Tropical Agricultural Research Vol. 6 1994

A Financial Assessment of Soil Conservation with Sloping Agricultural Land Technology in T_4 Category of Tea Fields: Replacement Cost Approach

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ABSTRACT. Soil degradation in the hill country has been a major problem in Sri Lanka. This is more so in the tea plantations which occupy a sizeable portion of this region. Despite the efforts of the government and various other agencies, there is a lack of awareness and interest on the part of the tea growers in mitigating this problem. This could be attributed to their lack of perception in regard to the probable gains accruing from appropriate soil conservation measures. To step up the rate of adoption of such measures among tea growers, the gains from soil conservation must be demonstrated. Since the market mechanism hardly provides a proper assessment for the valuation of losses inherent in soil degradation, it is found necessary to use surrogate market techniques for this purpose.

This study examines the private level financial benefits accruing to tea growers through the adoption of Sloping Agricultural Land Technology (SALT) in tea fields where bush cover is less than 40%. The replacement cost method has been used to analyze the financial gains from soil conservation and calculating threshold rate of soil erosion. Data have been collected from published and unpublished documents of the Tea Research Institute, The Environmental and Forestry Division-Mahaweli Authority of Sri Lanka and a few other sources.

At a 20% discount rate over a 10 year period, the discounted cost of adopting the SALT system is Rs. 65,973/-, whereas the corresponding figure relating to unchecked soil erosion is higher, at Rs. 88,810/-. These results indicate that tea growers will have to bear less cost by adopting the SALT system than permitting unabated soil erosion. It has also been calculated that the financial threshold rate of erosion for adopting the SALT system is

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about 78-80 t/ha/yr. If the socially desirable rate of soil erosion is about 9 t/ha/yr, this being the tolerable level of soil loss of tea soils; it is clear that market intervention is needed to keep soil loss within this limit.

INTRODUCTION

Soil erosion of tea land is generally considered to be more severe than in the case of the other two major plantation crops, namely rubber and coconut. This is because of the steep topography of tea plantations, and the methods of crop and soil management practiced (Krishnarajah, 1985).

The importance of curbing soil erosion in tea growing areas has been widely cited (Eden, 1931, Hasselo *et. al.*, 1965, Manipura, 1972, and Basnayake, 1985). However, the rate of adoption of adequate soil conservation measures in tea is not satisfactory (Ekanayake, 1993).

This situation of a lower adoption rate of soil conservation measures in up-country and mid-country has presumably arisen, due to the lack of awareness of the financial losses from soil erosion. As has been shown, the economic problem of soil erosion is three fold (Griffin and Bormerly, 1982). One of them is the depletion of silt (sediment), nutrient and organic matter from the affected site. This is a direct cost to the tea grower, which could be used to compare the cost of adopting soil conservation measures. Deterioration in land productivity leading to yield drop, being the direct measurement of the cost of soil erosion, although appealing, is an intricate exercise, and therefore, a causal relationship cannot be properly established (Lal, 1988).

In the light of the above argument, the main objective of this study is to examine the relative profitability of adopting the Sloping Agricultural Land Technology (SALT)[2] system in erosion prone tea lands in the mid-country, where existing bush population is less than 40% (T_4)[3]. Furthermore, an attempt is made to arrive at the financial threshold rate of soil erosion at present costs.

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[2] A formal SALT model developed for tea, includes a double hedge row of shrubs, preferably Nitrogen fixing species, planted along the contour, spaced 6-7 meters apart (Ekanayake 1993).

[3] Less than 40% cover seedling.

MATERIALS AND METHODS

The Forestry and Land Use Mapping Project of the Upper Mahawali Catchment Project (FORLUMP) has undertaken an assessment of soil erosion in major land use types (Stockings 1992). Less than 40% stand in the tea lands are identified as category T_4, and labelled as high erosion hazard. The estimated rate of erosion in this land category is about 100 to 200 t/ha/yr (Stockings, 1992). The lowest in the range (100t/ha/yr) is selected as the rate of soil erosion for this analysis. The opportunity cost of the land under the SALT system is calculated with information from the Agricultural Economics Unit and the Agronomy Division of the Tea Research Institute, Talawakele. The rate of soil erosion with the SALT system was collected from publications of the FORLUMP and the International Board for Soil Research and Management (IBSRAM). Nutrient and organic matter content in mid-country tea soil was collected from published data (Jayman *et.al.*, 1981). Nutrient content of fallow soil was taken as 30-45 cm deep soils in the same area. Establishment and maintenance costs of the SALT system were collected from the Upper Mahawali Watershed Management Project (UMWP) and the Agronomy Division of the Tea Research Institute. Labour cost is taken at Rs. 80/- a day, and details of cost of fertilizers were collected from the Ceylon Fertilizer Cooperation.

The selection of the soil conservation measure for the analysis is deliberate. Due to its agronomic superiority and as a biological conservation measure, the SALT concept has gained wide acceptance all over the world (Anonymous, 1993). The selection of the land use type T_4 is also intentional, because it has been and continues to be the most erosion prone land use category with tea (Stockings, 1992). In order to assess the cost of soil erosion, the replacement cost approach is used. The approach is based on the premise that, the cost of replacing productive assets that have been damaged because of the undesirable on-site management can be measured (Dixon *et.al.*, 1986). Therefore an attempt has been made to value the most important items in eroded soil that are vital for crop production.

Eroded soil has to be replaced by fallow land (cost of such soil is reckoned only as the transport cost). Nutrient content and organic matter content of fallow soil must be subtracted from that of the eroded soil, and only the balance should be incorporated to the field. This will maintain the pre-eroded condition of the soil. Field maintenance and repair costs (desilting drains, *etc.*) have to be integrated to show the total cost of soil erosion.

Adoption of the SALT system involves various costs. These relate to establishment and maintenance costs, the opportunity cost of land, and the cost of soil erosion under the SALT system.

After estimating the cost of soil replacement and the cost of adopting the SALT system, the present worth of each approach is calculated at a 20% discount rate, for a period of 10 years.

The threshold rate of soil erosion compared with adopting the SALT system is calculated using break-even analysis. While keeping the present worth of the cost of the SALT system constant (for a 10 year period at a 20% discount rate), the rate of soil erosion is allowed to vary until it equals the present worth of the cost of the SALT system. This rate of soil erosion has been identified as the financial threshold rate of soil erosion, under the present cost scenario.

RESULTS AND DISCUSSION

Total cost of soil erosion in T_4 tea lands

Estimation of cost of nutrient losses

An estimation of nutrient and organic matter losses, along with the soil loss of 100 t/ha/yr are in Table 1. The nutrient losses are Nitrogen 20, Phosphorus 10, Potassium 10 and organic matter 480 kg/ha/yr.

Tea fertilizers which supply Nitrogen, Phosphorus and Potassium are Urea (percentage N is 46 w/w), Eppawala Appatite (percentage P_2O_5 is 32.5 w/w) and Muriate of Potash (percentage K is 60 w/w), respectively. Adding organic matter in the form of compost is most preferred for tea fields. The cost of commercial fertilizers (Rs/kg) are Urea 10, Eppawela Rock Phosphate 3.6, and Muriate of Potash 10. The cost of preparation of compost is taken as Rs. 2/- /kg (Katheirvettapillai, 1990). It is shown in Table 2 that the nutrient and organic matter lost due to erosion could be replaced at a cost of Rs. 1,671/- /ha/yr, if the erosion rate is 100 t/ha/yr.

Table 1. Nutrient and organic matter losses with soil erosion in T_4 type tea lands.

Nutrient	content in tea soil (a)	content in fallow soil(b)	(a-b)	replacement (kg/ha/yr)
Nitrogen	0.13%	0.11%	0.02%	20
Phosphorus	0.05%	0.04%	0.01%	10
Potassium	0.04%	0.03%	0.01%	10
Org. matter	1.44%	0.96%	0.48%	480

Table 2. Total cost of soil erosion in T_4 type tea lands (Rs/ha/yr).

Item	Cost of soil erosion (Rs/ha/yr)
Replacement of Nitrogen	430
Replacement of Phosphorus	111
Replacement of Potassium	170
Replacement of Organic Matter	960
Sub total of Nutrient Replacement	1,671
Replacement of cost of soil	8,000
Labour cost for above replacement	8,240
Labour cost for field maintenance	1,600
Total cost (Rs/ha/yr)	19,511

Estimation of soil replacing cost

Since the objective is to bring back the original productivity status, the soil loss itself has to be compensated. Therefore, bringing soil from a fallow field around 4 to 5 miles away is assumed. It is further assumed that the truck rental charge for a fallow soil load is Rs. 400/-. Labour charges for loading, unloading and spreading a truck load of soil are about Rs. 400/-

(Samarakoon Banda and Abeygunawardane, 1993). One truck load contains 5 tons of soil. Therefore, the cost of replacing soil in one hectare per year amounts to Rs. 8,000/-, and the labour cost for operations in loading, unloading and spreading, amounts to Rs 8,240/- (3 labour days for nutrient replacement).

The maintenance operations, such as, repairing the damaged channels, desilting of channels are to be accomplished in the absence of soil conservation methods. Labour allocation for such operations is taken to be 20 man days/ha/yr (Anonymous, 1989). Therefore, the cost of field maintenance is about Rs 1,600/- /ha/yr.

Table 2 shows that the cost of soil erosion to a private farmer is about Rs. 19,511/- /ha/yr in T_4 land use type, with a soil erosion rate of 100 t/ha/yr. This cost could be avoided by adopting the SALT system.

Total cost of SALT system in T_4 tea land

Establishment cost of SALT system

Table 3 gives the establishment cost of the SALT system in T_4 type tea lands. It is assumed that a length of 1300 m of SALT hedge rows is required per hectare (Ekanayake, 1993). The calculated maximum and minimum establishment costs of the SALT system are Rs. 14,000/- and 17,000/- /ha, respectively. However, in this analysis, the maximum establishment cost is taken in order to put more stress on the SALT system.

The principal item with SALT hedge row maintenance is lopping (pruning of the top growth and branches). It was estimated that four loppings are required per year. At the rate of 10 workers/ha/lopping, the labour requirement is 40 man days. For the purpose of after care of hedge rows, an addition of 10 workers/ha/yr was estimated (Ekanayake 1993). These labour costs are to be Rs. 4,000/- /ha/yr.

Opportunity cost of the removed tea

When the SALT system is introduced to the existing old seedling tea lands (T_4 land use type) there will be a removal of a certain number of tea bushes. This is to accommodate unobstructed hedge rows along the contour. Staggered hedge rows are possible, keeping all the tea bushes intact.

Table 3. Cost of establishment of SALT system in T_4 type tea lands.

Operation	Labour/ha Max.	Labour/ha Min.	Min. Rs/ha	Max. Rs/ha
Tracing contour	10	8	800	640
Uprooting old tea	40	30	3200	2400
Land preparation	40	30	3200	2400
Planting hedge rows	30	20	2400	1600
Aftercare 1st year	15	10	1200	800
Cost of planting materials unit cost (Rs)				
Gliricidia 5000 sticks per ha 1			5000	5000
Vetiver grass 25000 sprigs per ha @ 0.4			100	1000
Total cost (Rs/ha)			13840	16800

However, it is superior to have continuous hedge rows as far as erosion control is concerned (Ekanayake, 1993). A maximum of 10% bush removal is assumed in T_4 type old seedling tea lands. An average yield of 600 kg of made tea/ha/yr is assumed for T_4 tea lands. Based on these assumptions 60 kg of made tea/ha/yr will be the yield loss. The net income from 60 kg of made tea is Rs. 1,968[4]/-.

[4]. This is arrived at by the gross margin of Rs 32.8/kg of made tea in following manner:

1. Net sale average = Rs 65/made tea kg

   Variable costs:

2. Plucking cost = Rs 23/made tea kg
3. Manufacturing cost = Rs 9.20/made tea kg

gross margin of kg of made tea =(1)-[(2)+(3)] = Rs.32.8/made tea kg

Estimation of cost of soil erosion with SALT system

In Mulgama Hadabima settlement, it was reported that the demonstration plot involved 40 times more soil erosion without SALT hedge rows compared to those with SALT hedge rows (60 t/ha without hedge rows as against to 1.5 t/ha with hedge rows). This was for a period of 5 month in mixed vegetable cropping land use (Stockings, 1992). Anonymous, 1993 reports that the reduction in soil loss as a result of hedge rows ranged from 33 to 99% in the first year of establishment, 60 to 99% in the second year, and 50 to 100% in the third year. On a conservative estimate, 80% of erosion reduction from the second year onwards is taken for this study. It is also assumed that the SALT system does not have any impact on the reduction of soil erosion during the year of establishment.

Using the information in Table 1 the cost of replacing soil at the rate of 20 t/ha/yr (on the basis of 80% reduction in soil loss with the SALT system) is calculated. The nutrient replacement will cost Rs. 334/- /ha/yr, while the soil replacement cost will be Rs. 3248/- /ha/yr. Therefore, adopting SALT will again involve Rs. 3582/- /ha/yr, under the assumed 80% erosion reduction.

Table 4 shows that the total cost of adopting the SALT system is Rs. 40,679/-/ha in the first year and Rs. 9,550/-/ha from the second year onwards.

Table 4. Total cost of adopting SALT in T_4 type tea lands (Rs/ha).

Item	1st yr Rs/ha	2nd yr Rs/ha
Cost of establishment	16800	-
Cost of maintenance	4000	4000
Cost of soil erosion with SALT	17911	3582
Opportunity cost of removed tea	1968	1968
Total	40679	9550

Since SALT is a soil fertility improvement technique which has a long lasting effect, a 10-year period is taken to appraise its financial feasibility. Using present worth of the two cost streams, namely, the total cost of soil erosion and the total cost of adopting SALT system, it could easily be identified as the low cost option. A discount rate[5] of 20% is used for this purpose. The effect of inflation is ignored in both cost streams. Calculated present worth of costs are given in Table 5.

Table 5 indicates that a tea grower would have to incur a lower cost with the SALT system compared to the cost imposed by soil loss. Present worth of the cost of soil erosion compared to adopting SALT is more than Rs. 15,000/-/ha, at the 20% discount rate within a 10-year period. The study adduces the possible cost reduction, or conversely, the financial gains to a tea grower by adopting SALT as a soil conservation measure. Therefore, it could be shown that adopting the SALT system in tea lands of type T_4 is a financially profitable option, if the observed erosion rate is 100 t/ha/yr or more.

Table 5. Present value of cash flows of adopting SALT and unabated soil erosion.

Yr	Discount factor	Cost of erosion (Rs/ha/yr)	Cost of SALT (Rs/ha/yr)	Present value of erosion	Present value of SALT
1	0.833	19511	40679	16253	33886
2	0.694	19511	9550	13541	6628
3	0.579	19511	9550	11297	5529
4	0.482	19511	9550	9404	4603
5	0.402	19511	9550	7843	3839
6	0.335	19511	9550	6536	3199
7	0.279	19511	9550	5444	2664
8	0.233	19511	9550	4546	2225
9	0.194	19511	9550	3785	1853
1	0.162	19511	9550	3161	1547
Present worth				81,810	65,973

[5] Medium term investment borrowing rate of 18% is being used by National Planing Division, for private financial analysis. Commercial borrowing rate is around 22%. Therefore, 20% is used as discount factor for the analysis.

The financial threshold rate of soil erosion(t/ha/yr) could be calculated using the data in Tables 1 and 2. The total cost of soil erosion does vary with the rate of erosion. This is because, the amount of nutrient, as well as the soil to be replaced, vary with the rate of erosion. Therefore, present worth of the cost of soil erosion too would vary with the rate of erosion. Table 6 relates to present worth of costs of soil erosion at different erosion rates. The present worth of cost of the SALT system does not vary with the rate of erosion. This is because, the total cost of the SALT system is to be borne irrespective of the rate of erosion. Therefore, the financial threshold rate of soil erosion is the rate of erosion at which present worth of the cost of the SALT system equals the present worth of the cost of erosion (10-yr period and at 20% discount rate). Table 6 shows that the erosion rate 78-80 t/ha/yr is the financial threshold (break even) erosion rate at which both cost streams' present worth is equal. However, had intangible benefits of the SALT system be incorporated, the financial threshold rate of erosion would have reduced further.

Table 6. Impact of erosion rate variation on present worth of cost of soil erosion at constant cost of SALT system.

Rate of erosion (t/ha/yr)	100	95	90	85	80	78
Present worth of cost of erosion (Rs.000)	82	78	74	71	67	65
Present worth of cost of SALT (Rs.000)	66	66	66	66	66	66

CONCLUSIONS AND POLICY IMPLICATIONS

The study has shown that tea growers accrue financial gains in terms of cost reduction, by adopting the SALT system as a soil conservation measure. The implicit gain is about Rs. 15,000/-/ha in terms of present value at a 20% percent discount rate within a 10-year period. The sensitivity analysis indicates that, if the soil erosion rate is more than 78 t/ha/yr, adopting the SALT system in T_4 tea lands is profitable at private level accounting. However, this is a much higher figure than the tolerance level of 9 t/ha/yr for tropical soils (Krishnarajah, 1985); and if the rate of erosion is lower than 78 t/ha/yr, tea growers would be better off correcting the on-site damage by replacing productive assets, rather than by adopting the SALT system. Therefore, if the financially acceptable rate of soil erosion is to be maintained in conformity with the socially desirable level, the excess net cost of adopting the SALT system (below the threshold rate) must be compensated for through state intervention, and there is a divergence between the private and social cost of soil erosion. If the rate of erosion were to be kept at 20 t/ha/yr, maximum attainable level of erosion control in T_4 field with SALT, it follows that there could even be a subsidy in present worth term of Rs. 22,527/-/ha[6]. If the off-site damages and inter temporal issues are considered, offering a subsidy scheme for SALT is further justifiable.

Furthermore, adopting the SALT system in T_4 type tea lands imposes a loss to the tea grower during the first year (Rs. 17,633/- in present worth term). Therefore, during the first year itself, there could be financial encouragement by means of a subsidy to the SALT system adopters, in order to encourage its adoption.

The analysis has deliberately chosen the following assumptions to reach the possible upper ceiling (rationality is assumed) of the cost of adopting SALT.

- not including any secondary benefits from SALT,

- taking the upper limit of cost of establishment and maintenance of SALT,

- allowing erosion rate of 100 t/ha in the year of establishment of SALT,

Therefore, in this analysis, the total cost of the SALT system would probably be at the upper limit. Extra gains from the SALT system have been widely discussed (Alles, 1994; Anonymous, 1993; Anonymous,1988). However, as none of such beneficial effects have been experimentally proved, particularly with tea, they have not been incorporated in this analysis. If they were to be included in the model, it would have further enhanced the benefits from SALT. While only a small element of doubt could be cast upon such beneficial effects, their exclusion does not nullify

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[6]. Since Present Worth of cost of adopting SALT is Rs. 65,973/- and present Worth of replacement cost at 20 t/ha/yr is Rs. 43,446/- the difference is Rs. 22,527/-/ ha (in present worth terms).

the financial gains of the SALT system. Even with the probable upper limit of the cost of adopting SALT, it generates financial gains to tea growers.

The popularization of the SALT system is particularly important in upland areas, where degraded soil does not support productivity improvement, either through infilling or replanting tea. To ensure a successful infilling or replanting programme, it is necessary that soil fertility be improved. As a biological soil conservation method, the SALT system would be ideal for improving degraded soil in the up-lands, particularly in the mid-country.

Limitations of the study

The study assumes that the rate of soil erosion in T_4 type tea lands is 100 t/ha/yr throughout the 10-year period. In reality, each consecutive year would have a progressively reduced rate of erosion, and this would really be the case with severely degraded tea fields in the up-lands. Such sequential rate of erosions in the same field over the time have not properly been investigated. On the other hand, if the replacement is really taking place, there is enough soil to be eroded at the rate of 100 t/ha/yr.

Valuation of productive assets in lost soil may not be perfect. For example, the role of trace elements, such as, Silicon or Molybdenum in tea cultivation may be vital. However, as far as the amount involved is considered, it will not make any difference to the results. The same argument is true with organic matter replacement. The value of organic matter in the soil is not really that of the compost that is added to the fallow soil. However, with the existing valuation techniques, particularly for the commodities where no market is developed, it is impossible to have a perfect valuation.

Nutrient content in fallow soil is again an assumption that has been made due to the lack of data. Sometimes, soil from a fallow land may be more fertile than the eroded soils from T_4 tea land. However, it is assumed that such fertile land should already be in cultivation, and hence left over lands are relatively poor in fertility status.

ACKNOWLEDGEMENTS

Authors wish to acknowledge Mr. B. Sivaram for his many helpful suggestions.

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