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Justification for Government Investments on Natural Resource Conservation: Economic Analysis of Soil Conservation in a Micro-watershed

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ABSTRACT. Unabated soil erosion in watersheds, due to insufficiency of investments for conservation, has caused irreversible losses to agricultural productivity and supply of water to major reservoirs that provide water for agriculture and hydro-power generation. Natural resource economics theory has explained the insufficiency of investments on watershed conservation as arising from market failure that dampens private investments, thus justifying government investments. This study empirically examines the justification for government investments on watershed conservation. Financial and economic benefit cost analysis are carried out to test the hypothesis that soil conservation is privately non-worthy but economically worthy and hence justifies government investment. The loss of soil nutrients due to soil erosion is estimated based on analysis of soil samples in different land uses. The value of irreversible loss of soil is accounted for by including the discounted forgone earnings from agricultural land use from year 25 to infinity. The financial analysis is conducted using subsidized and unsubsidized prices of fertilizers to test the hypotheses that a government subsidy to agriculture leads to reduced private investments on soil conservation. The benefit of soil conservation is estimated using the soil nutrient replacement cost method. The average loss of nutrients in Bopitiya micro-watershed is estimated as 44.28 kg N, 0.206 kg P, 2.68 kg K ha^{-1} $year^{-1}$ and 0.089 kg organic matter ha^{-1} $year^{-1}$. The total on-site and off-site benefits of soil conservation in Bopitiya micro-watershed are Rs. 0.36 million $year^{-1}$ and Rs. 0.30 million, respectively. The analysis indicates that adoption of soil conservation is not financially profitable in Bopitiya micro-watershed, implying that farmers would not invest on soil conservation, unless the government provides a subsidy.

INTRODUCTION

The need to conserve watersheds to achieve sustainable development in Sri Lanka has been recognized by the government (Flemming, 1991). Watershed conservation contributes to the economy mainly by sustaining (on-site) agricultural productivity and maintaining (off-site) capacity of reservoirs used for irrigation and hydropower generation. Over the past half-century, watersheds have been subject to overexploitation, extensive and unplanned human settlement, and erosive use of land for agriculture. This has lead to, degradation of land fertility, reduced domestic water supplies, land slides, silting of streams,

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reservoirs and depletion of the water table with the consequence of declining agricultural productivity and increasing economic costs in maintaining public utilities such as roads and reservoirs and supplying irrigation water and generating electricity. Somaratne (2001) has estimated the on-site and off-site cost of degradation of the upper Mahaweli watershed as Rs. 953 and 15 million $year^{-1}$, respectively. The on-site and off-site costs of soil erosion of the same watershed were estimated as Rs. 721.7 and 22.3 million $year^{-1}$, respectively by Gunathilake (1998) . It is clear from the above information that unless sufficient investments are made on watershed conservation, either by private land users or the government, degradation of watersheds in Sri Lanka would continue incurring substantial economic costs.

Natural resource economics theory, explains the insufficiency of investments on soil conservation (a major activity of watershed conservation) as arising from market failure that prevents optimal levels of private investments, thus justifying government investments.

The broad objective of the study was to examine empirically the justification for government investments on soil conservation in watersheds. The following hypothesis were tested:

i. Soil conservation, although not financially worthwhile for farmers to invest, it is economically worthwhile. Therefore government investment is justified.
ii. Subsidies on agricultural inputs (on price of fertilizer considered in this study) does not have a sufficient impact on the financial worthiness of soil conservation to influence farmers' decision to invest.

THEORETICAL JUSTIFICATION[1]

Theory and research in environmental economics explain watershed degradation, as caused by failure of market, to guide land users to invest optimally on watershed conservation (soil conservation as considered in this study). In a market economy, individuals take independent decisions on investments. Individual decision-making is based on a comparison of private costs and benefits and not on comparison of social costs and benefits. Private decision-making in a market economy is guided by market prices of resources and commodities. Where market prices encompass the social values of benefits and costs (*i.e.*, where the market is perfect) individual decisions on resource allocation will result in socially optimal investments on watershed conservation. Where market prices do not encompass the social costs and/or benefits the private decisions will not be congruent with socially optimal investment on watershed conservation. Hence the socially optimal investment on watershed conservation will not occur. Some of the benefits and costs of watershed conservation are not encompassed in market prices due to inherent weaknesses of the market (referred to as a market failure) and interventions by the government in influencing prices (referred to as government failure). Market failure occurs due to several reasons such as lack of non-attenuated property rights for resources, production and

1 See Kotagama (2002) and Barbier (1995) for a more detailed graphical and mathematical description, respectively.

consumption externalities, public-good nature of benefits and costs of watershed conservation. Government failure occurs due to price fixing, provision of subsidies by the government and placing other restrictions on free operation of the market, to achieve socio-political expectations such as food security and social equity.

The costs of watershed conservation are costs on soil and water conservation activities undertaken in private upstream farms and other public land areas. Costs of conserving public areas are ignored, despite its importance, for convenience of explanation and as this study relates mainly to private decision making. Thus private cost of watershed conservation undertaken by upstream farmers is considered to be equal to the social cost of watershed conservation.

The benefits from watershed conservation are on-site/upstream benefits and off-site/downstream benefits. The on-site benefits are maintenance of soil fertility (physical and chemical), maintenance of water holding capacity of soil resulting in sustenance or improvement in agricultural productivity. The on-site benefits are private benefits, appropriated directly by farmers. The on-site benefits may be lowered due to market failures. The market failures could be the lack of non-attenuated property rights for land to assure appropriation of benefits of soil conservation to the private farmers[1]. Further, as the benefits of conservation are realized over a long period of time (temporal externality) and with high rates of time preferences of particularly poor farmers, the level of benefits appropriated at present will be low.

The off-site benefits of watershed conservation are sustenance of natural water supplies, reduced silting of waterways and reservoirs and reduced land slides, resulting in sustenance of the supply of domestic and irrigation water, hydro power generation, reduced cost on flood and land slide damages. These benefits are appropriated more by down stream dwellers than by the upstream farmers who decide to invest on watershed conservation.

Social optimal level of conservation will not be achieved as mentioned earlier due to on-site market failures and in addition due to spatial and temporal externalities and public goods nature of off-site benefits of watershed conservation. An externality is a situation where one person's activity (on-site watershed conservation) affects another person (off-site) and is not being compensated by the market. The spatial externality is that the on-site conservation activities invested by upstream farmers lead to benefits of reduced erosion thereby sustained supplies of water for irrigation and hydroelectricity generation would be enjoyed by off-site dwellers. The off-site benefits also have a public goods nature. That is, once on-site farmers undertake soil conservation the off-site benefits that are not divisible are available to all to benefit without rivalry. In such situations, of lack of rivalry on access to a commodity, the beneficiaries will avoid payment for receiving a benefit. The off-site farmers and users of electricity who receive a public good will not compensate the on-site farmers who bear the cost of watershed conservation. The temporal externality is such that the cost of watershed conservation is undertaken by the present generation whilst the benefits are enjoyed mostly by the future generation

1 See Kotagama *et al.* (1998) for a review of empirical studies that relate market failure as a cause of soil erosion.

Where the markets fail, to appropriate benefits to those who invest on watershed conservation, the level of investment would be low, as they would invest only up to where privately appropriated benefits equate private investment. Therefore, to achieve the socially optimal level of conservation on-site market failures should be corrected and the off-site beneficiaries should compensate the on-site farmers who invest on watershed conservation. Where the market fails to implement the compensation mechanism, the government could tax the off-site beneficiaries and compensate the costs of conservation undertaken by on-site farmers to invest socially optimally. If the beneficiaries cannot be taxed directly due to high transaction costs or due to equity reasons, then the government has to finance watershed conservation through general taxes charged from other sectors. However, issues of how and from whom to appropriate finances and how and to whom finances should be disbursed to conserve soils is a subject of analysis of political economy (Kotagama, 2002) that is not addressed in this paper.

Finally, investment on watershed conservation will be non-optimal due to market imperfection created by the government too (referred to as government failure). The provision of a subsidy on the price of fertilizer will underestimate the benefit of retaining soil fertility through soil conservation. Thus the level of investment on soil conservation by on-site farmers will be less than without a subsidy on price of fertilizer. Hence the logical theoretical expectation is that government failure should be rectified by removal of subsidies, to achieve socially optimal investments on watershed conservation.

METHODOLOGY

The study site

This study was based on the Bopitiya micro-watershed in the Central Province of Sri Lanka. This watershed is considered to be representative of bio-physical and socio-economic aspects relating to watersheds in the Central Province of Sri Lanka. The landscape of this watershed is in the form of an amphitheater or a basin like structure. All the lands at the lower elevations of the basin are developed for paddy cultivation with homesteads. The upper slopes of the steep wall of the basin are either under forest cover or used for seasonal crops during the rainy seasons. The soils are mostly Immature Brown Loams with Reddish Brown Latasolic soils and Reddish Brown Earth's. The watershed drains into the Kivullinda Oya. Bopitiya micro-watershed feeds the Victoria Reservoir directly. The total land area including all land use types in Bopitiya micro-catchment is 700.7 ha which is about 0.5% of the total catchment area that feeds the Victoria Reservoir.

Estimation of values

The main source of income of the dwellers in the Bopitya micro-watershed is vegetable farming. There is currently a shift to cultivating tea. The level of household income and other socio-economic characteristics (such as resource ownership/access, education level) are similar to situation in Sri Lanka.

The private and economic worthiness of investment on soil conservation is analyzed through financial and economic investment worthiness analysis. The financial and economic Net Present Values (NPV) of investment on soil conservation were estimated. The NPVs should be positive for investment in soil conservation to be worthy either financially or economically. The methodological approach used by Gunethilaka (1998) was used in this study with modifications. Equation 1 gives the NPV of investments on soil conservation in a land use l.

$$NPV_1 = \Sigma [\alpha_j (BC_t) - CC_{jt}] / (1 + r)^t \quad 1=1, ... M \qquad (1)$$

where;

BC_t is the benefit from soil conservation (on-site and off-site) at time t (Rs ha^{-1} yr^{-1})
CC_{jt} is the cost for j^{th} soil conservation measure at time t (Rs ha^{-1} yr^{-1})
r is the interest rate (either financial or economic)
t is the investment-returns or project period
α_j is the factor by which the j^{th} soil conservation measure reduces the soil loss each year.

The on-site BC_t was estimated using the soil nutrient replacement cost method. This method, despite its weakness in fully and accurately estimating the benefits of soil conservation, has been widely used to estimate the on-site benefit of soil conservation (Barbier, 1995)[1]. The method is based on the presumption that the on-site benefit of soil conservation is equivalent to the cost that has to be incurred to apply fertilizer, to replace the loss of soil nutrients due to soil erosion. Replacement cost of soil nutrients caused by soil erosion (here after referred to as benefit of soil conservation) in a land us L in a given year t (BC_t in Rs ha^{-1} yr^{-1}) is given in equation 2.

$$BC_t = (S_t - S_{(t+1)}) \sum_{j=1}^{k} N_{ij} P_j + C_{ib} \qquad (2)$$

where;

S_t-$S_{(t+1)}$ is the soil loss from time t to t+1 (t ha^{-1})
N_{ij} is the quantity of j^{th} nutrient in l^{th} land use type (kg t^{-1})
P_j is the price (subsidized or unsubsidized) of j^{th} nutrient in l^{th} land use type (kg t^{-1})
C_{ib} is the cost of in transporting and applying fertilizer (Rs ha^{-1}).

The quantities of soil eroded (S_t-$S_{(t+1)}$) in different land use types in the Bopitiya micro-watershed were calculated using the rates of soil erosion estimated by Stockings (1992) for similar land uses. In this study, 15 different land use patterns in the watershed were identified (see Table 2). For the analysis of nutrient contents of soil, the soil samples were collected in three different places of each land uses (low, medium and high erosion) using the Augur. The average nutrient contents of each land use were used in the analysis. Soil nutrient contents (N_{ij}) in the watershed was estimated using laboratory methods as; Kjeldhal method for nitrogen (N) content; Olsams method to find the phosphorus (P)

1 See Kotagama (1998) for a summary of studies done in Sri Lanka using the replacement cost method to estimate on-site benefit of soil conservation.

content; ammonium acetate method to find the Potassium (K) content and Walky Black method to find the organic matter content. The nutrients that need to be replaced were valued using (P_j) market prices (subsidized) of nutrients as of year 2001 and FOB prices (unsubsidized) in the relevant analysis. Cost of transport and applying fertilizer (C_{ib}) was obtained from literature and was adjusted to estimate the 2001 value.

The distribution of benefits of soil conservation over time (BC_t) was based on distribution of increased productivity due to soil conservation in potato and vegetable lands, used by the Asian Development Bank in assessing the economic worthiness of the Upper Watershed Management Project of Sri Lanka (Abeygunawardena *et al.*, 1999). This distribution assumes that the benefit of soil conservation would gradually increase (by about 10% a year) up to the maximum in the 10^{th} year and would sustain over years.

The capital costs of soil conservation (CC_{jL}), was based on expenditures by farmers in the watershed in adopting different soil conservation measures and the maintenance cost was based on technical estimates used by the Environmental Action 1 Project (EA1P) that is providing subsidies for soil conservation to the farmers (Weerapperuma, 2002). The following α_j values for the different conservation methods adopted was used based on recommendations of the Land and Water Resources Division, of the Department of Agriculture: Stone Terraces (ST) 90%; Lock and Spill Drains (LSD) 85%: SALT 85% and Leader Drains (LD) 80%. The extent of adoption was measured based on length of structures constructed.

The interest rate (r) used for the financial and economic analysis were 20% and 6%, respectively. The financial interest that was based on current commercial lending rates on agricultural loans by banks. The economic interest rate is the rate recommended by the Department of National Planning. The cost and returns were shadow priced using conversion factors recommended by the Department of National Planning, Sri Lanka.

The off-site benefits were included to the economic benefit stream. The off-site benefit was estimated using the benefit transfer method using the estimate of Kotagama *et al.* (1988) on off-site benefit of soil conservation in the upper Mahaweli watershed. The project investment-return period was considered as 25 years.

RESULTS AND DISCUSSION

Adoption level of soil conservation and financial cost

Table 1 shows the adoption level of different soil conservation methods during the years 1997–2001 by the farmers in the Bobitiya micro-watershed and the associated financial costs. Soil conservation has been adopted only in 31% of the total land area of the watershed. The soil erosion in some land uses such as Eucalyptus, coconut and paddy cultivation, open forest scrub and tank is very low. The total extent of land use with low erosion is 233.5 ha. Hence over the moderate to high erosion land uses (467.2 ha) soil conservation has been adopted in about 48% of the land area. The total cost for the adoption of soil conservation measures on 90.22 ha of the catchment area has been Rs. 733,964.00 (Rs. 8,135 ha^{-1}).

Benefit of soil conservation

The soil nutrients available in 15 different types of land uses are given in Table 2. The rate of soil erosions and estimated losses of nutrients due to erosion in different land uses are shown in Table 3. The benefit of investing on soil conservation based on current market prices of nutrients is given in Table 4.

Table 1. The level of adoption of soil conservation measures and financial costs.

Gramaseva Division	Total no. of farmers adopted soil conservation measures	ST		LSD		LD		SALT		Area
		m	Rs.	m	Rs.	m	Rs.	m	Rs	ha
Kiriwanagoda	26	108	5,504	2132	43,400	-	-	246	2,952	7.89
Oluwawatta	63	401	18,157	5519	110,187	-	-	365	4,260	20.32
Ududeniya Madihe	13	90	4,050	1161	18,531			573	6,876	3.04
Ddudeniya	12	-	-	1323	27,783	-	-	156	1,872	0.42
Bopitiya	42	277	13,541	5053	94,407	-	-	260	2,948	13.15
Maussawa	17	1637	80,070	1254	20,820	220	22,000	112	1,344	5.77
Bowlana	76	1008	50,687	11737	190,679	73	7,300	675	6,556	36.52
Total	249	3521	172,009	28179	505,847	293	29,000	2387	26,808	87.02

ST - Stone Terraces; LSD - Lock and Spill Drains; LD - Leader Drains; SALT - Sloping Agricultural Techniques.
The extent of adoption of soil conservation is measured in terms of metres of conservation structures built/planted.

The total on-site benefit of soil conservation in the Bopitiya watershed is Rs. 0.369 million yr^{-1} and benefit per ha is Rs. 5,146 yr^{-1}. Vegetable cultivation in 11% of the watershed contribute to about 62% to the on-site cost of soil erosion in the watershed. The on-site benefit of soil conservation in public and private lands are Rs. 0.177 and 0.192 million, respectively. As a percentage of the total on-site cost the on-site cost of soil erosion in public lands is 48%. This shows the importance of including soil conservation measures in public lands in watershed management projects. The estimate by Kotagama *et al.* (1998) on offsite benefit of soil conservation, which is Rs. 423 ha^{-1} yr^{-1} was used to calculate total offsite benefit of the watershed. The total off site benefit of soil conservation in the Bopitiya watershed is Rs. 0.3 million yr^{-1}.

Banda and Abeygunawardena (1995) have estimated the replacement cost of soil erosion in Nuwara Eliya district as Rs. 6,116 ha^{-1} $year^{-1}$, which is about twice higher than the replacement cost estimates on vegetables estimated in this study. This study has considered loss of nutrients based on existing nutrients of the soil based on soil nutrient analysis of existing land uses. Where existing fertility of the soil is low the loss of nutrients due to erosion is also low resulting to lower replacement costs. In this study, the loss of soil nutrients due to soil erosion was estimated based on analysis of soil samples in different land uses, whilst most previous studies have used secondary data.

Table 2. Nutrient contents in different land uses.

Land use	Nutrient availability							
	N %	N kg ha^{-1}	P ppm	P kg ha^{-1}	K ppm	K kg ha^{-1}	OM ppm	OM kg ha^{-1}
1. Pinus	0.18	3,600	2.25	4.50	88.00	176.00	2.69	5.38
2. Eucalyptus	Very low erosion							
3. Barren lands	0.07	1,400	9.50	19.00	36.00	72.00	3.78	7.56
4. Scrub	Low erosion							
5. Open forest	Very low erosion							
6. Natural grass lands	0.22	4,400	1.50	3.00	36.00	72.00	5.01	10.02
7. V.P. Tea	0.16	3,200	1.50	3.00	48.00	96.00	2.92	5.84
8. Tea seedling (well managed)	0.18	3,600	13.00	26.00	70.00	140.00	3.41	6.82
9. Tea seedling (moderately managed)	0.03	600	3.00	6.00	36.00	72.00	2.56	5.12
10. Paddy (irrigated and rain-fed)	Very low erosion							
11. Coconut	Very low erosion							
12. Mixed tree crops	0.07	1,400	7.50	15.00	36.00	72.00	1.22	2.44
13. Pepper cultivation	0.30	6,000	3.50	7.00	100.00	200.00	3.18	6.36
14. Vegetable cultivation	0.13	2,600	11.17	22.34	134.67	269.34	2.44	4.88
15. Kandyan home garden	0.59	11,800	2.17	4.34	159.33	318.66	3.40	6.80

Table 3. Loss of nutrients in different land uses due to soil erosion.

Land use	Rate of soil erosion t ha^{-1} year^{-1}	Nutrient loss kg ha^{-1} year^{-1}			
		N	P	K	Organic matter
1. Pinus	40	72.00	0.090	3.520	0.107
2. Eucalyptus		Very low erosion			
3. Barren lands	15	10.65	0.142	0.540	0:056
4. Scrub		Low erosion			
5. Open forest		Very low erosion			
6. Natural grass lands	10	22.40	0.015	0.360	0.050
7. V.P. tea	24	38.40	0.036	1.152	0.070
8. Tea seedling (well managed)	20	36.80	0.260	1.400	0.068
9. Tea seedling (moderately managed)	75	21.00	0.225	2.700	0.192
10. Paddy (irrigated and rainfed)		Very low erosion			
11. Coconut lands		Very low erosion			
12. Mixed tree crops	10	7.00	0.075	0.360	0.012
13. Pepper cultivation	25	75.00	0.087	2.500	0.079
14. Vegetable cultivation	100	130.00	1.117	13.467	0.244
15. Kandyan home garden	5	29.50	0.011	0.796	0.017

Table 4. On-site benefit of soil conservation (replacement cost).

Land use	On-site benefit Rs. ha^{-1} year^{-1}	Extent (ha)	Total on-site benefit million ha^{-1} year^{-1}
1. Pinus	1305.80	113.72	0.148
2. Eucalyptus		42.05	
3. Barren lands	258.70	99.27	0.026
4. Scrub		93.35	
5. Open forest		2.94	
6. Natural grass lands	479.80	6.00	0.003
7. V.P. tea	1303.20	20.53	0.027
8. Tea seedling (well managed)	1299.40	27.19	0.028
9. Tea seedling (moderately managed)	1116.70	21.56	0.030
10. Paddy (irrigated and rainfed)		76.08	
11. Coconut lands		7.91	
12. Mixed tree crops	261.60	22.91	0.006
13. Pepper cultivation	1578.00	6.24	0.100
14. Vegetable cultivation	2799.80	81.89	0.229
15. Kandyan home garden	506.00	67.89	0.034
16. Settlement		9.01	
17. Tank		2.16	
Total	5146.10	700.70	0.369

The market prices of nutrients used were; N - Rs. 14.35 kg^{-1}, P - Rs. 47.09 kg^{-1}, K - Rs. 35.00 kg^{-1}, Organic Matter - Rs. 1.50 kg^{-1}.
Transport cost and labour costs incurred by farmers were used.

Financial analysis

The analysis is done on vegetable cultivation, pepper cultivation, Kandyan homegarden and seedling and VP tea cultivation. The work sheet on VP tea cultivation is given in Table 5. The results of the financial analysis with market prices (subsidized prices) and FOB prices (unsubsidized prices) are given in Tables 6 and 7, respectively.

All the soil conservation measures provide negative net present values. Hence it may be concluded that soil conservation is financially unprofitable and that farmers would not privately invest on adopting soil conservation.

As indicated in Table 7, the net present values are negative with unsubsidized fertilizer prices, indicating that even under unsubsidized prices of fertilizer soil conservation is not financially profitable and farmers would therefore not invest on soil conservation. Hence the hypothesis based on environmental economic theory that subsidizing fertilizer use as a cause of non-adoption of soil conservation is rejected.

Table 5. The analytical work sheet on estimating the financial viability of soil conservation under VP tea cultivation (FOB prices of nutrients).

Year	Cost Rs ha^{-1} LSD	LD	ST	SALT	On-site benefit Rs ha^{-1}	Net benefit Rs ha^{-1} LSD	LD	ST	SALT
2001	10,500	10,000	24,700	-	-	(10,500)	(10,000)	(24,700)	-
2002	780	633			23	(761)	(615)	20	
2003	780	633		-	87	(706)	(563)	79	-
2004	780	633		-	230	(584)	(449)	207	-
2005	780	633		-	500	(355)	(233)	450	
2006	780	633		-	877	(34)	69	790	
2007	780	633		-	1,335	354	435	1,201	-
2008	780	633		-	1,730	690	751	1,557	-
2009	780	633		-	1,988	910	958	1,790	-
2010	780	633		-	2,111	1,015	1,056	1,900	-
Continued up to year 2024									
2024	789	633		-	2,111	1,015	1,056	1,900	-
2025	780	633		-	63,229	52,964	49,950	56,906	-

NPV (Rs)

Interest rate	LSD	LD	ST	SALT
17%	(7,561)	(6,721)	(15,559)	-
20%	(8,212)	(7,411)	(16,616)	-
21%	(8,339)	(7,551)	(16,837)	-
IRR	0.09	0.09	0.07	-

FOB - Free on board. The NPV within parenthesis are negative. SALT soil conservation measure is not adopted under mature tea. The net benefit of Rs. 63229 accounts for the irreversibility value of soil loss. ST - Stone Terraces; LSD - Lock and Spill Drains; LD - Leader Drains; SALT - Sloping Agricultural Techniques.

Table 6. Financial profitability of soil conservation (market prices of fertilizer).

Type of cultivation	NPV at 20% interest rate LSD	LD	ST	SALT
VP tea lands	(9646)	(8761)	(18134)	-
Seedling tea - moderately managed	(10220)	(12271)	(18741)	-
Seedling tea - well managed	(9652)	(8767)	(18141)	-
Export crops (pepper)	(2087)	-	(10110)	(15740)
Vegetable cultivation	(5050)	-	(8147)	(12608)
Kandyan home gardens	(10936)	(7478)	(19378)	-

Numbers within parenthesis are negative.
ST - Stone Terraces; LSD - Lock and Spill Drains; LD - Leader Drains; SALT - Sloping Agricultural Techniques.

Table 7. Financial profitability of soil conservation (FOB prices of fertilizer).

Type of cultivation	NPV - Financial analysis 20% discount rate by using unsubsidized fertiliser			
	LSD	LD	ST	SALT
VP tea lands	(8212)	(7411)	(16616)	-
Seedling tea - moderately managed	(8254)	(10421)	(16660)	-
Seedling tea - well managed	(8799)	(7963)	(17237)	-
Export crops (pepper)	(2005)	-	(10023)	(15667)
Vegetable cultivation	(4867)	-	(7953)	(12452)
Kandyan home gardens	(10539)	(7104)	(18992)	-

Numbers within parenthesis are negative.
ST - Stone Terraces; LSD - Lock and Spill Drains; LD - Leader Drains; SALT - Sloping Agricultural Techniques.

Economic analysis

Investing on soil conservation in all land use types with all methods of soil conservation is economically worthy (Table 8). The finding that adoption of soil conservation is financially non-worthy but economically worthy justifies government investments on soil conservation. Further, conservation in public lands, too is economically worthy, particularly considering the off-site benefits.

Table 8. Results of economic analysis.

Type of cultivation	NPV - Economic analysis 6% discount rate			
	LSD	LD	ST	SALT
VP tea lands	27568	26723	26191	-
Seedling tea - moderately managed	31846	26559	30721	-
Seedling tea - well managed	23427	22826	21806	-
Export crops (pepper)	28423	0	17993	11412
Vegetable cultivation	31481	0	27420	29462
Kandyan home gardens	15695	18756	13801	-
Mixed tree crop lands	0	1797	(3406)	-
Natural grass lands	6334	10886	10447	-
Barren lands	11514	10260	13950	-
Pinus cultivation	22100	22495	25813	-
Typical farm land	34423	32934	35930	15190

ST - Stone Terraces; LSD - Lock and Spill Drains; LD - Leader Drains; SALT - Sloping Agricultural Techniques.

Sensitivity analysis done on both the financial and economic analysis considering different prices of fertilizer, cost of conservation and interest rates did not change the above conclusion. However, the nature of the benefit function of soil conservation was found to be substantially sensitive in the financial analysis. If the full benefits of soil conservation are received earlier some of the soil conservation methods in some land uses are financially worthy. This study has used the most recently available and applied information on the benefit function, however given the sensitivity of it, further soil scientific research need to be undertaken to empirically establish the nature of the soil conservation benefit function.

CONCLUSIONS

The study indicated that adoption of soil conservation is not financially profitable in Bopitiya micro-watershed, implying that farmers would not invest on soil conservation. Economic analysis of soil conservation indicated that soil conservation is beneficial to society. Therefore, government investment, on soil conservation was justified. Further the results of the financial analysis using the unsubsidized price of fertilizer, indicated that even with unsubsidized fertilizer prices soil conservation benefits (in terms of replacing lost soil nutrients) do not outweigh soil conservation costs. Hence, the hypothesis that provision of a government subsidy to agriculture (fertilizer) leads to reduced private investments on soil conservation is rejected. The result of the study supports the present government policy of investment on soil conservation in watersheds. The benefit function of soil conservation was found to be very sensitive on the temporal distribution of benefits. Further, soil scientific research need to be undertaken to empirically establish the benefit function of soil conservation.

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