Analysis of Factors Affecting Adoption of Soil Conservation Measures among Rural Households of Gursum District, Ethiopia

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ABSTRACT

Land degradation in the highlands of Ethiopia is reaching an irreversible state. It has become increasingly difficult to maintain the current level of production of basic food items. Government and non-governmental organizations have attempted to promote soil conservation technologies. However, their attempts have not succeeded in activating voluntary adoption to the expected level. This paper examines the main determinants of farmers' adoption decisions and the use intensity of level bund soil conservation measures using a cross-sectional sample of 280 farm households in the Gursum district of Eastern Ethiopia. Tobit analysis was employed to analyze the data. The results showed that highland agro-ecological location, slope, educational level of the household head, extension service, land tenure security, access to credit, and off-farm income are important factors that positively influence the adoption and intensity of use of level bunds in the study area, whereas livestock holding had a negative influence. This study suggested that to assure voluntary soil conservation adoption, the government needs to entrust land tenure security to farmers, promote formal and informal training on land management and utilization, and establish a targeted credit scheme that would integrate crop production and soil conservation in the study area.

Keywords: soil conservation, intensity of adoption, Tobit model, Ethiopia

บทคัดย่อ

การชะล้างพังทลายหน้าดินในแถบพื้นที่สูงของเอธิโอเปียได้ก้าวมาถึงระยะที่ไม่สามารถจะกลับเปลี่ยนไปสู่สภาพเดิมทำให้ยากต่อการที่จะรักษาระดับผลผลิตของพืชอาหารให้คงอยู่เท่าเดิม หน่วยราชการและองค์กรเอกชนได้ดำเนินการส่งเสริมเทคโนโลยีการอนุรักษ์ดินแก่เกษตรกรแต่ไม่สามารถจะสร้างการยอมรับโดยสมัครใจได้ตามเป้าหมาย บทความนี้วิเคราะห์การตัดสินใจของเกษตรกรในการยอมรับเทคโนโลยีการอนุรักษ์ดินและการทำกิจกรรมการอนุรักษ์ดินในรูปแบบของการทำคันดินแนวระดับ สัมภาษณ์ครัวเรือนเกษตรกรจำนวน 280 ครัวเรือน ในตำบลเกอร์ซัม ภาคตะวันออกของเอธิโอเปีย และวิเคราะห์ข้อมูลโดยใช้แบบจำลองโทบิท จากผลการวิเคราะห์พบว่าฟาร์มที่ตั้งในเขตนิเวศเกษตรพื้นที่สูง ความลาดชันของพื้นที่ระดับการศึกษาของหัวหน้าครัวเรือน การได้รับการส่งเสริม ความมั่นคงในการถือครอง

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ที่ดิน การเข้าถึงแหล่งสินเชื่อ และรายได้นอกฟาร์ม เป็นปัจจัยที่ส่งผลทางบวก ในขณะที่จำนวนปศุสัตว์ที่ครัวเรือนถือครองส่งผลทางลบต่อการยอมรับเทคโนโลยีและระดับการทำกิจกรรมการอนุรักษ์ดิน การศึกษาครั้งนี้มีข้อเสนอแนะว่าเพื่อเพิ่มระดับการยอมรับเทคโนโลยีการอนุรักษ์ดินโดยสมัครใจของเกษตรกร ภาครัฐจำเป็นต้องมีกลไกสร้างความมั่นคงด้านการถือครองที่ดิน ส่งเสริมการฝึกอบรมทักษะการใช้ประโยชน์และจัดการที่ดินอย่างเป็นทางการและไม่เป็นทางการ และจัดตั้งโครงการให้ความช่วยเหลือด้านสินเชื่อเพื่อบูรณาการด้านการเพาะปลูกพืชและการอนุรักษ์ดินแก่เกษตรกร

คำสำคัญ: การอนุรักษ์ดิน ระดับการยอมรับ แบบจำลองโทบิท เอธิโอเปีย

INTRODUCTION

Sustainable agricultural development is widely acknowledged to be a critical component of a development strategy to combat both poverty and environmental degradation. In many countries, degradation of agricultural land poses a serious threat to the future production potential and current livelihoods of the peasant households (Scherr, 1996). Ethiopia is one of the poorest countries on earth and is heavily dependent on peasant agriculture. The extensive degradation of its agricultural lands is most severe in the highlands of Ethiopia where pressure from humans and livestock is the greatest. The annual cost of onsite soil loss from soil degradation is estimated to be between 2–3 percent of Ethiopia's agricultural gross domestic product that was USD 5,528.7 million in 2005 (Yesuf *et al.*, 2005).

The economic importance of the effect of soil degradation is context specific and depends on the natural climate, level of economic development, and importance of agriculture to the national economy. The impact may be more remarkable in Ethiopia (Bekele and Drake, 2003). However, the possible impacts of land degradation problems were not properly understood prior to the landmark famine of 1974 that claimed the lives of 300,000 or the equivalent of 3 percent of the peasants of the country (Yeraswork, 2000).

Further, in 1978, a highly publicized article, which was circulated in the capital, Addis Ababa, pointed out that about one billion tons of top soil was being lost every year in the famine-stricken Ethiopian highlands (Brown and Wolf, 1978). In fact, famine has ravaged Ethiopia repeatedly. Following the 1974 Northern Ethiopian famine, the country faced an escalating problem similar to that experienced in its eastern regions in 1985. These facts raised awareness of the threat of soil erosion to the viability of smallholder agriculture. This awareness has also led to action and the government of Ethiopia has called for investment in soil conservation (SC) in famine stricken areas of the country. Hence, it is only very recently that the SC problem has received policy attention in Ethiopia (Shiferaw and Holden, 1998; Amsalu, 2006).

Since then, the government, in collaboration with international donor agencies (for example, the UN World Food Program), has undertaken SC programs. During such programs, the Eastern Ethiopian highlands were also targeted. Nevertheless, some studies (for example, Shiferaw and Holden, 1998; Yeraswork, 2000; Bekele and Drake, 2003) claimed that the programs did not succeed in activating voluntary adoption of conservation practice among farmers.

In January 2010, the population of the country reached 85 million (CIA, 2010) which is more than twice the population in 1975. The population is growing at a rate close to 3 percent per annum which has triggered farm holdings to become smaller and more fragmented. In addition, farmers are forced to cultivate fragile and marginal hilly lands. On top of this, farmers have become reluctant to adopt SC measures. This situation has exacerbated the complexity of land degradation in the country.

Nor is Eastern Ethiopia an exception to these problems. In this part of the country, where the study area was located, the situation is more serious. Here, the topography is so rugged and undulating that the farmland is heavily fragmented and fallowing is rare. It is, therefore, relevant to comprehend the factors that influence the adoption of SC measures by farmers in this district. An understanding of these factors would assist in the formulation and implementation of policy programs designed to promote voluntary adoption by farmers and to indicate future research directions. The purpose of this study was, therefore, to assess the extent of use of level bund SC technology and identify the factors that determine farmers' adoption of this SC technology in the Gursum district of Eastern Ethiopia.

THE STUDY AREA

The study was carried out in the rural areas of the Gursum district, Eastern Ethiopia situated in the northeastern part of the East Harerge zone of Oromia regional state. The rural areas cover an estimated area of 88,900 hectares under various land uses. According to a report from the District Disaster Prevention and Preparedness Office (DPPO) in 2007, 25.7 percent (22,847 ha) of this area was under cultivation and a further 17 percent (15,113 ha) was grazing land. Forest, bushes and shrubs made up 21 percent (18,669 ha) and the remainder was classified as settlement area. However, according to the same source, 48 percent of the total land area is degraded. The application of manure, fertilizers, crop rotation, and short fallowing methods are not extensively exercised in the district. To counteract the effect of soil degradation, farmers construct structural SC measures.

Farmers in the study area practice physical SC measures which include stone and soil bunds, and traditional and diversion ditches. Stone bunds are only found in very few areas in the district where the stone is available. Mostly, stone bunds are found in mountainous areas where the bunds are constructed by community participation in a farmer's field. Stone bunds harbor rodents and crop pests and are long term SC techniques which also take up a very large space on a farm. For these reasons, farmers do not like to construct stone bunds on their farms unless the problem of soil erosion is so severe that it cannot be managed by soil bunds. Soil bunds are the most dominant and widely practiced SC technique in the study area. Unlike the stone bunds, soil bunds take up less space and are a short term SC measure. Some farmers destroy the soil bunds and disperse the accumulated soil over the whole field every three to five years and later on they reconstruct the bunds in different locations on the farm. Other farmers also maintain their bunds and cultivate crops on them. The reason for destroying the bunds or cultivating crops on them is to make use of the accumulated and established soil on and around the bunds.

Traditional ditches are small furrow-like structures constructed each season after sowing on the same date. It is normally a cultivating practice and its main purpose is to protect the seed from being washed away and to drain excess water from the field and protect rill formation. Diversion ditches are constructed in the district on the upper side of the cultivated land in order to protect the farm from runoff coming from higher ground. Most often, they are constructed by groups of farmers.

The district has a bimodal rainfall distribution, with a short rainy season from March to May and a heavy primary rainy season from July to September. Agriculture in the area is characterized by small-scale subsistence mixed farming-systems, with livestock production as an integral part. Intercropping with sorghum, maize, and haricot beans dominates the cropping system.

Cash income for household financial requirements is mainly generated from the sale of livestock and crop products. Households facing seasonal food shortages and lacking access to credit to overcome the problem may, however, work as daily laborers for other farm households in exchange for food grains or cash. A limited number of households generate off-farm income. A few households also generate income from non-farm activities such as petty trading activities.

PREVIOUS STUDIES AND VARIABLES EXPLAINING ADOPTION OF SC

In measuring SC adoption and the adoption level, different authors have used various proxies, including the number of practices adopted (Baidu-Forson, 1999), the proportion of area by SC measure (Adesina and Zinnah, 1993), the meters per hectare adopted (Yirga, 2003; Gebremedhin and Swinton, 2003), the amount of money spent on SC (Illukpitiya and Gopalakrishnan, 2004), and the total number of days spent on SC (Araya and Adjaye, 2001).

SC decision variables used in adoption studies have often lacked a firm theoretical basis, possibly because economic theories do not provide a strong foundation for determining the factors affecting SC behavior (Norris and Batie, 1987). Besides, in the process of adoption, farmers may consider not only economic incentives but also a variety of other non–economic attributes (Bekele and Drake, 2003).

In the literature on SC adoption, the natural physical environment, together with social, economic, and institutional factors are important in determining SC decision-making behavior both in the developed and developing world. However, the specific socio-economic and institutional variables affecting decision-making behavior may differ between developed and developing countries and different sites within the same region and country, as well as between different farm households (Bekele and Drake, 2003). Moreover, the magnitude and direction of influence of the different variables vary between different types of conservation practices.

In the case of SC technology adoption, Mahboubi *et al.* (2005) emphasized that farmers' awareness of soil erosion problems was a prerequisite to adoption. Indeed, perception of soil erosion problems is frequently found to positively correlate with the adoption of SC technologies (Shiferaw and Holden, 1998; Bekele and Drake, 2003). Awareness also has something to do with the age of a farmer in influencing adoption. For example, although younger farmers have limited experience to detect the soil erosion problems, they adopt conservation practices once they perceive the problem is serious. Older farmers have more experience to perceive land degradation problems and are very responsive to adopting SC measures. Thus, it is often difficult to detect any correlation between the age of a farmer and adoption decisions of SC practices.

There is mixed evidence regarding the relationship between farmers' educational levels and their decision to adopt SC practices (Knowler and Bradshaw, 2007). In fact, education commonly correlates positively with the adoption of SC practices (Okoye, 1998). However, some studies have found education to negatively correlate with adoption (Shiferaw and Holden, 1998) or even to be an insignificant factor (Clay *et al.*, 1998). This has happened because most of the farmers in the survey were illiterate and the average level of education was too low to make any significant impact on the SC adoption decision.

One of the biophysical factors commonly assessed in many adoption studies, is farm size. Shiferaw and Holden (1998) showed that land size has a positive correlation with the adoption of SC technologies because conservation structures take proportionally more space on small farms so that the benefit from conservation may not compensate for the decline in production due to the loss in area devoted to conservation structures (Bekele and Drake, 2003). Nevertheless, some researchers showed that land size had a negative correlation with the adoption of SC technologies (for example, Clay *et al.*, 1998) when farming was the only source of income for the households and the opportunity cost of land degradation to small farm land owners was high. In a few instances, the correlation of land size with adoption of SC technologies was found to be insignificant (for example, Agbamu, 1995). This occurs when the economic importance of agriculture to a household is insignificant.

The physical characteristics and geographical location of the farm are correlated with the erosion potential of the land and adoption of SC measures (Shiferaw and Holden, 1998). In this regard, Bekele and Drake (2003) and Tiwari *et al.* (2008) showed that farms located within rainy regions and having steep slopes and erodible soils were positively associated with SC adoption.

With respect to tenure, conventional wisdom suggests that owned land is better maintained by farmers than leased land (Knowler and Bradshaw, 2007). Yirga (2003) also confirmed that improved security of land tenure significantly increased the probability and intensity of adoption of SC. However, other studies (for example, Lapar and Pandey, 1999) noted that improved land tenure is a necessary but not sufficient condition for smallholder farmers to undertake SC practices on their farms.

The presence of off-farm activities was found to positively influence SC adoption (Tiwari *et al.*, 2008). The type of SC technology was less labor intensive, so the presence of off-farm activities did not affect its adoption adversely, whereas off-farm income negatively influenced the SC adoption decision (Swinton, 2000). This could happen where farmers might give less attention to farmland when they received more income from the off-farm employment. Access to credit is also another important factor in the adoption decision. Tiwari *et al.* (2008) showed that there was a significant and positive relationship between access to credit and the willingness to invest in soil conservation.

Among the information sources that positively influence adoption often included in the SC adoption studies is contact with agricultural extension officers. However, Agbamu (1995) pointed out that, for the effect of this factor to be visible, the information dissemination needs to be effective, accurate or appropriate.

Some studies (for example, Bekele and Drake, 2003) hypothesized that the size of livestock holding affects the conservation decision positively but found a negative effect. Although the literature is not clear about the effect of livestock holdings on smallholders' conservation decisions, Shiferaw and Holden (1998) noted more specialization into livestock away from cropping may reduce the economic impact of soil erosion.

The effect of market access on the SC adoption decision is also ambiguous (Nkonya *et al.*, 2004). The closer the households are around the urban centers, the better the chance of employment opportunities and the less the dependence on agriculture will be. This may cause the economic importance of erosion to be reduced. Better market access may also increase the use of inputs and improve the productivity of crops that are oriented for market. Consequently, households may get increased income which would motivate them to give greater attention to SC activities as well (*ibid*).

RESEARCH METHOD

Sampling and data collection

In the study area, most crop production activities and a sedentary way of life exist only in the highlands and midland agro-ecological zones. It is in these zones that land degradation is severe and farmers practice SC activities to mitigate the problems of land degradation. There are some peasant associations (PAs) in both zones but access to them is difficult, although some are more accessible. Taking these facts into consideration, this study employed a purposive and stratified sampling technique to sample households. The study covered four PAs in the two zones, that is, two PAs from each zone. From these PAs, a total of 280 sample households were randomly selected proportional to the population size of the PAs. The survey was undertaken between December and March 2010.

Individual interviews, focus group discussions, key informant interviews, and field observation methods were undertaken to collect information on the adoption of SC technologies and farming systems using a checklist and a structured questionnaire. A structured survey questionnaire was prepared and pre-tested to undertake the household survey. The primary data collected included demographic characteristics, crop and livestock production, farming systems, productive resources, access to rural financial services, and land use and management, as well as livelihood strategies employed by the sample household.

Analytical method

The specific attributes influencing the utility of farmers and the adoption decisions were far from uniform. Nevertheless, the utility maximizing objective of individual farmers might be the same everywhere. Hence, farmers' adoption decisions on the SC technologies were assumed to be based upon utility maximization (see for example, Rahm and Huffman, 1984; Bekele and Drake, 2003).

For empirical purposes, the expected utility of adoption can be framed as a binary choice (adopt or not adopt), or as some continuous choice over a predefined interval or intensity of adoption. The former implies a logit or probit model, as in Shiferaw and Holden (1998), Lapar and Pandey (1999), and Amsalu (2006). However, to consider the intensity of adoption, a Tobit model is required, as in Lynne *et al.* (1988), Adesina and Zinnah (1993), and Baidu-Forson (1999). The present study also employed a Tobit model.

Let j=1 represent the adoption of a level bund SC measure and j=0 represent non-adoption and assume U_{ij} represents the utility from the *j* adoption decisions of farmer *i*. Let M represent the set of socioeconomic, institutional, and physical factors. Although not directly observable, the utility function of a representative farmer (*i*) from using a given measure (*j*) can be written as Equation 1:

$$U_{ij} = \alpha_j F_i(M_i) + e_{ij},\ j = 1, 0;\ i = 1,...,n \quad (1)$$

where α_j is parameter to be estimated and e_{ij} is a disturbance term with assumed zero mean and constant variance. The i^{th} farmer adopts, that is, if $U_{i1} > U_{i0}$ or if the non-observable (latent) random variable $Y^* = U_{i1} - U_{i0} > 0$. The probability that $Y_i = 1$ (that the farmer adopts the level bund SC technology) is a function of the independent variables:

$$\begin{aligned} P_i &= \Pr(Y_i = 1) = \Pr(U_{i1} > U_{i0}) \\ &= \Pr[(\alpha_1 F_i(M_i) + e_{i1} > \alpha_0 F_i(M_i) + e_{i0}] \\ &= \Pr[e_{i1} - e_{i0} > F_i(M_i)(\alpha_o - \alpha_1)] \\ &= \Pr[\varepsilon_i > -\beta F_i(M_i)] \Rightarrow 1 - G_\varepsilon[\beta F(M)] \\ &= F_i(\beta X_i) \end{aligned} \quad (2)$$

where X is the explanatory variable, and β are the parameters to be estimated, Pr(.) is a probability function, as e_{i1} and e_{i0} are random variables, $e_{i1} - e_{i0}$ is also a random variable, so ε_i is a random error term, $F(\beta X_i)$ is the accumulative distribution function for ε_i evaluated at βX_i, and $G_\varepsilon[\beta F(M)]$ is the probability that $\varepsilon < \beta F(M)$. The probability that a farmer will adopt the level bund SC technology is a function of the vector of explanatory variables and of the unknown parameters and error term.

Then, assuming ε_i is normal and F is a cumulative normal distribution function, following Baidu-Forson (1999), F is specified in the underlying stochastic model in Tobit form:

$$\begin{aligned} Y_i^* &= \beta X_i + \varepsilon_i \\ Y &= Y_i^* \text{ if } Y_i^* > 0 \\ Y &= 0 \quad \text{if } Y_i^* \le 0 \end{aligned} \quad (3)$$

where Y_i is the observed dependent variable, Y_i^* is the latent dependent variable, X_i , β and ε_i are as explained before. Equation (3) is referred to as the censored regression model or the Tobit model (Greene, 2008). The model, therefore, measures not only the probability that a farmer adopts the level bund SC technology but also the intensity of use of the technology once adopted.

The model coefficients are estimated by maximizing the Tobit likelihood function. However, the coefficients of the Tobit model may not be sensible to interpret in the same way as the coefficients in an uncensored linear model are interpreted (Norris and Batie, 1987; Greene, 2008). Hence, it is necessary to compute the derivatives of the estimated Tobit model to predict the effects of changes in the exogenous variables.

The Tobit model has an advantage in that its coefficients can be further disaggregated to determine the effect of a change in the *i*-th variable on changes in the probability of adopting the technology and the expected use intensity of the technology. The disaggregation of the coefficients can be made by the decomposition technique of the Tobit model that has been proposed by McDonald and Moffit (1980) and Maddala (1997). Accordingly, a change in X (explanatory variables) has two effects. It affects the conditional mean of Y_i in the positive part of the distribution, and it affects the probability that the observation will fall in that part of the distribution. A similar approach was used in this study.

Therefore, the marginal effect of an explanatory variable on the expected value (mean proportion) of the dependent variable is given by Equation 4 (Greene, 2008):

$$\frac{\partial E(Y_i)}{\partial (Y_i)} = F(z)\beta_i \quad (4)$$

where $\beta_i X_i/s$ is denoted by z. According to McDonald and Moffitt (1980), the change in the probability of using soil conservation measures as independent variable X_i changes is Equation 5:

$$\frac{\partial F(z)}{\partial (X_i)} = f(z)\frac{\beta_i}{\sigma} \quad (5)$$

where f and F are the density function and cumulative distribution function of Y_i^*, respectively. Finally, following McDonald and Moffitt (1980) and Norris and Batie (1987), the changes in the intensity of use with respect to a unit change in an explanatory variable among users can be given by Equation 6:

$$\frac{\partial E(Y^*)}{\partial X_i} = \beta_i\left[1 - Z\frac{f(z)}{F(z)} - \left(\frac{f(z)}{F(z)}\right)^2\right] \quad (6)$$

where $F(z)$ is the cumulative normal distribution of z, $f(z)$ is the value of the derivatives of the normal curve at a given point (unit normal density), z is the z-score for the area under the normal curve.

Variables used in the model

An adopter in this study was defined as a farmer that has allocated some area of the farm to establish level bund soil conservation structures. In other words, the dependent variable (adoption intensity) was measured by the proportion of the farm area with a level bund SC measure. Previous studies have related farmer's adoption behavior to various personal, physical, economic and/or institutional factors (for example, Ervin and Ervin, 1982; Norris and Batie, 1987; Shiferaw and Holden, 1998; Lapar and Pandey, 1999). The variables considered for investigation were based on the SC adoption literature. Their definitions, measurements, descriptive statistics, and anticipated effects are presented in Table 1. The data were estimated using a Tobit model.

RESULTS

Soil conservation measures

Farmers in the study area used both traditional and introduced soil bund measures. Though it was said that both soil bund measures had existed in the study area, in reality it was very difficult to distinguish which one was traditional and which one was not. According to the information of the District Disaster Prevention and Preparedness Office (DPPO) of the Agriculture and Rural Development Office (ARDO), key informants interviews and the researchers direct observation's of the structures, there was no marked difference between these technologies. The only differences that were mentioned by those consulted were the approaches in constructing the structures and whether they were constructed based on technical advice or not. Otherwise, they appeared to be exactly the same. Therefore, in this study they were treated as one conservation measure, (a level bund). Accordingly, the survey results revealed that 67 percent (188) of the 280 sampled households used level bunds.

Socioeconomic characteristics of sample households

Demographic characteristics

The average age of the head of the sample households was 42.25 years (Table 1). The heads of households that had adopted level bunds were older and had more years of schooling. There was a statistically significant mean age difference between the household heads of adopter and non adopter households. The mean household size of sample households in the study area was 6.26 members, composed of 2.37 children up to 14 years old, 3.81 adults between 15 and 64 years old, and 0.09 elders more than 64 years old.

Resource endowment

Landholding, labor availability and livestock holding are key resources to the rural livelihood in the study area. The land size in the study area varied between 0.125 and 2 ha among sample households. The average cultivated land holding for sample households was 0.58 hectare per household (Table

Table 1 Definition and measurement of variables used in the model

(n=280)

Variables	Definition and unit of measurement			
Dependent variable				
TOTASLBF	Percent area share of level bund in the farm			
Independent variable		Mean	SD	Expected sign
AGEHH	Age of household head	42.25	9.37	+/-
NECOAHMB	Number of economically active household members	3.17	1.27	+/-
EDUCTLEV	Educational level of household head in years	2.12	2.32	+
FREQEXCT	Frequency of contact with extension agent	1.52	0.93	+
LANDSIZE	Land holding in hectare	0.58	0.30	+
TLU	Livestock holding in tropical livestock unit (TLU)	2.62	1.34	+/-
MARKACC	Average distance to the nearest market in kilometers	4.69	3.15	+/-
OFFINC	Off-farm income earned in last production year, in Ethiopian Birr	498.54	545.3	+/-
PERCEPLD[O]	Perception of the household head regarding soil erosion problems: 1 if perceive, 0 otherwise.	0.84 (235)	0.37	+
LANDTSEC[O]	Land tenure security : 1 if the farmer feels land secured; 0 otherwise	0.73 (204)	0.45	+
AGROECO[O]	Agro-ecological location where the farmland found, 1 if highland, 0 if in midland.	0.63 (176)	0.48	+
SLOPE[O]	Slope category of a farm: 1 if the farmland is not plain or flat; 0 if it is flat.	0.58 (162)	0.49	+
ACCFCRT[O]	Access for credit, 1 if a farmer has access; 0 otherwise.	0.50 (139)	0.50	+

Note: [O] Mean for dummy variables indicating percent with value 1 and number in parenthesis represents frequency distribution

1). There was a statistically significant difference in the mean cultivated land holding between user and non user sample households of level bunds.

The average available labor was estimated to be 2.83 persons per day for all sample households. However, it was 2.87 and 2.75 persons per day for adopter and non adopter households of level bunds, respectively. There was no significant mean labor difference between the two sample groups.

Another important component of the farming system in the study area was livestock rearing. Sample farmers rear livestock (cattle, goat, sheep, equine animals, and poultry) for multiple purposes, including draftpower, milk, meat, eggs, and as a source of income. The average size of the livestock holding was 2.29 and 3.29 for adopters and non adopters of level bund, respectively, with a total sample average of 2.62 livestock holding in tropical livestock units (TLU; Table 1). The difference in livestock holding between the two sample groups was found to be statistically highly significant ($p < .000$).

Empirical results

The results of the level bund SC adoption analysis are presented in Table 2. The Tobit coefficients and their standard errors are given in the first and second columns. The frequency of contact with an extension agent, educational level of the household head, off-farm income, access to credit, land tenure security, agro-ecological location, and slope of the farm significantly and positively impacted on the level of bund adoption and the adoption level, whereas livestock holding had a significant negative influence. Although the cultivated land size and market access were not significant at the chosen levels, the positive sign of their Tobit coefficient indicates that these factors also favor the adoption of level bunds in the study area.

Table 2, (fourth column) shows the change in the probabilities of using level bunds when the variables change by one unit. For example, an increase of one visit in the frequency of contact by the extension agent with a farmer would result in an 11.44 percent increase in the probability of the adoption of level bund conservation measures, and ability to get access to formal credit, would result in a 16.86 percent increase in the probability of adoption of level bunds.

Table 2 Maximum likelihood estimates of Tobit model (level bund SC measure)

Variables	β_i	Standard error	Change in probabilities	Change among uses	Total change
CONSTANT	-4.64	1.23			
AGEHH	0.001	0.02	0.0001	0.0006	0.0004
NECOACHMB	-0.03	0.14	-0.0034	-0.02	-0.01
EDUCTLEV	0.25***	0.08	0.0318	0.18	0.13
FREQEXCT	1.12***	0.20	0.1144	0.82	0.58
LANDSIZE	0.04	0.61	0.0032	0.02	0.01
TLU	-0.25*	0.14	-0.0327	-0.19	-0.13
MARKACC	0.04	0.06	0.0051	0.03	0.02
OFFINC	0.001***	0.0003	0.0001	0.0008	0.0006
PERCEPLD	-0.12	0.55	-0.0150	-0.09	-0.06
LANDSEC	1.61***	0.45	0.2224	1.10	0.78
AGROECO	1.42***	0.40	0.1184	1.00	0.71
SLOPE	2.32***	0.39	0.3037	1.63	1.16
ACCFCRT	1.32***	0.35	0.1686	0.97	0.69

Note: * = $p < .10$; *** = $p < .01$

Further, the last two columns of Table 2, (columns 5 and 6), describe the change in intensity of adoption among users of level bunds, and the change in intensity of adoption over the entire sample households, respectively, when an independent variable changes by one unit. Hence, the result can be interpreted as, for example, an increase of one visit in the frequency of contact by the extension agent with a farmer would result in increases of 0.82 and 0.58 in the intensity of the adoption of level bunds among users and the whole sample households, respectively.

DISCUSSION

As expected, contact with extension agents and thus exposing farmers to available information stimulated the adoption rate and this result is consistent with innovation-diffusion theory. The model output also proved that education is an important instrument for households to make use of the available information and adopt level bund SC technology. These findings of the present study support one another and concur with the findings of Agbamu (1995), Okoye (1998), Illukpitiya and Gopalakrishnan (2004). This may have resulted from the fact that farm household heads with better education and receiving frequent visits from an extension agent helped them to understand the importance of conserving their farmland and adopt level bunds. This is an important indication of the role of education and extension services in the adoption of SC technologies in the district.

The results obtained that related to economic factors, off-farm income and access to credit, are in agreement with the results of Illukpitiya and Gopalakrishnan (2004) in Sri Lanka and Tiwari *et al.* (2008) in Nepal. These authors found and concluded that off-farm income and access to credit have direct correlations with the probability of adoption and use intensity. Like these countries, in Ethiopia, the public sector has no policy to undertake soil conservation activities on smallholders' land. Nevertheless, the existing financial support services and credit services from projects sponsored by the World Bank for the cultivation of new crops and livestock farming, and off-farm income have influenced the probability of adoption and use intensity of level bunds in the district.

The findings in the present study regarding tenure security reflects the existing situation in the Gursum district where no farmers have been taken off their land for any purpose and land redistribution has not taken place in the district for the past 19 years. Moreover, household heads have not been prevented from bequeathing land to their successors. Above all, soil bunds are not a long term SC measure. Therefore, the positive correlation between land tenure security and soil bunds under the existing situation would not be surprising. This finding is also in line with Gebremedhin and Swinton (2003) who reported the same result for the same type of SC technology.

The negative correlation of the size of the livestock holding with the adoption of level bunds in the present study agreed with the finding of Bekele and Drake (2003) who reported the same result for the same technology. In the Gursum district, because of the growing lucrative market for livestock, both domestically and in neighboring countries, households receive a high income from livestock which seemed to result in households paying less attention to the adoption of level bund SC technology. The present result also supports the argument of Shiferaw and Holden (1998) who said that more specialization into livestock away from crop production may reduce the economic impact of soil erosion and hence farmers may not be motivated to adopt SC technologies.

The study result regarding slope and agro-ecological location of a farm was in accord with other studies (for example, Ervin and Ervin, 1982; Norris and Batie, 1987; Lapar and Pandey, 1999). These authors also found that the physical erosion potential (explained by the slope and agro-ecological location of a farm) has a positive effect on SC adoption. This was also applicable in the present study area, as the Gursum district has rugged and hilly topography and the rainfall pattern also increases moving from the midland to the highlands. In addition, land cover is very poor and erosion is severe.

CONCLUSIONS AND POLICY IMPLICATION

The present study presents some results on factors that influence smallholders' adoption and the level of use of level bund SC technologies based on data collected in the degraded northeastern highlands of Ethiopia. The results of the Tobit model showed that the educational level of the household head, frequency of contact with an extension agent, off-farm income, access to credit, land tenure security, slope, and agro-ecological location of the farm have influenced the adoption and use intensity of level bunds positively and significantly whereas livestock holding has had a statistically significant and negative influence.

Land tenure security has been a major concern of land users in deciding whether or not to invest in measures to promote conservation on a long-term basis. The land users should have confidence in the legal provisions and enforcement mechanisms to guarantee their rights to the resource. Indeed, unlike the northern regions of Ethiopia, the regional government has not redistributed smallholders land for the past 19 years in the study area. However, there seems to be no guarantee to the farmers that redistribution of land will not occur in their district. This study indicates that land tenure security is an indispensable factor for the adoption of SC technologies. Therefore, smallholders' land registration and certification for the holding would serve to develop a sense of ownership of the holding.

The decision to adopt SC technologies is an investment decision which involves considerable uncertainty to the farmer. Thus, an additional level of training affects the level of knowledge that the farmer has about how SC technologies might work and affects his choice of the type and amount of information to acquire. Hence, to increase the adoption and level of use of SC, in addition to ensuring farmers conform with regulatory agricultural extension works, the government and NGOs need to focus on the provision of formal and informal training on the sustainable use of natural resources.

Further, the study results confirmed that credit access and off-farm income assisted the adoption of SC. The most important issue with respect to access to credit should be its link with land development and the initiation of off-farm and non-farm employment. Hence, there is a dire need for policy-led intervention to diversify the livelihood of households in the study area within and outside agriculture through establishing a targeted credit scheme for the smallholders.

The negative influence of livestock holding on the adoption and use intensity of the conservation technologies in the district needs to be critically considered by the policy makers and development organizations (ARDO and other NGOs). Both feed and food come from the farmland and land is very scarce in the district. Therefore, to make the income from livestock sustainable, the land should be conserved. The income from livestock need not discourage SC activity. Otherwise, in the long run, both the crop production and livestock production will be bankrupted. Therefore, the local government and NGOs need to adopt an integrated forage production and SC program in the study district as an important development intervention option.

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