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Valuation of Environmental Services in Sri Lanka – A Case Study of Soil and Watershed Benefits in the Southern Province

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Chapter 1 Environmental Services in the Southern Province

1.1 Introduction

1. The Southern Province of Sri Lanka, long considered an economically lagging region, is embarking on a new strategy of promoting greater economic development and creating more income opportunities. As part of this overall plan, several large developments are proposed that will likely have implications for critical ecosystems and environmental service flows on which the Southern population greatly depends.[1] While the benefits that accrue under the economic development plan may be substantial, the sustainability of such income generation may be outweighed by the degradation in income derived from those linked to the environment – such as agriculture, forestry, fishing and tourism.[2] Ambitious investment programs such as these need to be harmonized with the fundamental sustainability concepts declared in the Government's 10-year development framework, "land in harmony with nature", otherwise the benefits of such developments may come at the expense of greater vulnerability for those whose livelihoods depend on natural resources.[3]

2. The Southern Province comprises three districts: Galle, Matara, and Hambantota; it stretches along the southern coast of Sri Lanka, extending 65 kilometers inland at its widest point (Map 1.1). It has a gross area of 554,200 hectares and is about 250 km long from the town of Bentota in the west to Yala National Park in the east. The total population of the province is about 2.4 million, of which about 90 percent are considered rural and about 28 percent are poor (World Bank, 2007).[4]

3. The Southern Province is also one of the richest in terms of its environmental service values and biodiversity; itincludes the Hambantota District, which has been declared the model environmental district by the Government of Sri Lanka (GoSL). Among the wide array of environmental service flows in the Southern Province, two of the most significant are the benefits of agriculture and those derived from watershed functions.

4. Agriculture, the predominant economic activity, contributes about 30 percent of provincial Gross Domestic Product (GDP) and about 48 percent of employment. However, the importance of

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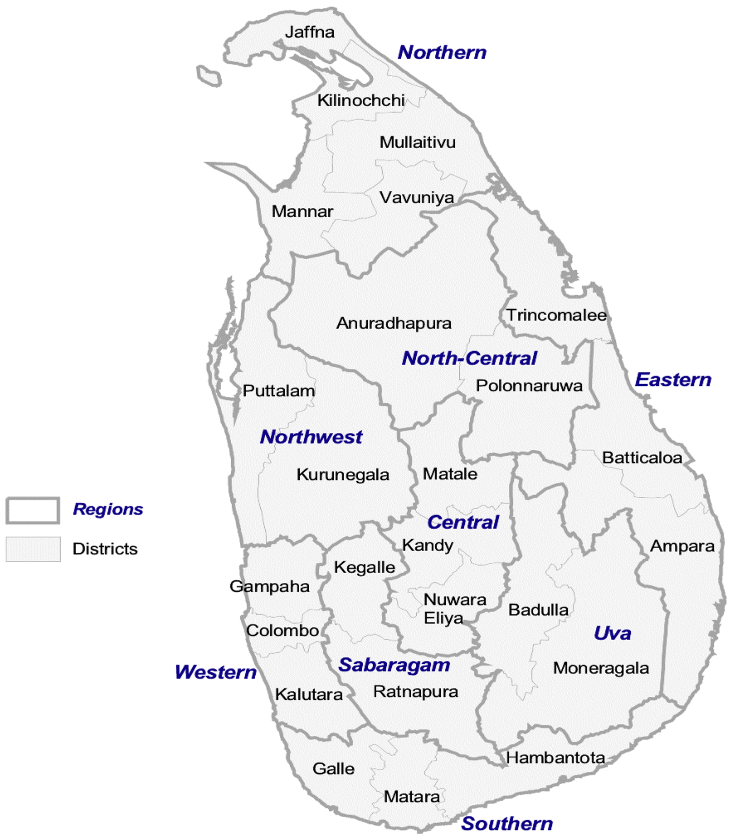
[1] In particular, the plan calls for the development of a harbour in the district of Hambantota and a second international airport.

[2] See companion policy note on the benefits of recreation and tourism in the Southern Province (World Bank, 2009).

[3] The Government's framework called the Mahinda Chintana (MC): Vision for a New Sri Lanka was presented at the Sri Lanka Development Forum in 2007.

[4] Using the poverty headcount ratio (%); Galle: 26%, Matara: 27%, Hambantota: 32%.

agriculture as an employer varies across the province and increases considerably in the east; 32 percent of the population in Galle is dependent on agriculture as compared with 48 percent in Hambantota (World Bank, 2007). The major export crops grown in the region include tea, rubber, coconut, cinnamon, rice, and various fruits. The province produces 33 percent of Sri Lanka's tea and 75 percent of the world's cinnamon (Department of Census and Statistics, 2004). During 1999-2000, the combined value of annual and perennial farm production in the region was estimated at SLRs25 billion.



Map 1.1 – Map of Sri Lanka

5. Critical to continued agricultural productivity is soil conservation. The clearing of forests (i.e., slash and burn) for new lands typically increases runoff and siltation rates in steeply sloped lands, and intensive farming practices have been linked to declining productivity. Key to the sustainable management of soil productivity is nutrient management and the adoption of conservation techniques that can conserve soil depth. Agricultural lands in the Southern Province are particularly vulnerable to the effects of erosion – with steeply sloped lands in the west and dry, arid lands to the east. The costs of soil erosion from development and crop intensification are a serious threat to agricultural livelihoods.

6. The protection of watersheds in the Southern Province is also vital to the population and environment. Watersheds provide critical service flows such as supplying water for agricultural irrigation and domestic water use. They also play a major role in regulating water flows for flood attenuation, sediment control, water filtration or purification, forestry, fishing and recreation, just to name a few. Development that alters these regulatory and provisioning services ultimately affects many lives either directly or indirectly.

7. The purpose of this policy note is to quantify the benefits of soil conservation and watershed functions for use in policy and development planning. This will enable policymakers to weigh the benefits from future development activities and to better understand the potential tradeoffs. Without quantifying environmental services, there remains a propensity to neglect their value in development and planning decisions, resulting in ineffective environmental policies and regulations.

8. The valuation of environmental services is important to enable fully informed and efficient decisions regarding the environment and natural resource management. The environment is considered a common property resource; as a public good, most environmental goods and services are not traded in the market and therefore do not have a price (or, are partially priced). Without a price, markets fail to capture the value of environmental goods and services, resulting in their under provision and mismanagement. Therefore, in order to address sustainable economic development and environment protection within a country's economic policy, the translation of the benefits and costs of environmental services into monetary terms is a difficult but necessary first step. Focusing on the "use-values" of ecosystems in the Southern Province, this study produces results that inform policymakers in making development decisions sensitive to environmental considerations.

9. The policy note is structured as follows. Chapter 2 covers the importance of soil conservation in each of the agricultural growing districts in the Southern Province, and estimates annual soil loss from rainfall erosion. The costs of replacing these lost nutrients are estimated and weighed against the benefits from alternative conservation measures. In Chapter 3, watershed benefits are evaluated for a selected set of river basins in the Southern Province. The benefits are disaggregated into different environmental service flows that have both market and non-market values. Specific values included are the regulatory and provisioning functions of wetlands, mangroves, coral reefs as well as the value of water for supplying drinking water for communities and agricultural irrigation. Finally, the policy note provides conclusions and further discussion in Chapter 4.

Chapter 2 Benefits of Soil Conservation

2.1 Sri Lanka and its ecological geography

10. Sri Lanka traditionally has been divided into three climatic zones on the basis of rainfall: the Wet Zone in the southwestern region including the central hill country, the Dry Zone covering mainly the northern and eastern part of the country, and the Intermediate Zone skirting the central hills except in the south and the west (Figure 2.1). The Wet Zone covers the area receiving mean annual rainfall over 2500 mm without pronounced dry periods. The Dry Zone receives less than 1750 mm with a distinct dry season from May to September. The Intermediate Zone receives between 1750 and 2500 mm and has a short and less prominent dry season. Three elevation (and temperature) zones are traditionally recognized: the low country, below 300 m elevation; the mid-country between 300 and 900 m; and the up-country above 900 m. Both Wet and Intermediate zones spread across all three categories of elevation while the Dry Zone is confined to the Low country, so seven agro-*climatic* zones cover the entire island.

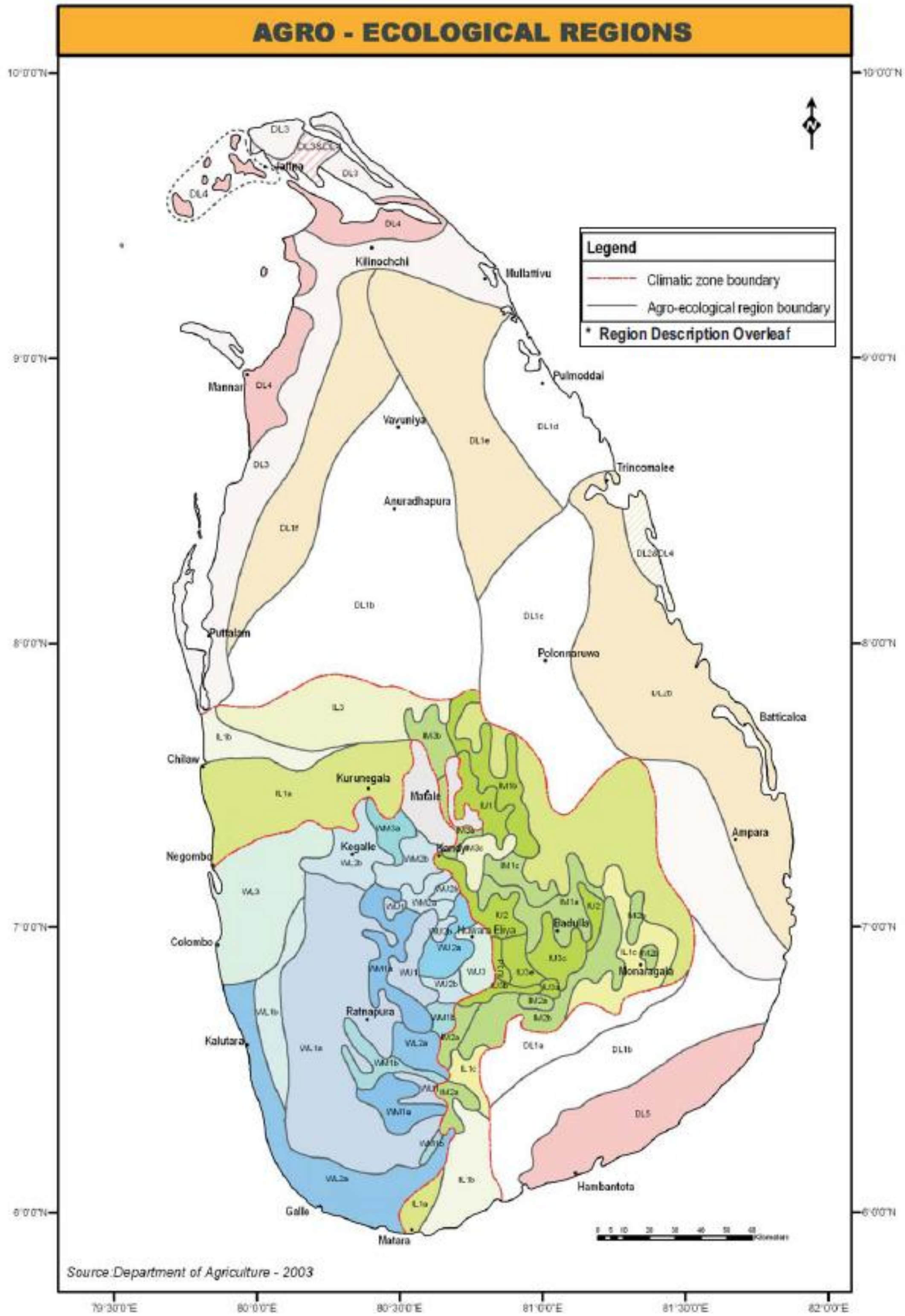
11. Sri Lanka is also divided into 24 Agro-Ecological Zones (AEZ). The differentiation of the Wet Zone into its distinctive agro-ecological regions was governed primarily by differences in rainfall and elevation. In the Dry Zone, on the other hand, the nature of the soil primarily determines the identity of individual agro-ecological regions and in the Intermediate zone rainfall, elevation and soil play an equally important role.

12. The Southern Province is characterized by a wide range of land forms from flat coastal plains in the south to hills in the north. The climate ranges from wet and humid in the west to dry and arid in the east. As a result, the Southern Province covers a wide range of natural ecosystems, and the land and water use patterns as well as the agricultural cropping systems are extremely varied. These range from forests and tea estates in rolling upland country in the north and east, through low-lying coconut and paddy areas in the wetter coastal plains, to semiarid lowland plains in the eastern dry zone. The latter are suitable only for subsistence shifting cultivation or livestock production.

2.2 Soil productivity

13. The soil productivity of agricultural activities is one of the most important environmental service flows in the Southern Province (other than perhaps water). Unless soils are managed in a sustainable manner, exposed lands remain vulnerable to the effects of erosion. Soil erosion has numerous impacts on crop productivity, food production, economic growth, income distribution, and the environment. It can reduce crop yields in several ways such as through the reduction of plant nutrients, degradation of soil structure, and non-uniform removal of soil within a field. When fertile soil is removed, along with it go the nutrients and organic matter which are significant to the growth of plants and crops.

Figure 2.1 Agro - Ecological Zones of Sri Lanka



Source: Department of Agriculture (2003)

14. Previous studies of soil erosion in Sri Lanka suggest that erosion is occurring at a significant rate (Stocking, 1992; Nayakekorala, 1998). However of the handful of assessments that actually quantify the economic losses from soil erosion, none were conducted for areas in the Southern Province. In a study of the Upper Mahaweli Watershed, on-site costs of soil erosion ranged from USD 3.84/ha/year for home gardens to USD 122.75/ha/year for shifting cultivation with a total cost of over USD 14 million per year in 1993 prices (Vieth *et al*., 2001). Soil erosion losses in the Nuwara Eliya district were estimated to be approximately Rs. 814 million per year (Abeygunawardnea and Samarakoon, 1993). In another study conducted on potato lands in the Nuwaraeliya district of Sri Lanka, the estimated on-site nutrient replacement cost ranged from Rs. 4,251/ha to Rs. 3,443/ha in the Maha and Yala seasons, respectively (Samarakoon and Abeygunawardena, 1992).[5] Other, more global, estimates derived from the Global Assessment of Soil Degradation (GLASOD) suggest that nearly 33% of Sri Lanka's land area is severely or very severely degraded in terms of reduced agricultural productivity (Oldeman *et al.,* 1990, 1991; Oldeman, 1992, 1993).[6]

2.3 The Approach

15. The direct approach to estimating the on-site costs of soil erosion is to quantify yield losses attributable to erosion, and value these losses using market prices. However, measured data on the relationship between erosion and yield is often difficult to obtain, especially in developing countries. In these data scarce instances it is common to use the simpler replacement cost method (RCM) as an appropriate alternative (Dixon and Hufschmidt 1986). The RCM assumes that the productivity of soil can be maintained if lost nutrients and organic matter are manually replaced. This is of course an over-simplification, as soil fertility actually depends on a host of other inputs in addition to nutrients. Generally, the RCM is assumed to provide a lower limit on costs, unless soils are composed of deep, fertile layers (Hufschmidt *et al*., 1983). Most soils in the Southern Province are composed of sand and clay which makes soil depth moderately shallow and more erodible.

16. To assess the economic impacts of soil erosion, this report employs a model to estimate soil loss due to water erosion then imputes the replacement cost of this loss. The replacement cost is the amount of money it would take to sustain the soils' productivity by physically replacing the nutrients lost in the erosion process – in the absence of conservation tillage techniques. The cost implications of two methods of manual replacement are explored. The report also provides cost estimates of three commonly used soil conservation techniques and evaluates the investment payback period of adopting these practices. Section 2.4 below first presents the model used to estimate soil nutrient losses with the results in Section 2.5. Section 2.6 then presents total nutrient losses across all crops for the province and also calculates the cost of two manual nutrient replacement methods. Section 2.7 then evaluates the payback period for three soil conservation methods.

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[5] Maha and Yala seasons are the two main rainfall seasons in Sri Lanka fed by North East and South West Monsoons.

[6] GLASOD was conducted by the UNEP and the International Soil Reference and Information Centre (ISRIC) in the 1980s.

2.4 Modeling soil nutrient loss

17. Models of soil erosion play critical roles in soil and water resource conservation and non-point source pollution assessments, including: sediment load assessment and inventory, conservation planning and design for sediment control, and for the advancement of scientific understanding. The most widely used soil erosion model is the Universal Soil Loss Equation (USLE), an empirically-based model which relates management and environmental factors directly to soil loss and/or sediment yields through statistical relationships. The USLE enables planners to predict the average rate of soil erosion for each feasible alternative combination of crop system and management practice in association with a specified soil type, rainfall pattern, and topography. The USLE is an erosion model designed to compute long-term average soil losses from sheet and rill erosion under specified conditions.

18. The USLE method stands in sharp contrast to process-based (physically-based) models which mathematically describe the erosion processes of detachment, transport, and deposition; through the solutions of the equations describing those processes, the process-based models provide estimates of soil loss and sediment yields from specified land surface areas. The appeal of the USLE is its relatively modest informational requirements in contrast to more complex process-based models.

19. The USLE estimates the average annual soil loss (A) by using a simple multiplicative functional relation expressed as $A = RKLSCP$ where R is the rainfall erosivity, K is the soil erodibility, L and S are slope length and slope angle factors, C is the crop management factor and P is the erosion control practice factor. With site-specific information, the USLE estimates can offer a good first-order approximation of soil erosion due to rainfall events. The basic procedure is as follows:

Step 1. Information was initially collected on rainfall, soil type, AEZ area and crop area for each district in the Southern Province.[7] Values for each parameter of the USLE were also compiled at the crop and AEZ level in each district.[8]

Step 2. Estimates of average annual soil loss rates were calculated using the USLE for each crop, soil type, AEZ and district. Results are presented in Table A2.1 (Annex 2).

Step 3. Soil loss rates were then matched to Agricultural Census information on crop area to calculate the total loss by crop in each AEZ and district.[9] Results are presented in Table A2.2 (Annex 2).

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[7] Rainfall data were collected from station observations; soil type and AEZ area delineation were from the soil resources inventory and agro-ecological zoning (AEZ) maps; agricultural crop information was assembled from the Agricultural Census in 2002 and updated with information from 2005-06.

[8] Several parameter values were from Wijesekera and Samarakoon (2001) and Joshuwa (1977).

Step 4. Total soil losses were then associated with crop-level nutrient content measurements to calculate the loss of nitrogen, phosphorus, potassium (N.P.K.) and organic matter.[10] Low and high content ranges were developed to account for possible differences in soil nutrient balances in each AEZ. Nutrient levels are presented in Table A2.3 (Annex 2).

Step 5. Nutrient losses were then multiplied by current input prices for N.P.K. and organic matter to arrive at a total cost of lost nutrients per hectare per year (Tables 2.1 and 2.2) and annual losses (Tables 2.3 and 2.4) due to soil erosion. This information was then added to labor and transport cost information for a total replacement cost (Table 2.5).

2.5 Estimates of soil nutrient loss

20. Erosion rates (tons/ha/year) are highest in the Wet Zone (districts of Galle and Matara) and some areas of the Intermediate Zone (district of Matara), especially among minor export and fruit crops (Table A2.1). Rainfall patterns in these areas are in excess of 2000 mm/year and feature rolling and undulating terrain which is particularly prone to higher erosion rates. However, when erosion rates are combined with actual cropping area, tea, coconut and rubber plantations become more significant in terms of annual soil losses (tons/year), with fruit crops representing a relatively small share (Table A2.2).

21. Linking annual losses with soil nutrient content, and multiplying by input prices, Tables 2.1 and 2.2 below show the costs of soil nutrient erosion, again with the highest <u>per hectare</u> losses in the Wet Zone areas of Galle and Matera among minor exports crops and fruit growing. After multiplying by actual crop area in each district and AEZ in Tables 2.3 and 2.4 we see that tea, minor export crops and coconut plantations represent the largest costs in terms of soil nutrient loss. Again, it should be re-emphasized that the wide variation in loss estimates stems from the nutrient content of soils, the crop, and the rainfall patterns in each of the Agro-Ecological Zones. In designing extension programs, or evaluating the feasibility of alternative interventions, one would need to take these ranges into account, ideally at the plot-level.

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[9] Crops included in the analysis included the major crops of paddy, tea, rubber, coconut, minor export crops, fruit crops and natural forests. Minor export crops included cinnamon, coffee, cocoa, pepper, cashews, cardamom, cloves, nutmeg, betel and arecnut. Fruit crops included mango, orange, lime, plantain, papaya, pineapple, rambutan and jackfruit (though not strictly classified as a fruit crop). Natural forests were only included to illustrate soil erosion rates of unmanaged areas.

[10] Urea is used as a nitrogen-release fertilizer; Triple super phosphate (TSP) is used for phosphorus; and Muriate of potash (MOP) for potassium. Due to the high price of TSP, ERP (eppawala rock phosphate) or IRP (imported rock phosphate) are often used as a substitute. For input pricing in the scenarios we use urea, MOP and TSP.

Table 2.1 Total annual per hectare costs of nutrient losses for paddy, tea, rubber and coconut (USD/ha/year)

District	Climatic zone	Agro-ecological region		Area (km²)	Area %	Average Annual rainfall	Paddy Low	Paddy High	Tea Low	Tea High	Rubber Low	Rubber High	Coconut Low	Coconut High
Galle	Wet zone	Low country	WL1a	919.0	56.6	>3200	2.07	9.42	4.48	37.13	3.88	34.28	19.40	34.33
			WL2a	706.0	43.4	>2400	1.57	7.14	3.39	28.12	2.94	25.96	14.70	26.00
Matara	Wet zone	Low country	WL1a	459.0	35.8	>3200	2.30	10.43	4.96	41.10	4.30	37.94	21.48	38.00
			WL2a	483.0	37.6	>2400	1.74	7.90	3.75	31.13	3.25	28.74	16.27	28.78
	Intermediate zone	Low country	IL1a	166.0	12.9	>1400	0.75	4.94	2.92	24.18	2.53	22.32	5.29	12.47
			IL1b	175.0	13.6	>1100	0.60	3.91	2.31	19.13	2.00	17.66	4.18	9.87
Hambantota	Intermediate zone	Low country	IL1b	623.0	23.9	>1100	0.31	2.01	1.19	9.83	1.03	9.08	2.15	5.07
	Dry zone	Low country	DL1b	363.0	13.9	>900	0.24	1.48	0.95	7.84	0.82	7.24	0.84	2.94
			DL5	1623.0	62.2	>650	0.18	1.11	0.71	5.88	0.61	5.42	0.63	2.20
Total							9.77	48.36	24.64	204.33	21.36	188.65	84.94	159.64

Note: Calculations based on Step 5 in Section 2.4.

Table 2.2 Total annual per hectare costs of nutrient losses for minor export crops, fruit crops and natural forest (USD/ha/year)

							Minor export crops		Fruit crops		Natural forest	
District	Climatic zone	Agro-ecological region		Area (km²)	Area %	Average Annual rainfall	Low	High	Low	High	Low	High
Galle	Wet zone	Low country	WL1a	919.0	56.6	>3200	7.68	63.65	7.88	63.65	2.86	3.80
			WL2a	706.0	43.4	>2400	5.81	48.21	5.97	48.21	2.16	2.87
Matara	Wet zone	Low country	WL1a	459.0	35.8	>3200	8.50	70.45	8.72	70.45	3.16	4.20
			WL2a	483.0	37.6	>2400	6.44	53.36	6.61	53.36	2.39	3.18
	Intermediate zone	Low country	IL1a	166.0	12.9	>1400	5.00	41.45	5.13	41.45	1.85	9.31
			IL1b	175.0	13.6	>1100	3.96	32.80	4.06	32.80	1.46	7.37
Hambantota	Intermediate zone	Low country	IL1b	623.0	23.9	>1100	2.03	16.85	2.09	16.85	0.75	3.79
	Dry zone	Low country	DL1b	363.0	13.9	>900	1.62	13.44	1.66	13.44	0.70	3.02
			DL5	1623.0	62.2	>650	1.21	10.07	1.25	10.07	0.53	2.26
Total							42.25	350.28	43.38	350.28	15.87	39.81

Note: Calculations based on Step 5 in Section 2.4.

Table 2.3 Total annual costs of nutrient losses for paddy, tea, rubber and coconut (USD/year)

District	Climatic zone	Agro-ecological region		Area (km²)	Area %	Average Annual rainfall	Paddy Low	Paddy High	Tea Low	Tea High	Rubber Low	Rubber High	Coconut Low	Coconut High
Galle	Wet zone	Low country	WL1a	919.0	56.6	>3200	19,094	86,722	73,333	608,030	19,126	168,912	137,631	243,498
			WL2a	706.0	43.4	>2400	15,426	70,060	31,385	260,223	5,142	45,412	80,083	141,683
Matara	Wet zone	Low country	WL1a	459.0	35.8	>3200	14,596	66,291	84,019	696,631	1,535	13,558	110,620	195,710
			WL2a	483.0	37.6	>2400	17,279	78,478	23,537	195,155	7,380	65,174	88,166	155,983
	Intermediate zone	Low country	IL1a	166.0	12.9	>1400	4,572	29,987	772	6,399	1,700	15,015	9,851	23,230
			IL1b	175.0	13.6	>1100	2,310	15,153	502	4,166	867	7,656	8,218	19,378
Hambantota	Intermediate zone	Low country	IL1b	623.0	23.9	>1100	2,762	18,115	522	4,328	73	643	10,644	25,098
	Dry zone	Low country	DL1b	363.0	13.9	>900	947	5,755	-	-	-	-	2,432	8,470
			DL5	1623.0	62.2	>650	4,294	26,081	-	-	-	-	8,149	28,382
Total							81,281	396,641	214,071	1,774,933	35,822	316,371	455,793	841,432

Note: Calculations based on Step 5 in Section 2.4.

Table 2.4 Total annual costs of nutrient losses for minor export crops, fruit crops and natural forest (USD/year)

District	Climatic zone	Agro-ecological region		Area (km²)	Area %	Average Annual rainfall	Minor export crops Low	Minor export crops High	Fruit crops Low	Fruit crops High	Natural forest Low	Natural forest High
Galle	Wet zone	Low country	WL1a	919.0	56.6	>3200	45,605	378,130	1,052	8,493	33,177	44,083
			WL2a	706.0	43.4	>2400	26,536	220,020	612	4,942	19,304	25,650
Matara	Wet zone	Low country	WL1a	459.0	35.8	>3200	24,163	200,340	1,153	9,312	22,895	30,421
			WL2a	483.0	37.6	>2400	19,258	159,674	919	7,422	18,248	24,246
	Intermediate zone	Low country	IL1a	166.0	12.9	>1400	5,141	42,629	245	1,982	4,838	24,396
			IL1b	175.0	13.6	>1100	4,289	35,561	205	1,653	4,036	20,351
Hambantota	Intermediate zone	Low country	IL1b	623.0	23.9	>1100	2,135	17,706	2,090	16,877	14,853	74,899
	Dry zone	Low country	DL1b	363.0	13.9	>900	992	8,228	971	7,843	8,104	34,807
			DL5	1623.0	62.2	>650	3,325	27,571	3,254	26,280	27,155	116,632
Total							131,446	1,089,859	10,501	84,803	152,609	395,485

Note: Calculations based on Step 5 in Section 2.4.

2.6 Replacement cost of soil nutrient loss

22. This study compares two alternative scenarios under the replacement cost approach. In the first scenario, eroded soil can be recovered by ploughing and replenishing nutrient losses with chemical fertilizers and organic matter.[11] In the second scenario soil from fallow land is transported to the site and chemical fertilizers and organic matter are added. The cost differential is between ploughing the soil on-site and transporting soil from off-site. But there is also another difference: the nutrient content of the cropping soil will be different from that of the newly placed fallow soil – thus there will be a difference in the amount of additional N.P.K. and organic matter required to bring soil productivity to pre-existing levels. Unfortunately, there is no data at this level of detail, so it assumed that the increase in productivity by hauling in fallow soil would be roughly the same as what soil productivity would be after ploughing. Therefore, additional N.P.K. and organic matter requirements would be the same in either case – and the only difference is ploughing versus the transport cost.

23. Table 2.5 below summarizes the impacts of soil erosion and the associated replacement costs for all crops in the Southern Province. Losses of nitrogen, whether low or high in content, represent the largest nutrient cost with total N.P.K. between 1-5 million USD per year (117.9-534.0 million Rs.). Through better nutrient management, this would represent a cost savings to farmers of 14-61 million USD in 20 years using a 5 percent discount rate.

24. Several methods can be undertaken by the farmer to reduce soil erosion and nutrient losses. The first method entails ploughing and adding lost nutrients and the other is to import soil from another location. Under the first method of ploughing, adding fertilizers and organic matter increases the cost to 3.9 - 7.7 million USD per year (426.3-842.4 million Rs.), whereas hauling in new soil is approximately 3.1-6.9 million USD per year (335.0-751.2 million Rs.). Combining the cost savings of better nutrient management with the potential savings from less manual labor costs above, this would represent an overall cost savings of 50-100 million USD over a 20 year time horizon, using a 5 percent discount rate.

[11] Ploughing is not required in the case of tree crops.

Table 2.5 Summary of nutrient losses and replacement costs (USD in parentheses)

	Nutrient loss (tons/year)		Price [a]	Total cost Rs. (USD)	
	Low	High	(Rs./kg)	Low	High
Nutrient replacement					
Nitrogen	787	3,552	84.00	66,105,420	298,368,952
(Urea)				(606,472)	(2,737,330)
Phosphorus	58	250	126.74	7,295,482	31,642,789
(Triple super phosphate (TSP))				(66,931)	(290,301)
Potassium	208	737	123.00	25,582,275	90,595,257
Muriate of potash (MOP)				(234,700)	(831,149)
Organic matter	18,903	113,441	1.00	18,902,786	113,441,185
				(173,420)	(1,040,745)
Sub-total (nutrients)	**19,955**	**117,979**		**117,885,963**	**534,048,183**
				(1,081,523)	**(4,899,525)**
Ploughing					
Total number of hectares [b]	154,199				
Ploughing charges			2,000/ha	308,397,436	308,397,436
				(2,829,334)	(2,829,334)
Ploughing + nutrient replacement				**426,283,400**	**842,445,620**

			(3,910,857)	**(7,728,859)**
Soil replacement [c]				
Total soil loss (tons/year)	1,809,535			
Truck rental and soil spreading [d]		600/load	217,144,203	217,144,203
			(1,992,149)	(1,992,149)
Soil + nutrient replacement			**335,030,166**	**751,192,386**
			(3,073,671)	**(6,891,673)**

a - Fertilizer prices as of July, 2008 (subsidized)

b - Not including tree-crops

c – It is assumed that imported soil would still require the same level of nutrient replenishment

d – Assumes a 5 mile distance, renting a 5-ton truck (Rs. 400) and loading/unloading the soil (Rs. 200)

2.7 Soil recovery through conservation measures

25. In addition to field maintenance and nutrient replacement there are a number of other conservation measures that farmers can adopt such as stone terracing[12], contour drains[13] or SALT (Sloping Agricultural Land Technologies)[14], which serve to minimize soil erosion. The Land and Water Resource Center of the Department of Agriculture of Sri Lanka estimates that stone terracing and contour drains can reduce soil erosion by up to 50 percent and up to 90 percent using SALT techniques. Table 2.6 presents the initial investment and recurrent costs of these measures and alongside are the low and high cost estimates of nutrient losses. The savings that these soil conservation investments represent may prove to be more profitable for the farmer in the longer run.

26. When might it pay for the farmer to invest in soil conservation techniques? Table 2.7 compares the net present value (NPV) of the investment versus the annual nutrient loss costs as calculated above.[15] The comparison also includes four yield scenarios where the benefits of conservation may be more than just nutrient savings. Assuming that the alternative conservation techniques are effective according to the percentages above, a discount rate of 5%, and covering the 154,000 hectares from the simulation above, it turns out that investments would only pay back in 30+ years in the high nutrient loss scenario, assuming no corresponding yield increase. However, the payback period decreases to less than 10 years with yield increases in excess of 10 percent (in the high nutrient cost scenario). Across measures, lateral drains and SALT methods are more cost-effective over time (i.e. lateral drains because of their lower capital cost, and SALT methods because of their relative effectiveness). Of course, these are very broad and crude averages based on simulating the economic payoff of investments for the entire area in the Southern Province. In reality this calculation should be made at the farm-level where the benefits (avoided losses) and costs of these techniques are scaled to the plot level and would widely differ from the provincial average.

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[12] Terraces are artificial earth embankments constructed on hillsides on contours at regular intervals. Contour terraces are usually built of stone and reduce the length of slope and thus the movement of runoff water.

[13] Contour drains and terraces are the most popular mechanical soil conservation measures in Sri Lanka. The lock-and-spill lateral drain is the most widely used drain type in tea smallholdings and large plantations. The lateral drains are connected to a leader drain designed to carry away excess runoff.

[14] SALT is a technology package of soil conservation and food production that integrates several soil conservation measures. Basically, the SALT method involves planting field crops and perennial crops in bands 3-5 m wide between double rows of nitrogen-fixing shrubs and trees planted along the contour. These minimize soil erosion and maintain the fertility of the soil. Field crops include legumes, cereals, and vegetables, while the main perennial crops are cacao, coffee, banana, citrus and fruit trees. SALT helps considerably in the establishment of a stable ecosystem. The double hedgerows of leguminous shrubs or trees prevent soil erosion. Their branches are cut every 30-45 days and incorporated back into the soil to improve its fertility. The crop provides permanent vegetative cover which aids the conservation of both water and soil. The legumes and the perennial crops maintain soil and air temperatures at levels favorable for the better growth of different agricultural crops.

[15] The comparison is made to nutrient losses since it is assumed that the conservation technique would offset nutrient losses and not necessarily all crop productivity losses.

Table 2.6 Costs of soil conservation measures

	Lowland (Rs./ha)[1]	Annual nutrient loss cost (Low) (Rs.)	Annual nutrient loss cost (High) (Rs.)
Soil conservation measures			
Stone terracing			
Establishment	61,053		
Annual maintenance	1,221	117,885,963	534,048,183
Lateral drains			
Establishment	9,158		
Annual maintenance	3,053	117,885,963	534,048,183
SALT			
Establishment	25,398		
Annual maintenance	4,884	117,885,963	534,048,183

Source: Author's calculations

1 – Values adapted from Ananda and Herath (2001)

Table 2.7 Economic feasibility of soil conservation measures

Scenario	Conservation method	Number of years for investment payback - low nutrient cost	Number of years for investment payback – high nutrient cost
Scenario 1			
(No yield increment)	**Stone terraces**	-	46
	Lateral drains	-	31
	SALT	-	31
Scenario 2			
(5% yield increment)	**Stone terraces**	50	24
	Lateral drains	45	16
	SALT	45	16
Scenario 3			
(10% yield increment)	**Stone terraces**	32	18
	Lateral drains	28	11
	SALT	28	12
Scenario **4**			
(20% yield increment)	**Stone terraces**	21	12
	Lateral drains	17	8
	SALT	18	8

Source: Author's calculations

2.8 Discussion

27. The benefits of soil conservation are substantial and critical in maintaining agricultural livelihoods in the Southern Province. The potential cost savings of better nutrient management through the addition of fertilizers and manual labor ranges between 50-100 million USD over a 20 year period using a 5 percent discount rate. Investments in conservation tillage measures to counter the effects of erosion, such as terracing, contour drains, and SALT (Sloping Agricultural Land Technologies), have economic payback periods between 8-30 years depending on crop yield response.

28. It is clear that interventions to limit the degradation of soils, through better nutrient management or soil conservation techniques should be promoted through greater extension efforts and programs that work with farmers during and throughout the adoption process. The estimates of nutrient loss derived here show significant variation among crops and geographical location – so programs should be catered to the crop and environmental conditions of the area. Crops such as tea, minor export and fruit crops in the Wet zone (districts of Galle and some parts of Matara) experience some of the highest erosion rates (tons/hectare/year) and should be the focus of some targeted conservation efforts. However, after accounting for the extent under production, rubber and coconut plantations also rank as high priority crops in terms of the annual costs of nutrient loss.

Chapter 3 Valuation of Watershed Benefits

3.1 Introduction

29. A watershed is an area of land that drains into a common water source. Connecting and encompassing terrestrial, freshwater, and coastal ecosystems, watersheds perform a wide variety of valuable services, including the supply and purification of fresh water, the provision of habitat that safeguards fisheries and biological diversity, the sequestering of carbon that helps mitigate climatic change, and the support of recreation and tourism (see Table 3.1). From an economic standpoint, watersheds are considered natural assets that deliver a flow of goods and services to society. Quite often, however, commercial markets tend to value these services only partially if at all.

30. The failure to adequately incorporate the value of natural services into decisions regarding the use and management of watersheds understates the net benefits that society derives from watersheds. Changes in land-use, from forest to farmland, or from farmland to urban settlements, diminish the ability of a watershed to perform its ecological functions. In much of the world, the conversion and modification of watersheds have already progressed. The calculations presented here suggest that conversion has been excessive.

Table 3.1 Ecosystem goods and services provided by watersheds

Water supplies for agricultural, industrial, and urban-domestic uses
Water filtration/purification
Flow regulation
Flood control
Erosion and sedimentation control
Fisheries
Timber and other forest products
Recreation/tourism
Habitat for biodiversity preservation
Aesthetic enjoyment
Climate stabilization
Cultural, religious, inspirational values

31. In Sri Lanka, water is becoming an increasingly scarce resource mainly due to reduced precipitation, growing water demand, inefficient water use and environmental degradation (especially in watersheds). Current and anticipated trends in water use, especially for agricultural irrigation, suggest that areas in all AEZs will experience water shortages in the future unless there is a dramatic shift in water management among users (Amarasinghe *et al*., 1999). Combined with a growing population demanding an ever increasing amount of water on a daily basis, the role of watersheds in regulating economic, social and environmental services is immediately apparent. In order to create more sustainable water use management, development plans must understand the tradeoffs associated with the different users and beneficiaries. To these ends, policymakers require more knowledge on the benefits (both market and non-market) of current environmental flows that watersheds provide in order to better gauge alternative development tradeoffs.

3.2 Watershed benefits in Sri Lanka

32. Watersheds provide an innumerable array of benefits; this study focuses on the valuation of several major functions - the benefits of water for agricultural irrigation and domestic water use at the river basin level in the Southern Region as well as the environmental service flow benefits from wetlands, mangroves and coastal reef systems. The economic values that accrue to each of these watershed types is important from a macro-economic perspective since each are inextricably linked to key economic sectors in the Southern Region.

33. The agricultural sector is a major water user and is responsible for over 90 percent of water withdrawals, mainly for irrigated rice cultivation, and particularly in the Dry Zone of the Southern Province. For the purposes of this study, the value of water as an input to agricultural production is evaluated in the paddy growing areas in each river basin.

34. The services water provides for domestic water use, although relatively small in terms of annual water withdrawals, has an enormous opportunity cost when one considers the investments that would be necessary to sustain a safe and reliable water supply for the population of Sri Lanka. In this case, we measure the benefits attributable to domestic water services by estimating the economic value of water using example data from previous water supply projects and studies in the region.

35. Other important components of watersheds are the wetland values of Sri Lanka. Wetlands are valuable ecosystems that comprise both land ecosystems that are strongly influenced by water, and aquatic ecosystems with special characteristics due to shallowness and proximity to land. Although various different classifications of wetlands exist, a useful approach is one provided by the Ramsar Convention on Wetlands.[16] It divides wetlands into three main categories of wetland habitats: (1) marine/coastal wetlands; (2) inland wetlands; and (3) man-made wetlands. The marine and coastal wetlands include estuaries, inter-tidal marshes, brackish, saline and freshwater lagoons, mangrove swamps, as well as coral reefs and rocky marine shores such as sea cliffs. Inland wetlands refer to such areas as lakes, rivers, streams and creeks, waterfalls, marshes, peat lands and flooded meadows. Lastly, man-made wetlands include canals, aquaculture ponds, water storage areas and even wastewater treatment areas.

36. The wetlands of Sri Lanka, which fit into the Ramsar definition, can be divided into similar categories (see also Box 3.1):

- **Inland natural fresh water wetlands** (e.g., rivers, stream, marshes, swamp forests and 'villus')
- **Marine and salt water wetlands** (e.g., lagoons, estuaries, mangroves, sea grass beds, and coral reefs)
- **Man-made wetlands** (e.g., tanks, reservoirs, rice fields and salterns)

37. To make the distinction between rivers and wetlands more clear, we evaluate the irrigation and domestic water supply benefits separately from other categories of wetlands, mangroves and coral reefs. For the latter types, wetlands/lagoons/estuaries, mangroves and coral reefs, we measure sub-categories of environmental services flows in detail along four broad themes (Millennium Ecosystem Assessment, 2005):

[16] As defined by the Ramsar Convention on Wetlands, wetlands are "areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres" (Article 1.1 of the Convention text).

- **Provisioning services**: Products obtained from wetlands such as food, water and raw materials for building and clothing

- **Cultural services**: Nonmaterial benefits obtained from wetlands such as recreation, scientific, aesthetic and spiritual information

- **Regulating services**: Benefits obtained from ecosystem processes such as the recycling of nutrients and human waste, watershed protection and climate regulation

- **Supporting services**: Ecosystem functions necessary to maintain all other services such as space for human settlement, cultivation, energy production and habitat for animals

38. Depending on the economic, social and environmental context, each of these service values will be under various degrees of utilization and even over-exploitation. For example, wetland areas that serve as fisheries possess a productive value that is highly dependent on the number of fisherman and the efficiency of equipment they use. Rapid economic development in the area may lead to higher demand and effort beyond the regenerative capacity of the wetlands' supportive nursery function and fish stocks can be exhausted. This in turn will translate into higher fish prices from higher search and transport costs. This example highlights that since wetlands are biological resources, each of these environmental service values will have (supply service) thresholds that can be crossed without better sustainable resource management. Currently, wetland values are under a number of threats in Sri Lanka:

- **Habitat deterioration/degradation** (e.g., reclamation, clearing of vegetation, water pollution, garbage disposal, regulation of water flow (dams), un-planned irrigation structures and mining (sand/coral))

- **Direct loss/exploitation of species** (e.g., poaching (for consumption), ornamental fish and plant trade and water pollution)

- **Spread of invasive alien species** (e.g., direct exploitation or destruction of native species, superior competitors for resources, deterioration of the quality of wetlands and agricultural pests/weeds)

- **Natural phenomena** (e.g., drought, the 2004 Tsunami, sea level rise, increases in seawater temperature)

Box 3.1 Wetland types in Sri Lanka (Kotagama and Bambaradeniya, 2006)

FRESH WATER INLAND WETLAND TYPES:

Streams and rivers: Sri Lanka has an extensive network of rivers and streams that drains a total of 103 distinct natural river basins. In terms of length, these flowing water bodies cover more than 4500 km. Mahaweli, Walawe and Kelani rivers originate from the central highlands and flow through all three peneplains of the island. The river basins originating in the wet highlands are perennial while many of those in the dry zone are seasonal. The Mahaweli river accounts for the largest basin, covering 16% of the island and thereby has a high socio-economic and ecological value. The streams and rivers that flow through the high and mid altitude areas of the island have resulted in several water fall habitats.

The "Villu" wetlands: Although there are no large natural lakes in Sri Lanka, there are several floodplain lakes, commonly referred to as "Villus", which cover a total area of 12500 ha. Often they are cutoff former river bends. Many of the larger "Villus" are located in the Mahaweli floodplain in the East. A typical example is the inter-connected Handapan and Pendiya Villus (796 ha), which is the largest in the entire Mahaweli Villu system.

Fresh water Marshes: These are shallow inland depressions located mainly in rural areas either connected to a river or receiving water through surface run-off river floodwater and ground water seepage. Partially decomposed organic material in such marshes form peat, characterized by water logged sticky soil. A typical example is the Muthurajawela Marsh which is the largest peat bog in Sri Lanka.

Fresh water Swamp Forest: This is a late successional stage of a freshwater marsh ecosystem, comprising of trees that are adapted to grow in shallow stagnant water. Swamp forests are seasonally inundated with river water. It is the rarest wetland type in Sri Lanka and a good example is the Walauwa-Watta Wathurana Swamp Forest (12 ha) located in the Kalu river basin.

SALT WATER/ BRACKISH WETLANDS:

Estuaries and Mangroves: These are inter-connected coastal wetland types. Estuaries are formed in places where rivers enter the sea. The daily tidal fluctuation and the intermediate salinity between salt and freshwater (commonly termed "brackish water") are main characteristics of this ecosystem. There are about 45 estuaries in Sri Lanka. The mangroves comprise very diverse plant communities that are adapted to grow in unstable conditions of estuarine habitat. The mangroves are a rapidly diminishing wetland type in Sri Lanka, consisting of less than 10,000 ha of discontinuously distributed patches along the coastline. Typical example of estuaries with mangrove wetlands in Sri Lanka includes Maduganga estuary, Bentota estuary and Kalaoya estuary. The latter is the largest mangrove in Sri Lanka.

Lagoons: These are salt or brackish water coastal wetlands separated from the sea by a low sand bank with one or more relatively narrow permanent or seasonal outlets to the sea. These can also harbour other coastal wetland types such as mangroves, mud flats and sea grass beds. About 42 lagoons are found around the coast in Sri Lanka. Examples include the Bundala Lagoon, Mundel Lake, and Kalametiya Lagoon.

Coral reefs and Sea grass beds: These are two important sub-tidal marine wetlands (below 6 m in depth) in Sri Lanka. Coral reefs consist of calcareous structures secreted by a group of marine invertebrates. Coral reefs are famous for their spectacular beauty. The rich biological diversity of coral reefs could be compared to that of a tropical rainforest. Extensive coral reef habitats can be found in the Gulf of Mannar region, Trincomalee to Kalmunai in the east coast and in several areas of the south and south-western coast, including Rumassala and Hikkaduwa.

Sea grass beds are composed of rooted, seed bearing marine plants. These are found in shallow, sheltered marine waters, as well as in lagoons and estuaries. Most extensive sea grass beds are present in the northwest coastal waters of Sri Lanka (eg. Kalpitiya to Mannar).

Inland Salt Villus: Salt water containing Villus within the Wilpattu National Park is a unique ecosystem, which appears as shallow lakes (referred to as 'vila') in sandy soils.

MAN-MADE WETLANDS:

Tanks and Reservoirs: Although there are no natural lakes in Sri Lanka, an array of ancient irrigation tanks has substituted the former wetland type. Numbering nearly 10,000, these man-made wetlands depict the rich cultural heritage of Sri Lanka. The major irrigation reservoirs (each more than 200 ha) cover an area of 7820 ha, while the seasonal/minor irrigation tanks (each less than 200 ha) account for 52250 ha. Typical ancient irrigation tanks include the Parakrama Samudraya and the Minneriya tank.

Rice Fields: Rice fields are characterized by the presence of a standing water body, which is temporary and seasonal. Hence, flooded rice fields can be considered agronomically managed marshes. They are temporary and seasonal aquatic habitats, managed with a variable degree of intensity. The total area under rice cultivation at present is about 780,000 ha (approximately 12% of the total land area), which is distributed over all the agro-ecological regions except for areas located at very high elevation. Approximately 75% of rice lands in Sri Lanka are located within inland valley systems of varying form and size while the rest are found in alluvial plains and also on terraced uplands in the interior.

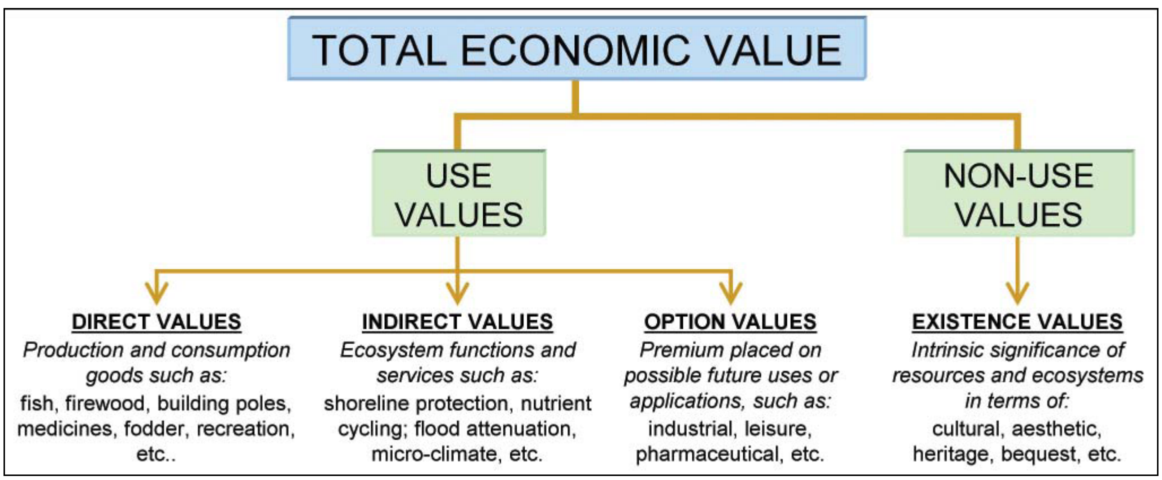
3.3 Total economic value: a framework for defining watershed economic benefits

39. Watersheds possess many different market and non-market values. Benefit-cost analyses of investment projects in the past typically under-estimated the environmental service flow values of watersheds; practitioners had viewed the value of natural ecosystems only in terms of the raw materials and physical products that generate income for human production and consumption, especially focusing on commercial activities and profits. These direct uses however represent only a small proportion of the total value of watersheds, which generate economic benefits far in excess of just physical or marketed products.

40. The concept of total economic value (TEV) has now become one of the most widely used frameworks for identifying and categorizing ecosystem benefits. Instead of focusing only on direct commercial values, it also encompasses the subsistence and non-market values, ecological functions and nonuse benefits (Figure 3.1). As well as presenting a more complete picture of the economic importance of ecosystems, it clearly demonstrates the high and wide-ranging economic costs associated with their degradation, which extends beyond the loss of direct use values.

41. Looking at the total economic value of a watershed essentially involves considering its full range of characteristics as an integrated system – its resource stocks or assets, flows of environmental services, and the attributes of the ecosystem as a whole. Broadly defined, the total economic value of water ecosystems such as wetlands, mangroves and coral reefs includes:

Figure 3.1 Total Economic Value (TEV)



- Direct values: raw materials and physical products which are used directly for production, consumption and sale such as those providing energy, shelter, food, agricultural production, water supply, transport and recreational facilities.
- Indirect values: the ecological functions which maintain and protect natural and human systems through services such as maintenance of water quality and flow, flood control and storm protection, nutrient retention and micro-climate stabilization, and the production and consumption activities they support.

- Option values: the premium placed on maintaining a pool of species and genetic resources for future possible uses, some of which may not be known now, such as leisure, commercial, industrial, agricultural and pharmaceutical applications and water-based developments.
- Existence values: the intrinsic value of ecosystems and their component parts, regardless of their current or future use possibilities, such as cultural, aesthetic, heritage and bequest significance.

3.4 Methods for valuing ecosystem benefits

42. The simplest and most commonly used method for valuing any economic good or service is the consideration of its market price, which indicates how much it costs to buy the good or service, or what it is worth to sell. In many cases market prices can provide an accurate indicator of the value of ecosystem goods, when they are freely bought or sold.

43. However market prices do not necessarily reflect the real economic value of the ecosystem. Many wetland goods and services are never traded, are under-valued by market prices, are subject to prices which are highly distorted, or have public good characteristics which imply that they cannot be accurately allocated or priced by the free market. Conventional wisdom now recognizes that market prices may be insufficient for valuing ecosystem services and functions which tend to be under-priced or not priced at all, as well as for subsistence-level use of natural resources which are consumed within the household or are not traded through formal markets. Yet these categories of benefits typically contribute a large proportion of the total economic value of wetlands, and failing to consider them runs the risk of seriously under-valuing wetlands in economic development decision making.

44. For these reasons, it is often necessary to find alternative or additional techniques for valuing ecosystem goods and services, for their total economic value to be more comprehensively measured. Parallel to the advances made in the definition and conceptualization of total economic value, techniques for quantifying environmental values and expressing these in monetary terms have also moved forward over the last decade.

45. Today a wide range of methods for valuing ecosystem benefits are available and used, which move beyond the use of direct market prices. These methods include approaches which elicit people's preferences directly (such as through contingent valuation methods) as well as approaches which use indirect methods to impute people's preferences through their purchase of related goods and services (e.g., through production functions, dose-response relationships, travel costs, replacement costs, or mitigative or avertive expenditures).

46. The background studies carried out in this assessment used a combination of the above methods to elicit ecosystem service values for wetlands, mangroves and coral reefs. Given the complex and comprehensive nature of each study's computation of valuing ecosystem benefits, Annex 3 provides much more detail on their use and applicability for this study.

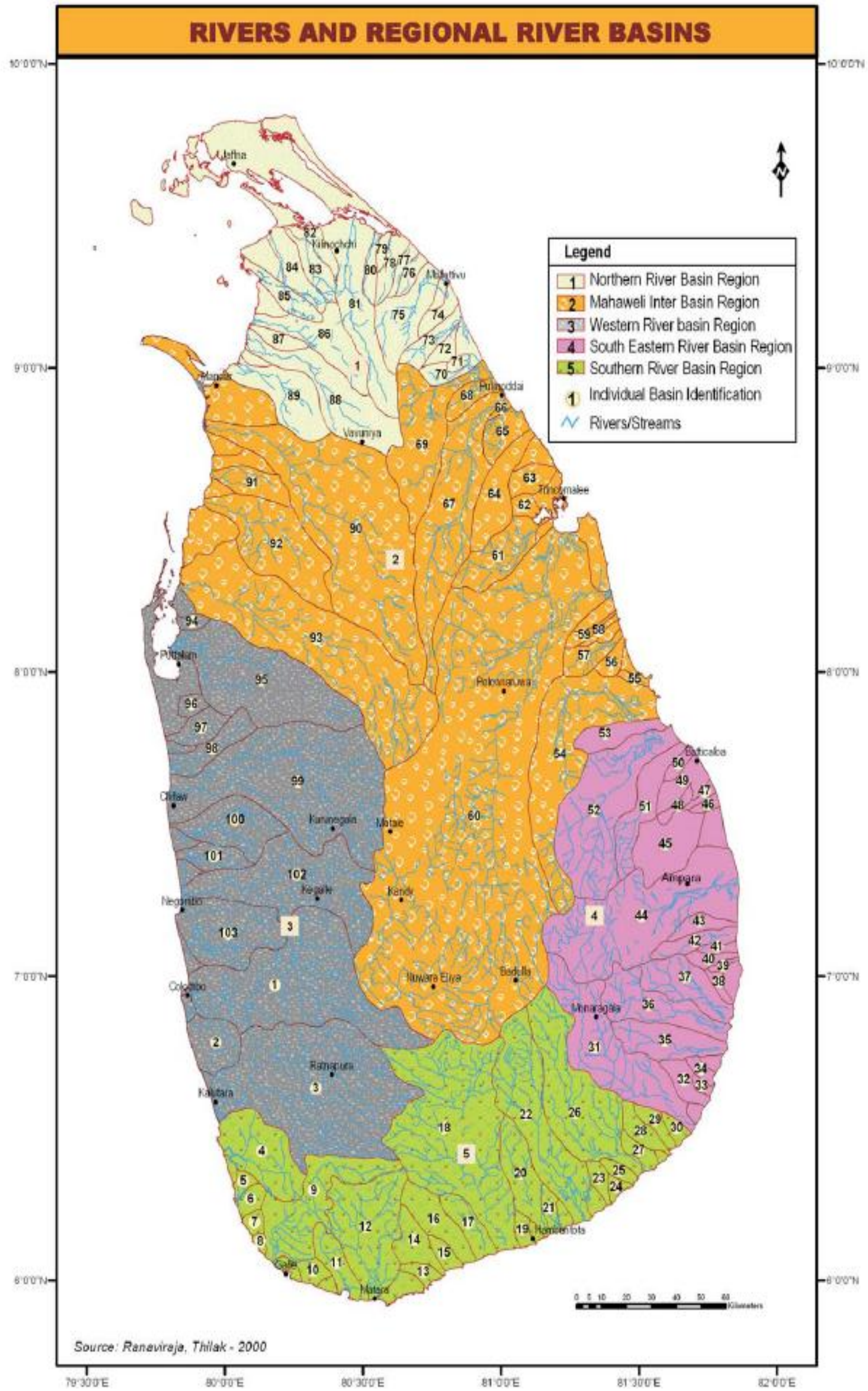
3.5 Watershed study areas

47. Sri Lanka is comprised of approximately 103 river systems, 27 of which reside in the Southern Region with a combined catchment area of 10,429 km^2 (Table 3.2 and Figure 3.2). In this study we cover watershed benefits for a selected number of the larger river basins that also contain important wetland, mangrove, and coral reef areas in the Southern Province (river basins are highlighted in Table 3.2). The primary reason for this selection was dictated by the public availability of river basin data and the availability of research studies for use in the Southern River Basin Region.

Table 3.2 Basins and rivers in the Southern Region (Study basins highlighted)

No.	Name of Basin/River	Catchment area (km²)
4	Bentota Ganga	622
5	Madu Ganga	59
6	Madampe Lake	90
7	Telwatta Ganga	51
8	Ratgama Lake	10
9	Gin Ganga	922
10	Koggala Lake	64
11	Polwatta Ganga	233
12	Nilwala Ganga	960
13	Soinimodera Oya	38
14	Kirama Oya	223
15	Rekawa Oya	755
16	Urubokka Oya	348
17	Kachigal Ara	220
18	Walawe Ganga	2,442
19	Karagan Oya	58
20	Malala Oya	399
21	Embilikala Oya	59
22	Kirindi Oya	1,165
23	Bambawe Ara	79
24	Mahasilawa Oya	13
25	Buytawa Oya	38
26	Menik Ganga	1,272
27	Katupila Ara	86
28	Kurunde Ara	131
29	Namadagas Ara	46
30	Karambe Ara	46

Figure 3.2 Rivers and Basins in Sri Lanka



Source: Central Environment Authority (2000)

3.6 Valuation approach

48. Comprehensive studies, which elicit all environmental service flows, are not available for all of the selected sites, consequently it was not possible to estimate economic values of river basins, wetlands, mangroves and coral reefs directly. This would require surveying each site for each of the benefits described above and involves a longer term research effort to monitor the status of the watersheds. Instead the results of similar studies performed in Sri Lanka and other countries were used employing the **benefit transfer method (BT)** to infer values. The benefit transfer method is not a valuation methodology *per se*, but rather refers to the use of values or functions obtained in one context (a study site) to estimate values in a different context (a policy site). In the absence of detailed policy site information, the benefit transfer method provides a low cost way of obtaining values when time and resources do not allow for full valuation (Ruijgrok 2001; World Bank, 1998). Although all BT studies are subject to uncertainties, in addition to those that exist in the results of the original valuation study (Brouwer, 2000; Rosenberger and Stanley, 2006), it should be re-emphasized that in this exercise BT *study site* estimates were from Sri Lankan studies, with few exceptions. In the few instances which required international BT transfers, an income adjustment was made to the estimated values.[17] In addition, for Sri Lankan studies conducted in the past, adjustments were made by indexing estimates to the current value of the Rupee.[18]

49. The economic value of the study sites for wetlands, mangroves and coral reefs is summarized in Table 3.3. The first column lists the different types of provisioning, cultural, regulating and supporting services discussed earlier and columns 2 through 5 lists the estimates from the selected study sites. For comparative purposes, the second column presents the unit values of wetland services from the Millennium Ecosystem Assessment (MEA) (MEA, 2005). It is likely that these values are gross over-estimates of the overall value of wetlands due to the use of global average unit values, thus these values are not considered in the total value of benefits in the Southern Region.

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[17] Benefit transfer involves two possible methods – the benefit value or function approach. In order to convert an estimate in one country (X) to a value in another country (Y), an adjustment to reflect differences in real income is needed. A typical adjustment is:

$$Value_y = Value_x \, (PPP\ GNP_y \,/ PPP\ GNP_x\,)^E \qquad (1)$$

where PPP GNP denotes the purchasing power parity GNP per capita and E is the elasticity with respect to real income. For simplicity we adopt an elasticity of 1.00, which implies a 1.0% change in WTP relative to a 1% change in real income. This method was adopted by Batagota (2003) for estimating the non-use benefits of mangroves.

[18] For values derived in Sri Lankan Rupees, these were adjusted to the current exchange rate in 2009 USD values. For example, if a study conducted in 2003 used an exchange rate of approximately 90 Rupees to one USD, this value was converted to the current exchange rate of 116 Rupees to one USD.

50. Wetland, mangrove and coral reef benefits are highly site-specific and depend on a host of economic and environmental characteristics. The study acknowledges the limits of using constant $/ha measures across sites, however it does not preclude their use when the study and policy sites are from similar geographical or socio-demographic areas. The background studies used here were either in the actual policy area, or from credible studies that produced internally-consistent results from rigorous local data collection in other areas of Sri Lanka. While far from ideal, the use of locally generated results is generally preferred to using coefficients derived from other regions or even countries.

3.61 Wetland benefits

51. The selected study site for wetland benefits (column 3 in Table 3.3), Muthurajawela Marsh, is a coastal wetland located between 10 and 30 km to the north of Colombo. It covers an area of 3,068 hectares and its total economic value was estimated to be approximately $8.1 million a year, or $2,700 per hectare (Emerton and Kekulandala, 2003). Flood attenuation accounted for $5.4 million; industrial wastewater treatment $1.8 million, support to downstream fisheries $220,000, firewood $88,000, fishing $70,000, leisure and recreation $60,000, domestic sewage treatment $48,000, freshwater supplies for local populations $42,000, and carbon sequestration $8,700. As is typical for urban wetlands, ecosystem services contributed to most (90%) of this value, followed by fisheries (36% of total resource use values). These values were converted to per hectare units and multiplied by the wetland catchment area of subsequent policy site wetlands covered by the study. One additional adjustment was made to the estimates of leisure and recreation. Muthurajawela Marsh is close to an urban center while many of the policy sites can be considered "rural". In these instances, some services provided by policy sites may be less significant and so services were discounted by this rural effect. For example, some sites are highly visited by tourists, and derive a significant use value, whereas some rural sites' recreational visitation may be quite low. In these cases the cultural service values are assumed to be only 10% of the value of Muthurajawela. Ten percent was selected only to avoid any possible over-estimation of these benefits.

3.62 Mangrove forest benefits

52. Mangrove forests provide critical and important economic, social and ecological services for the existence of biophysical and socio-economic subsystems, particularly tropical mangroves that are rich in both floral and faunal biodiversity. Mangrove forests provide fish, fruits, medicinal plants, construction materials, timber, firewood, woodchips, charcoal and dyes to coastal communities. The use of mangroves for tourism and recreation is also increasing. Mangroves protect tropical coastal areas from hurricanes, floods, saline water intrusion and coastal erosion while maintaining the water table and biodiversity. They provide habitats for migratory species, nursery and breeding grounds for marine life. Most importantly, mangrove forests treat pollutants and protect marine ecosystems from land-based activities. They may also have significant non-use values such as cultural, aesthetic and spiritual.

53. The study used for the valuation of mangrove benefits (column 4 in Table 3.3) is from Batagoda (2003), which evaluated three distinct mangrove forests namely, Kiralakele mangrove forest in the Hambantota District, Maduganga mangrove forest in the Galle District and Ranweli village mangrove forest in the Puttalama District. Each of the valuation studies quantified the benefits of non-wood forest resources, local and global recreation benefits, local and global option/bequest/existence values, the provision of breeding grounds for fish, erosion control, biodiversity maintenance, carbon sequestration, storm protection and pollution treatment.

54. The appeal of this study is two-fold: 1) Kiralakele and Maduganga are mangrove forests within the Southern Province, and 2) the valuation of non-use benefits (i.e., option, bequest, and existence values) used more than one method across both local and international respondents.[19] This produced a wider range of estimates under alternative surveying methods, of which this study adopted the most conservative value as a lower bound.[20] Other valuation studies of mangroves, especially assessments of the damage caused by the 2004 Tsunami, have been conducted but with a more limited coverage of all the possible benefits of mangroves (Gunawardena and Rowan, 2005; IUCN, 2007; Ranasinghe and Kallesoe, 2006).[21]

55. Similar to the wetlands assessment, per hectare unit values were multiplied by the mangrove area of the policy site. In some instances recreational values were only valued at 10% of the full service value, owing to the rural location of the mangrove and to guard against exaggeration.

56. One important note should be made at this point on the inclusion of non-use values. Since non-use values measure the willingness to pay to preserve an area for future use or existence they are not currently realized in any market or contribute to any economic activity. They only represent future earning potential and therefore should not be added to the other direct and indirect values in this assessment. Although they appear in the following economic analysis they will be discussed separately since they point to a potential source of revenue that could be realized as part of a tourism strategy for the area.

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[19] The contingent valuation exercise used a payment card and open-ended approach to calculate a person's Willingness-to-Pay (WTP) for mangrove benefits. The payment card approach yielded a lower estimate and this value was subsequently used in this study (see Annex 3 for details).

[20] One cautionary note is warranted for future detailed studies. Since an individual's utility of mangroves is conditioned by their socio-economic characteristics, socio-economic variables of users should be collected and used to calibrate estimates for the evaluation.

[21] For example, a 2005 Total Economic Value (TEV) assessment of the Rekawa mangrove lagoon ecosystem found that it was worth $1,088/ha/year, or $217,600 per year, based on 200-ha of mangrove. Forestry net benefits accounted for $4,800 per year, lagoon fishery $53,600 per year, coastal fishery $98,600 per year, erosion control and buffer against damage from storms $60,000 per year, and existence, bequest and option values to local communities $520 per year.

Table 3.3 Economic value of study sites for wetlands, mangroves and coral reefs

Wetland, mangrove or coral reef area	MEA average value ($/ha/year)	Muthurajawela Marsh ($/ha/year)	Mangrove Forests ($/ha/yr)	Coral Reefs ($/km²/yr)
Catchment area (ha)		***3,068***		
Mangrove area (ha)				
Reef area (ha)				
Provisioning services	***601***	***136***	***75***	***3,017***
(products obtained from wetlands/ mangroves/ reefs)				
Agricultural production	-	85	57	-
Fishing	374	18	11	3,017
Hunting	123	-	-	-
Water supply	45	11	-	-
Raw materials (thatch, timber, fodder, fertilizer, etc.)	45	-	3	-
Fuelwood	14	22	4	-
Other (genetic, medicinal, and ornamental resources)	-	-	-	-
Cultural services	***1,373***	***15***	***7,548***	***89,655***
(nonmaterial benefits obtained from wetlands/ mangroves/ reefs)				
Aesthetic information	881	-	-	-
Recreation and tourism	492	15		89,655
Local	-	-	764	-
International	-	-	979	-
Option value				
Local	-	-	1,221	-
International	-	-	851	-
Bequest value				
Local	-	-	1,404	-
International	-	-	460	-

Existence value				
Local	-	-	723	-
International	-	-	1,146	-
Other (e.g., artistic, spiritual, historic, or scientific information)	-	-	-	-
Regulating services	***1,086***	***1,978***	***4,856***	***530,172***
(benefits obtained from ecosystem processes)				
Flood control/water regulation	464	1,364	65	530,172
Water treatment	288	-	4,592 [2]	-
Industrial wastewater treatment	-	456	-	-
Domestic sewage treatment	-	12	-	-
Nursery function	201	-	134 [3]	-
Climate regulation of mangroves	133	89	62	-
Other (e.g., sediment control, biological control)	-	56 [1]	3 [4]	-
Supporting services	***214***	***-***	***14***	***-***
(ecosystem functions necessary to maintain all other services)				
Habitat/refugia for biodiversity	214	-	14	-
Other (e.g., primary products, soil formation, nutrient/biogeochemical cycling)	-	-	-	-
Total value (USD)	**3,274**	**2,128**	**12,494**	**622,845**
Exchange rate ($1USD = Rs. as of Apr. 2009)	116	116	116	116
Total value (Rs.)	**379,784**	**246,892**	**1,449,271**	**72,250,000**

Notes: 1 - Support to downstream fisheries; 2 - Pollution treatment and nutrient retention; 3 - Breeding ground for fish; 4 - Erosion control

Rural factor = 0.10

3.63 Coral reef benefits

57. Tropical coastal zones contain a variety of ecosystems such as coral reefs, mangroves, and sea grass beds, which are all utilized as resources. The coral reef is the most diversified and complex marine ecosystem. It provides many benefits including food from reef fish, recreation for tourists, coastal protection and lime for the building industry. Hence, many people depend on coral reefs for their livelihood as a source of income in monetary terms, as well as for subsistence.

58. The study used for valuation of coral reef benefits (column 5 in Table 3.3) is from Berg *et al*. (1998), which estimated the value of Sri Lanka's coral reefs to be between $140,000 and $7.5 million per km^2 over a period of 20 years. They developed three types of benefit functions to characterize several of the direct and indirect benefits. Direct economic benefits of resource use were modeled through the use of a *fish-habitat function* (through fishing or ornamental fish collection) and a *tourist attraction function* (from the value of tourism expenditures). [22]

59. Indirect economic benefits of coral reefs were modeled through a *physical-structure function* which measured the value of protection against coastal erosion. Benefits were calculated through the use of two different methods - a preventive-expenditure approach (PE) and through the loss of property-values (PV). The PE approach calculated the cost of replacing the coral reef with protective structures (e.g., groynes, revetments, and underwater wave-breakers off the coast), and the PV approach estimated the cost of land loss (i.e., price of lost land, buildings, roads, etc) as a result of coastal erosion plus the loss of income resulting from lost land-use opportunities (e.g., loss of agricultural land). The latter approach is likely to be very sensitive to property values established in relatively inefficient rural markets, while the PE approach is based on actual costs of physical structures. Thus for the purposes of this study we adopt the estimates derived from the PE approach. Unit values are expressed in $USD/km^2/year and were multiplied by the area of the reef. As with wetlands and mangroves, all values taken from the study were initially adjusted to current prices.

3.64 Value of water for domestic services at the river basin level

60. The value of water for domestic uses was calculated using information from a recent study by Molle and Renwick (2005) which estimated the benefits from drinking water wells in the context of the Uda Walawe Irrigation and Resettlement Project (UWIRP). Benefits were valued by estimating the average replacement cost of providing an equivalent amount of water to the volume abstracted. Similar communal water supply projects in the region, mostly based on wells, found a cost of Rs 14/m^3, assuming a project lifetime of 20 years. Molle and Renwick (2005) used an

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[22] The *fish-habitat function* utilized an effect-on-production approach (EOP), where the net value of fish production was calculated using fishing revenue, expenses, catch rates per unit effort and assumptions on the fishery's Maximum Sustained Yield (MSY). The *tourist-attraction function* was defined through two different methods - a financial-revenue approach (FR) and through a contingent valuation approach. For the purposes of this study estimates from the contingent valuation approach were adopted since this method of valuation also includes additional social values captured in consumer surplus.

average cost of Rs 15/m^3 which seems reasonable when compared to other water schemes in the area, such as the Lunugamwehera Water Supply Scheme in the neighboring Kirindi Oya basin, which provides drinking water at a cost of Rs 21/m^3. The total replacement cost is calculated as the average replacement cost of Rs 15/m^3, times the average current domestic usage of 20 l/capita/day, times the population without access to piped water in the basin.

3.65 Value of water in irrigated paddy production at the river basin level

61. The benefits of irrigation water for paddy production were from a study conducted by Renwick (2001), which valued water as an intermediate input to a producer-level profit maximization problem. The value of the intermediate good (water) is defined as the net economic contribution of that good to the value of the final output. The residual method is then used to calculate the value of irrigation water in irrigated paddy production by identifying of the incremental contribution of water to the value of total output. Under this approach, all costs of production, except water, are subtracted from the value of production. This remaining (or residual) value provides a proxy measure of the value of irrigation. The farm-level survey conducted in the Kirindi Oya basin area found that the average per hectare economic return to water was approximately Rs 16,748 (US$144 in 2009 prices). In our study we multiplied the value of water by the number of hectares under irrigated paddy production in each river basin.

3.66 Interpretation of watershed values

62. Owing to the variety of elicitation methods and underlying data used to calculate benefits above, some values can be interpreted as being more accurate. For example, implicit values of water for agricultural and domestic services are calculated using market data on production and prices which are observable - so the final estimates are likely to be close to the actual value. Wetland, mangrove and coral reef estimates are also derived from background market observations on provisioning and cultural services however there may be some overlap between certain regulating or supporting service functions. For example, migratory fish species may spend part of their life in mangroves and another in coral reefs. Similarly, mangroves and coral reefs provide important coastal protection functions, but in areas where both co-exist, what is the appropriate benefit partition between the two?

63. The conservative approach taken in this study is to attribute these service benefits to only one of the geographical types (mangroves or coral reefs) when there is co-existence. For example if the benefits of coastal protection are estimated to be $100 from mangroves and $50 for coral reefs, we only use the mangrove estimate (i.e. the maximum between the two). Or in the case of fishing benefits, we only take the higher benefit of the two. By incorporating this rule, we avoid the possibility of double counting of benefits.

3.7 Valuation of watershed benefits

64. The value of water for paddy irrigation and domestic water use is presented in Table 3.4 and the service values of wetlands, mangroves and coral reefs, along with total river basin benefits in Table 3.5. Summaries by ecological service value are provided in Tables 3.6 and 3.7. Benefit details on each wetland, mangrove and coral reef attribute are given in Annex 4. Irrigated paddy area and the population without piped water access were not available for all river basins since most statistics are normally compiled at the administrative level. Nonetheless, we were able to compile information for some of the largest river basins in the Southern Province.

65. Not surprisingly, the largest water values for irrigated paddy production occur in two of the largest catchment areas - Walawe Ganga and Kirindi Oya, with several million USD in annual water service flows. Domestic water service benefits are also significant in these river basins where the average percentage of households with access to piped water is only 33.4% (Department of Census and Statistics, 2001). The largest domestic water consumption benefits, of the areas with information, take place in the Nilwala Ganga owing to the rural population base and piped water coverage rates of only 28%. Total irrigation and domestic water use benefits across the 10 river basins amount to over 7 million USD per year with over 80% of this value derived from irrigated paddy.

66. The annual environmental service flow benefits of wetlands, mangroves and coral reefs amount to over **33 million USD** per year, with the majority stemming from the services provided by flood control and regulation (columns 5-8 in Table 3.5 and Table 3.6). One-third of the regulating service benefits accrue in the Lunugamvehera Reservoir with a catchment area of over 7400 hectares, which services numerous other tanks and reservoirs in the area. Cultural service values are high in areas where there exists a large and robust tourism sector, such as the Bentota and Manduganga Estuaries. Currently Yala derives significant direct use values from the recreational benefits of park visitation and wildlife safaris, but also possesses tremendous non-use values from the extensive mangroves areas (see Annex 4).

Table 3.4 Value of water for irrigated paddy and domestic water consumption in selected river basins ($USD/year)

River Basin	Location	Total value	Irrigated paddy (ha)	Irrigated paddy ($USD)	Pop without piped water access	Domestic services	Industrial uses (MCM)
Bentota Ganga		166,320	1,155	166,320	-	-	-
	Bentota Estuary						
	Maduganga Estuary [R]						
Gin Ganga		705,600	4,900	705,600	-	-	-
	Hikkaduwa National Park						
	Rumassala Marine Sanctuary						
	Unawatuna Reef						
Polwata Ganga		235,872	1,638	235,872	-	-	-
	Koggala Lagoon						
	Weligama Bay & Reef						
Nilwala Ganga		1,194,018	4,700	676,800	547,920	517,218	
Walawe Ganga		2,560,470	15,000	2,160,000	424,242	400,470	3.23
	Rekawa Lagoon & Reef						
	Kahanda Estuary & Kahandamodera Mangrove						
	Kalametiya Lagoon						
	Lunama Lagoon						
Karagan Oya		82,656	574	82,656	-	-	-
	Karagan Lewaya						
	Maha Lewaya						

	Koholankala Lewaya (Bundala National Park) [R]						
Malala Oya		49,666	-	-	52,614	49,666	0.06
	Malala Lewaya (Bundala National Park) [R]						
Kirindi Oya		2,056,211	12,904	1,858,176	149,850	198,035[1]	0.22
	Lunugamvehera Reservoir						
	Embilikala Lewaya (Bundala National Park) [R]						
	Bundala Lewaya (Bundala National Park) [R]						
Menik Ganga		259,295	1,220	175,680	88,578	83,615	0.39
	Kataragama religious festival						
	Ruhuna (Yala) National Park						
	Yala Fishery Management Area						
	Mangroves in Ruhuna (Yala) National Park						
	Weerawila-Tissa-Pannangamuwa-Debara-Yoda Tanks						
	Pilinnawa Coastal Wetland						
Bambawe Aru			-	-	-	-	-
	Palatupana Lagoon						
	Total	**7,310,106**	42,091	**6,061,104**	1,263,204	**1,249,002**	3.90

Notes: MCM – million cubic meters; R - Ramsar Site; Current exchange rate 116 Rs./$USD (as of Apr. 2009)

1 – Calculated using a cost of Rs 21/m^3

Table 3.5 Wetland, mangrove and coral reef benefits for selected river basins ($USD/year)
(Shaded total value = irrigation and domestic benefits + wetland/mangrove/coral reef benefits)

River Basin	Location	Area (ha)	Total value	Provisioning services	Cultural services	Regulating services	Supporting services	Irrigation and Domestic services
Bentota Ganga		62,200	5,804,193					166,320
	Bentota Estuary	1,700	3,556,578	84,885	87,179	3,383,792	722	
	Maduganga Estuary [R]	915	2,081,294	117,940	217,947	1,743,601	1,806	
Gin Ganga		92,200	4,049,205					705,600
	Hikkaduwa National Park	104	335,622	5,260	39,897	290,465	-	
	Rumassala Marine Sanctuary	1,707	2,384,077	30,026	25,325	2,328,726	-	
	Unawatuna Reef	100	623,907	4,079	89,655	530,172	-	
Polwata Ganga		23,300	1,636,409					235,872
	Koggala Lagoon	727	1,235,809	89,930	34,872	1,110,719	289	
	Weligama Bay & Reef	100	164,728	12,507	8,966	143,256	-	
Nilwala Ganga		96,000	1,194,018					1,194,018
Walawe Ganga		244,200	5,162,092					2,560,470
	Rekawa Lagoon & Reef	250	1,113,765	25,366	34,872	1,050,638	2,889	
	Kahanda Estuary & Kahandamodera Mangrove	51	160,296	5,811	3,888	150,274	322	
	Kalametiya Lagoon	604	1,008,447	81,111	2,964	924,127	246	
	Lunama Lagoon	192	319,111	25,804	872	292,363	72	

Karagan Oya		5,800	2,433,533					82,656
	Karagan Lewaya	835	1,321,874	113,300	12,388	1,196,185	-	
	Maha Lewaya	260	411,601	35,279	3,857	372,465	-	
	Koholankala Lewaya (Bundala National Park) [R]	390	617,402	52,919	5,786	558,697	-	
Malala Oya		39,900	1,078,669					49,666
	Malala Lewaya (Bundala National Park) [R]	650	1,029,004	88,198	9,643	931,162	-	
Kirindi Oya		116,500	15,235,789					2,056,211
	Lunugamvehera Reservoir	7,438	11,675,650	1,009,253	11,035	10,655,362	-	
	Embilikala Lewaya (Bundala National Park) [R]	430	680,725	58,346	6,380	616,000	-	
	Bundala Lewaya (Bundala National Park) [R]	520	823,203	70,558	7,715	744,930	-	
Menik Ganga		127,200	3,845,396					259,295
	Kataragama religious festival	-	12,375	-	12,375	-	-	
	Ruhuna (Yala) National Park	151,200	85,645	3,430	82,215	-	-	
	Yala Fishery Management Area	-	111,274	111,274	-	-	-	
	Mangroves in Ruhuna (Yala) National Park	326	124,152	24,562	-	94,880	4,709	
	Weerawila-Tissa-Pannangamuwa-Debara-Yoda Tanks	1,590	3,242,253	215,745	23,589	3,002,918	-	
	Pilinnawa Coastal Wetland	100	10,402	3,299	1,484	5,620	-	
Bambawe Aru		7,900	24,983					
	Palatupana Lagoon	160	24,983	13,618	2,374	8,992	-	
		Total	40,464,287	2,282,499	725,277	30,135,345	11,056	7,310,106

Notes: R - Ramsar Site; Current exchange rate 116 Rs./$USD (as of Apr. 2009)

Table 3.6 Value and share of wetland, mangrove and coral reef services

	Value (USD/year)	Percent
Provisioning services	***2,282,499***	
(products obtained from wetlands/ mangroves/ reefs)		
Agricultural production	1,294,071	56.7
Fishing	440,861	19.3
Hunting	-	0.0
Water supply	174,741	7.7
Raw materials (thatch, timber, fodder, fertilizer, etc.)	2,507	0.1
Fuelwood	370,319	16.2
Other (genetic, medicinal, and ornamental resources)	-	0.0
Cultural services	***725,277***	
(nonmaterial benefits obtained from wetlands/ mangroves/ reefs)		
Aesthetic information		
Recreation and tourism	725,277	100.0
***Option, Bequest and Existence value (not included in totals)**	3,166,127	
Regulating services	***30,135,345***	
(benefits obtained from ecosystem processes)		
Flood control/water regulation	25,262,498	83.8
Water treatment	3,768,505	12.5
Nursery function	102,279	0.3
Climate regulation	68,283	0.2
Other (e.g., sediment control, biological control)	933,780	3.1

Supporting services	***11,056***	
(ecosystem functions necessary to maintain all other services)		
Habitat/refugia for biodiversity	11,056	100.0
Other (e.g., primary products, soil formation, nutrient/biogeochemical cycling)	-	0.0
Total	33,154,178	

67. Nearly half of the provisioning services come from, again, Lunugamvehera Reservoir where most of the benefits accrue to agricultural irrigation. However, the Kirindi Oya river basin also supports a large fisheries sector.[23]

68. Overall, watersheds provide 40 million USD in environmental service flows per year in the Southern Province once the value of water for irrigation and domestic use is added to wetland, mangrove and coral reef benefits. **Over a 10-20 year period this would represent between 353-545 million USD**, using a 5 percent discount rate. A significant proportion of the annual value can be easily ascertained (and cross-referenced) from other studies of agriculture, fisheries and irrigation investment benefits in the Southern Province (Bakker *et al*., 1999; Dissanayake and Smakhtin, 2007; Hermans *et al*., 2006; IIMI, 1995; Imbulana *et al*., 2002; Molle and Renwick, 2005; Renwick, 2001; Smakhtin and Weragala, 2005; Somaratne *et al*., 2005). Flood control and water regulation benefits comprise the largest share, with the value of water for irrigated paddy production second. While provisioning services is significant for the livelihoods of the population in the province, the value is modest compared to the other values. However, the benefits from agriculture, fishing and fuel wood are likely to be under-valued in this context when one begins to imagine the costs of possible substitutes and from where these goods would originate.

[23] Other studies have quantified significant inland fisheries benefits in the Kirindi Oya basin – which includes Lunugamwehera Reservoir and the Debera Wewa, Tissa Wewa, Yoda Wewa, Pannegamuwa, and Weerawila tanks. Annual returns of the five commercially important fisheries in the Kirindi Oya Irrigation and Settlement Project (KOISP) were estimated based on actual monthly returns to fisherman, by reservoir, for the three surveyed reservoirs. Total annual economic returns to the five reservoirs from inland fishing were Rs 38.1–39.6 million (or US$544,000–566,000) per year (Renwick, 2001).

69. Cultural services are one area where enormous potential still exists in the form of greater recreational and nature-based opportunities. The Southern Province with its rich wildlife and protected area system is relatively 'un-tapped' from an economic development standpoint. While the lower bound values calculated here amount to only $700,000 USD in annual use values, note that significant non-use values (option, bequest and existence) were estimated in the order of $3 million USD annually (Table 3.6). While these were not included in the tabulation totals above they do represent a significant potential source of development and conservation revenue. In the companion policy note on nature-based tourism these benefits were evaluated in greater detail (including the park system) and were on the order of $6 million USD annually or $55 million in 10 years, just in entrance fees to the five parks in the study (World Bank, 2010). Accounting for the full range of direct and indirect expenses (i.e., accommodation, food, gifts, etc.) from increasing international tourist visitation to its full potential, this could amount to $248 million USD annually or $2.2 billion in 10 years.

Table 3.7 Summary of watershed benefits in the Southern Province

Service function	Annual flow (USD/year)	%
Provisioning	2,282,499	5.6
Cultural	725,277	1.8
Regulating	30,135,345	74.5
Supporting	11,056	0.0
Irrigated paddy	6,061,104	15.0
Domestic water	1,249,002	3.1
Total	40,464,283	100.0

4.1 Conclusions and discussion

70. The Government of Sri Lanka has committed to a 10-year development framework of increased growth and policymakers in the Southern Province have embarked on an ambitious program of improved roads and other large infrastructure projects. The development challenge will be to realize the benefits from these projects while still encompassing the basic tenets of sustainable development, particularly in light of the rich natural resources and biodiversity of the province. Coupled with this challenge are the development issues of increasing income and livelihoods of the area, which are highly dependent on environmental services which are vulnerable to irreparable damage from blind pro-growth activities.

71. This policy note estimates the environmental service flows that currently constitute a significant proportion of the Southern Province's economy – namely agriculture and watershed benefits. Through the quantification of such benefits, which captures market and non-market values, policymakers are better informed to weigh benefits of future development activities and consider potential tradeoffs. More specifically, the valuation of environmental services allows policymakers to efficiently address sustainable economic development and environment protection within the country's economic policy.

72. Agriculture is a main income earner for nearly half of the population and contributes 30 percent to the provincial economy. Underpinning the productivity of agriculture are the benefits of soil conservation that are not only controlled at the individual plot level, but also affected through development in the surrounding areas. The clearing of land for non-agricultural purposes often leads to increased rainfall erosion decreasing soil depth, permeability and eventually leading to decreased agricultural yields.

73. The benefits of soil conservation practices are substantial in the Southern Province with the cost of soil *nutrient* losses in the order of 1-5 million USD per year. If appropriate nutrient management measures were undertaken, this would represent a cost savings between 14-61 million USD in 20 years, using a 5% discount rate. Soil conservation techniques such as stone terracing, lateral drains and Sloping Agricultural Land Technologies (SALT) have been shown to reduce soil losses from 50-90%. Comparing the benefits (avoided costs) from soil nutrient losses with investments in these conservation measures over a 30-year time horizon, they would reach full cost recovery in 8-30 years depending on the technique, yield response and individual farm-level circumstances. Thus private landowners face a difficult decision of weighing the benefits and costs of investing in soil conservation while taking into consideration the possible externalities of public development projects that affect nearby landholdings. Clearly more sustainable development would take into consideration its affect on adjacent landholdings and its affect on agriculture through potential soil erosion.

74. Watershed management is perhaps the most significant issue since they supply such a wide variety of environmental services to the population and environment. Due to the numerous beneficial flows it is difficult to visualize any development that would not affect any of these values to some degree. Sustainable development in this context would perform an initial stocktaking of all

of the market and non-market values derived from the watershed and then weigh these with the potential project benefits. Policymakers would then better able to understand the potential tradeoffs when gauging the project feasibility and potential compensation to affected livelihoods. In this study the following benefit flows were included in the valuation:

- Water supplies for agricultural, industrial, and urban-domestic uses
- Water filtration/purification
- Flow regulation
- Flood control
- Erosion and sedimentation control
- Fisheries
- Timber and other forest products
- Recreation/tourism
- Habitat for biodiversity preservation
- Aesthetic enjoyment
- Climate stabilization
- Cultural, religious, inspirational values

75. Watershed benefits were calculated for ten major river basins containing values accruing from wetlands, mangroves, coral reefs in addition to the value of water for domestic water supply services and agricultural irrigation. Using several different economic valuation methods it was found that over $40 million USD in market and non-market benefits are realized per year. From a more broad planning perspective, this would represent **between $353-545 million USD over a 10-20 year horizon**, using a 5 percent discount rate. Nearly three-quarters of this value is derived from the flood control and water regulating functions of the watersheds and over $7 million USD from domestic water supplies and the value of water for agricultural irrigation. Another increasingly important value of watersheds is the recreational and cultural aspects of these areas. Significant use values currently exist in the form of visitation to cultural sites and national parks, as well as non-use values from option and existence values. This benefit area is viewed as one of the most promising from an economic development perspective.

Annex 2

Map A2: Soil Map of Sri Lanka

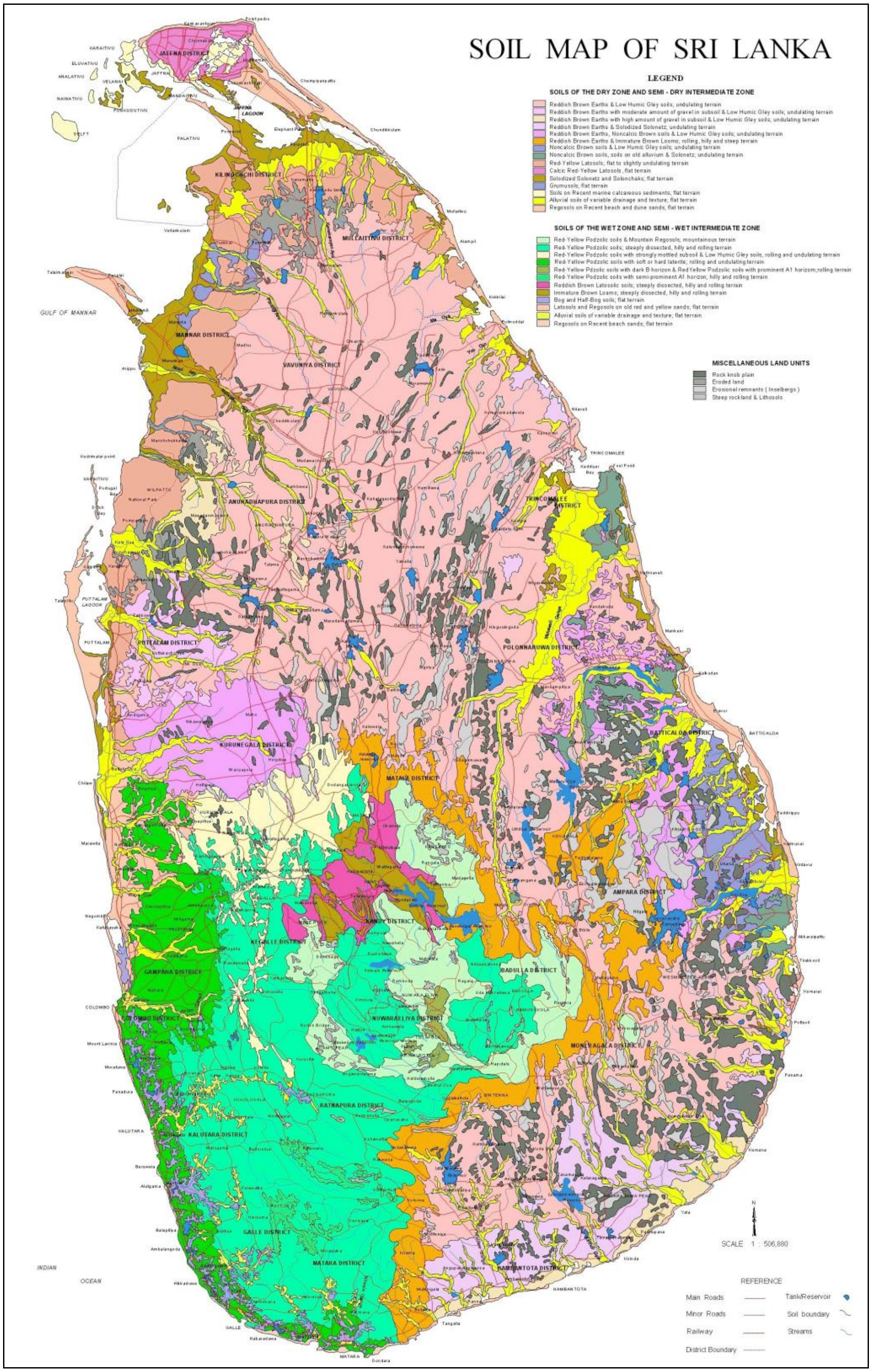

Table A2.31 Average annual soil loss rates, by AEZ, soil group and crop (tons/hectare/year)

District	Climatic Zone	Agro-ecological region		Average annual rainfall (mm)	Terrain *	Major soil groups	Paddy	Tea	Rubber	Coconut	Minor Export crops	Fruit crops	Natural forest
Galle	Wet zone	Low country	WL1a	>3200	RUF	*Red Yellow Podzolic*	3.5	13.7	13.7	14.1	23.5	23.5	0.9
			WL2a	>2400	RUF	*Red Yellow Podzolic*	2.7	10.4	10.4	10.7	17.8	17.8	0.7
Matara	Wet zone	Low country	WL1a	>3200	RUF	*Red Yellow Podzolic*	3.9	15.2	15.2	15.6	26.0	26.0	1.0
			WL2a	>2400	RUF	*Red Yellow Podzolic*	3.0	11.5	11.5	11.8	19.7	19.7	0.7
	Intermediate zone	Low country	IL1a	>1400	RUF	*Red Yellow Podzolic*	1.8	6.9	6.9	7.1	11.8	11.8	0.4
			IL1a	>1400	RUF	*Reddish Brown Latazolic*	1.4	5.3	5.3	5.5	9.1	9.1	0.3
			IL1a	>1400	RUF	*Low Humic Gley*	2.2	8.5	8.5	8.7	14.5	14.5	0.5
			IL1a	>1400	RUF	*Regosol soils*	3.9	15.0	15.0	15.5	25.8	25.8	0.9
			IL1b	>1100	RUF	*Red Yellow Podzolic*	1.4	5.5	5.5	5.7	9.5	9.5	0.3
			IL1b	>1100	RUF	*Reddish Brown Latazolic*	1.1	4.3	4.3	4.4	7.3	7.3	0.3
			IL1b	>1100	RUF	*Reddish Brown Earth*	1.7	6.8	6.8	7.0	11.6	11.6	0.4
			IL1b	>1100	RUF	*Low Humic Gley*	1.7	6.8	6.8	7.0	11.6	11.6	0.4
			IL1b	>1100	RUF	*Regosol soils*	3.1	12.0	12.0	12.4	20.6	20.6	0.8
Hambantota	Intermediate zone	Low country	IL1b	>1100	RUF	*Red Yellow Podzolic*	0.7	2.8	2.8	2.9	4.9	4.9	0.2
			IL1b	>1100	RUF	*Reddish Brown Latazolic*	0.6	2.2	2.2	2.3	3.8	3.8	0.1
			IL1b	>1100	RUF	*Reddish Brown Earth*	0.9	3.5	3.5	3.6	6.0	6.0	0.2

		IL1b	>1100	RUF	*Low Humic Gley*	0.9	3.5	3.5	3.6	6.0	6.0	0.2
		IL1b	>1100	RUF	*Regosol soils*	1.6	6.2	6.2	6.4	10.6	10.6	0.4
Dry zone	Low country	DL1b	>900	U	*Reddish Brown Earth*	0.7	2.9	2.9	3.0	5.0	5.0	0.2
		DL1b	>900	U	*Low Humic Gley*	0.7	2.9	2.9	3.0	5.0	5.0	0.2
		DL5	>650	UF	*Reddish Brown Earth*	0.6	2.2	2.2	2.2	3.7	3.7	0.1
		DL5	>650	UF	*Low Humic Gley*	0.6	2.2	2.2	2.2	3.7	3.7	0.1
		DL5	>650	UF	*Solodized - Solonetz*	0.6	2.2	2.2	2.2	3.7	3.7	0.1

* RUF – Rolling, undulating & flat; U – Undulating; UF – Undulating & flat

Table A2.32 Average annual soil losses, by AEZ and crop (tons/year)

District	Climatic zone	Agro-ecological region		Average annual rainfall (mm)	Terrain *	Paddy	Tea	Rubber	Coconut	Minor Export crops	Fruit crops	Natural forest
Galle	Wet zone	Low country	WL1a	>3200	RUF	32,462	224,667	67,599	100,095	139,719	3,138	10,016
			WL2a	>2400	RUF	26,225	96,152	18,174	58,242	81,297	1,826	5,828
Matara	Wet zone	Low country	WL1a	>3200	RUF	24,814	257,405	5,426	80,451	74,026	3,441	6,912
			WL2a	>2400	RUF	29,376	72,110	26,083	64,120	58,999	2,742	5,509
	Intermediate zone	Low country	IL1a	>1400	RUF	13,934	2,365	6,009	17,119	15,752	732	1,471
			IL1b	>1100	RUF	7,041	1,539	3,064	14,280	13,140	611	1,227
Hambantota	Intermediate zone	Low country	IL1b	>1100	RUF	8,417	1,599	257	18,496	6,542	6,236	4,516
	Dry zone	Low country	DL1b	>900	U	2,887	-	-	8,595	3,040	2,898	2,098
			DL5	>650	UF	13,086	-	-	28,801	10,187	9,711	7,031
Total						158,242	655,837	126,613	390,198	402,702	31,335	44,608

* RUF – Rolling, undulating & flat; U – Undulating; UF – Undulating & flat

Table A2.33 Nutrient content of soils, by AEZ and nutrient type

Units = % or mg/kg	Paddy		Tea		Rubber		Coconut		Minor export crops		Fruit crops		Natural forest	
	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
Low Country Wet Zone														
Nitrogen (%)	0.03	0.20	0.03	0.20	0.03	0.20	0.10	0.20	0.03	0.20	0.03	0.20	0.10	0.13
Phosphorus (mg/kg)	2.50	25.00	2.50	35.00	5.00	50.00	30.00	50.00	2.50	35.00	5.00	35.00	101.00	205.00
Potassium (mg/kg)	27.00	94.00	12.00	94.00	2.00	150.00	101.00	150.00	12.00	94.00	12.00	94.00	396.00	470.00
Organic matter (%)	2.80	7.90	0.50	7.90	0.30	3.00	1.72	2.28	0.50	7.90	0.50	7.90	9.00	12.00
Low Country Intermediate Zone														
Nitrogen (%)	0.03	0.20	0.03	0.20	0.03	0.20	0.03	0.09	0.03	0.20	0.03	0.20	0.10	0.50
Phosphorus (mg/kg)	3.00	5.00	2.50	35.00	5.00	50.00	24.00	50.00	2.50	35.00	5.00	35.00	101.00	700.00
Potassium (mg/kg)	12.00	94.00	12.00	94.00	2.00	150.00	58.00	100.00	12.00	94.00	12.00	94.00	396.00	2715.00
Organic matter (%)	0.50	3.00	0.50	7.90	0.30	3.00	0.70	1.64	0.50	7.90	0.50	7.90	9.00	12.00
Low Country Dry Zone														
Nitrogen (%)	0.03	0.20	0.03	0.20	0.03	0.20	0.03	0.09	0.03	0.20	0.03	0.20	0.10	0.50
Phosphorus (mg/kg)	3.00	5.00	2.50	35.00	5.00	50.00	5.00	22.00	2.50	35.00	5.00	35.00	140.00	700.00
Potassium (mg/kg)	12.00	47.00	12.00	94.00	2.00	150.00	2.00	50.00	12.00	94.00	12.00	94.00	525.00	2715.00
Organic matter (%)	0.50	3.00	0.50	7.90	0.30	3.00	0.30	0.50	0.50	7.90	0.50	7.90	9.00	12.00

3.1 Commonly-used valuation tools and their application in the adopted case studies

Definitions and descriptions adapted from:

Molle and Renwick (2005): Value of water for domestic services

Renwick (2001): Value of water for irrigated paddy production

Emerton and Kekulandala (2003): Wetlands

Batagoda (2003): Mangroves

Berg *et al*. (1998): Coral Reefs

Direct market valuation: The simplest and most straightforward way of valuing watershed goods and services is to look at their market prices - what they cost to buy or what they are worth to sell.

- Wetlands: Emerton and Kekulandal (2003)
  In the case of the Muthurajawela Wetland, market price-based valuation techniques are used to assess the economic benefits associated with *fishing, agricultural and plant-based handicraft production* activities in the marsh area.

- Mangroves: Batagoda (2003)
  Of the total benefits of mangrove forests, *recreational use value and direct extractive use value* i.e., non-timber forest products (NTFPs) extraction are elicited from households and converted into a flow of real resources.

- The value of water for irrigated paddy production: Renwick (2001)
  The residual method, based on a producer-level profit maximization model, is used to calculate the *value of irrigation water in irrigated paddy production*. The residual approach entails identification of the incremental contribution of each input to the value of the total output. It is the most widely used methodology for valuing irrigation water (Young 1996). Under this approach, all costs of production, except water, are subtracted from the value of production. This remaining (or residual) value provides an estimate of the value of irrigation.

As is often the case with environmental goods and services, many of the economic benefits have no market price, or are subject to prices that are highly distorted. In these cases a range of alternative valuation techniques could, in principle, be applied:

Replacement costs: Even where watershed goods and services have no market themselves, they often have alternatives or substitutes that can be bought and sold. These replacement costs can be used as a proxy for watershed resource and ecosystem values, although usually represent only partial estimates, or under-estimates.

- Value of water for domestic services: Molle and Renwick (2005)
  The benefits derived from *drinking water* wells is valued by estimating the average replacement cost of providing an amount of water equivalent to the volume abstracted. Total replacement cost is calculated as the average replacement cost of Rs 15/m^3, times the average current domestic usage of 20 l/capita/day, times river basin population.

- Wetlands: Emerton and Kekulandal (2003)
  In the case of the Muthurajawela Wetland, replacement costs are used to assess the value of *flood attenuation benefits* in terms of infrastructure required to provide a similar level of services.

Effects on production: Other economic processes often rely on watershed resources as inputs, or on the essential life support provided by watershed services. Where they have a market, it is possible to look at the contribution of watershed goods and services to the output or income of these wider production and consumption opportunities in order to assess their value.

- Wetlands: Emerton and Kekulandal (2003)
  In the case of the Muthurajawela Wetland, effects on production techniques are used to assess the economic value of wetland *wastewater treatment services and provision of fish breeding and nursery habitat functions in terms of their contribution to downstream fisheries* in Negombo lagoon.

- Coral Reefs: Berg *et al*. (1998)
  The value of the *fish-habitat function* can be estimated using the effect-on-production approach (EOP). The quality of the environment determines the ecosystem productivity. This includes the output of the fish-habitat function of coral reefs, since there is a close relationship between habitat structure and fish-community composition. Resource uses impacting on environmental quality, e.g. habitat deformation, will affect the productivity of the ecosystem. Hence, sustainable fisheries maximize the value of the fish-habitat function in the long term.

Damage costs avoided: The reduction or loss of watershed goods and services frequently incurs costs in terms of damage to, or reduction of, other economic activities. These damage costs avoided can be taken to represent the economic losses foregone by conserving watersheds.

- Wetlands: Emerton and Kekulandal (2003)
  In the case of the Muthurajawela Wetland, damage costs avoided are used to assess the value of *carbon sequestration* in terms of climate change-related damage costs avoided.

Mitigative or avertive expenditures: It is almost always necessary to take action to mitigate or avert the negative effects of the loss of watershed goods and services, so as to avoid economic damage. These mitigative or avertive costs can be used as indicators of the value of conserving watersheds in terms of expenditures avoided.

- Wetlands: Emerton and Kekulandal (2003)
  In the case of the Muthurajawela Wetland, mitigative/avertive expenditures are used to assess the *value of wastewater treatment and water recharge services* in terms of alternative expenditures avoided.

- Coral Reefs: Berg *et al*. (1998)
  The economic benefits of the *physical-structure function* can be described in through the preventive-expenditure approach (PE) which is defined by the cost of replacing the coral reef with protective constructions, e.g. groynes, revetments, and underwater wave-breakers off the coast.

Hedonic pricing: Hedonic methods look at the differentials in property prices and wages between locations, and isolate the proportion of this difference that can be ascribed to the existence or quality of watershed goods and services.

- Coral Reefs: Berg *et al*. (1998)
  The economic benefits of the *physical-structure function* can also be described through the loss of property-values (PV), which is defined by the cost of land loss (i.e. price of lost land, buildings, roads, etc) as a result of coastal erosion plus the loss of income resulting from lost land-use opportunities (e.g. loss of agricultural land).

Travel costs: Watersheds (wetlands/mangroves/coral reefs) typically hold a value in terms of a recreational resource or destination. Although in many cases no charge is made to view or enjoy natural ecosystems and species, people still spend time and money to reach sites within the watershed. This expenditure - such as on transport, food, equipment, accommodation, time, etc. - can be calculated, and a demand function constructed relating visitation rates to expenditures made. These travel costs serve as a proxy of the value that people place on leisure, recreational or tourism aspects of sites within the watershed.

- Wetlands: Emerton and Kekulandal (2003)
  In the case of the Muthurajawela Wetland, travel costs are used to assess the value of *recreation and tourism* in terms of expenditures made on visiting the wetland.

- Mangroves: Batagoda (2003)
  Both *domestic and international recreation benefits* of mangrove forests were estimated using the travel cost method (TCM) for two mangrove sites, namely, Maduganga estuary and mangrove islets situated in the Galle District and the Ranweli holiday resort situated in the Puttalama District.

Contingent valuation (CV): Even where watershed goods and services have no market price, and no close replacements or substitutes, they frequently have a high value to people. Contingent valuation techniques infer the value that people place on watershed goods and services by asking them their willingness to pay for them (or willingness to accept compensation for their loss) under the hypothetical scenario that they would be available for purchase.

- Mangroves: Batagoda (2003)
  The non-use value of mangrove forest in Sri Lanka was estimated using the contingent valuation method. The objective was: 1) to measure the willingness to pay (WTP) by local residents of Sri Lanka for their *existence, bequest and option value* of mangrove forests in Sri Lanka; 2) to measure the willingness to pay (WTP) by foreign visitors to Sri Lanka for their *existence, bequest and option value* of mangrove forests in Sri Lanka and 3) to establish socio-economic factors affecting the WTP for the non-use value of mangrove protection.

- Coral Reefs: Berg *et al*. (1998)
  The value of the *tourist-attraction function* can be defined through a financial-revenue approach (FR) or through a contingent valuation approach. The financial revenue approach calculates the direct financial profits provided by tourism that are dependent on the coral reef, while the contingent valuation approach investigates tourists' willingness to pay to maintain the coral reef. Thus, the contingent valuation approach also includes social values, thus, these estimates could be expected to be higher than the value arrived at by the financial revenue approach.

Benefits transfer: The benefit transfer method is used to estimate economic values for ecosystem services by transferring available information from studies already completed in another location and/or context. For example, values for recreational fishing in a particular state may be estimated by applying measures of recreational fishing values from a study conducted in another state.

The basic goal of benefit transfer is to estimate benefits for one context by adapting an estimate of benefits from some other context. Benefit transfer is often used when it is too expensive and/or there is too little time available to conduct an original valuation study, yet some measure of benefits is needed. It is important to note that benefit transfers can only be as accurate as the initial study.

- Mangroves: Batagoda (2003)
  The benefits of providing *breeding grounds for fish, erosion control, biodiversity maintenance, carbon sequestration, storm protection and pollution treatment* were valued as indirect use benefits of mangroves.

Table A3.11 Valuation of Muthurajawela wetland benefits, Emerton and Kekulandala (2003)

Economic Benefit	Valuation technique	Data required	Included/excluded in study
Fisheries	Marsh fisheries: Market prices of output	Fishing population, catch and prices	☑ Yes
Agriculture	Marsh farming: Market prices of output	Farming population, area, yield and prices	☑ Yes
Plant-based handicrafts	Marsh species: Market prices of output	Artisan population, production and prices	☒ No - insufficient data
Leisure and recreation	Marsh recreation: Visitor travel costs	Visitor numbers, type and expenditures	☑ Yes
Flood attenuation	Surrounding area: Service replacement costs	Required infrastructure and costs	☑ Yes
Nutrient retention and wastewater treatment	Waste treatment: Mitigative expenditures	Required infrastructure and costs	☑ Yes
	Local population: Health status	Medical expenditures; relationship between pollution and health	☒ No - insufficient data
Fish breeding and nursery	Downstream fisheries: Negombo fishery income	Fishing population, catch and prices; relationship between marsh degradation and catch	☒ No - insufficient data
	On-site fisheries: Marsh fishery income		☑ Yes - reflected in direct value
Water supply and recharge	Local water users: Avertive expenditures	Required infrastructure and costs	☑ Yes
Landscape values	Adjacent property: Hedonic methods	Comparative property prices	☒ No - insufficient data
Carbon sink	Global climate change: Damage costs avoided	Carbon sequestration capacity and associated costs avoided	☑ Yes
Option values Existence values	Potential users: Contingent valuation	Willingness to pay	☒ No - insufficient data

Table A3.12 Direct and indirect economic benefits of Muthurajawela Marsh, Emerton and Kekulandala (2003) (Shaded values are adjusted to current exchange rates and used in the analysis)

Economic benefit	Value (Rs million/year)	Value ($USD/ha/year) [1]
Flood attenuation	485.51	**1,364.2**
Industrial wastewater treatment	162.31	**456.1**
Agricultural production	30.29	**85.1**
Support to downstream fisheries	20.00	**56.2**
Firewood	7.96	**22.4**
Fishing	6.26	**17.6**
Leisure, recreation and recreation	5.28	**14.8**
Domestic sewage treatment	4.32	**12.1**
Freshwater supplies for local population	3.78	**10.6**
Carbon sequestration	0.78	**89.2** [2]
Total	**726.49**	**2,128.4**

1 - Implied value per hectare based on catchment area, authors' calculations. 1 USD = 116 Rs.

2 – Carbon sequestration benefit based on 75 hectares of mangrove area in Muthurajawela Marsh

Table A3.13 Valuation of Mangrove Forests in Sri Lanka, reproduced from Batagoda (2003) (Shaded values are used in the analysis, after adjusting for current exchange rates)

Value component	**Value (US$/ha/year)[1]**	**Value (US$/hh/year)[1]**	**Valuation technique**
1. DIRECT USE VALUE			
Non-Timber Forest Resources			
Stock of Kirala fruits (*Sonneratia* species)	751.0		Forest inventory survey and logbook yield survey
Stock of Karan Koku (*Lacrostichum* species)	3,784.0		Forest inventory survey
Flow of Kirala fruit	24.0	23.0	Forest gate survey
Flow of Karan leaves	35.0	43.0	Household survey
Flow of green leaf vegetables	11.0	14.0	Household survey
Flow of fish	13.0	17.0	Household survey
Flow of raw fuel wood	4.0	5.0	Household survey
Flow of dried fuel wood	5.0	7.0	Household survey
Total flow of NTFRs	**92.0**	108.0	Forest gate & Household surveys
RECREATIONAL VALUE			
Local recreation value	**933.0**	10.0 [2]	Travel cost survey
Global recreation value	**1,096.0**	0.00013 [2]	Travel cost survey
2. OPTION VALUE			
Local option value			
WTP minimum	**1,491.0**		CVM payment card
WTP maximum	**1,851.0**	2.9	CVM open ended
Global option value			
WTP minimum	**1,039.0**		CVM payment card
WTP maximum	**1,179.0**	18.0	CVM open ended
3. NON-USE VALUE			
Local bequest value			CVM payment card

WTP minimum	**1,714.0**	3.3	CVM open ended
WTP maximum	**2,037.0**		
Global bequest value			
WTP minimum	**562.0**		CVM payment card
WTP maximum	**638.0**	1.1	CVM open ended
Local existence value			
WTP minimum	**883.0**		CVM payment card
WTP maximum	**1,001.0**	1.7	CVM open ended
Global existence value			
WTP minimum	**1,399.0**		CVM payment card
WTP maximum	**1,630.0**	24.0	CVM open ended
4. INDIRECT USE VALUE			
Erosion control	**3.6**		Benefit transfer from Ruitenbeek (1992)
Biodiversity maintenance	**18.0**		Benefit transfer from Ruitenbeek (1992)
Breeding ground for fish	**218.0**		Benefit transfer from Bann (1999)
Carbon sequestration	**75.5**		Estimated from Sathirathai (1997)
Pollution treatment and nutrient retention	**4,494.0**		Benefit transfer from Lal (1990)
Windbreaker and storm protection	**76.8**		Benefit transfer from Bann (unpublished)
Economic value of mangrove			Estimated taking all minimum values –
taking minimum value	12,229.0		only Total flow of NTFRs used

1 – Values originally calculated at 1 USD = 95 Rs.

2 - Average consumer surplus per person

Table A3.14 Accumulated net present value of coral reefs in Sri Lanka over 20 years (USD 1000 km^{-2} reef), reproduced from Berg *et al*. (1998) (Shaded values are used in the analysis, after adjusting for current exchange rates)

	Fish-habitat function		Tourist-attraction [2] function			Physical-structure function				Total quantifiable value	
Year	Low	High	FR low [3]	FR high [3]	CV [4]	PV low [5]	PV high [5]	PE low [6]	PE high [6]	Low	High
1	**7**	9	4	148	**208**	0.1	158	**1230**	4180	12	4397
5 [1]	30	38	21	700	985	0.6	669	1230	4180	52	5203
10 [1]	50	63	39	1309	1841	1.0	1104	1230	4180	90	6064
15 [1]	63	79	55	1839	2587	1.3	1366	1230	4180	120	6845
20 [1]	71	89	69	2300	3234	1.5	1570	1230	4180	142	7504

1 – All values are discounted with financial discount rate of 9%; 1 USD = 50 Rs.

2 – 6% annual growth of the tourist industry

3 – FR = financial revenue approach

4 – CV = contingent valuation approach

5 – property-value and land value approach; 6 – preventative-expenditure approach

Annex 4

Benefits of wetlands, mangroves and coral reefs in the study

Bentota Estuary

(Shaded rows have no, or minimal, values)

	BT (MEA)	BT (Muthurajawela)	BT (Mangroves)	Total
Catchment area (ha)	***1,700***	***1,700***	***1,700***	***1,700***
Mangrove area (ha)	***50***	***50***	***50***	***50***
Reef area (ha)	***-***	***-***	***-***	***-***
Provisioning services	***812,600***	***85,982***	***901***	***84,885***
(products obtained from wetlands/ mangroves/ reefs)				
Agricultural production	-	-	-	-
Fishing	635,800	29,903	532	29,556
Hunting	-	-	-	-
Water supply	76,500	18,056	-	18,056
Raw materials (thatch, timber, fodder, fertilizer, etc.)	76,500	-	164	164
Fuelwood	23,800	38,023	205	37,110[1]
Other (genetic, medicinal, and ornamental resources)	-	-	-	-
Cultural services	***2,334,100***	***25,221***	***377,420***	***377,420***
(nonmaterial benefits obtained from wetlands/ mangroves/ reefs)				
Aesthetic information	1,497,700	-	-	-
Recreation and tourism	836,400	25,221	-	-
Local	-	-	38,205	38,205
International	-	-	48,974	48,974
Option value	-	-	-	-
Local	-	-	61,054	61,054
International	-	-	42,545	42,545
Bequest value	-	-	-	-

Local	-	-	70,185	70,185
International	-	-	23,013	23,013
Existence value	-	-	-	-
Local	-	-	36,157	36,157
International	-	-	57,287	57,287
Other (e.g., artistic, spiritual, historic, or scientific information)	-	-	-	-
Regulating services	***1,626,750***	***3,215,129***	***242,776***	***3,383,792***
(benefits obtained from ecosystem processes)				
Flood control/water regulation	788,800	2,319,176	3,264	2,254,229[1]
Water treatment	489,600	-	229,593	229,593
Industrial wastewater treatment	-	775,320	-	775,320
Domestic sewage treatment	-	20,636	-	20,636
Nursery function	341,700	-	6,682	6,682
Climate regulation of mangroves	6,650	4,461	3,092	4,461[2]
Other (e.g., sediment control, biological control)	-	95,536	144	92,870[1]
Supporting services	***363,800***	***-***	***722***	***722***
(ecosystem functions necessary to maintain all other services)				
Habitat/refugia for biodiversity	363,800	-	722	722
Other (e.g., primary products, soil formation, nutrient/biogeochemical cycling)	-	-	-	-
Total value (USD)	**5,137,250**	**3,326,332**	**621,819**	**3,846,820**
Exchange rate ($1USD = Rs. Apr. 2009)	116	116	116	116
Total value (Rs.)	**595,921,000**	**385,854,527**	**72,131,041**	**446,231,083**

Notes: 1- Mangrove areas netted out of catchment area; 2 – Only the maximum is taken between Muthurajawela and mangroves;

Rural factor = 0.10

Maduganga Estuary (Ramsar Site)

(Shaded rows have no, or minimal, values)

	BT (MEA)	BT (Muthurajawela)	BT (Mangroves)	Total
Catchment area (ha)	***915***	***915***	***915***	***915***
Mangrove area (ha)	***125***	***125***	***125***	***125***
Reef area (ha)	**-**	**-**	**-**	**-**
Provisioning services	***437,370***	***124,155***	***9,418***	***117,940***
(products obtained from wetlands/ mangroves/ reefs)				
Agricultural production	-	77,877	7,166	74,404[1]
Fishing	342,210	16,095	1,331	15,227[1]
Hunting	-	-	-	-
Water supply	41,175	9,719	-	9,719
Raw materials (thatch, timber, fodder, fertilizer, etc.)	41,175	-	409	409
Fuelwood	12,810	20,465	512	18,181[1]
Other (genetic, medicinal, and ornamental resources)	-	-	-	-
Cultural services	***1,256,295***	***13,575***	***943,551***	***943,551***
(nonmaterial benefits obtained from wetlands/ mangroves/ reefs)				
Aesthetic information	806,115	-	-	-
Recreation and tourism	450,180	13,575	-	-
Local	-	-	95,512	95,512
International	-	-	122,435	122,435
Option value	-	-	-	-
Local	-	-	152,635	152,635
International	-	-	106,363	106,363
Bequest value	-	-	-	-
Local	-	-	175,463	175,463
International	-	-	57,532	57,532

Existence value	-	-	-	-
Local	-	-	90,393	90,393
International	-	-	143,217	143,217
Other (e.g., artistic, spiritual, historic, or scientific information)	-	-	-	-
Regulating services	***888,620***	***1,321,943***	***606,940***	***1,743,601***
(benefits obtained from ecosystem processes)				
Flood control/water regulation	424,560	1,248,263	8,161	1,085,895[1]
Water treatment	263,520	-	573,983	573,983
Industrial wastewater treatment	-	-	-	-
Domestic sewage treatment	-	11,107	-	11,107
Nursery function	183,915	-	16,706	16,706
Climate regulation of mangroves	16,625	11,153	7,729	11,153[2]
Other (e.g., sediment control, biological control)	-	51,421	361	44,757[1]
Supporting services	***195,810***	***-***	***1,806***	***1,806***
(ecosystem functions necessary to maintain all other services)				
Habitat/refugia for biodiversity	195,810	-	1,806	1,806
Other (e.g., primary products, soil formation, nutrient/biogeochemical cycling)	-	-	-	-
Total value (USD)	**2,778,095**	**1,459,673**	**1,561,714**	**2,806,898**
Exchange rate ($1USD = Rs. Apr. 2009)	116	116	116	116
Total value (Rs.)	**322,259,020**	**169,322,107**	**181,158,852**	**325,600,140**

Notes: 1- Mangrove areas netted out of catchment area; 2 – Only the maximum is taken between Muthurajawela and mangroves

Rural factor = 0.10

Hikkaduwa National Park

(Shaded rows have no, or minimal, values)

	BT (MEA)	**BT (Muthurajawela)**	**BT (Reefs)**	**Total**
Catchment area (ha)	***104***	***104***	***104***	***104***
Mangrove area (ha)	-	-	-	-
Reef area (ha)	***45***	***45***	***45***	***45***
Provisioning services	***49,712***	***5,260***	***1,343***	***6,603***
(products obtained from wetlands/ mangroves/ reefs)				
Agricultural production	-	-	-	-
Fishing	38,896	1,829	1,343	3,172[1]
Hunting	-	-	-	-
Water supply	4,680	1,105	-	1,105
Raw materials (thatch, timber, fodder, fertilizer, etc.)	4,680	-	-	-
Fuelwood	1,456	2,326	-	2,326
Other (genetic, medicinal, and ornamental resources)	-	-	-	-
Cultural services	***142,792***	***1,543***	***39,897***	***39,897***
(nonmaterial benefits obtained from wetlands/ mangroves/ reefs)				
Aesthetic information	91,624	-	-	-
Recreation and tourism	51,168	1,543	39,897	39,897 [1]
Local	-	-	-	-
International	-	-	-	-
Option value	-	-	-	-
Local	-	-	-	-
International	-	-	-	-
Bequest value	-	-	-	-
Local	-	-	-	-
International	-	-	-	-

Existence value	-	-	-	-
Local	-	-	-	-
International	-	-	-	-
Other (e.g., artistic, spiritual, historic, or scientific information)	-	-	-	-
Regulating services	***99,112***	***196,417***	***235,927***	***290,465***
(benefits obtained from ecosystem processes)				
Flood control/water regulation	48,256	141,879	235,927	235,927[2]
Water treatment	29,952	-	-	-
Industrial wastewater treatment	-	47,431	-	47,431
Domestic sewage treatment	-	1,262	-	1,262
Nursery function	20,904	-	-	-
Climate regulation of mangroves	-	-	-	-
Other (e.g., sediment control, biological control)	-	5,845	-	5,845
Supporting services	***22,256***	***-***	***-***	***-***
(ecosystem functions necessary to maintain all other services)				
Habitat/refugia for biodiversity	22,256	-	-	-
Other (e.g., primary products, soil formation, nutrient/biogeochemical cycling)	-	-	-	-
Total value (USD)	**313,872**	**203,220**	**277,166**	**336,964**
Exchange rate ($1USD = Rs. Apr. 2009)	116	116	116	116
Total value (Rs.)	**36,409,152**	**23,573,559**	**32,151,250**	**39,087,860**

Notes: 1- Mangrove and coral reef benefits added; 2 – Only the maximum is taken between Muthurajawela and mangroves

Rural factor = 0.10

Rumassala Marine Sanctuary

(Shaded rows have no, or minimal, values)

	BT (MEA)	BT (Muthurajawela)	BT (Reefs)	Total
Catchment area (ha)	***1,707***	***1,707***	***1,707***	***1,707***
Mangrove area (ha)	***-***	***-***	***-***	***-***
Reef area (ha)	***1***	***1***	***1***	***1***
Provisioning services	***715,233***	***30,026***	***30***	***30,056***
(products obtained from wetlands/ mangroves/ reefs)				
Agricultural production	-	-	-	-
Fishing	638,418	30,026	30	30,056[1]
Hunting	-	-	-	-
Water supply	-	-	-	-
Raw materials (thatch, timber, fodder, fertilizer, etc.)	76,815	-	-	-
Fuelwood	-	-	-	-
Other (genetic, medicinal, and ornamental resources)	-	-	-	-
Cultural services	***2,343,711***	***25,325***	***897***	***25,325***
(nonmaterial benefits obtained from wetlands/ mangroves/ reefs)				
Aesthetic information	1,503,867	-	-	-
Recreation and tourism	839,844	25,325	897	25,325[2]
Local	-	-	-	-
International	-	-	-	-
Option value	-	-	-	-
Local	-	-	-	-
International	-	-	-	-
Bequest value	-	-	-	-
Local	-	-	-	-
International	-	-	-	-

Existence value	-	-	-	-
Local	-	-	-	-
International	-	-	-	-
Other (e.g., artistic, spiritual, historic, or scientific information)	-	-	-	-
Regulating services	***1,135,155***	***2,328,726***	***5,302***	***2,328,726***
(benefits obtained from ecosystem processes)				
Flood control/water regulation	792,048	2,328,726	5,302	2,328,726[2]
Water treatment	-	-	-	-
Industrial wastewater treatment	-	-	-	-
Domestic sewage treatment	-	-	-	-
Nursery function	343,107	-	-	-
Climate regulation of mangroves	-	-	-	-
Other (e.g., sediment control, biological control)	-	-	-	-
Supporting services	***365,298***	-	-	-
(ecosystem functions necessary to maintain all other services)				
Habitat/refugia for biodiversity	365,298	-	-	-
Other (e.g., primary products, soil formation, nutrient/biogeochemical cycling)	-	-	-	-
Total value (USD)	**4,559,397**	**2,384,077**	**6,228**	**2,384,107**
Exchange rate ($1USD = Rs. Apr. 2009)	116	116	116	116
Total value (Rs.)	**528,890,052**	**276,552,917**	**722,500**	**276,556,417**

Notes: 1- Mangrove and coral reef benefits added; 2 – Only the maximum is taken between Muthurajawela and mangroves

Rural factor = 0.10

Unawatuna Reef

(Shaded rows have no, or minimal, values)

	BT (MEA)	BT (Muthurajawela)	BT (Reefs)	Total
Catchment area (ha)	***100***	***100***	***100***	***100***
Mangrove area (ha)	-	-	-	-
Reef area (ha)	100	100	100	100
Provisioning services	***46,400***	***2,821***	***3,017***	***5,838***
(products obtained from wetlands/ mangroves/ reefs)				
Agricultural production	-	-	-	-
Fishing	37,400	1,759	3,017	4,776[1]
Hunting	-	-	-	-
Water supply	4,500	1,062	-	1,062
Raw materials (thatch, timber, fodder, fertilizer, etc.)	4,500	-	-	-
Fuelwood	-	-	-	-
Other (genetic, medicinal, and ornamental resources)	-	-	-	-
Cultural services	***137,300***	***1,484***	***89,655***	***89,655***
(nonmaterial benefits obtained from wetlands/ mangroves/ reefs)				
Aesthetic information	88,100	-	-	-
Recreation and tourism	49,200	1,484	89,655	89,655[2]
Local	-	-	-	-
International	-	-	-	-
Option value	-	-	-	-
Local	-	-	-	-
International	-	-	-	-
Bequest value	-	-	-	-
Local	-	-	-	-
International	-	-	-	-

Existence value	-	-	-	-
Local	-	-	-	-
International	-	-	-	-
Other (e.g., artistic, spiritual, historic, or scientific information)	-	-	-	-
Regulating services	***66,500***	***136,422***	***530,172***	***530,172***
(benefits obtained from ecosystem processes)				
Flood control/water regulation	46,400	136,422	530,172	530,172[2]
Water treatment	-	-	-	-
Industrial wastewater treatment	-	-	-	-
Domestic sewage treatment	-	-	-	-
Nursery function	20,100	-	-	-
Climate regulation of mangroves	-	-	-	-
Other (e.g., sediment control, biological control)	-	-	-	-
Supporting services	***21,400***	**-**	**-**	**-**
(ecosystem functions necessary to maintain all other services)				
Habitat/refugia for biodiversity	21,400	-	-	-
Other (e.g., primary products, soil formation, nutrient/biogeochemical cycling)	-	-	-	-
Total value (USD)	**271,600**	**140,727**	**622,845**	**625,666**
Exchange rate ($1USD = Rs. Apr. 2009)	116	116	116	116
Total value (Rs.)	**31,505,600**	**16,324,316**	**72,250,000**	**72,577,249**

Notes: 1- Mangrove and coral reef benefits added; 2 – Only the maximum is taken between Muthurajawela and mangroves

Rural factor = 0.10

Koggala Lagoon

(Shaded rows have no, or minimal, values)

	BT (MEA)	BT (Muthurajawela)	BT (Mangroves)	Total
Catchment area (ha)	***727***	***727***	***727***	***727***
Mangrove area (ha)	20	20	20	20
Reef area (ha)	-	-	-	-
Provisioning services	***314,791***	***90,924***	***1,507***	***89,930***
(products obtained from wetlands/ mangroves/ reefs)				
Agricultural production	-	61,876	1,147	61,320[1]
Fishing	271,898	12,788	213	12,649[1]
Hunting	-	-	-	-
Water supply	-	-	-	-
Raw materials (thatch, timber, fodder, fertilizer, etc.)	32,715	-	66	66
Fuelwood	10,178	16,261	82	15,895[1]
Other (genetic, medicinal, and ornamental resources)	-	-	-	-
Cultural services	***998,171***	***10,786***	***150,968***	***150,968***
(nonmaterial benefits obtained from wetlands/ mangroves/ reefs)				
Aesthetic information	640,487	-	-	-
Recreation and tourism	357,684	10,786	-	-
Local	-	-	15,282	15,282
International	-	-	19,590	19,590
Option value	-	-	-	-
Local	-	-	24,422	24,422
International	-	-	17,018	17,018
Bequest value	-	-	-	-
Local	-	-	28,074	28,074
International	-	-	9,205	9,205

Existence value	-	-	-	-
Local	-	-	14,463	14,463
International	-	-	22,915	22,915
Other (e.g., artistic, spiritual, historic, or scientific information)	-	-	-	-
Regulating services	***695,491***	***1,043,254***	***97,110***	***1,110,719***
(benefits obtained from ecosystem processes)				
Flood control/water regulation	337,328	991,789	1,306	965,810[1]
Water treatment	209,376	-	91,837	91,837
Industrial wastewater treatment	-	-	-	-
Domestic sewage treatment	-	8,825	-	8,825
Nursery function	146,127	-	2,673	2,673
Climate regulation of mangroves	2,660	1,784	1,237	1,784[2]
Other (e.g., sediment control, biological control)	-	40,856	58	39,789[1]
Supporting services	***155,578***	***-***	***289***	***289***
(ecosystem functions necessary to maintain all other services)				
Habitat/refugia for biodiversity	155,578	-	289	289
Other (e.g., primary products, soil formation, nutrient/biogeochemical cycling)	-	-	-	-
Total value (USD)	**2,164,031**	**1,144,964**	**249,874**	**1,351,906**
Exchange rate ($1USD = Rs. Apr. 2009)	116	116	116	116
Total value (Rs.)	**251,027,596**	**132,815,781**	**28,985,416**	**156,821,059**

Notes: 1- Mangrove areas netted out of catchment area;; 2 – Only the maximum is taken between Muthurajawela and mangroves

Rural factor = 0.10

Weligama Bay & Reef

(Shaded rows have no, or minimal, values)

	BT (MEA)	BT (Muthurajawela)	BT (Reefs)	Total
Catchment area (ha)	***100***	***100***	***100***	***100***
Mangrove area (ha)	-	-	-	-
Reef area (ha)	10	10	10	10
Provisioning services	***43,300***	***12,507***	***302***	***12,808***
(products obtained from wetlands/ mangroves/ reefs)				
Agricultural production	-	8,511	-	8,511
Fishing	37,400	1,759	302	2,061[1]
Hunting	-	-	-	-
Water supply	-	-	-	-
Raw materials (thatch, timber, fodder, fertilizer, etc.)	4,500	-	-	-
Fuelwood	1,400	2,237	-	2,237
Other (genetic, medicinal, and ornamental resources)	-	-	-	-
Cultural services	***137,300***	***1,484***	***8,966***	***8,966***
(nonmaterial benefits obtained from wetlands/ mangroves/ reefs)				
Aesthetic information	88,100	-	-	-
Recreation and tourism	49,200	1,484	8,966	8,966[2]
Local	-	-	-	-
International	-	-	-	-
Option value	-	-	-	-
Local	-	-	-	-
International	-	-	-	-
Bequest value	-	-	-	-
Local	-	-	-	-
International	-	-	-	-

Existence value	-	-	-	-
Local	-	-	-	-
International	-	-	-	-
Other (e.g., artistic, spiritual, historic, or scientific information)	-	-	-	-
Regulating services	***95,300***	***143,256***	***53,017***	***143,256***
(benefits obtained from ecosystem processes)				
Flood control/water regulation	46,400	136,422	53,017	136,422 [2]
Water treatment	28,800	-	-	-
Industrial wastewater treatment	-	-	-	-
Domestic sewage treatment	-	1,214	-	1,214
Nursery function	20,100	-	-	-
Climate regulation of mangroves	-	-	-	-
Other (e.g., sediment control, biological control)	-	5,620	-	5,620
Supporting services	***21,400***	**-**	**-**	**-**
(ecosystem functions necessary to maintain all other services)				
Habitat/refugia for biodiversity	21,400	-	-	-
Other (e.g., primary products, soil formation, nutrient/biogeochemical cycling)	-	-	-	-
Total value (USD)	**297,300**	**157,246**	**62,284**	**165,030**
Exchange rate ($1USD = Rs. Apr. 2009)	116	116	116	116
Total value (Rs.)	**34,486,800**	**18,240,548**	**7,225,000**	**19,143,449**

Notes: 1- Mangrove and coral reef benefits added; 2 – Only the maximum is taken between Muthurajawela and mangroves

Rural factor = 0.10

Rekawa Lagoon & Reef

(Shaded rows have no, or minimal, values)

	BT (MEA)	**BT (Muthurajawela)**	**BT (Mang./Reef)**	**Total**
Catchment area (ha)	***250***	***250***	***250***	***250***
Mangrove area (ha)	***200***	***200***	***200***	***200***
Reef area (ha)	***4.5***	***4.5***	***4.5***	***4.5***
Provisioning services	***119,500***	***33,922***	***15,205***	***24,113***
(products obtained from wetlands/ mangroves/ reefs)				
Agricultural production	-	21,278	11,466	15,721[1]
Fishing	93,500	4,397	2,265	3,145[1,2]
Hunting	-	-	-	-
Water supply	11,250	2,655	-	2,655
Raw materials (thatch, timber, fodder, fertilizer, etc.)	11,250	-	655	655
Fuelwood	3,500	5,592	819	1,937[1]
Other (genetic, medicinal, and ornamental resources)	-	-	-	-
Cultural services	***343,250***	***3,709***	***150,968***	***150,968***
(nonmaterial benefits obtained from wetlands/ mangroves/ reefs)				
Aesthetic information	220,250	-	-	-
Recreation and tourism	123,000	3,709	-	-
Local	-	-	15,282	15,282
International	-	-	19,590	19,590
Option value	-	-	-	-
Local	-	-	24,422	24,422
International	-	-	17,018	17,018
Bequest value	-	-	-	-
Local	-	-	28,074	28,074
International	-	-	9,205	9,205

Existence value	-	-	-	-
Local	-	-	14,463	14,463
International	-	-	22,915	22,915
Other (e.g., artistic, spiritual, historic, or scientific information)	-	-	-	-
Regulating services	***264,850***	***375,984***	***994,961***	***1,050,638***
(benefits obtained from ecosystem processes)				
Flood control/water regulation	116,000	341,055	36,915	81,268[1]
Water treatment	72,000	-	918,373	918,373
Industrial wastewater treatment	-	-	-	-
Domestic sewage treatment	-	3,035	-	3,035
Nursery function	50,250	-	26,729	26,729
Climate regulation of mangroves	26,600	17,845	12,366	17,845[3]
Other (e.g., sediment control, biological control)	-	14,049	578	3,388[1]
Supporting services	***53,500***	***-***	***2,889***	***2,889***
(ecosystem functions necessary to maintain all other services)				
Habitat/refugia for biodiversity	53,500	-	2,889	2,889
Other (e.g., primary products, soil formation, nutrient/biogeochemical cycling)	-	-	-	-
Total value (USD)	**781,100**	**413,615**	**1,164,023**	**1,228,608**
Exchange rate ($1USD = Rs. Apr. 2009)	116	116	116	116
Total value (Rs.)	**90,607,600**	**47,979,387**	**135,026,713**	**142,518,572**

Notes: 1- Mangrove areas netted out of catchment area; 2 - Mangrove and coral reef benefits added; 3 - Only the maximum is taken between Muthurajawela and mangroves

Rural factor = 0.10

Kahanda Estuary & Kahandamodera Mangrove

(Shaded rows have no, or minimal, values)

	BT (MEA)	BT (Muthurajawela)	BT (Mangroves)	Total
Catchment area (ha)	***51***	***51***	***51***	***51***
Mangrove area (ha)	***22.3***	***22.3***	***22.3***	***22.3***
Reef area (ha)	-	-	-	-
Provisioning services	***24,378***	***6,920***	***1,680***	***5,811***
(products obtained from wetlands/ mangroves/ reefs)				
Agricultural production	-	4,341	1,278	3,721[1]
Fishing	19,074	897	237	742[1]
Hunting	-	-	-	-
Water supply	2,295	542	-	542
Raw materials (thatch, timber, fodder, fertilizer, etc.)	2,295	-	73	73
Fuelwood	714	1,141	91	733[1]
Other (genetic, medicinal, and ornamental resources)	-	-	-	-
Cultural services	***70,023***	***757***	***16,833***	***16,833***
(nonmaterial benefits obtained from wetlands/ mangroves/ reefs)				
Aesthetic information	44,931	-	-	-
Recreation and tourism	25,092	757	-	-
Local	-	-	1,704	1,704
International	-	-	2,184	2,184
Option value	-	-	-	-
Local	-	-	2,723	2,723
International	-	-	1,898	1,898
Bequest value	-	-	-	-
Local	-	-	3,130	3,130
International	-	-	1,026	1,026

Existence value	-	-	-	-
Local	-	-	1,613	1,613
International	-	-	2,555	2,555
Other (e.g., artistic, spiritual, historic, or scientific information)	-	-	-	-
Regulating services	***51,569***	***75,050***	***108,278***	***150,274***
(benefits obtained from ecosystem processes)				
Flood control/water regulation	23,664	69,575	1,456	40,609[1]
Water treatment	14,688	-	102,399	102,399
Industrial wastewater treatment	-	-	-	-
Domestic sewage treatment	-	619	-	619
Nursery function	10,251	-	2,980	2,980
Climate regulation of mangroves	2,966	1,990	1,379	1,990[2]
Other (e.g., sediment control, biological control)	-	2,866	64	1,677[1]
Supporting services	***10,914***	***-***	***322***	***322***
(ecosystem functions necessary to maintain all other services)				
Habitat/refugia for biodiversity	10,914	-	322	322
Other (e.g., primary products, soil formation, nutrient/biogeochemical cycling)	-	-	-	-
Total value (USD)	**156,884**	**82,727**	**127,113**	**173,240**
Exchange rate ($1USD = Rs. Apr. 2009)	116	116	116	116
Total value (Rs.)	**18,198,532**	**9,596,320**	**14,745,146**	**20,095,885**

Notes: 1- Mangrove areas netted out of catchment area;; 2 – Only the maximum is taken between Muthurajawela and mangroves

Rural factor = 0.10

Kalametiya Lagoon

(Shaded rows have no, or minimal, values)

	BT (MEA)	BT (Muthurajawela)	BT (Mangroves)	Total
Catchment area (ha)	***604***	***604***	***604***	***604***
Mangrove area (ha)	***17***	***17***	***17***	***17***
Reef area (ha)	-	-	-	-
Provisioning services	***363,004***	***81,956***	***1,281***	***81,111***
(products obtained from wetlands/ mangroves/ reefs)				
Agricultural production	-	51,407	975	50,935[1]
Fishing	225,896	10,624	181	10,506[1]
Hunting	74,292	-	-	-
Water supply	27,180	6,415	-	6,415
Raw materials (thatch, timber, fodder, fertilizer, etc.)	27,180	-	56	56
Fuelwood	8,456	13,509	70	13,199[1]
Other (genetic, medicinal, and ornamental resources)	-	-	-	-
Cultural services	***829,292***	***8,961***	***12,832***	***12,832***
(nonmaterial benefits obtained from wetlands/ mangroves/ reefs)				
Aesthetic information	532,124	-	-	-
Recreation and tourism	297,168	8,961	-	-
Local	-	-	1,299	1,299
International	-	-	1,665	1,665
Option value	-	-	-	-
Local	-	-	2,076	2,076
International	-	-	1,447	1,447
Bequest value	-	-	-	-
Local	-	-	2,386	2,386
International	-	-	782	782

Existence value	-	-	-	-
Local	-	-	1,229	1,229
International	-	-	1,948	1,948
Other (e.g., artistic, spiritual, historic, or scientific information)	-	-	-	-
Regulating services	***577,873***	***866,782***	***82,544***	***924,127***
(benefits obtained from ecosystem processes)				
Flood control/water regulation	280,256	823,990	1,110	801,908[1]
Water treatment	173,952	-	78,062	78,062
Industrial wastewater treatment	-	-	-	-
Domestic sewage treatment	-	7,332	-	7,332
Nursery function	121,404	-	2,272	2,272
Climate regulation of mangroves	2,261	1,517	1,051	1,517[2]
Other (e.g., sediment control, biological control)	-	33,943	49	33,037[1]
Supporting services	***129,256***	***-***	***246***	***246***
(ecosystem functions necessary to maintain all other services)				
Habitat/refugia for biodiversity	129,256	-	246	246
Other (e.g., primary products, soil formation, nutrient/biogeochemical cycling)	-	-	-	-
Total value (USD)	**1,899,425**	**957,699**	**96,903**	**1,018,316**
Exchange rate ($1USD = Rs. Apr. 2009)	116	116	116	116
Total value (Rs.)	**220,333,300**	**111,093,030**	**11,240,694**	**118,124,614**

Notes: 1- Mangrove areas netted out of catchment area;; 2 – Only the maximum is taken between Muthurajawela and mangroves

Rural factor = 0.10

Lunama Lagoon

(Shaded rows have no, or minimal, values)

	BT (MEA)	**BT (Muthurajawela)**	**BT (Mangroves)**	**Total**
Catchment area (ha)	***192***	***192***	***192***	***192***
Mangrove area (ha)	***5***	***5***	***5***	***5***
Reef area (ha)	-	-	-	-
Provisioning services	***115,392***	***26,052***	***377***	***25,804***
(products obtained from wetlands/ mangroves/ reefs)				
Agricultural production	-	16,341	287	16,202[1]
Fishing	71,808	3,377	53	3,343[1]
Hunting	23,616	-	-	-
Water supply	8,640	2,039	-	2,039
Raw materials (thatch, timber, fodder, fertilizer, etc.)	8,640	-	16	16
Fuelwood	2,688	4,294	20	4,203[1]
Other (genetic, medicinal, and ornamental resources)	-	-	-	-
Cultural services	***263,616***	***2,849***	***3,774***	***3,774***
(nonmaterial benefits obtained from wetlands/ mangroves/ reefs)				
Aesthetic information	169,152	-	-	-
Recreation and tourism	94,464	2,849	-	-
Local	-	-	382	382
International	-	-	490	490
Option value	-	-	-	-
Local	-	-	611	611
International	-	-	425	425
Bequest value	-	-	-	-
Local	-	-	702	702
International	-	-	230	230

Existence value	-	-	-	-
Local	-	-	362	362
International	-	-	573	573
Other (e.g., artistic, spiritual, historic, or scientific information)	-	-	-	-
Regulating services	***183,641***	***275,497***	***24,278***	***292,363***
(benefits obtained from ecosystem processes)				
Flood control/water regulation	89,088	261,930	326	255,436[1]
Water treatment	55,296	-	22,959	22,959
Industrial wastewater treatment	-	-	-	-
Domestic sewage treatment	-	2,331	-	2,331
Nursery function	38,592	-	668	668
Climate regulation of mangroves	665	446	309	446[2]
Other (e.g., sediment control, biological control)	-	10,790	14	10,523[1]
Supporting services	***41,088***	***-***	***72***	***72***
(ecosystem functions necessary to maintain all other services)				
Habitat/refugia for biodiversity	41,088	-	72	72
Other (e.g., primary products, soil formation, nutrient/biogeochemical cycling)	-	-	-	-
Total value (USD)	**603,737**	**304,398**	**28,501**	**322,014**
Exchange rate ($1USD = Rs. Apr. 2009)	116	116	116	116
Total value (Rs.)	**70,033,492**	**35,310,159**	**3,306,087**	**37,353,571**

Notes: 1- Mangrove areas netted out of catchment area;; 2 – Only the maximum is taken between Muthurajawela and mangroves

Rural factor = 0.10

Karagan Lewaya

(Shaded rows have no, or minimal, values)

	BT (MEA)	BT (Muthurajawela)	BT (Mangroves)	Total
Catchment area (ha)	***835***	***835***	***835***	***835***
Mangrove area (ha)	-	-	-	-
Reef area (ha)	-	-	-	-
Provisioning services	***399,130***	***113,300***	-	***113,300***
(products obtained from wetlands/ mangroves/ reefs)				
Agricultural production	-	71,068	-	71,068
Fishing	312,290	14,687	-	14,687
Hunting	-	-	-	-
Water supply	37,575	8,869	-	8,869
Raw materials (thatch, timber, fodder, fertilizer, etc.)	37,575	-	-	-
Fuelwood	11,690	18,676	-	18,676
Other (genetic, medicinal, and ornamental resources)	-	-	-	-
Cultural services	***1,146,455***	***12,388***	-	***12,388***
(nonmaterial benefits obtained from wetlands/ mangroves/ reefs)				
Aesthetic information	735,635	-	-	-
Recreation and tourism	410,820	12,388	-	12,388
Local	-	-	-	-
International	-	-	-	-
Option value	-	-	-	-
Local	-	-	-	-
International	-	-	-	-
Bequest value	-	-	-	-
Local	-	-	-	-
International	-	-	-	-

Existence value	-	-	-	-
Local	-	-	-	-
International	-	-	-	-
Other (e.g., artistic, spiritual, historic, or scientific information)	-	-	-	-
Regulating services	***795,755***	***1,196,185***	***-***	***1,196,185***
(benefits obtained from ecosystem processes)				
Flood control/water regulation	387,440	1,139,125	-	1,139,125
Water treatment	240,480	-	-	-
Industrial wastewater treatment	-	-	-	-
Domestic sewage treatment	-	10,136	-	10,136
Nursery function	167,835	-	-	-
Climate regulation of mangroves	-	-	-	-
Other (e.g., sediment control, biological control)	-	46,925	-	46,925
Supporting services	***178,690***	***-***	***-***	***-***
(ecosystem functions necessary to maintain all other services)				
Habitat/refugia for biodiversity	178,690	-	-	-
Other (e.g., primary products, soil formation, nutrient/biogeochemical cycling)	-	-	-	-
Total value (USD)	**2,520,030**	**1,321,874**	**-**	**1,321,874**
Exchange rate ($1USD = Rs. Apr. 2009)	116	116	116	116
Total value (Rs.)	**292,323,480**	**153,337,353**	**-**	**153,337,353**

Notes:

Rural factor = 0.10

Maha Lewaya

(Shaded rows have no, or minimal, values)

	BT (MEA)	BT (Muthurajawela)	BT (Mangroves)	Total
Catchment area (ha)	***260***	***260***	***260***	***260***
Mangrove area (ha)	-	-	-	-
Reef area (ha)	-	-	-	-
Provisioning services	***124,280***	***35,279***	-	***35,279***
(products obtained from wetlands/ mangroves/ reefs)				
Agricultural production	-	22,129	-	22,129
Fishing	97,240	4,573	-	4,573
Hunting	-	-	-	-
Water supply	11,700	2,762	-	2,762
Raw materials (thatch, timber, fodder, fertilizer, etc.)	11,700	-	-	-
Fuelwood	3,640	5,815	-	5,815
Other (genetic, medicinal, and ornamental resources)	-	-	-	-
Cultural services	***356,980***	***3,857***	-	***3,857***
(nonmaterial benefits obtained from wetlands/ mangroves/ reefs)				
Aesthetic information	229,060	-	-	-
Recreation and tourism	127,920	3,857	-	3,857
Local	-	-	-	-
International	-	-	-	-
Option value	-	-	-	-
Local	-	-	-	-
International	-	-	-	-
Bequest value	-	-	-	-
Local	-	-	-	-
International	-	-	-	-

Existence value	-	-	-	-
Local	-	-	-	-
International	-	-	-	-
Other (e.g., artistic, spiritual, historic, or scientific information)	-	-	-	-
Regulating services	***247,780***	***372,465***	***-***	***372,465***
(benefits obtained from ecosystem processes)				
Flood control/water regulation	120,640	354,698	-	354,698
Water treatment	74,880	-	-	-
Industrial wastewater treatment	-	-	-	-
Domestic sewage treatment	-	3,156	-	3,156
Nursery function	52,260	-	-	-
Climate regulation of mangroves	-	-	-	-
Other (e.g., sediment control, biological control)	-	14,611	-	14,611
Supporting services	***55,640***	***-***	***-***	***-***
(ecosystem functions necessary to maintain all other services)				
Habitat/refugia for biodiversity	55,640	-	-	-
Other (e.g., primary products, soil formation, nutrient/biogeochemical cycling)	-	-	-	-
Total value (USD)	**784,680**	**411,601**	**-**	**411,601**
Exchange rate ($1USD = Rs. Apr. 2009)	116	116	116	116
Total value (Rs.)	**91,022,880**	**47,745,763**	**-**	**47,745,763**

Notes:

Rural factor = 0.10

Lunugamvehera Reservoir

(Shaded rows have no, or minimal, values)

	BT (MEA)	BT (Muthurajawela)	BT (Mangroves)	Total
Catchment area (ha)	***7,438***	***7,438***	***7,438***	***7,438***
Mangrove area (ha)	-	-	-	-
Reef area (ha)	-	-	-	-
Provisioning services	***4,470,238***	***1,009,253***	-	***1,009,253***
(products obtained from wetlands/ mangroves/ reefs)				
Agricultural production	-	633,056	-	633,056
Fishing	2,781,812	130,833	-	130,833
Hunting	914,874	-	-	-
Water supply	334,710	79,001	-	79,001
Raw materials (thatch, timber, fodder, fertilizer, etc.)	334,710	-	-	-
Fuelwood	104,132	166,363	-	166,363
Other (genetic, medicinal, and ornamental resources)	-	-	-	-
Cultural services	***10,212,374***	***110,351***	-	***11,035***
(nonmaterial benefits obtained from wetlands/ mangroves/ reefs)				
Aesthetic information	6,552,878	-	-	-
Recreation and tourism	3,659,496	110,351	-	11,035
Local	-	-	-	-
International	-	-	-	-
Option value	-	-	-	-
Local	-	-	-	-
International	-	-	-	-
Bequest value	-	-	-	-
Local	-	-	-	-
International	-	-	-	-

Existence value	-	-	-	-
Local	-	-	-	-
International	-	-	-	-
Other (e.g., artistic, spiritual, historic, or scientific information)	-	-	-	-
Regulating services	***7,088,414***	***10,655,362***	***-***	***10,655,362***
(benefits obtained from ecosystem processes)				
Flood control/water regulation	3,451,232	10,147,078	-	10,147,078
Water treatment	2,142,144	-	-	-
Industrial wastewater treatment	-	-	-	-
Domestic sewage treatment	-	90,287	-	90,287
Nursery function	1,495,038	-	-	-
Climate regulation of mangroves	-	-	-	-
Other (e.g., sediment control, biological control)	-	417,997	-	417,997
Supporting services	***1,591,732***	***-***	***-***	***-***
(ecosystem functions necessary to maintain all other services)				
Habitat/refugia for biodiversity	1,591,732	-	-	-
Other (e.g., primary products, soil formation, nutrient/biogeochemical cycling)	-	-	-	-
Total value (USD)	**23,362,758**	**11,774,966**	**-**	**11,675,650**
Exchange rate ($1USD = Rs. Apr. 2009)	116	116	116	116
Total value (Rs.)	**2,710,079,928**	**1,365,896,089**	**-**	**1,354,375,432**

Notes:

Rural factor = 0.10

Koholankala Wetland in Bundala National Park *(Ramsar Site)*

(Shaded rows have no, or minimal, values)

	BT (MEA)	BT (Muthurajawela)	BT (Mangroves)	Total
Catchment area (ha)	***390***	***390***	***390***	***390***
Mangrove area (ha)	-	-	-	-
Reef area (ha)	-	-	-	-
Provisioning services	***234,390***	***52,919***	-	***52,919***
(products obtained from wetlands/ mangroves/ reefs)				
Agricultural production	-	33,193	-	33,193
Fishing	145,860	6,860	-	6,860
Hunting	47,970	-	-	-
Water supply	17,550	4,142	-	4,142
Raw materials (thatch, timber, fodder, fertilizer, etc.)	17,550	-	-	-
Fuelwood	5,460	8,723	-	8,723
Other (genetic, medicinal, and ornamental resources)	-	-	-	-
Cultural services	***535,470***	***5,786***	-	***5,786***
(nonmaterial benefits obtained from wetlands/ mangroves/ reefs)				
Aesthetic information	343,590	-	-	-
Recreation and tourism	191,880	5,786	-	5,786
Local	-	-	-	-
International	-	-	-	-
Option value	-	-	-	-
Local	-	-	-	-
International	-	-	-	-
Bequest value	-	-	-	-
Local	-	-	-	-
International	-	-	-	-

Existence value	-	-	-	-
Local	-	-	-	-
International	-	-	-	-
Other (e.g., artistic, spiritual, historic, or scientific information)	-	-	-	-
Regulating services	***371,670***	***558,697***	***-***	***558,697***
(benefits obtained from ecosystem processes)				
Flood control/water regulation	180,960	532,046	-	532,046
Water treatment	112,320	-	-	-
Industrial wastewater treatment	-	-	-	-
Domestic sewage treatment	-	4,734	-	4,734
Nursery function	78,390	-	-	-
Climate regulation of mangroves	-	-	-	-
Other (e.g., sediment control, biological control)	-	21,917	-	21,917
Supporting services	***83,460***	***-***	***-***	***-***
(ecosystem functions necessary to maintain all other services)				
Habitat/refugia for biodiversity	83,460	-	-	-
Other (e.g., primary products, soil formation, nutrient/biogeochemical cycling)	-	-	-	-
Total value (USD)	**1,224,990**	**617,402**	**-**	**617,402**
Exchange rate ($1USD = Rs. Apr. 2009)	116	116	116	116
Total value (Rs.)	**142,098,840**	**71,618,644**	**-**	**71,618,644**

Notes:

Rural factor = 0.10

Malala Wetland in Bundala National Park *(Ramsar Site)*

(Shaded rows have no, or minimal, values)

	BT (MEA)	BT (Muthurajawela)	BT (Mangroves)	Total
Catchment area (ha)	***650***	***650***	***650***	***650***
Mangrove area (ha)	-	-	-	-
Reef area (ha)	-	-	-	-
Provisioning services	***390,650***	***88,198***	-	***88,198***
(products obtained from wetlands/ mangroves/ reefs)				
Agricultural production	-	55,322	-	55,322
Fishing	243,100	11,433	-	11,433
Hunting	79,950	-	-	-
Water supply	29,250	6,904	-	6,904
Raw materials (thatch, timber, fodder, fertilizer, etc.)	29,250	-	-	-
Fuelwood	9,100	14,538	-	14,538
Other (genetic, medicinal, and ornamental resources)	-	-	-	-
Cultural services	***892,450***	***9,643***	-	***9,643***
(nonmaterial benefits obtained from wetlands/ mangroves/ reefs)				
Aesthetic information	572,650	-	-	-
Recreation and tourism	319,800	9,643	-	9,643
Local	-	-	-	-
International	-	-	-	-
Option value	-	-	-	-
Local	-	-	-	-
International	-	-	-	-
Bequest value	-	-	-	-
Local	-	-	-	-
International	-	-	-	-

Existence value	-	-	-	-
Local	-	-	-	-
International	-	-	-	-
Other (e.g., artistic, spiritual, historic, or scientific information)	-	-	-	-
Regulating services	***619,450***	***931,162***	***-***	***931,162***
(benefits obtained from ecosystem processes)				
Flood control/water regulation	301,600	886,744	-	886,744
Water treatment	187,200	-	-	-
Industrial wastewater treatment	-	-	-	-
Domestic sewage treatment	-	7,890	-	7,890
Nursery function	130,650	-	-	-
Climate regulation of mangroves	-	-	-	-
Other (e.g., sediment control, biological control)	-	36,528	-	36,528
Supporting services	***139,100***	***-***	***-***	***-***
(ecosystem functions necessary to maintain all other services)				
Habitat/refugia for biodiversity	139,100	-	-	-
Other (e.g., primary products, soil formation, nutrient/biogeochemical cycling)	-	-	-	-
Total value (USD)	**2,041,650**	**1,029,004**	**-**	**1,029,004**
Exchange rate ($1USD = Rs. Apr. 2009)	116	116	116	116
Total value (Rs.)	**236,831,400**	**119,364,407**	**-**	**119,364,407**

Notes:

Rural factor = 0.10

Embilikala Wetland in Bundala National Park (Ramsar Site)

(Shaded rows have no, or minimal, values)

	BT (MEA)	BT (Muthurajawela)	BT (Mangroves)	Total
Catchment area (ha)	***430***	***430***	***430***	***430***
Mangrove area (ha)	-	-	-	-
Reef area (ha)	-	-	-	-
Provisioning services	***258,430***	***58,346***	-	***58,346***
(products obtained from wetlands/ mangroves/ reefs)				
Agricultural production	-	36,598	-	36,598
Fishing	160,820	7,564	-	7,564
Hunting	52,890	-	-	-
Water supply	19,350	4,567	-	4,567
Raw materials (thatch, timber, fodder, fertilizer, etc.)	19,350	-	-	-
Fuelwood	6,020	9,618	-	9,618
Other (genetic, medicinal, and ornamental resources)	-	-	-	-
Cultural services	***590,390***	***6,380***	-	***6,380***
(nonmaterial benefits obtained from wetlands/ mangroves/ reefs)				
Aesthetic information	378,830	-	-	-
Recreation and tourism	211,560	6,380	-	6,380
Local	-	-	-	-
International	-	-	-	-
Option value	-	-	-	-
Local	-	-	-	-
International	-	-	-	-
Bequest value	-	-	-	-
Local	-	-	-	-
International	-	-	-	-

Existence value	-	-	-	-
Local	-	-	-	-
International	-	-	-	-
Other (e.g., artistic, spiritual, historic, or scientific information)	-	-	-	-
Regulating services	***409,790***	***616,000***	***-***	***616,000***
(benefits obtained from ecosystem processes)				
Flood control/water regulation	199,520	586,615	-	586,615
Water treatment	123,840	-	-	-
Industrial wastewater treatment	-	-	-	-
Domestic sewage treatment	-	5,220	-	5,220
Nursery function	86,430	-	-	-
Climate regulation of mangroves	-	-	-	-
Other (e.g., sediment control, biological control)	-	24,165	-	24,165
Supporting services	***92,020***	***-***	***-***	***-***
(ecosystem functions necessary to maintain all other services)				
Habitat/refugia for biodiversity	92,020	-	-	-
Other (e.g., primary products, soil formation, nutrient/biogeochemical cycling)	-	-	-	-
Total value (USD)	**1,350,630**	**680,725**	**-**	**680,725**
Exchange rate ($1USD = Rs. Apr. 2009)	116	116	116	116
Total value (Rs.)	**156,673,080**	**78,964,146**	**-**	**78,964,146**

Notes:

Rural factor = 0.10

Bundala Wetland in Bundala National Park *(Ramsar Site)*

(Shaded rows have no, or minimal, values)

	BT (MEA)	**BT (Muthurajawela)**	**BT (Mangroves)**	**Total**
Catchment area (ha)	***520***	***520***	***520***	***520***
Mangrove area (ha)	***-***	***-***	***-***	***-***
Reef area (ha)	***-***	***-***	***-***	***-***
Provisioning services	***312,520***	***70,558***	***-***	***70,558***
(products obtained from wetlands/ mangroves/ reefs)				
Agricultural production	-	44,258	-	44,258
Fishing	194,480	9,147	-	9,147
Hunting	63,960	-	-	-
Water supply	23,400	5,523	-	5,523
Raw materials (thatch, timber, fodder, fertilizer, etc.)	23,400	-	-	-
Fuelwood	7,280	11,631	-	11,631
Other (genetic, medicinal, and ornamental resources)	-	-	-	-
Cultural services	***713,960***	***7,715***	***-***	***7,715***
(nonmaterial benefits obtained from wetlands/ mangroves/ reefs)				
Aesthetic information	458,120	-	-	-
Recreation and tourism	255,840	7,715	-	7,715
Local	-	-	-	-
International	-	-	-	-
Option value	-	-	-	-
Local	-	-	-	-
International	-	-	-	-
Bequest value	-	-	-	-
Local	-	-	-	-
International	-	-	-	-

Existence value	-	-	-	-
Local	-	-	-	-
International	-	-	-	-
Other (e.g., artistic, spiritual, historic, or scientific information)	-	-	-	-
Regulating services	***495,560***	***744,930***	***-***	***744,930***
(benefits obtained from ecosystem processes)				
Flood control/water regulation	241,280	709,395	-	709,395
Water treatment	149,760	-	-	-
Industrial wastewater treatment	-	-	-	-
Domestic sewage treatment	-	6,312	-	6,312
Nursery function	104,520	-	-	-
Climate regulation of mangroves	-	-	-	-
Other (e.g., sediment control, biological control)	-	29,223	-	29,223
Supporting services	***111,280***	***-***	***-***	***-***
(ecosystem functions necessary to maintain all other services)				
Habitat/refugia for biodiversity	111,280	-	-	-
Other (e.g., primary products, soil formation, nutrient/biogeochemical cycling)	-	-	-	-
Total value (USD)	**1,633,320**	**823,203**	**-**	**823,203**
Exchange rate ($1USD = Rs. Apr. 2009)	116	116	116	116
Total value (Rs.)	**189,465,120**	**95,491,525**	**-**	**95,491,525**

Notes:

Rural factor = 0.10

Mangroves in Ruhuna (Yala) National Park

(Shaded rows have no, or minimal, values)

	BT (MEA)	BT (Muthurajawela)	BT (Mangroves)	Total
Catchment area (ha)	-	-	-	-
Mangrove area (ha)	***326***	***326***	***326***	***326***
Reef area (ha)	-	-	-	-
Provisioning services	-	-	***24,562***	***24,562***
(products obtained from wetlands/ mangroves/ reefs)				
Agricultural production	-	-	18,689	18,689
Fishing	-	-	3,471	3,471
Hunting	-	-	-	-
Water supply	-	-	-	-
Raw materials (thatch, timber, fodder, fertilizer, etc.)	-	-	1,068	1,068
Fuelwood	-	-	1,335	1,335
Other (genetic, medicinal, and ornamental resources)	-	-	-	-
Cultural services	-	-	***1,892,374***	***1,892,374***
(nonmaterial benefits obtained from wetlands/ mangroves/ reefs)				
Aesthetic information	-	-	-	-
Recreation and tourism	-	-	-	-
Local	-	-	-	-
International	-	-	-	-
Option value	-	-	-	-
Local	-	-	398,071	398,071
International	-	-	277,395	277,395
Bequest value	-	-	-	-
Local	-	-	457,608	457,608
International	-	-	150,044	150,044

Existence value	-	-	-	-
Local	-	-	235,746	235,746
International	-	-	373,509	373,509
Other (e.g., artistic, spiritual, historic, or scientific information)	-	-	-	-
Regulating services	***43,358***	***29,087***	***85,950***	***94,880***
(benefits obtained from ecosystem processes)				
Flood control/water regulation	-	-	21,283	21,283
Water treatment	-	-	-	-
Industrial wastewater treatment	-	-	-	-
Domestic sewage treatment	-	-	-	-
Nursery function	-	-	43,568	43,568
Climate regulation of mangroves	43,358	29,087	20,157	29,087[1]
Other (e.g., sediment control, biological control)	-	-	942	942
Supporting services	**-**	**-**	***4,709***	***4,709***
(ecosystem functions necessary to maintain all other services)				
Habitat/refugia for biodiversity	-	-	4,709	4,709
Other (e.g., primary products, soil formation, nutrient/biogeochemical cycling)	-	-	-	-
Total value (USD)	**43,358**	**29,087**	**2,007,596**	**2,016,526**
Exchange rate ($1USD = Rs. Apr. 2009)	116	116	116	116
Total value (Rs.)	**5,029,528**	**3,374,100**	**232,881,129**	**233,916,994**

Notes: 1- Only the maximum is taken between Muthurajawela and mangroves

Rural factor = 0.10

Weerawila-Tissa-Pannangamuwa-Debara-Yoda Tanks

(Shaded rows have no, or minimal, values)

	BT (MEA)	BT (Muthurajawela)	BT (Mangroves)	Total
Catchment area (ha)	***1,590***	***1590***	***1590***	***1590***
Mangrove area (ha)	***-***	***-***	***-***	***-***
Reef area (ha)	***-***	***-***	***-***	***-***
Provisioning services	***760,020***	***215,745***	***-***	***215,745***
(products obtained from wetlands/ mangroves/ reefs)				
Agricultural production	-	135,327	-	135,327
Fishing	594,660	27,968	-	27,968
Hunting	-	-	-	-
Water supply	71,550	16,888	-	16,888
Raw materials (thatch, timber, fodder, fertilizer, etc.)	71,550	-	-	-
Fuelwood	22,260	35,563	-	35,563
Other (genetic, medicinal, and ornamental resources)	-	-	-	-
Cultural services	***2,183,070***	***23,589***	***-***	***23,589***
(nonmaterial benefits obtained from wetlands/ mangroves/ reefs)				
Aesthetic information	1,400,790	-	-	-
Recreation and tourism	782,280	23,589	-	23,589
Local	-	-	-	-
International	-	-	-	-
Option value	-	-	-	-
Local	-	-	-	-
International	-	-	-	-
Bequest value	-	-	-	-
Local	-	-	-	-
International	-	-	-	-

Existence value	-	-	-	-
Local	-	-	-	-
International	-	-	-	-
Other (e.g., artistic, spiritual, historic, or scientific information)	-	-	-	-
Regulating services	***1,515,270***	***3,002,918***	***-***	***3,002,918***
(benefits obtained from ecosystem processes)				
Flood control/water regulation	737,760	2,169,112	-	2,169,112
Water treatment	457,920	-	-	-
Industrial wastewater treatment	-	725,152[1]	-	725,152
Domestic sewage treatment	-	19,300	-	19,300
Nursery function	319,590	-	-	-
Climate regulation of mangroves	-	-	-	-
Other (e.g., sediment control, biological control)	-	89,354	-	89,354
Supporting services	***340,260***	***-***	***-***	***-***
(ecosystem functions necessary to maintain all other services)				
Habitat/refugia for biodiversity	340,260	-	-	-
Other (e.g., primary products, soil formation, nutrient/biogeochemical cycling)	-	-	-	-
Total value (USD)	**4,798,620**	**3,242,253**	**-**	**3,242,253**
Exchange rate ($1USD = Rs. Apr. 2009)	116	116	116	116
Total value (Rs.)	**556,639,920**	**376,101,336**	**-**	**376,101,336**

Notes: 1 - Value for pollution treatment and nutrient retention from agricultural activities in the area

Rural factor = 0.10

Pilinnawa Wetland

(Shaded rows have no, or minimal, values)

	BT (MEA)	BT (Muthurajawela)	BT (Mangroves)	Total
Catchment area (ha)	***100***	***100***	***100***	***100***
Mangrove area (ha)	-	-	-	-
Reef area (ha)	-	-	-	-
Provisioning services	***10,400***	***3,299***	-	***3,299***
(products obtained from wetlands/ mangroves/ reefs)				
Agricultural production	-	-	-	-
Fishing	-	-	-	-
Hunting	-	-	-	-
Water supply	4,500	1,062	-	1,062
Raw materials (thatch, timber, fodder, fertilizer, etc.)	4,500	-	-	-
Fuelwood	1,400	2,237	-	2,237
Other (genetic, medicinal, and ornamental resources)	-	-	-	-
Cultural services	***137,300***	***1,484***	-	***1,484***
(nonmaterial benefits obtained from wetlands/ mangroves/ reefs)				
Aesthetic information	88,100	-	-	-
Recreation and tourism	49,200	1,484	-	1,484
Local	-	-	-	-
International	-	-	-	-
Option value	-	-	-	-
Local	-	-	-	-
International	-	-	-	-
Bequest value	-	-	-	-
Local	-	-	-	-
International	-	-	-	-

Existence value	-	-	-	-
Local	-	-	-	-
International	-	-	-	-
Other (e.g., artistic, spiritual, historic, or scientific information)	-	-	-	-
Regulating services	***48,900***	***5,620***	***-***	***5,620***
(benefits obtained from ecosystem processes)				
Flood control/water regulation	-	-	-	-
Water treatment	28,800	-	-	-
Industrial wastewater treatment	-	-	-	-
Domestic sewage treatment	-	-	-	-
Nursery function	20,100	-	-	-
Climate regulation of mangroves	-	-	-	-
Other (e.g., sediment control, biological control)	-	5,620	-	5,620
Supporting services	***21,400***	***-***	***-***	***-***
(ecosystem functions necessary to maintain all other services)				
Habitat/refugia for biodiversity	21,400	-	-	-
Other (e.g., primary products, soil formation, nutrient/biogeochemical cycling)	-	-	-	-
Total value (USD)	**218,000**	**10,402**	**-**	**10,402**
Exchange rate ($1USD = Rs. Apr. 2009)	116	116	116	116
Total value (Rs.)	**25,288,000**	**1,206,649**	**-**	**1,206,649**

Notes:

Rural factor = 0.10

Palatupana Lagoon

(Shaded rows have no, or minimal, values)

	BT (MEA)	BT (Muthurajawela)	BT (Mangroves)	Total
Catchment area (ha)	***160***	***160***	***160***	***160***
Mangrove area (ha)	-	-	-	-
Reef area (ha)	-	-	-	-
Provisioning services	-	***13,618***	-	***13,618***
(products obtained from wetlands/ mangroves/ reefs)				
Agricultural production	-	13,618	-	13,618
Fishing	-	-	-	-
Hunting	-	-	-	-
Water supply	-	-	-	-
Raw materials (thatch, timber, fodder, fertilizer, etc.)	-	-	-	-
Fuelwood	-	-	-	-
Other (genetic, medicinal, and ornamental resources)	-	-	-	-
Cultural services	***219,680***	***2,374***	-	***2,374***
(nonmaterial benefits obtained from wetlands/ mangroves/ reefs)				
Aesthetic information	140,960	-	-	-
Recreation and tourism	78,720	2,374	-	2,374
Local	-	-	-	-
International	-	-	-	-
Option value	-	-	-	-
Local	-	-	-	-
International	-	-	-	-
Bequest value	-	-	-	-
Local	-	-	-	-
International	-	-	-	-

Existence value	-	-	-	-
Local	-	-	-	-
International	-	-	-	-
Other (e.g., artistic, spiritual, historic, or scientific information)	-	-	-	-
Regulating services	***-***	***8,992***	***-***	***8,992***
(benefits obtained from ecosystem processes)				
Flood control/water regulation	-	-	-	-
Water treatment	-	-	-	-
Industrial wastewater treatment	-	-	-	-
Domestic sewage treatment	-	-	-	-
Nursery function	-	-	-	-
Climate regulation of mangroves	-	-	-	-
Other (e.g., sediment control, biological control)	-	8,992	-	8,992
Supporting services	***34,240***	***-***	***-***	***-***
(ecosystem functions necessary to maintain all other services)				
Habitat/refugia for biodiversity	34,240	-	-	-
Other (e.g., primary products, soil formation, nutrient/biogeochemical cycling)	-	-	-	-
Total value (USD)	**253,920**	**24,983**	**-**	**24,983**
Exchange rate ($1USD = Rs. Apr. 2009)	116	116	116	116
Total value (Rs.)	**29,454,720**	**2,898,044**	**-**	**2,898,044**

Notes:

Rural factor = 0.10

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