Costs and Benefits of Soil Fertility Management strategies in Tea Lands

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Land Degradation in Tea Lands in Sri Lanka

Land degradation has been a major environmental issue

Steepness

poor management practices.

Leader drains
Lateral drains
Stone terraces
Shade
SALT

Actual Level 16-36% of standard

10% of tea land abandoned - Reduction of productivity

30% of entire tea land - marginal or uneconomic in mid country

The management of soil fertility in tea lands is very important for sustainability of the tea industry

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Two Major Types of Degradation

Soil fertility decline leads to highly erodible soils

Soil Erosion

Fertility Decline

Erosion removes most fertile soil (topsoil)

The Triangle of Soil Fertility

Chemical Fertility

S.O.M.

Physical Fertility

Biological Fertility

Soil Organic Matter is linked to all aspects of soil fertility &Soil Quality

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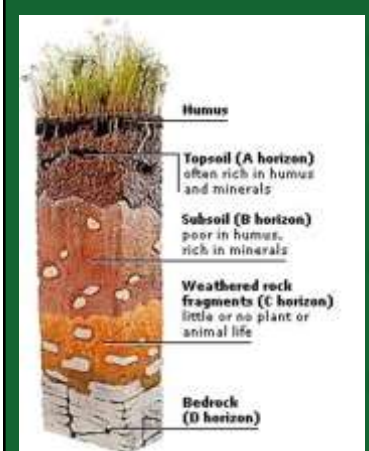
Importance of Top Soil



Loss of 1 inch per acre of topsoil represents 167 tons per acre

30 years required to develop 1 inch of soil with properties of typical topsoil

Topsoil- enriched with OM & granular aggregates provide larger soil pores, reduce soil density, enhance water infiltration & aeration

Properties influenced by OM- soil structure; moisture holding capacity; diversity and activity of soil organisms

When topsoil is eroded, yield declines due to nutrient loss & damage to soil physical properties

12-18 inches soil loss = 30 -50 % loss of productivity

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Cost of Soil Erosion

On site

Loss of Soil/Nutrients

Loss of water

Ecological Damage

Additional fertilizer

Irrigation

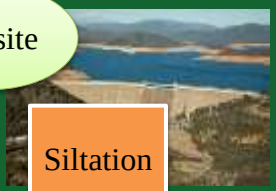
Decrease soil depth

Soil biodiversity

Crop loss

Plant composition

Off site



Siltation

Reduction of water storage in reservoirs

River & lake flooding

Reduction of hydropower generation

Reduction of irrigation capacities

Shortens the lifetime & increase the maintenance cost

Water treatment

Loss of natural resources

Management of Soil Fertility

Strategies for soil fertility improvement

Conservation of existing soil fertility

Improve the fertility of soil

Leader drains/lateral drains/terraces (stone & live/SALT hedge rows)

Forking/Burying of prunings

Weed management

Shade management

Adding compost

Applying inorganic Fertilizer

Infilling vacancies

Mulching & cover crops

Objectives

- To identify benefits of soil fertility management
- To calculate investment requirement for soil fertility management in tea plantations

Benefits of Soil Fertility Management

- *Minimize the onsite effect of soil erosion*

i. Minimize soil & nutrient loss

Growers use technologies for compensating the loss in the soil fertility, applying more nutrients and using management practices that increase production costs.

Benefits of Soil Fertility Management Contd.

Soil erosion in tea lands

Agro Ecological Zone	Land Use	Soil Loss mt/ha/yr	Reference
Uva high lands Passara	*VP Field*	*3.41*	Prasad Dharmasena and M.S. Bhat (2011)
	Old seedling tea	*25.52*	
Tea lands in the upper catchment of Mahaweli	Poorly managed OST	51.00	Gunathilake & Gopalakrishnan, (1999)
	Well managed OST	15.00	
	VP tea	2.00	
	Mulched(during monsoon)	*0.70*	Manipura et.al. (1972)
	Un-mulched (during monsoon)	*40 .00*	
	Well managed Tea	0.33	
	Poorly managed Tea	20 .00	

contd…

Agro Ecological Zone	Land Use	Soil Loss mt/ha/yr	Reference
Mid Country Wet Zone - Peradeniya	*Old seedling tea without conservation measures*	40.00	Stocking, M. (1992)
	Well managed clonal (VP)tea on contour with lateral drains	0.24	
Hill Country wet zone Talawakelle	Clean weeded one year old clonal tea	52.60	
	One year old clonal tea with mulch	0.07	
	A four year tea replanting period	250	Hasselo & Sikurajapathy (1985)
Tea lands in the upper catchment of Mahaweli	Weeded tea	51.9	Manipura (1972)

Benefits of Soil Fertility Management Contd.

Nutrients lost by erosion

Region	Land use	Rate of erosion t/ha/yr	Nutrients lost-kg			
			N	P	K	OC
Mid Country Wet Zone (Peradeniya)	OST (without conservation measures)	40	66.7	16.7	33.3	400
	VP tea (well managed on contour with lateral drains)	0.24	0.4	0.1	0.2	2.4
Uva high lands - Passara	VP Field	3.41	4.8	0.92	13.6	60.03
	OST	25.52	29.34	2.1	182.4	319.01

Benefits of Soil Fertility Management Contd.

ii. Reduce yield losses

Yield loss for different erosion rates within a 30 year time span

	Yield loss (kgMT/ha/yr)	
Elevation	@ Soil loss 10mt/ha/yr	@ Soil loss 150mt/ha/yr
High	1.0	207.1
Mid	0.5	102.4
Low	0.2	56.6

Ananda, G. Herath & Anthony. Chisholm (2001)

Soil loss tolerance limit low, mid, up country - 7, 9 & 13 mt/ha/yr

Soil erosion influences the tea yields significantly

Benefits of Soil Fertility Management Contd.

iii. Avoid a drop in the value of tea land

iv. Minimize loss of income & profit to the farmer

v. Minimize biological losses

Addition of OC & nutrients

Strategies	N	P	K	OC
Shade management		kg/ha/yr		
Low country				
Albizzia	38	2	8	500
Gliricidea	150	8	75	1850
Up country				
Grevellia	28	2	17	700
Erythrina	127	11	80	1425
Thatching	42	4	42	1200
SALT Hedge rows	280	21	140	2450
Compost using -weeds	108	12	136	1200
Burying of prunings	204	16	73	4200

Benefits of Soil Fertility Management Contd.

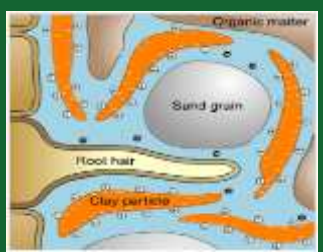
Biomass & amount of nutrients released from hedge row spps (kg/ha/yr)

Species	Total Biomass	Nutrients (N,P,K)
Calliandra	3,772	107, 1.8 , 136.9
Casia	3,045	85, 1.4, 86.3
Euphatorium	689	13, 0.3, 28.5
Flemingia	252	37.6, 0.9, 70.3
Gliricidia	1,453	38.9, 0.8, 72.7
Tithonia	1,879	48, 1.5,95.7

De Costa 2001

Benefits of Soil Fertility Management Contd.

i. Improve soil aeration & increase water holding capacity
ii. Increase efficiency of applied fertilisers
iii. Modifies the micro climate suitable for tea



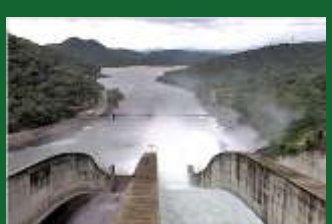
Benefits of Soil Fertility Management Contd.

- ***Minimize Offsite effects of soil erosion***

i. Reduce investment for reverse offsite damage of soil erosion

Due to sedimentation in reservoirs

ii. Minimize the reduction of hydropower generation
iii. Minimize the reduction of irrigation capacities
iv. Availability of natural resources for future generations



Benefits of Soil Fertility Management Contd.

Strategies	Direct & Indirect benefits
Construction of leader drains, lateral drains, stone terraces	Minimize on site & off site damage of soil erosion
Shade management	Addition of organic matter & nutrients, less soil erosion Build up of soil organic matter, increased water holding capacity, maintain favorable micro climate
In-filling of vacancies	Increase yield Reduce erosion & heavy weed infestation
Thatching or mulching, cover crops	Reduces surface runoff, increases the rate of infiltration Prevent soil erosion, retaining soil moisture during dry periods Provide nutrients, reduces weed growth

Benefits of Soil Fertility Management Contd.

Strategies	Direct & Indirect benefits
SALT	Minimize soil erosion, improve soil fertility, increase efficiency of applied fertilisers, yield increase , modifies the micro climate Reduces weed populations.
Adding compost	Addition of organic matter & nutrients, Improve soil aeration & water holding capacity, Reduce crop loss
Burying of pruning	Addition of organic matter & nutrients, Improve soil aeration & water holding capacity, Increase yield - 199kg/ha/yr
Forking	Improve soil aeration & water holding capacity Enhance tea yields- 20%

Establishment & Maintenance Cost of Soil Fertility Management as per TRI Recommendation (Rs/ha/yr)

Strategies	Requirement per ha	Establishment cost	Annual establishment cost	Annual maintenance cost	Total annual cost
Soil conservation		195427	10020	46750	56770
Leader drains	100m x 2	17188	573	6875	7448
Lateral drains	100mx5	57292	1910	6875	8785
Stone terraces	100mx2	34375	1146	5500	6646
Grass strips	100mx2	41250	4125		4125
SALT		45323	2266	27500	29766
Soil fertility improvement		**260760**	**14389**	**62326**	**76715**
Medium shade	270 plants	42387	4239	6875	11114
High shade	70 plants	39398	2627	3438	6064
In-filling of vacancies-(10%)		155600	5187		5187
Thatching or mulching, cover crops		23375	2338	5775	8113
Adding compost				27332	27332
Burying of pruning				13750	13750
Forking				5156	5156
Total		456186	24409	109076	133485

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Expenditure for Recommended Soil Fertility Management Strategies for Different Slopes (Rs/ha/yr)

Slope category	Establishment cost	Annual establishment cost	Annual maintenance cost	Total annual cost
Less than 25%	4,56,186	24,409	1,09,076	1,33,485
25-40%	5,25,509	28,095	1,11,826	1,39,920
Above 40%	6,20,613	32,640	1,13,888	1,46,528

Methods for Quantifying Benefits

1.The replacement approach

Replacement cost of nutrients loss ((Rs/ha) = Soil loss X Quantity of nutrients X Price of nutrient + Cost of labour + Cost of repair & maintenance of damages due to soil erosion

2.The productivity change approach

Lost /increase yield, resulting from soil imitations/improving, computed in terms of the reduction/increment in profits.

3.Replacement value of soil/ the drop in land values

4.Biological losses

5.Value of nutrients & organic matter added to the soil

Benefits & Costs

Strategies	Considered benefits	Value of benefits (Rs/ha/yr)	Annual Cost (Rs./ha/yr)
Construction of leader drains, lateral drains, stone terraces	Reduce nutrient loss due to lateral drains	28,563	8,785
Shade management	Value of nutrients & OC supplied by lopping LC + UC	1,02,472 92,936	HS-6,064 MS-11,114
In-filling of vacancies	Yield increase (@Rs.60/kg MT)	15,000	5,187
Thatching or mulching, cover crops	Addition of OC & nutrients	45,041	8,113
SALT	Addition of OC & nutrients	1,23,437	29,766
Adding compost	Addition of OC & nutrients	61,432	27,332
Burying of pruning	Addition of OC & nutrients- 3-5 years Yield increase	1,60,599+ 11,940	13,750-17,188
Forking	Yield increase	24,000	5,156

Additional Investment Required (Rs/ha/yr)

Slope category	Annual expenditure for standard level	Annual actual expenditure	Additional investment required
Less than 25%	1,33,485	33,085	1,00,400
25-40%	1,39,920	34,114	1,05,806
Above 40%	1,46,528	35,172	1,11,357

Actual level of soil conservation & fertility improvement strategies varied between 16-36% of the standard level

(Survey conducted by Agricultural Economics Division, 2006 & Diagnostic survey conducted by Advisory & Extension Division, 2008)

Reasons for Not Adopting Soil Fertility Management Practices

1. **Limited knowledge about how soil degradation impacts growers' earnings**
2. **Not adequately appreciated the "real" cost of land degradation to the economy**
3. **Labour scarcity**
4. **Financial constraints of the growers**

Conclusions

- **Review of past studies on soil fertility management strategies in tea lands revealed that poor adoption of soil fertility management strategies has adversely affected sustainability of tea industry.**
- **Even though some benefits were not taken in to account, soil fertility management strategies in general are seen cost effective at current input prices.**
- **Tea plantations need to invest on soil fertility management in order to bring soil fertility levels up to the required levels to sustain the industry**
- **Additional investment requirement to improve soil fertility management level up to the expected level is in the range of Rs. 1,00,400 - 1,11,357 ha/yr**

THANK YOU

Major Land Use Types with the Rates of Soil Erosion in Mahaweli Catchments

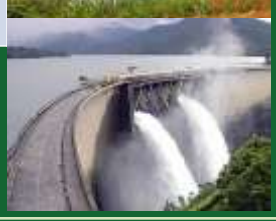
Land Use category	Erosion rate t $ha^{-1}year^{-1}$	Kotmale (ha)	Victoria (ha)	Randenigala (ha)	Rantambe (ha)	Total (ha)
Tobacco	70	3,456	29,465	4,828	16,017	53,766
OST (PM)	**51**	**12,472**	**11,260**	**5,554**	**5,189**	**34,475**
OST (WM)	**15**	**2,852**	**4,765**	**1,787**	**4,784**	**14,188**
VP tea	**2**	**9,140**	**8,253**	**4,071**	**3,803**	**25,267**
Vege. Gardens	25	1,291	22,424	3,875	20,867	48,457
Home Gardens	1	278	16,334	3,775	8,182	28,569
Forest	1	11,512	17,627	2,723	3,794	35,656
Total Land (ha)		55,000	134,100	43,899	78,800	311,799
Total Erosion t $year^{-1}$		1,231,740	3,031,020	1,083,186	2,339,750	7,685,696

24% of catchment area – tea cultivation

Gunathilake & Gopalakrishnan (1999)

Sedimentation in Reservoirs (Volume in mm^3)

Year	Kotmale	Victoria	Randenigala	Rantambe
1980	176.78	709.19	835.04	11.05
1993		713.08		8.963
1995	170.58		768.83	7.000
1999		(only few lines)		7.116
2000				7.119
% Loss	**3.52**	**0.62**	**7.93**	**36.22**
Annual Avg.Loss	**0.23%**	**0.047%**	**0.53%**	**36.22%**



Hathurusinha & Ediriweera (2003)

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