GZFES, 2005). Among the village, the study was conducted in Karasodity village and Dako village from April 2015 to March 2016.

Sample size and data collection methods

A two-stage sampling technique was used when selecting respondents. In the first stage, two kebeles (Karasodity and Deko) were selected purposively based on experience of implementing SWC practices. These numbers of kebeles were considered to be sufficient for drawing valid statistical inferences and manageable to be surveyed with the available finance and time. From each Kebele, one sub watershed was selected purposely based on availability of SWC practices and degraded land adjacently. SWC practices were implemented since 2009 for the purpose of land rehabilitation and to control further degradation through soil erosion by the district and village agricultural offices through mobilizing the community. Majority of the physical SWC practices constructed were soil bunds, fanya juu, half-moons, trenches, micro basins, and cut off drain in area closures, grazing and fallow land. Similarly, the commonly practiced biological SWC include maintaining natural vegetation and tree plantation in area closures, plantation of valley bottoms, and stabilization of physical structures using natural vegetations, vetiver grass and elephant grass. At the second stage, a total of 120 household heads were selected using random sampling technique. The sample comprised of 56 HHs from Karasodity and 64 HHs from Dako Kebele who were within the sub watersheds (30% of total HH from each). Both secondary and primary data were used for this study. The primary data were collected from sample respondents through a structured questionnaire via face to face interview with the heads or working members of households and focus group discussion. The secondary data were collected from district and village agriculture offices.

Analytical methods

The qualitative and quantitative data were analyzed using descriptive statistics and econometric model. Descriptive statistics such as mean, standard deviation and percentage were used along with the econometric model to analyze the collected data, and SPSS version 20 and STATA version 11 were used for this purpose.

Econometric model was used to assess the environmental and economic performance of SWC practices. The factors that affected

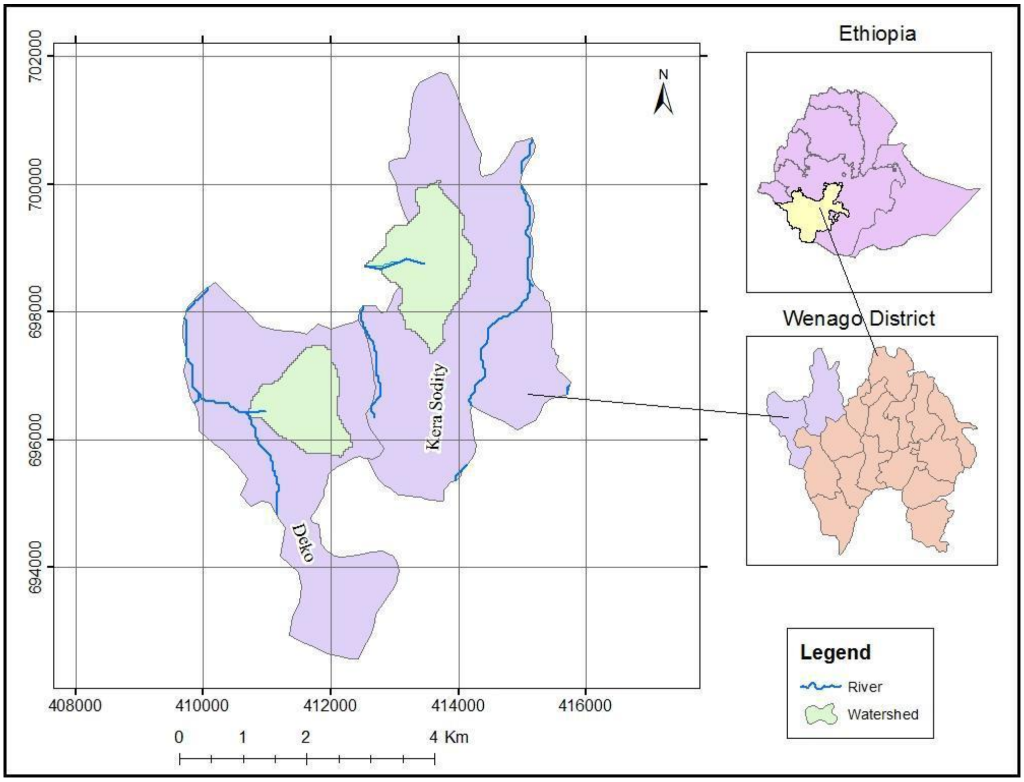

Figure 1. Location of the study area.

EP were family size of the household (FS), frequency of extension service (FEXSR), training (TR) and type of SWC practices. Whereas the factors considered to evaluate economic level of HH were access of input (ACCIP), total benefit of SWC (TPSWC), age of the household head (AGHH), livestock holding (LIVSTOCK), land size, frequency of extension services (FEXSR), access of credit (ACCR) and total land to labor ratio.

The Heckman two-step econometric estimation procedure was employed to assess environmental and the economic effectiveness of SWC practices. The first step of the Heckman model was an „environmental performance". This equation was used to construct a selectivity term known as the „inverse Mills ratio" which is added to the second step „outcome" equation that explains economic level of the household. The inverse Mill"s ratio is a variable for controlling bias due to sample selection (Heckman, 1979). If the coefficient of the „selectivity" term is significant then the hypothesis that an unobserved selection process governs the participation equation is confirmed. Moreover, with the inclusion of extra term, the coefficient in the second step „selectivity corrected" equation is unbiased. Specification of the Heckman two-equation procedure, which is written in terms of the probability of environmental performance (EP), and economic level of the household (ELHH), is:

The participation equation/the binary probit:

$$Y_{i1} = X_{1i}\beta_1 + U_{1i}; U_{1i} \approx N(0,1) \quad (1)$$

EP = 1 if $y_{1i}>0$

EP = 0 if $y_{1i} \leq 0$

Where: Y_{1i} = the latent dependent variable, which is not observed. X_{1i} = vectors that are assumed to affect the probability of sampled household environmental performance. β_1 = a vector of unknown parameter in environmental performance equation. U_1 = residuals that are independently and normally distributed with zero mean and constant variance. EP = environmental performance. ELHH = economic level of the household.

The observation equation

$$\text{ELHH} = Y_{2i} = X_{2i}\beta_2 + \alpha\lambda_i + U_{2i}; U_2 \approx N(0, \delta 2) \quad (2)$$

Where: Y_{2i}= observed if and only if EP =1. The variance of X_{2i} is normalized to one because only EP, not Y_1 is observed. The error terms, $U_1$and U_2 are assumed to be bivariat and normally distributed. Y_{2i}= regressed on the explanatory variables, X_{2i} and the vector of inverse Mills ratios λ_i from the selection equation by ordinary least Squares (OLS). Y_{2i} = the observed dependent variable.

X_{2i} = factors assumed to affect the economic level of the household. β = vector of unknown parameter in the economic level of the household equation. U_{2i} = residuals in the observation equation that are independently and normally distrusted with zero mean and variance δ^2.

$$\text{Mill ratios } (\lambda_i) = \frac{F(X_1\beta_1)}{1 - F(X_1\beta_1)} \quad (3)$$

Where: $X\beta$ = a density function and $1 - F(X_1\beta_1)$ = distribution function.

An econometric Software known as STATA version 11 was

Table 1. The summary of definition and measurement of variables in the model.

Variable name	Description	Expected sign (Relationship)
Dependent variable		
EP	Environmental effectiveness of SWC practices; 1 if a HH is practicing SWC measures continuously, 0 otherwise	
ELHH	Economic level of HH : It is continuous dependant variable in the second step of Heckman selection equation	
Independent variable		
FS	Family size of the household; Number of people in the HH	±
LIVESTOCK	Livestock holding measured in TLU	±
FEXSR	Frequency of extension services; a dummy variable that takes a value of 1 if the household head has access extension service and 0 otherwise.	+
TR	Training on SWC received by the farmer; 1 if a HH got training and 0 otherwise	+
TPSWC	Types of physical soil water conservation; 1 if a HH practiced physical SWC and 0 otherwise	+
TBSWC	Types of biological soil water conservation; 1 if a HH practiced biological SWC and 0 otherwise	+
ACCIP	Access of input; 1 if the HH got input for practicing SWC and otherwise 0	+
TPSWC	total benefit of soil water conservation, 1 if yes and 0 otherwise	+
AGHH	Age of the household head in years	±
LAND SIZE	HH Landholding in hectare	±
ACCR	Access of credit, 1 if the HH obtained credit and 0 otherwise	+
TLLR	Land to labor ratio is measured as the ratio of the area operated to the number of family members (in man-equivalent)	-
FI	Farm income	+

employed to run the Heckman two-step selection model. Before fitting important variables in the Heckman two-step selection model it was necessary to test multicolinearity problem. As Gujarati (2003) indicated, multicolinearity refers to a situation where it becomes difficult to identify the separate effect of independent variables on the dependent variable because of the existing strong relationship among them. In other words, multicolinearity is a situation where explanatory variables are highly correlated.

Multicolinearity was tested using variance inflation factor (VIF) of the variables which is defined as $VIF = \frac{1}{1-R_j^2}$. For each coefficient in a regression as a diagnostic statistic is used. R_j^2 Represents a coefficient of determination the subsidiary or auxiliary regression of each independent continuous variable X. As a rule of thumb, Gujarati (2003) stated that if the VIF value of a variable exceeds 10, which will happen if R_j^2 exceeds 0.90, then, that variable is said to be highly collinear. Therefore, for this study, VIF was used to detect multicolinearity problem for continuous variables. On the other hand, for dummy variables contingency coefficient was used.

Definition of study variables and working hypothesis

Environmental performance (EP): It is a dummy variable that represents the probability of environmental performance of the study area. For the household participated in biological and physical SWC practices takes the value of 1 where as it takes the value of 0 for the household having low biological and physical SWC practices performance.

Economic level of the household (ELHH): It is continuous dependen variable in the second step of Heckman selection equation. It is measured in terms of birr (1birr = 0.046US$) of the households which is selected for regression analysis and takes positive values.

Wide range of factors influences environmental and economic effectiveness of SWC practices. Hence, potential independent variables that can influence effectiveness of SWC are identified and they are presented in Table 1.

Model specification of economic level of HH

ELHH = $\beta_0 + \beta_1$(ACCIP) $+ \beta_2$(TPSWC) $+ \beta_3$(AGHH) $+ \beta_4$(LIVESTOCK) $+ \beta_5$(LS)$+ \beta_6$(FEXSR)$+ \beta_7$(ACCR)$+ \beta_8$(LLR)$+ \beta_9$(FI) (4)

ELHH = Economic Level of household, ACCIP = access to input, TPSWC = total benefit from soil and water conservation, AGHH = age of house hold, LIVESTOCK = livestock holding, FS = family size, FEXSR = frequency of extension service, ACCR = access to credit, TLLR = total land to labor ratio and FI = farm income)

RESULTS AND DISCUSSION

Descriptive statistics

The average household family size was 7.81 persons. The survey result indicated there was significant difference in the family size of the HHs. The mean age was 37.56 years. The HH (household head) age has significant role on the performance of the SWC practices. It could be due to HH with higher age often associated with long years of farming experience to invest more in

Table 2. Some of HH socioeconomic characteristics.

Variable	Mean	Standard deviation	t-value
Age of the household (year)	37.56	9.23	36.33
Livestock (TLU)	6.01	3.19	16.82
Non-farm income (ETB)	688.64	470.3	13.09
Farm income (ETB, Ethiopian birr)	708.30	187.93	21.91
Family size (person)	7.81	2.5	27.12
Total land to labor (total land per FS)	0.03	0.02	14.38
Frequency of extension services	2.59	1.07	21.5
Market distance (km)	20.24	7.95	22.74
Total land allocated (ha)	0.24	0.13	16.39

Source: Own Survey data, 2016.

Table 3. Determinants of probability of environmental performance.

Variable	Coef.	Std.err	Z	P>/Z/	— (Marginal effect)
FS	0.332	0.259	1.96	0.0201**	0.342
FEXSR	0.731	0.309	2.36	0.018**	0.186
TR	0.958	0.577	1.66	0.097*	0.0019
TPSWC	0.33	0.317	1.96	0.020**	0.023
TBSWC	11.62	0.754	8.91	0.000***	3.27

Number of observations = 120 Prob> χ^2 = 0.0000, LR χ^2 (14) = 450.76, Pseudo R^2 = 0.2068, Log likelihood = -864.42. ***, ** and * represents significance at 1, 5 and 10% probability levels, respectively. Source: Model output of Own Survey data, 2016.

conservation (Teshome et al., 2013).

The average non-farm income was ETB 688.64 and the farm income ETB 708.30 (Table 2). The sources of income for sample households come from both farm and nonfarm activities. Farm income consists of both incomes from sales of livestock and livestock products and from sales of crops. Non-farm income sources are mainly from petty trade at local market places and daily works.

In the survey area, the average land allocated for production of crops is 0.24 ha per household. There is significant variation in the size of landholding among households. The landholding of farmers in the study area is very small. It is clear that the propensity of retaining conservation structures increases with increasing availability of land resources. The average livestock holding of households in the study area is 6.01 TLU. Cattle, sheep, goats and poultry are the main livestock reared by sample households in both districts. Few equines (mostly donkeys) are also reared in the study area. Distance to market and an all-weather road, which was a proxy for market accessibility was found to have a positive and significant influence on intensity of SWC technology practicing.

Environmental and economic effectiveness of the SWC practices

Econometric model was used to assess the economic and environmental performance of biological and physical soil and water conservation practices. The factors that affected environmental performance in one hand affected economic level of the household in the other hand.

Environmental performances

Family size of the household (FS): As expected, this variable was statistically significant at less than 1% probability level and had a positive effect on the environmental performance (Table 3). The positive and the significant relationship indicated that as the number of family increases some may involve and might reduce labor constraints needed for the construction and maintenance of conservation measures. The marginal effect of the variable also confirms that for every increase in adult equivalent in the household, the probability of improvement of environmental performance increase by 34.2% (Table 3). Teshome et al. (2016) suggested that households who have more persons fulltime involved in agriculture are more likely to invest in and maintain SWC practices. This can be explained by the fact that labor inputs constitute the largest cost factors for SWC line interventions. This result is in agreement with Kebede and Mesele (2014) who reported the positive effect of age shows that with increasing age, farmers accumulate experience about the importance of land management. Similarly, larger family size leads to a lower land-man ratio, which normally should make investment in SWC more attractive (Bekele and Drake, 2003).

Frequency of extension services (FEXSR): As expected, this variable had positive relationship with environmental performance and statistically significant at 5% probability level (Table 3) The positive and significant correlation of contact with extension agents in this study implies that farmers having contacts with extension agents tend to understand the problem of soil erosion and the benefits of conservation measures on environment and they are more likely to continually use conservation structures (Adugnaw and Desalew, 2013). Contact with extension services enables farmers to have access to information on new innovations and advisory inputs on establishment and management of technologies.

Training (TR): As expected, this variable was statistically significant at less than 10% probability level and had a positive effect on the environmental performance (Table 3). Training delivered by development agents and district experts is one means to create awareness about the problems of erosion and the benefits of SWC measures to motivate farmers to invest in SWC measures. This result is consistent with Teshome et al. (2016) who reported training on SWC is positively related to the actual and final adoption phases of SWC measures, and further revealed that technical support (availability of training and SWC programs) influenced the continued use of SWC measures. The result of the marginal effect indicates that a unit increase in training would increase the probability of the environmental effectiveness of SWC measures by 0.19 %.

Types of physical soil water conservation (TPSWC): As expected, this variable had positive relationship with environmental performance and statistically significant at 5% probability level.

Types of biological soil water conservation (TBSWC): As expected, this variable had positive relationship with environmental performance and statistically significant at less than 1% probability level. This implies the SWC practices reduced soil erosion, enhanced soil fertility, encouraged water retention and facilitated the growth of vegetation. This result is in agreement with study of Akalu et al. (2014) who revealed that SWC practices have ecological, economic and social benefits. The finding is in line with Kirubel and Gebreyesus (2011) who reported that after the implementation of different SWC measures improves the micro climate of the area as a result of increasing vegetation cover. This is because of increasing vegetation cover in the sub watersheds, which is a direct reflection of the improvement of available water and soil fertility in the area for the greenness of the environment. The result of Amsalu (2006) indicates that farmers were encouraged to continue to use SWC practices perhaps due to effectiveness of the measure in erosion control on steep slopes.

Economic performance SWC practices

Studies made on farmers‟ decision on continued use of soil conservation structures and related theories indicated that wide range of social, demographic, socioeconomic, physical and institutional factors influence effectiveness (Table 4).

Access of input (ACCIP): As expected, this variable had positive relationship with household biological and physical soil and water conservation practices and statistically significant at less than 1% probability level (Table 4). Access to input would enhance implementation of soil and water conservation. This implies, as input, SWC tools needed for the construction of SWC measures (e.g., shovels, spades), seed and seedlings for plantation of biological SWC measures. The availability of efficiently working (conservation) tools is also a prerequisite for construction and maintenance of SWC measures (Teshome et al., 2016).

Total benefit of soil water conservation (TPSWC): Unexpectedly, this variable had negative relationship with SWC practices and statistically significant at less than 1% probability level. It indicates the fact that the benefits from investing in SWC practices accrue over time. The SWC practices are sometimes not profitable (economically performing) from a private-economic point of view (Kassie et al., 2011; Adimassu et al., 2012). This is because the ecological and social benefits of SWC practices were not quantified in monetary values (Teshome et al., 2014). This implies that these SWC practices are more technically effective than economically efficient (Amsalu and de Graaff, 2007). As Anteneh et al. (2014) noted, to ensure continued use, the conservation component must be profitable to the farmer. Particularly, farmers are very curious about the yield effect of the technology since the structures take up productive land, and maintenance is often labor intensive and costly. In addition, Yitayal and Adam (2014) conclude that SWC interventions may not result in significant improvement on crop productivity and income and hence there is a need to critically evaluate such a program regularly

Age of the household head (AGHH): It was a continuous variable measured in number of years. As expected, this variable had a positive relationship with biological and physical soil and water conservation practices and it was found to be statistically significant at less than 1% probability level. The positive and significant relationship indicates that age is a proxy measure of farming experience of household. Therefore,

Table 4. Determinants of economic level of the household in the study area.

Variable	Coef.	Z	P>/Z/
ACCIP	0.06	2.33	0.020**
TPSWC	-0.039	-2.27	0.023**
AGHH	0.080	4.19	0.000**
LIVESTOCK	0.110	2.38	0.017**
LAND SIZE	15.62	8.91	0.000***
TOTAL LAND TO LABOR	-124.43	-11.29	0.000***
FEXSR	-0.251	-1.85	0.064*
ACCR	-0.364	-2.19	0.029**
FI	0.301	1.74	0.082*

Number of observation =120, Censored observation = 38, Uncensored observation = 82 Wald; χ^2 (13) =1509.85, R^2 =0.945, Adj R^2=0.939. *, ** and *** represents significance at 10, 5 and 1% probability levels, respectively. Source: Model output of Own Survey data, 2016.

as the age of household increase, they would have better knowledge, experience. Similarly, Kebede and Mesele (2014) reported the positive effect of age shows that with increasing age, farmers accumulate experience about the importance of land management. The study of Amsalu and de Graaff (2007) indicated that the likelihood of adoption of conservation practices is more among older farmers than the younger ones, perhaps due to the experiences of older farmers to perceive erosion problems and their limited participation in off-farm activities.

Livestock: As expected, this variable had positive relationship with SWC practices and statistically significant at less than 1% probability level. This variable represents the livestock holding of the household in tropical livestock unit. The number of cattle, an indication of economic security, had a positive influence on performance of SWC. Livestock ownership is an important component of the farming system in the area since farming is integrated with crop and livestock production. Therefore, the fact that livestock is considered as an asset that could be used in the production process or exchanged for cash or other productive assets suggests a positive influence on conservation decision (Bekele and Drake, 2003). Our study result is inconsistent with Shiferaw and Holden (1998) who indicated more specialization into livestock away from cropping may reduce the economic impact of soil erosion and lower the need for soil conservation. Amsalu and de Graaff (2007) also showed that the effect of livestock on conservation decision is negative. On the other hand, those farmers who have large number of livestock may have more capital to invest in soil conservation practices. The results of Amsalu and de Graaff (2007) showed that the effect of livestock size with SWC practice decision was significantly negative. Large livestock size discourages conservation investments, perhaps due to the tendency of households to focus more on livestock than on crop production. In addition, temporal yield gains through manure application might reduce potential productivity losses due to erosion, and thus reduce conservation efforts.

Land size: As expected, this variable had a positive sign and significant at less than 1% level. The effect of cultivated land size is found to be positive and significant on the performance of SWC. Land shortage which partly aggravated the land degradation problem, because of population pressures on the natural resources base might lead to further land fragmentation, over-grazing, deforestations, steep slope cultivation and absence of fallowing, which in turn increase the accelerated soil erosion. Amsalu and de Graaff (2007) found positive and significant, suggesting that farmers who hold large farms are more likely to invest in conservation. As Teshome et al. (2016) indicated that the potential loss of land for SWC and temporal yield decline do not constrain SWC for large holdings.

Frequency of extension services (FEXSR): This variable had negative relationship with economic performance of SWC practices and statistically significant at 10% probability level. The negative and significant correlation of contact with extension agents in this study implies that farmers having fewer contacts with extension agents tend to understand the problem of soil erosion and the benefits of conservation measures and they are more likely to continually use conservation structures. But farmers with better access to information would be more willing to invest in soil conservation measures (Tesfaye et al., 2016). Kebede and Mesele (2014) reported development agents negatively influenced the continued use of SWC technologies by farmers due to their involvement in activities such as rural land-tax estimation. Farmers hesitate to contact the DAs, and thus are less likely to accept the technology to improve the economic effectiveness of SWC practices.

Access of credit (ACCR): As expected, this variable had negative relationship with SWC practices and statistically significant at 5% probability level. This indicated the farmers had no access to credit. Tenge et al. (2007) reported that availability of credit facilities is an important incentive for farmers to invest on SWC measures. The study of Tesfaye et al. *(*2016) shows that awareness raising among farmer communities with respect to the benefits of sustainable land use management seems crucial. In another study by Tesfaye et al. (2014) report that among the main driving forces behind farmers" decision to implement soil conservation measures are access to credit to pay for the initial investment costs.

Total land to labor ratio (TLLR): As expected, this variable had a negative sign and significant at less than 1% level. Land to labor ratio measured as the ratio of the area operated to the number of family members engaged in farming is used as an indicator of the population pressure. Households with lower land to labor ratio may have incentives to invest in soil conservation. Labor is also one of the crucial inputs for the implementation of soil conservation measures (Tesfaye et al., 2014). The amount of farm labor has an influence on the actual and maintenance of SWC measures. This suggests that households who have more persons fulltime involved in agriculture are more likely to invest in and maintain SWC measures. This can be explained by the fact that labor inputs constitute the largest cost factors for SWC interventions. Derjew et al. (2013) found that higher land labor ratio had negative influence on the use of conservation technologies negatively. Therefore, in this study it is found that higher land to labor ratio negatively related to the use of improved soil conservation technologies.

Lambda: According to the model output, the Lambda (Inverse Mills Ratio) or selectivity bias correction factor has positive, but statistically insignificant impact on economic level of the household.

Rho: Is the correlation between the error terms of the substantive and selection models. Rho has a potential range between -1 and +1 and can give some indication of the likely range of selection bias. A correlation with an absolute value of 1 would occur if the regression coefficients of the selection model and the regression coefficients of the substantive model were estimated by identical processes (that is, potential selection bias). Conversely, a value of rho closer to zero would suggest that data are missing randomly or the regression coefficients of the selection model and the regression coefficients of the substantive model were estimated by unrelated processes (that is, less evidence of selection bias) (Cuddeback et al., 2004).

CONCLUSION AND RECOMMENDATION

The Heckman two-step econometric estimation procedure was employed to assess the economic and environmental performance of SWC practices. The study was conducted to evaluate the environmental and economic effectiveness of SWC practices. SWC practices showed statistically significant and positive effect on the environmental effectiveness. Total benefit from SWC practices showed negative relationship with economic level of household. It indicates the fact that the benefits from investing in SWC practices accrue over time. Since farmers would likely continuously use SWC practices if the technology is profitable, the agriculture and natural resources office of the district should work to demonstrate the profitability of the measures. Development agents should practically show how conservation practices increase productivity and profitability by improving their approach. There should be consideration of the determinants affecting environmental and economic effectiveness of SWC such as profitability of SWC practices, social mobilization skill development agents, technical support, access to credit, and provision of efficiently working tools needed for the construction and maintenance of SWC when designing and implementing SWC practices from stakeholders.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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