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An Economic Analysis of Soil Conservation in Tobacco Lands in the Hanguranketha Area of Sri Lanka

Among the many environmental problems in Sri Lanka, land degradation induced by human activities occupies the foremost place, and soil erosion is the major cause of land degradation (NORAD, 1989). According to recent investigations, tobacco cultivation in upland areas causes a higher level of soil erosion (People's Bank, 1982; Stocking, 1986; Tiruchelvam, 1989; Wickramasinghe, 1989). This problem is crucial in many respects, especially from the viewpoint of environmental management in Sri Lanka since tobacco cultivation is mostly practised in watershed areas which drain into nationally important reservoir systems.

Tobacco is cultivated in Sri Lanka with support services provided by the Ceylon Tobacco Company (CTC). The company supplies credit facilities, inputs, extension services and a guaranteed market for cured tobacco. There are less erosive crops which can be grown in these areas such as vegetables. These crops are, however, faced with obstacles such as lack of assured markets, high price fluctuations, perishability and lack of storage facilities and comparatively weak institutional support. Under these circumstances, farmers prefer tobacco cultivation although they are aware of the highly erosive nature of the crop.

A farmer usually views soil conservation from a business perspective because he has to survive in a competitive world and often struggle to meet his basic needs. Although he may be concerned about social cost of soil erosion, his decision whether or not to adopt soil conservation practices is dominated by the economic impacts those practices have on his farm business or his survival (Lovejoy *et al.*, 1986).

Many researchers have shown that future returns to conservation of the soil's productive capacity are relatively modest, and discounting makes them almost insignificant in terms of present value (Miller, 1982). However, Nowak (1988) challenges the traditional assumption that soil conservation does not pay back. He points out that many research results show very low or negative returns for soil conservation because most of the researches do not capture all the costs (benefits) and of soil erosion (conservation). Economic valuation of off-farm effect of soil erosion could be difficult. Disregarding off-farm effects, there is little empirical evidence found in literature on quantification of on-farm impact of soil erosion, *i.e.*, loss of crop yields.

In the light of the above discussion, quantification of the loss of crop yield due to soil loss and incorporation of that into farmers' cash flow analysis are particularly germane. Further, farm level economic analysis is quite location-specific and could provide a farmer with the type of information he needs to assess the economic rationale for adopting different conservation practices. Therefore, the specific objectives of the study are *(i)* to quantify the impact of soil loss on the productivity of tobacco, carrot and capsicum and *(ii)* to incorporate the above information into cash flow analysis in order to examine the profitability of tobacco and tobacco based crop rotations with alternative soil conservation practices, *i.e.*, no conservation practices, bench terraces, lock and spill drains and stoned terraces.

THEORETICAL FRAMEWORK

The farmer's behaviour as an economic agent towards the use of soil conservation practices is mostly determined by the impact of these practices on his net revenue. The net present value (NPV) can be used as a criterion to decide whether adoption of conservation practices is profitable. As a simple and general rule, if a conservation practice provides positive NPV a farmer will adopt the practice and otherwise he will not adopt it. In selecting the best conservation practice, a farmer will compare the NPVs and select the practice which has the highest NPV.

Net revenue can be defined as:

$$NR_t = P_{yt}Y_t - \sum_{i=1}^{n} P_{it}X_{it} - C_{jt} \qquad \text{....(1)}$$

where P_{yt} is the price of the output at time t,
Y_t is the quantity of output produced per hectare at time t,
P_{it} is the price of the i-th input at time t,
X_{it} is the quantity of the i-th input at time t,
C_{jt} is the total cost of j-th conservation practice at time t.

Soil conservation either maintains or improves the crop yield. Soil fertility governs the crop yield and is a function of many variables. The information with respect to this relationship is either not very precise or not available (Segarra and Taylor, 1987). A simplification must therefore be made and the focus has to be on variables which are affected directly by soil erosion and which in turn affect crop yields. Top soil depth can be related to crop yield in this connection as previously identified by Burt (1981). McConnell (1983) and Segarra and Taylor (1987). The Mitscherlich-Spillman production function was found to be appropriate for explaining this relationship (Segarra and Taylor, 1987):

$$Y_t = a + b(1 - R^{Z_t}) \qquad \text{....(2)}$$

where Y_t is the crop yield at time t,
Z_t is the top soil depth at time t,
'a' is the constant representing the yield theoretically obtainable from the sub-soil,
a + b is the asymptotic value of crop yield when $Z_t \rightarrow \infty$,
R is the constant ratio of the marginal product of z_{t+1}-th top soil depth to the marginal product of z_t-th top soil depth.

The change of top soil depth in a farm over time can be expressed by the following equation:

$$Z_{t+1} = Z_t + SF_t - SL_{jt} \qquad \text{....(3)}$$

where SF_t is the soil formation in time t,
SL_{jt} is the soil loss under j-th conservation practice at time t.

Equation (3) can be used to predict top soil depths in subsequent years under different conservation practices for a given cropping pattern. These top soil depths can be substituted in equation (2) in order to obtain crop yields in the respective years. Thus net returns of a particular year can be calculated using the yields in equation (1).

METHOD

Primary and secondary data were used for the analysis. Calculation of the NPV for one hectare of a representative tobacco farm including the cost of soil conservation was the analytical base used in this study. The cost of production and average price data were gathered from the cost of cultivation reports of the Department of Agriculture. It was assumed that prices remain constant during the period of analysis. The capital cost of soil conservation structures and their maintenance costs were found from the CTC and the Soil Conservation Division of the Department of Agriculture, Sri Lanka. A ten-year time horizon was considered for the analysis for the following two reasons: Firstly, the analysis was carried out from the private perspective. Secondly, within this time period the yield effect of soil erosion (without conservation measures) becomes very significant, so farmers generally do not continue their cultivation in the same land after that period.

Nadkarni *et al.* (1992) point out that the use of high discount rates is inappropriate in project analysis since these higher discount rates reflect both time preference and inflation. Helliwell (1975) also points out that high interest rate in project analysis can be very damaging to the interest of the environment. However, Dixon and Meister (1986), while recognising the importance of the discount rate to be free from the effect of inflation, show that using zero or low discount rates is not the solution. Further, they point out that using low discount rates can lead to serious misallocation of resources in terms of achieving environmental objectives. According to them, the opportunity cost of capital, cost of borrowing money and the social rate of time preference are the criteria in selecting appropriate discount rate in economic analysis.

Dixon and Meister (1986) are of the opinion that appropriate discount rate is country-specific and to a larger extent be established as a matter of government policy. In the absence of such guidance they suggest to use a range of discount rates reflecting those currently in use. It has to be noted here that this analysis was carried out from the private perspective. Therefore, a range of discount rates, including a higher discount rate of 12 per cent, were used in the analysis giving the policy makers a choice.

Only one crop of tobacco per year in *Maha* season, which is the usual practice, was considered. The analysis was conducted for green leaf producers and producer curers separately. The crop rotations considered were tobacco-tobacco, tobacco-carrot and tobacco-capsicum. Four conservation levels, namely, no conservation, bench terraces, lock and spill drains and stoned terraces were considered with each cropping pattern.

The functional relationships between top soil depth and crop yields (equation 2) were developed using subjective elicitation (see Segarra and Taylor, 1987) of knowledgeable individuals through a field survey. Knowledgeable tobacco and vegetable farmers, agricultural instructors (extension workers) working in the area and field instructors of the CTC were interviewed with a questionnaire.

Top soil depth was measured in sixteen randomly selected plots in the area and the average value was used as an initial condition (Z_1). Estimated soil losses by the Land and

Water Use Division, Department of Agriculture, under different crops with different conservation practices were used for the analysis. Soil losses under the crops (without conservation), reduction of soil loss by different conservation methods and soil loss tolerance value for the area were used to calculate top soil depths in subsequent years under different cropping patterns.

RESULTS AND DISCUSSION

The yield equations developed based on the eliciting procedure are as follows:

Tobacco $Y = 3309.7 + 4682.7\,(1 - 0.85^{Z_i})$

Capsicum $Y = 1213.1 + 3320.2\,(1 - 0.86^{Z_i})$

Carrot $Y = 1339.2 + 4551.4\,(1 - 0.79^{Z_i})$

The NPVs for green leaf producers with different conservation levels are given in Table I. The NPVs under no conservation show an increasing trend with higher discount rates. This result might be surprising since in general the NPV declines as the discount rate increases. However, in this analysis the NPVs reflect both the yield changes of different conservation levels and the impact of discounting. The net returns gradually decline due to the yield loss and become negative from the seventh year onwards reducing the NPVs. Under higher discount rates, the negative component after the seventh year becomes small giving higher NPVs with higher discount rates.

TABLE I. NET PRESENT VALUES FOR TOBACCO FARMING WITH DIFFERENT SOIL CONSERVATION MEASURES FOR GREEN LEAF PRODUCERS

Conservation method	NPVs under different discount rates				Total soil loss (mt/ha)	
	5 per cent	8 per cent	10 per cent	12 per cent	Gross	Net
(1)	(2)	(3)	(4)	(5)	(6)	(7)
No soil conservation	2,898.1	3,149.3	3,265.6	3,539.1	700	610
Bench terraces	2,311.1	1,003.8	477.9	-63.9	105	15
Lock and spill drains	-548.4	-1,384.9	-1,876.1	-2,260.2	70	-20
Stoned terraces	1,483.7	-235.6	-1,140.0	-1,930.0	35	-55

According to the results presented in Table I, tobacco green leaf producers receive positive benefits from tobacco cultivation only with no soil conservation practices. Although there are positive NPVs with bench terraces and stoned terraces, those occur under low discount rates which are too low to be considered as private rates of time preference. There is a considerable reduction of yield without soil conservation and this yield loss is efficiently reduced by conservation measures. Nevertheless, the yield improvements by conservation measures are not capable of producing positive benefits for green leaf producers under the existing cost-price relations. The high cost of conservation measures and the negative NPVs with conservation imply that, most likely, these farmers will not adopt soil conservation measures unless there are other incentives such as subsidy for soil conservation.

The NPVs of tobacco farming for producer curers with different soil conservation levels are presented in Table II. The positive NPVs indicate that soil conservation are greater than those without soil conservation practices. However, there is a considerable difference of NPV with and without conservation only under lower discount rates.

It is noteworthy that the yield differences and the costs of conservation are the same for green leaf producers and for producer curers. Curing, however, increases the cost of production by 63.5 per cent, while cured tobacco gives 100 per cent increase in the revenues. Although the impact of soil conservation on yield is the same for both types of producers, value added by curing make it profitable for producer curers under the existing cost-price relationships. There is no competitive market for tobacco in the area as the CTC determines the price under monopsonic set-up. Therefore, the inconsistency in profitability on tobacco farming with conservation for different groups of farmers is due to the economic impact under the existing institutional set-up of tobacco farming.

TABLE II. NET PRESENT VALUES FOR TOBACCO PRODUCER CURERS UNDER DIFFERENT SOIL CONSERVATION LEVELS

Conservation method	NPVs under different discount rates				Total soil loss (mt/ha)	
	5 per cent	8 per cent	10 per cent	12 per cent	Gross	Net
(1)	(2)	(3)	(4)	(5)	(6)	(7)
No soil conservation	51,884.2	46,994.6	43,510.4	40,787.6	700	610
Bench terraces	63,680.4	54,495.8	49,156.9	44,990.9	105	15
Lock and spill drains	61,511.1	52,419.1	47,463.0	43,117.7	70	-20
Stoned terraces	64,086.9	54,039.1	48,567.2	43,289.9	35	-55

The total soil loss over the ten-year period can be considered as a criterion for selecting a better soil conservation measure because all the conservation measures give approximately similar results. Net soil loss values were obtained deducting the soil loss tolerance value from the gross soil loss. Zero or negative net soil loss implies that soil conservation measure is capable of arresting soil erosion adequately. In this respect, both lock and spill drains and stoned terraces can be considered as suitable conservation measures. Stoned terraces are superior compared to lock and spill drains if one considers the NPVs and soil loss together.

The NPVs for crop rotations were calculated only for the green leaf producers. Both carrot and capsicum gave higher returns compared to tobacco green leaf production. The NPVs for crop rotations with different soil conservation levels are given in Tables III and IV. The NPVs with and without soil conservation practices are positive and show little difference, particularly at higher discount rates. The soil loss figures, however, show the danger of crop rotations without soil conservation, although it is not indicated by the NPVs. This suggests the need for soil conservation measures in tobacco-vegetable rotations even though it does not make much difference in the NPVs.

TABLE III. NET PRESENT VALUES FOR TOBACCO-CARROT ROTATIONS WITH DIFFERENT LEVELS OF SOIL CONSERVATION

Conservation method	NPVs under different discount rates				Total soil loss (mt/ha)	
	5 per cent	8 per cent	10 per cent	12 per cent	Gross	Net
(1)	(2)	(3)	(4)	(5)	(6)	(7)
No soil conservation	57,711.5	50,186.6	45,964.8	42,271.5	440	350
Bench terraces	57,105.0	47,791.0	43,399.7	38,510.8	66	-24
Lock and spill drains	53,805.0	45,131.3	40,363.3	36,225.7	44	-46
Stoned terraces	55,994.8	46,139.1	42,405.1	36,399.3	22	-68

TABLE IV. NET PRESENT VALUES FOR TOBACCO-CAPSICUM ROTATIONS WITH DIFFERENT LEVELS OF SOIL CONSERVATION

Conservation method	NPVs under different discount rates				Total soil loss (mt/ha)	
	5 per cent	8 per cent	10 per cent	12 per cent	Gross	Net
(1)	(2)	(3)	(4)	(5)	(6)	(7)
No soil conservation	25,682.7	22,848.6	21,249.5	19,795.0	540	450
Bench terraces	26,968.9	21,968.8	19,774.7	16,905.5	81	-9
Lock and spill drains	24,198.3	19,768.0	17,229.8	15,152.9	54	-36
Stoned terraces	26,275.1	21,315.4	18,141.1	15,633.3	27	-63

Growing carrot and capsicum can be compared using the NPVs and total soil loss values. Carrot is a better crop for rotations due to low soil losses and high NPVs. Both the NPVs and soil loss values suggest that it is beneficial to practice crop rotations rather than cultivating tobacco continuously. Although there is a high potential to reduce soil erosion using crop rotations without drastic reduction in the farmer's income, further research including other crop rotations is needed to make concrete recommendations.

CONCLUSION AND POLICY IMPLICATIONS

Off-site benefits and costs of soil conservation were not considered in this study since the emphasis was on the farm level economy. The findings of this study support Nowak's (1988) arguments against the belief that soil conservations does not pay, since yield improvements by soil conservation is sufficient to make tobacco farming with conservation profitable. However, due to the economic impact, conservation pays only for producer curers. Thus the impact of soil conservation on the farm economy through reduction of yield loss is adequate to attract the farmers to soil conservation, given a favourable cost-price relation for their products.

Investment in soil conservation is profitable for producer curers and stoned terrace is the superior conservation measure in terms of soil loss and net returns. This is an important information to be disseminated among the farmers through the extension service. The impact of crop rotations with less erosive crops is also an important information that should be incorporated into the extension information package.

Profitability of the vegetables studied is sufficient to attract the farmers. The soil loss values with and without conservation practices are also encouraging. The existing weak institutional structure for vegetable crops has to be changed in order to induce the farmers to cultivate more vegetables. Strengthening the agricultural support service for vegetable crops is thus another important measure that could be used to reduce soil erosion in the area.

It is unlikely that the tobacco green leaf producers will adopt soil conservation measures, since they receive negative returns. This group of farmers receives less institutional support from the CTC and they are the group mostly exploited by the tobacco barn owners (Gunatilake, 1990). Therefore, they are not in a position to invest on soil conservation practices. However, soil erosion causes some social costs, and it is clear that market forces are unable to capture all the costs of soil erosion. Hence, government should intervene by giving subsidies or initiating cost sharing programme with the emphasis on green leaf producers as the target group.

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