Full Length Research Paper

Econometrics model on determinants of adoption and continued use of improved Soil and Water Conservation practices: the case of Boloso-Sore Woreda of Wolaita Zone, Ethiopia

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In the highlands of Ethiopia Soil degradation is a serious problem that threatens the sustainability of agriculture. Although efforts have been made to develop and promote several soil conservation technologies, their adoption has not been widespread. The major concern of this study was, to empirically examine the various personal, socio-economic, institutional and bio-physical factors that determine farmers’ decision on adoption and sustainable use of SWC technologies in Boloso Sore Woreda in SNNPR. A simple random sampling technique was employed to draw a total of 120 respondent households comprising 52 non-adopters and 68 adopters of SWC for the study. Descriptive statistics such as mean, standard deviation and percentages were used for analyzing the data. A binary logit model was employed to examine factors influencing the adoption and continued use of improved SWC. In this regard, a total of fourteen explanatory variables were included in the empirical model of which nine were significant. Among the major factors having significant influence on the adoption and continued use of improved SWC practices; education, farm size, slope and erosion levels, off-farm income, training and credit access have a positive and significant influence. Of these, the level of formal education in the household, training access and slope gradient of farm land were the most important in influencing the improved SWC adoption and continued use. Result of the study concluded that policy makers and development seekers must give due attention and high priority towards development of farmers’ capacity in improving the perception level that enables them to reflect attributes of an innovation. The survey results also indicated natural resource conservation policies that fail to account for inter household and inter-plot variation and the importance of physical factors (level of slope gradient and erosion) behind the use of soil conservation measures are unlikely to be effective.

Key words: Adoption, continued use, soil and water conservation, Logit Model; Boloso-sore woreda (Ethiopia).

INTRODUCTION

Background

Ethiopia is one of the world’s earliest countries in civilization which is endowed with a distinct wide range of agro-ecology that ranges from mountains and wetlands to valley and desert with a bountiful diversity in topography, climate and biological resources. Such diversity offers potentially favorable conditions for humans to live, though the potential has remained largely untapped as noticed in Wegayehu (2003).

Agriculture in Ethiopia is the main source of livelihood and national income in the country, which accounts for 47 percent of gross domestic product (GDP), 90 percent of total export earnings, and more than 80 percent of employment which makes agricultural land an indispensable resource upon which the welfare of the society is built. However, Agriculture remains predominantly subsistence, with smallholders cultivating more than 90 percent of total crop land and producing more than 90 percent of total agricultural output (World
The principal environmental problem in Ethiopia is land degradation, in the form of soil erosion, gully formation, soil fertility loss and severe soil moisture stress, which is partly the result of loss in soil depth and organic matter (Fitsum et al., 1999). Land degradation, owing mainly to poor land management and high population density, is the main cause of Ethiopia’s low agricultural productivity and vulnerability to drought. It can be described as a reduction of resource potential by a combination of processes acting on the land; such as soil erosion by water and wind, bringing about deterioration of the physical, chemical and biological properties of soil, which results in the soil’s inability to retain water, increased soil erosion and nutrient depletion (Maitima and Olson, 2001).

The excessive dependence of the Ethiopian rural population on natural resources, particularly land, as a means of livelihood is an underlying cause for land and other natural resources degradation (EPA, 1998; Wegayehu, 2003). The scale of the problem, however, dramatically increased due to the increase in deforestation, overgrazing, over cultivation, inappropriate farming practices, and increasing human population. The population density on arable land has more than doubled since 1950. Some 80 percent of the population still lives in rural areas, mainly in the highlands, where an estimated 50 percent of the land is degraded (WFP, 2005). Removing vegetative cover on steep slopes (slopes ranging between 15 and 50 percent) for agricultural expansion, firewood and other wood requirements as well as for grazing space has paved the way to massive soil erosion. Ethiopia loses annually 1.5 billion MT of topsoil from the highlands by erosion, which could have added about 1 to 1.5 billion MT of grain to the country’s harvest (Hurni, 1983 cited in Girma, 2001).

Despite the severity of the problem, it is only recently that land conservation has received policy attention in the country, the Ethiopian government first recognized the severity of the soil degradation problem following the 1973/74 famines in Wollo which drew the attention of external donors to land degradation problem and soon conservation become a priority (Berhanu and Swinton, 2003).

Although, the government has taken different soil and water conservation measures to mitigate land degradation problems in Ethiopia, the rate of adoption of the interventions is considerably low. According to information obtained from the Woreda BoA, in the study area there have been projects like especially, MERET and PSNP functioning since the past ten years, in the ten kebeles of the Boloso Sore Woreda. Review of relevant literatures points to the fact that a number of empirical studies have been undertaken on technology adoption under Ethiopian context (Table 1). However, no previous researches have been undertaken to assess and examine the extents to which farmers have adopted these improved soil conservation technologies and the main determinant factors affecting their adoption and sustainable use of the technologies. Moreover, many of the above studies lack the comparative evaluation of the indigenous and improved technologies with respect to the suitability to the local conditions and none of the achievements can also be extrapolated to the densely populated area of Bolos Sore Woreda of Wolaita Zone. Therefore, it becomes essential to investigate the main determinant factors, that would assist in the formulation and implementation of the policy and technology interventions designed to induce voluntary and continued use of SWC measures in the study area.

**OBJECTIVE OF THE STUDY**

**General objectives:**

To examine/assess the various personal, socio-economic, institutional and bio-physical factors that determine farmers’ decision on adoption and continued use of soil conservation technologies in Bolos Sore Woreda.

**Specific objectives:**

- To describe the current soil conservation practices (indigenous and/or improved) employed by farmers
- To identify the most important factors that determine farmers’ adoption decision on improved soil conservation measures.

**STUDY METHODOLOGY**

**Description of the Site**

**Location**

Boloso Sore is one of the 77 Woredas in the Southern Nations, Nationalities and Peoples’ Region of Ethiopia which is located at about 420 km from Addis Ababa in Wolaita Zone, 7°05′N 37°40′E / 7.083°N 37.667°E (Wikipedia, the free encyclopedia, 2011). Part of the Semien Omo Zone, Boloso Sore is bordered on the south by Sodo Zuria, on the southwest by Kindo Koysa, on the west by Loma Bosa, on the north by the Kembata Alaba and Tembaro Zone, on the northeast by the Hadiya Zone, and on the east by Damot Gale with the administrative center at Areka.

**Demographics**

Based on figures published by the Central Statistical Agency (2005), the Woreda has an estimated total population of 358,694, of whom 182,983 were men and 175,711 were women; 31,740 or 8.85% of its population...
Table 1: Distribution of sample households in sampled kebeles.

<table>
<thead>
<tr>
<th>Kebeles</th>
<th>Household Total Size</th>
<th>Sample Farmers</th>
<th>Total Sample size</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Non-adopter</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Adopter</td>
<td></td>
</tr>
<tr>
<td>Dolla</td>
<td>984</td>
<td>16</td>
<td>39</td>
</tr>
<tr>
<td>Dengera-medelicho</td>
<td>1042</td>
<td>17</td>
<td>40</td>
</tr>
<tr>
<td>Gurmo-koisha</td>
<td>1480</td>
<td>19</td>
<td>41</td>
</tr>
<tr>
<td>Total</td>
<td>3506</td>
<td>52</td>
<td>120</td>
</tr>
</tbody>
</table>

are urban dwellers, which is greater than the Zone average of 8.5% (CSA, 2005). With an estimated area of 632.66 square kilometers, Boloso Sore has an estimated population density of 567 people per square kilometer, which is greater than the Zone average of 156.5.

Topography, climate and soil type

Altitude ranges between 1800 and 2400 m.a.s.l., with undulating topography. Its slope ranges from 4 up to 60%. There are also seasonal and intermittent streams, with steep slopes. The area receives an annual rainfall of 1,578 mm and the mean maximum and minimum daily temperature are 25.4 °C and 13.4 °C. The rainfall is bimodal with two growing periods, the small rainy season (belg), extends from March to June. Main rainy season (meher) has duration from July to the end of October. The soils in the woreda vary from place to place but nitosols are the common ones (Wikipedia, the free encyclopedia, 2011).

Socio-economic and land use activities

The subsistence based living of the people in the area are highly dependent on agriculture production in which it is not more than hand to mouth. They are using mixed farming system. The main land covers of the area are perennials and seasonal crops such as; enset (a staple food of the area), coffee, cabbage, maize, haricot beans, sorghum, barley and teff (Eragrostis teff), sweet potato, Irish potato, taro, cassava and yam are important in the area. Crops like maize, haricot bean, enset, sweet potato and Irish potato are planted in the belg season. Crops like teff, wheat, Irish potato, haricot bean, and sweet potato are planted in the meher season. Furthermore, vegetation covers in the area are natural and plantation forest. The natural as well as plantation forest consists of low land coverage while plantation forest is mostly used monoculture system or exotic species.

METHODS OF DATA COLLECTION

Sampling method

In the first stage, Boloso-Sore Woreda was purposively selected for the study because of the fact that the improved SWC technology is widely popularized mainly by MERET and PSNP projects. Three kebeles, namely Dolla, Dengere-medalicho and Gurmo-koisha were also purposively selected by considering the severity of land degradation, previous and current efforts undertaken to mitigate the problem and enhance the sustainability of mitigation measures. In addition, the diffusion and implementation of improved soil conservation technologies were undertaken only in dega and woyna dega climatic zones, the selected kebeles are also found in these two climatic zones. In this study simple random sampling was selected as a preferred sampling method because each sample in the population has equal chance of being selected. In addition simple random sampling is an appropriate sampling method when small scale surveys (like the present study) are conducted, the estimation of sampling errors and significance tests could be based upon simple random sampling procedure. The survey covered 120 household heads (68 from the adopter and 52 from non-adopter household) randomly selected from the three kebeles. With regard to the sampling technique, proportional random sampling technique was used to select sample respondents from each kebeles (Table 1).

Data collection method

For this study both primary and secondary data sources were used. The primary data was collected from sample farmers and others such as Woreda experts and development agents who have involved in soil conservation in the study area using both formal, informal surveys and transect walks. Beside these, the study also employed information from secondary sources. Pilot study and transect walks across the village were conducted in order to obtain environmental and economic profile and other necessary information on the types of existing indigenous and improved SWC works undertaken.

Prior to the formal survey focus group discussions (FGD) were conducted in each of the three kebeles with people assumed to have sufficient information about the general features of the area to acquire useful and detailed information, which would have been difficult to collect through the questionnaire survey. Based on the
information obtained and learnt experience from the focus group discussion, questionnaire that was used latter in the formal survey. Moreover, the questionnaire was pre-tested for its appropriateness and further improvements also amended before it was used in the formal survey.

Formal survey was then conducted using structured questionnaires to gather information from sampled farmers’ households. The survey questionnaires included both open and close ended questions which were pre-tested by administering it to selected respondents. Subsequently, on the basis of the results obtained from the pretest, necessary modifications were made on the questionnaire which was ultimately translated from English into Amharic. Enumerators or data collectors were oriented and trained about the objectives of the study, the types of data required, the number and types of sample respondents to be interviewed before they start collecting the data and the collection of the data was undertaken with close supervision of the investigator. The enumerators selected for the survey were all speakers of the local language, Wolaitigna.

Beside these, the study also employed information from secondary sources which were obtained from various sources such as reports of MoA at different levels, CSA, Woreda and Kebele Administrative Office, NGOs, previous research findings, Internet and other published and unpublished materials, which were found to be relevant to the study.

**Model Specification, Variables Definition and Data Analysis**

The data obtained from this study was analyzed in two ways; using descriptive statistics and econometric model.

**The logit model**

Binary explanatory variables can be represented as dummy variables and a binary choice model assumes occurrences between two alternatives (in this case being adopter or non-adopter of improved soil and water conservation practices).

There are several methods to analyze the data involving binary outcomes. However, for this particular study, logit model was selected. The linear probability model (LPM) which is expressed as a linear function of the explanatory variables is computationally simple. However, despite its computational simplicity, as endorsed by Gujarati (2004), it has a serious defect in that the estimated probability values can lie outside the normal 0-1 range. Hence logit model is advantageous over LPM in that the probabilities are bound between 0 and 1. Moreover, logit best fits to the non-linear relationship between the probabilities and the explanatory variables. The dependent variable in this case is a dummy variable, which takes a value of zero or one depending on whether or not a farmer is adopter or non-adopter of improved soil and water conservation practices.

However, the independent variables are both continuous and binary. In this study, logistic econometric model was used to identify the factors (the independent variables) that affect farmers’ decision of adopting improved soil and water conservation practices in the study area. According to Chatterjee and Bertran (1991) the cumulative logistic probability function is specified econometrically as:

\[
P_i = F(Z_i) = \frac{1}{1 + e^{-Z_i}}
\]

\[
1 - P_i = 1 - F(Z_i) = \frac{1}{1 + e^{-Z_i}}
\]

(1) (2)

Where:

- \( P_i \) represents the probability of that \( i^{th} \) household making a certain choice (in this case being either adopter or non-adopter of improved soil and water conservation practices), for the given explanatory variables \( X_i \);
- \( e \) represents the base of natural logarithms (2.718);
- \( X_i \) represents the \( i^{th} \) household explanatory variables;
- \( n \) represents the number of explanatory variables, \( i = 1, 2, 3 \ldots, n \) and
- \( \alpha \) and \( \beta \) are regression parameters to be estimated, where \( \alpha \) is the intercept and \( \beta \) is the coefficients of \( X_i \) Coefficient interpretation will be understandable if the logistic model once written in terms of the odds and log of odds (Hosmer and Lemeshow, 1989). The odds ratio is simply the ratio of the probability of being adopter of the technology \( (P_i) \) to the probability that the farmer would be non-adopter \( (1-P_i) \). Therefore, the odds ratio will become:

\[
\frac{P_i}{1 - P_i} = \frac{1 + e^{Z_i}}{1 + e^{-Z_i}} = e^{\alpha + \sum_{i=1}^{n} \beta_i X_i}
\]

(3)

However, the \( P_i \) is non-linear, and therefore, to get linearity, taking the natural logarithms of odds ratio of equation (3), will result in the logit model as indicated in
equation (4) and the coefficient of the logit model presents the change in the log of the odds associated with a change in the explanatory variables.

\[ x_i = \ln \left( \frac{P_i}{1 - P_i} \right) = \alpha + \sum_{j=1}^{n} \beta_j x_{ij} = \alpha + \beta_1 x_{1i} + \beta_2 x_{2i} + \ldots + \beta_n x_{ni} \]  

(4)

Therefore, in the logistic model, as \( P \) (probability of the logit) goes from 0 to 1 which is not linear, \( Z \) (the logit) goes from \(-\infty\) to \(+\infty\) (which has no boundary but linear). As the logit (\( Z \)) becomes negative and increasingly large in magnitude then the odds ratio decreases from 1 to 0 and as \( Z \) becomes positive and increasingly large then the odds ratio increases from 1 to \(+\infty\). Coefficient interpretation will be understandable if the logistic model once written in terms of the odds ratio. The intercept is the value of the log odds in favor of adopting/not adopting the SWC if the other independent variables are zero.

VARIABLE DEFINITIONS

Dependent variables

Farmers adoption decision (ADPTOR): The dummy adoption decision whether to adopt or not adopt improved soil and water conservation practices in the study area. This variable is the dependent variable that is to be regressed in the Logistic linear regression model. The dependent variable will take values of 1 if the farmer decides to adopt the improved soil and water conservation practices, and 0, otherwise in the survey time.

Independent variables

Different theoretical and empirical studies conducted elsewhere on factors influencing adoption of agricultural technologies indicate the role of many personal, institutional, socio-economic and bio-physical factors in determining farmer’s adoption decision. The independent variables of the study were those which were expected (hypothesized) to have association with the adoption of agricultural technologies on basis of past research studies, based on the literature by Gujarati (2004) and prior knowledge of the study area.

Data analysis

The data collected from the farmers and other sources was analyzed using descriptive and econometric models. For the analytical methodologies, two statistical packages were used: SPSS 16 and LIMDEP 7 econometric software. The former package was used for descriptive analysis which used counts, percentages, means, standard deviations, chi-square and t-values in examining farmers’ demographic, physical, institutional, attitudinal and socio-economic characteristics. While the later (LIMDEP 7, according to Gujarati (2004) has built-in routines to estimate the logit model at the individual level) was put into use only for econometric analysis, i.e. logistic regression model which was used to identify the most important factors that affect farmers’ adoption decision of the sustainable use of improved SWC practices in the study area.

RESULTS AND DISCUSSIONS

In this chapter reports on the findings of descriptive and econometric analysis in line with the different adoption categories are presented.

Descriptive Statistics Results

As indicated above, the survey covered 120 household heads (68 from the adopter and 52 from non-adopter household) randomly selected from the three kebeles. The sample composed of 87% male headed households and 13% female-headed households.

The mean age for the non-adopter (41) and adopters (40) was almost similar. The non-adopters had slightly larger family size (7.37) than the adopters (6.68 persons). From a total of 61 (51%) illiterate household head respondents, about 33% and 67% were adopters and non-adopters, respectively. Adopters of improved SWC had an average of 24.75 years of farming experience. The corresponding figure for the non-adopters was 25.81 years. The average size of farmland owned by the sample respondents was 0.94 ha. Adopters owned, on average, almost similar farm size (0.94 ha) with that of the non-adopters (0.95 ha). Adopter and non-adopters have similarity in the possession of grown major annual crops like wheat, barley, bean, haricot-bean, maize, tef, sweet-potato, potato, and taro. From very limited types of perennial crops grown in the study area, namely enset, coffee, banana, avocado and mango, adopter relatively had higher possession of fruit perennial crops of banana, avocado and mango. The average size of livestock owned by the sample respondents was 2.65. Non-adopters owned, on average, slightly larger livestock size (2.72) than that of the adopters (2.60). The average off-farm income of the sample respondents was 141.77 birr. On average, non-adopter farmers earned birr 211.06 from off-farm activities as compared to only birr 88.78 for adopter farmers.

From a total of 120 respondent 70 (58%) owned farm land with gentle slope followed by 31 (26%) and 19 (16%) for flat and steep slopes respectively. Of the 31 household respondents who owned farm land with flat slope, 30 (97%) were non-adopters of the improved SWC practices. On the contrary from a total number of 19 household respondents who owned farm land with steep slopes, 17 (89%) were found out to be adopters of the improved SWC technologies. Rill and gully erosion
ECONOMETRIC ANALYSIS

Elaboration on explanatory variables

The goodness-of-fit measurements of the model are also given in the Table 3. The computed log likelihood ratio statistics (Chi-square) exceed the Chi-square critical values at 1 percent significance level confirming that the independent variables taken together influence the adoption of improved SWC technology.

Another goodness of fit measurement is computing the
ratio of number of correct predictions to total number of observation for both adopters and non-adopters to find the number of observations that are correctly predicted. The method is based on the principle that if the estimated probability of the event is less than 0.5, the event will not occur and if it is greater than 0.5 the event will occur. The result shows that the logistic regression model correctly predicted about 94.11 percent and 94.23 percent for adopters and non-adopters, respectively (Table 2). The higher values of the sensitivity and specificity measurements indicate the better classification of the events using the specified model.

The estimated coefficients of the logistic regression model shows that out of the fourteen variables that were hypothesized to explain factors affecting use of improved SWC technologies, nine (64.3%) of the variables were found to be significant, while the remaining five were not significant in explaining the variations in the dependent variable. From the nine statistically significant independent variables 3 were statistically significant at less than 1% probability level and the rest 6 were significant at 5% probability level. More specifically, the coefficients of education level (EDUHD) of the household head, slope gradient of farm land (SLOPGR) and training access (TRAINACS) on the improved SWC technologies were significant at less than 1% probability level. The coefficients of family size (FAMHSZ), farm size (FARMHSZ), erosion type/severity (EROTP), off-farm income (OFRMINC), credit access (CRDTACS), and possession of livestock were significant at 5% probability level. Of the 14 explanatory variables hypothesized to influence willingness of farmers’ to participate in soil conservation practices, 5 variables (age of household head-AGEHD, sex of household head-SEXHD, experience of the household head in farming-FRMEXP, soil fertility status of the farm-SOILFERT, and extension service access-EXTSRV) were less powerful in explaining farmers’ willingness to adopt the improved soil conservation practices, as their coefficients were non-significant at 1% and 5% probability level. The coefficients of the five variables were not statistically significant at the conventional probability levels implying that they were less important in explaining the variability in the willingness to adopt improved soil conservation practices.

The maximum likelihood estimates of the logistic regression model show that family size (FAMHSZ), education level (EDUHD), farm size (FARMHSZ), slope gradient (SLOPGR), erosion type (EROTP), off-farm income (OFRMINC), training access (TRAINACS), credit (CRDTACS) and livestock were important factors influencing use of improved SWC practices by farmers.

CONCLUSION

• Training farmers through strengthening and establishing both formal and informal type of framers' education, farmers' training centers, technical and vocational schools should be enhanced. In the future during introduction of improved SWC, more focus and attention should be given to educated farmers who are dynamic towards innovations and serving as a role model to change the community.

• Creating sufficient awareness to farmers about family planning in any development interventions performed by government and non-government organization is very vital. It would be better to acquaint the improved SWC technologies with other income generating and food security assuring crops (e.g. horticultural crops) especially to household having more family size. Empowering women participation has also a paramount importance, since the burden of feeding the family is most of the time levied on the women’s shoulder.

• SWC structures are more likely to be adopted and sustainably used if implemented and maintained on farm lands having steep slopes and high erosion intensity by giving the priority for it rather than employing them recklessly on fertile lands having no slope and erosion problems, because of limitations of resources.

• Any program and policy aimed at rural development has to give due attention and priority towards increasing the perception levels of farmers through organizing and facilitating experience-sharing programs at different levels. This implies the extension programs should give emphasis on establishing trainings and demonstration sites on SWC structures and the benefits to create sharing of new ideas among the farmers by testing the technology at their own locality.

• Due attention and policy consideration has to be given at improving off-farm income of farmers that can be achieved through introduction of better and new technologies that can improve off-farm income, provision of timely available credit that help in purchasing inputs and undertake supporting off-farm activities and establishment of infrastructure such as roads and networks for facilitating markets.

• Future intervention in SWC would be more attractive as the area of farm land is larger. If there is a necessity to employ the conservation work in small farm lands having high slopes and erosion problems, the existing improved SWC technology should harmonize integration with high value and market demanding crops. This would bring profitable returns for the farmers for the costs they incur for the construction and maintenance works and increase their enthusiasm toward continued use of the technologies.

• Specific technology shouldn’t be enforced to be adopted by all farmers in a specific targeted area. Side by side effort should be made to appreciate and strengthen the farmers’ area of interest and specialization rather than enforcing them to adopt the technology, which ultimately bring failures and misuse of funds.
REFERENCES


