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Factors Affecting the Use of Soil Conservation Measures by Upland Farmers in the Walawe River Watershed

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ABSTRACT. Many of the economic studies on soil conservation have been carried out in the upper Mahaweli watershed (UMW). It is cost effective if the findings of such studies can be readily extended to other watersheds, as proper management of other small watersheds is important. This study examines the factors influencing soil conservation decisions by farmers in the Walawe river upper watershed. Seventy farmers were interviewed with a structured questionnaire and the data were incorporated in a Tobit regression model with nine socio economic variables. Results reveal that two poverty related variables, farm size and asset level significantly influence soil conservation decisions by farmers. Physical potential for soil erosion is not a determinant of soil conservation. Comparison with a previous study conducted in UMW shows that results from one site cannot be readily extended to another site when two communities make decisions under different social, economic and institutional environments.

INTRODUCTION

Soil erosion from agricultural lands in the watersheds of Sri Lanka is a serious problem (Gunatilake, 1998; Gunatilake and Gunawardena, 1990). Mountainous lands account for about 20% of the total land area in Sri Lanka and about 3 million people live in the upland watersheds. These upland communities are characterized by widespread poverty and technological constraints which enhance the degradation of arable land (Kariyawasam, 1997). Soil erosion, on the one hand, reduces the productivity of the lands in the long run. On the other hand, eroded soils get into the water ways causing a series of off-site effects such as water pollution, reduction of reservoir capacity, reduction of irrigation capacity, increased frequency of floods, *etc.* In a free market economic system, farmers are expected to bear the on-site cost of soil erosion. However, off-site costs have to be born by the society, hence, appropriate public policies are crucial in curtailing soil erosion to a socially optimal level (Gunatilake, 2000). Designing and implementing appropriate soil conservation policies require site specific information on the socio-economic factors influencing soil conservation practices (Lynne *et al.*, 1988; Gunatilake and Abeygunawardena, 1992).

Soil erosion is a long-term problem that determines intergenerational transfer of wealth. Lack of investment in soil erosion means that future generations will have to bear the costs, such as the loss of productive capacity of the land and degradation of the

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downstream systems. Investment in soil erosion means reallocation of scarce resources available for other economic opportunities for the present generation (Pakpahan, 1992). Therefore, soil erosion represents an inter-temporal externality (Gunatilake, 2000). In many developing countries, the solutions to soil erosion problems were perceived in technological improvements and legislative measures (Blaikie, 1985). Soil conservation technologies, however, must be compatible with socio-economic concerns. Compatibility of technology and various socio-economic aspects is critically important for the success of a soil conservation program (Singh, 1992).

Gunatilake and Abeygunawardena (1992) have assessed the socio-economic factors affecting the use of soil conservation measures by tobacco farmers in the upper Mahaweli watershed (UMW). This study covers a sample of 120 farmers and applies a Tobit model in its analysis. Results of this study reveal that informal education, perception on soil erosion, positive attitudes towards environmental conservation positively influence the use of soil conservation measures. Farmers who have received soil conservation subsidies have shown better use of soil conservation measures. Dominance of profit attitudes and insecure land tenure have been identified as constraints in adoption of soil conservation measures. In another study, Gunatilake and Abeygunawardena (1993) used a mathematical programming model to show that poverty forces farmers to use erosive land use practices in the UMW.

Economic studies on soil erosion in Sri Lanka show an asymmetry in terms of site selection, as a majority of the previous studies were conducted in the UMW. Being the largest and economically most important watershed of Sri Lanka, attracting a major emphasis by UMW is not surprising. However, proper management of other small watersheds is also very important in terms of the overall environmental management of the country. Whether the findings of the studies carried out in the UMW can readily be extended to other small watersheds is questionable. Against this background, our objective is to carry out a study on factors influencing the use of soil conservation measures in the Walawe river upper watershed, and to compare the result with a similar study in the UMW by Gunatilake and Abeygunawardena (1992).

THEORETICAL FOUNDATION

The decision to use soil conservation practices (adoption) and the extensiveness of the used conservation practices (efforts) are determined by various personal, economic, institutional, and physical factors. This section describes how such factors possibly affect soil conservation and states the related hypotheses.

Age

Younger farmers may have better education and may be more involved with current innovative farming practices. As a result they may be more aware of soil erosion problems and available solutions. The shorter planing horizon and less than perfect capitalization of yield changes are the other reasons for older farmers not to apply soil conservation practices (Lee, 1980; Norris and Batie, 1987; McDowel and Sparts, 1989).

Education

Higher education is assumed to be associated with the access to new information on consequences of soil erosion and conservation measures as well as higher management expertise. Moreover, understanding of biological sciences or ecology is expected to create a positive impact on conservation in the decision making process. Abeygunawardena (1983), Noris and Batie (1987) and McDowel and Sparts (1989) hypothesized a positive relationship between education and conservation efforts.

Income or wealth

Higher income reduces the financial constraints to adopt conservation. Wealthy farmers who have higher social status usually have better access to the institutional support given for conservation (Blaike, 1985; Gunatilake, 2000). It is, therefore, assumed that there is a positive relationship between conservation effort and income or wealth.

Debt level

An anticipated reaction to higher debt levels is to exploit the soil resource without investing on soil conservation (Blakie, 1985).

Farm size

Operators of larger farms are likely to spend more money on conservation because in many cases a large farm size is associated with capital availability which make investment in conservation feasible. Large holders may enjoy economies of scale and hence generate higher surpluses (Gunatilake, 2000). Therefore, they may not face cash flow restrictions faced by small holders.

Subsidy

Receiving subsidy for soil conservation is expected to promote conservation effort since subsidies remove the financial constraint for conservation faced by many farmers. A positive relationship between conservation efforts and receiving subsidy is assumed (Gunatilake and Abeygunawardena, 1992).

Land tenure

It is generally accepted that farmers who cultivate others' land are less likely to invest in soil conservation because of many reasons. For instance, because of the perceived insecurity of his tenancy a tenant might find it profitable to mine the soil since he is not sure of receiving the benefit of conservation. Tenants are in general, poor farmers and they use part of their income as rent for the land, which act as a financial obstacle for soil conservation. Landowners may not be willing to invest on soil conservation in rented lands because they know that a part of the on–farm benefits of conservation would go to the tenants (Ervin, 1986). Therefore, a negative relationship between land tenure and soil conservation is assumed.

Erosion potential

Some factors described in universal soil loss equations such as slope, slope length, management factors, soil types are considered here. It is expected that farmers who face severe erosion potential are more likely to practice conservation (Abeygunawardena, 1983; Ervin and Ervin, 1982).

METHODS AND DATA

About 27% of the land area in the Walawe river upper watershed is under cultivation. Land uses include tea, rainfed crops, chena cultivation and homestead gardens. Tea is the main crop in the Walawe river upper watershed as 55% of the cultivated lands are under it. Therefore, management of the tea lands has a direct bearing on healthy sustenance of the watershed. Homestead gardens are composed of a residential unit and a cultivation of mixed fruit trees, spices, coconut and other plantation crops. Paddy cultivation is carried out in valleys. The prominent soil type in most part of the Walawe river upper watershed is Red Yellow Podzolics (Ultisols). In addition, Reddish Brown Latosols (Inceptisols), Immature Brown Loams (Inceptisols) and Reddish Brown Earth (Alfisols) are also found in intermediate and drier areas of the watershed. The lands are mostly mountainous and slopy where vulnerability to soil erosion is high (National Atlas of Sri Lanka, 1998).

In this study, a Tobit regression model is used to evaluate the relationship among investment on soil conservation measures and above mentioned physical, socio-economic, personal and institutional factors. There are different methods of measuring the adoption of soil conservation methods such as willingness to adoption, the actual adoption, and the conservation effort, difference between rate of erosion before and after conservation and expenditure on soil erosion. The adoption of soil conservation measures included both decisions to adopt soil conservation measures and the conservation effort (Gunatilake and Abeygunawardena, 1992). Soil conservation expenditure was used to measure the adoption and efforts on soil conservation in this study. This variable includes total capital expenditure, annual maintenance cost, and cost of family labour used in construction and maintenance of conservation measures. Soil conservation expenditure was used as the dependent variable in the Tobit model. This dependent variable is a limited dependent variable as it is partly qualitative and partly quantitative. In such situations OLS regression provide inconsistent estimates and Tobit regression is the appropriate technique (Judge *et al.*, 1988; Greene, 1993). The model is represented as:

$$Y_i = \beta_0 + \sum_i \beta_i X_i + U_i$$

Where, Y = total soil conservation expenditure
(Y = 0, means the farmer did not adopt any conservation measures.
Y > 1, indicated the farmer has adopted some conservation measures.)

X = independent variables
U = error term

Independent variables used in the model are:

X_1 = Formal education
X_2 = Age
X_3 = Value of total assets
X_4 = Off-farm employment
X_5 = Land tenure
X_6 = Debt level
X_7 = Subsidy
X_8 = Erosion potential
X_9 = Farm size

The data for this study were gathered using a structured questionnaire. The questionnaire was based on earlier work of Gunatilake and Abeygunawardena (1992). The total sample of 70 farmers was selected randomly. The survey was carried out in the Imbulpe and Balangoda Divisional Secretary divisions within the Walawe river upper watershed located in intermediate upcountry- zone 2 (IU-2), intermediate upcountry- zone 3 (IU-3), intermediate mid country- zone 2 (IM-2), wet zone upcountry- zone 1 (WU-1), wet zone upcountry- zone 2 (WU-2) and wet zone mid country- zone 3 (WM-3).

Farmer's age, education (ranked 1 through 5) were directly taken from the questionnaire. We had originally planned to include informal education as an independent variable. However, only very few farmers have been visited by the extension agents during last year. There was no adequate variability in the informal education variable. Therefore, informal education was not incorporated in the model. Our pervious experiences showed that it is not easy to obtain accurate information on income by interviewing farmers. Therefore, in place of income the total value of the assets was estimated using questions as well as visual observations. Off- farm employment was measured as a dummy variable. If a farmer gets more than 75% of his annual income from sources other than farming, he was assigned one and zero was assigned otherwise. Land tenure was measured as a proportion of rented lands out of total lands. Debt level was measured as the present value of amount to be re-paid plus the interest. Subsidy was directly obtained from the questionnaire. Erosion potential was measured by visual observations. The assigned ranks were low (1) medium (2) and severe (3). Farm size was measured as the total operated land area.

RESULTS

The survey covered 70 households. However, 2 questionnaires were removed from the sample due to inconsistencies found in the answers. Descriptive statistics of the data are given in Table 1. Of the 68 households interviewed, 54 have used soil conservation measures. Sixty three per cent of the sampled farms have tea. Tea receives a subsidy for establishment and replanting. Majority of the farmers had obtained the subsidy. This subsidy has a soil conservation component. The high rate of adoption reported in this study is due to this tea subsidy scheme. However, our observations revealed that there is a large variation in maintenance of the established soil conservation structures. In calculating the expenditure the present value of the maintenance cost were included to capture this variation.

Table 1. Descriptive statistics of the data used for Tobit model.

Variables	Mean	Standard Deviation	Minimum	Maximum
Soil conservation expenditure (Rs.)	29444	35580	0.00	222500
Education	3.382	0.963	1.00	6.00
Age (years)	51.132	12.662	28.00	75.00
Value of assets (Rs.)	185320	171860	40000	1000000
Off-farm employment	0.309	0.465	0.00	1.00
Land tenure	0.853	0.356	0.00	1.00
Debt (Rs.)	2522.1	8358.3	0.00	58000
Subsidy (Rs.)	1408.8	4803.3	0.00	32000
Erosion potential	2.00	0.792	1.00	3.00
Farm size (ha)	1.173	0.863	0.25	5.00

Initial run of the OLS regression provided a R^2 value of 0.64 and adjusted R^2 value of 0.59. The small difference between the two R^2 values indicates that given the number of explanatory variables the model has adequate number of observations. Examination of the correlation matrix indicates that the correlation between any explanatory variable does not exceed 0.80. Therefore, the data does not show a serous multicollinearity problem (see Appendix 1). A series of heteroscedasticity tests were conducted to diagnose heteroscedasticity (Table 2). Arch and Glejser tests indicate no heteroscedasticity while Bruise-Pegan-Godfry (B-P-G), and Harvey tests indicate the presence of heteroscedasticity. Weighting the data following Judge *et al.* (1988) for multiplicative heteroscedasticity did not improve the data. Autocorrelation is generally found in time series data. However, the data showed a DW statistics of 1.20 with a Rho value of 0.395 indicating the presence of autocorrelation in the data. The Tobit procedure in Shazam does not have direct method to correct for autocorrelation. Therefore, the data were transformed using Prais-Winsten method (Greene, 1993). The OLS with transformed data gave a DW statistic of 1.88 and a Rho value of 0.057 indicating no autocorrelation. Diagnostic tests after transforming the data for autocorrelation showed no heteroscedasticity. The transformed data were used for the Tobit analysis.

Table 2. Diagnostic test results for heteroscedasticity.

Test	Test statistics (Chi-Square)	Critical value	Remarks
Arch test	11.53	3.84	Heteroscedasticity
Harvey test	12.01	16.92	No Heteroscedasticity
Glejser test	21.85	16.92	Heteroscedasticity
B-P-G test	13.33	16.92	No Heteroscedasticity

The Tobit regression results are given in Table 3. Unlike the OLS procedure, the Tobit procedure does not provide a goodness of fit measure similar to R^2. The predicted probability of Y > the limit is 0.85, while the actual probability observed in the sample is 0.80. Log of the likelihood function was –643 and the squared correlation between observed and expected values is 0.64. All these measures indicate that the model has a reasonably good fit for the data. As discussed earlier the data finally used for fitting the Tobit model is free from multicollinearity, heteroscedasticity and autocorrelation. Therefore, the results are reliable and can be used for policy formulation.

Table 3. Tobit regression results.

Variables	Normalized coefficient	Standard error	T - ratio
Education	0.083	0.156	0.532
Age (years)	0.018	0.012	1.418
Value of assets (Rs.)	0.000	0.000	2.372**
Off-farm employment	-0.206	0.319	-0.644
Land tenure	-0.069	0.367	-0.189
Debt (Rs.)	0.000	0.000	-0.623
Subsidy (Rs.)	0.000	0.000	1.569
Erosion potential	-0.395	0.174	-2.272**
Farm Size (ha)	0.643	0.217	2.957**
Constant	-0.529	1.087	-0.487

** indicates significance at 0.05 level

As shown in Table 3, age shows a positive relationship to conservation expenditure. However, this is not statistically significant. Education shows the expected positive relationship to conservation expenditure. This relationship is also not significant. The value of assets shows the expected positive relationship to conservation expenditure with statistical significance. Off-farm employment, land tenure and debt level show the expected negative relationship to soil conservation. However, all three variables are not statistically significant. Subsidy shows a positive impact on soil conservation. This relationship is also not statistically significant. Erosion potential shows a statistically significant negative relationship to soil conservation. This result is quite contrary to our expectation. However, the results suggest the soil conservation expenditure in not based on the severity of soil erosion. Rather it is determined by the socio-economic variables. Farm size shows the anticipated impact on soil conservation with statistical significance.

One nice feature of the Tobit model is its ability to decompose the elasticity to two categories; elasticity of adoption and the elasticity of the extensiveness. Elasticity of adoption measures the percentage increase in probability of adoption in response to a change in an explanatory variable. Elasticity of extensiveness measures the percentage responsiveness in the expenditure on soil conservation with respect to a change in an explanatory variable. One per cent increase in assets and farm size, respectively, increase the probability of adoption of conservation measures by 0.42% and 0.62%. Similarly, 1% increase in assets and farm size, respectively, increase the conservation expenditure by 0.38% and 0.56%. Thus, expenditure elasticity of assets and farm size are both inelastic. Among the variables included in the present model only two variables, farm size and asset level, have shown the expected relationship to soil conservation expenditure. These results suggest that poverty is the most important factor in determining the use of soil conservation practices.

The Gunatilake and Abeygunawardena (1992) study identifies a number of factors affecting soil conservation for tobacco farmers in the upper Mahaweli watershed. Among them, perception on soil erosion, informal education and subsidy positively influence soil conservation while profit attitude and land tenure negatively influence on soil conservation. Among the different results, land tenure situation is different, as most of the farmers in the present sample own the land. Subsidy, in the case of UMW tobacco farmers has resulted in better soil conservation. However, in the Walawe river upper watershed, people have adopted soil conservation measures in order to obtain the planting/replanting subsidies and later ignored the maintenance of them. The Ceylon Tobacco Company administered a subsidy scheme in the UMW. The company had developed a very good system of monitoring soil conservation activities. With that good system of monitoring, subsidies have resulted in better soil conservation measures in the UMW while re-planting subsidy in the upper Walawe area failed to achieve the same results, probably due to lack of consistent follow-up on soil conservation activities.

Informal education variable was dropped from the present analysis due to inadequate number of visits made by extension agents. The socio-economic and institutional situation that prevailed in the UMW tobacco farming community was very much different to the farming community in Walawe upper watershed area. These differences have produced very different results. For example in the UMW, a number of factors have significantly influenced soil conservation decisions whereas in the upper

Walawe area only the poverty related variables, farm size and asset level, have influenced soil conservation decisions. The findings of the present study reinforce Gunatilake and Abeygunawardena's (1993) assertion that poverty plays a significant role in land degradation in developing countries. Overall, the results suggest that findings of the factors influencing soil conservation decisions from one watershed cannot be directly applied to another watershed.

CONCLUSIONS

This study carried out an analysis on soil conservation decisions by the farmers in the Walawe river upper watershed area. Randomly selected 70 farmers were interviewed with a structured questionnaire. Data were incorporated in a Tobit regression model. The results show that, among the many variables studied, asset level and farm size have statistically significant positive impact on soil conservation decisions. Expenditure elasticities of soil conservation for asset and farm size are inelastic. Erosion potential shows a statistically significant negative impact on soil conservation decisions. This indicates that socio-economic factors act as determinants of soil conservation rather than physical factors. Overall, the results show that poverty is the major determinant in soil conservation decisions in the Walawe river upper watershed. Comparison of the results with a similar study conducted in the UMW shows that findings in one watershed cannot be readily extended to another watershed when social, economic and institutional factors are different in the two communities.

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APPENDICES

Appendix 1. Correlation matrix of the independent variable of the Tobit model.

	X1	X2	X3	X4	X5	X6	X7	X8	X9
X1	1								
X2	-0.346	1							
X3	0.173	0.116	1						
X4	0.099	0.317	0.136	1					
X5	-0.008	-0.039	0.132	0.188	1				
X6	-0.170	0.122	-0.101	0.065	0.066	1			
X7	0.110	0.108	0.644	-0.029	0.1180	0.053	1		
X8	0.00	-0.089	-0.269	-0.203	0.694	0.091	-0.169	1	
X9	0.112	0.021	0.671	0.602	0.144	0.104	0.547	-0.202	1