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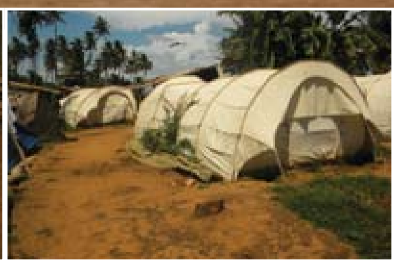
INVESTING IN COASTAL ECOSYSTEMS

Valuation of Ecosystem Services of the Maha Oya



Valuation of Ecosystem Services of the Maha Oya

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Executive Summary

The Maha Oya is one of Sri Lanka's major rivers, and flows into the western coast of the country. It has been a source of sand, clay and water for many decades. However, over recent years, clay and sand mining have increased, to meet the rapidly growing construction demands of the country. These mining activities, carried out both legally and illegally, have led to the degradation of the Maha Oya and its associated ecosystems, impacting ecosystem services and affecting both on-site and off-site human populations. This study aimed to estimate the value of key ecosystem services generated by the Maha Oya, so as to present the economic rationale and justification for ecosystem conservation and restoration in order to safeguard its hydrological, ecological and socio-economic benefits. Valuation techniques used in the study included market prices, effect on production, replacement costs, damage costs, mitigative and avertive costs. Data was gathered by means of field surveys, and from a review of relevant literature. The study was carried out by Environmental Foundation, and funded by the Mangroves for the Future initiative.

The study found that the current values associated with water use, fisheries, sand and clay extraction, and tourism in the study area are worth at least LKR 1.7 billion per year. The economic costs of ecosystem degradation, including those associated with land degradation, coastal protection, river rehabilitation and displacement of people, were estimated to be almost LKR 1.2 billion in the current year.

The economic impacts of ecosystem conservation and degradation to various stakeholders were assessed through modelling two different scenarios. These were 'Business as Usual' (BAU) – a situation where ecosystem degradation progressively worsens over time, and 'Ecosystem Restoration and Sustainable Management' (ERSM) – a situation where sufficient investments are made to improve and safeguard the integrity and health of the ecosystem. The study shows that overall; there is a clear economic gain from ERSM as compared to a continuation of BAU. Calculated over 25 years, it yields an incremental benefit of LKR 849 million: the net present value of ERSM (LKR 7.6 billion) exceeds that of BAU (LKR 6.8 billion). ERSM leads to a significant reduction in the damage costs associated with ecosystem degradation and loss, while maintaining (and even in some cases increasing) the economic values generated from the sustainable use of land and resources. Under BAU, costs are incurred to government and local communities as ecosystem service provision declines, undermining income and employment as well as giving rise to a range of physical expenditures and losses. Under the ERSM scenario, all stakeholders benefit.

The results of this study show that the stakeholder groups that are driving ecosystem degradation and loss – primarily the mining industries that operate in and around the river − are not bearing its costs. These accrue as externalities to society at large and the broader economy, mainly affecting government and local communities. The study recommends the preparation of a Management and Action Plan for the Maha Oya and its associated ecosystems, focusing on ecosystem restoration and sustainable management. It calls for a multi-stakeholder approach to problem solving, including the effective coordination and cooperation between responsible government agencies such as the Geological Survey and Mines Bureau, Irrigation Department, Coast Conservation Department and local administrative bodies. The enforcement of existing laws and policies to minimise illegal activities that exacerbate the externalities of environmental degradation is also essential. It recommends the use of a variety of economic instruments which would internalise environmental externalities, and provide incentives for sustainable land and resource management. These basically aim to penalise those whose activities contribute to ecosystem degradation, so as to raise funds for restoration and compensate for the costs of environmental damage. It is also essential to prepare a compensation scheme for those in

riverine and coastal areas that suffer from the impacts of environmental degradation. Additionally it is important to ensure that adequate economic incentives are provided to those who contribute towards ecosystem conservation and restoration, through the provision of funding, livelihood support and other rewards. These recommendations, if incorporated into policy and action plans, and if implemented effectively can help to ensure that the resources of the Maha Oya can be utilised in a sustainable manner, benefitting all stakeholders, minimising environmental degradation and preserving ecosystem services.

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1. Introduction

1.1 The study

The study on the valuation of ecosystem goods and services in the Maha Oya and associated ecosystems was funded by a Mangroves for the Future large grant project ‘Increasing the resilience of coastal and riverine communities to climate change and other threats by conserving the ecosystems of the Maha Oya and associated coastal wetlands in Sri Lanka’.

The rationale for the study is as follows. The Maha Oya ecosystem provides many direct and indirect services to those in the immediate vicinity, including income, employment, water and fisheries, among others. Many people outside the project area also benefit from the clean water and mineral resources provided by the ecosystem.

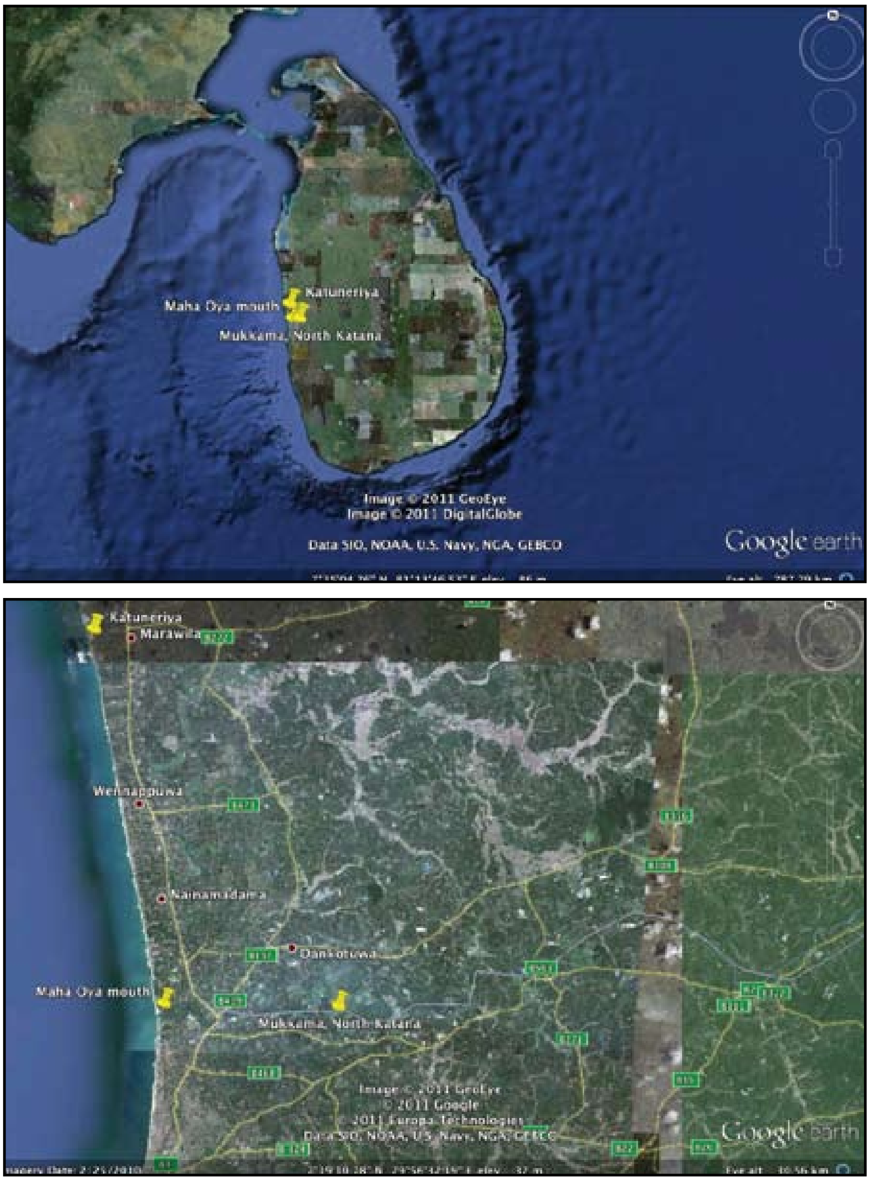
Despite the economic importance of its services, the Maha Oya has been subjected to much degradation. The most widespread is erosion and land degradation caused by mechanised and unsustainable sand and clay mining practices over the years. This has led to the erosion of river banks and loss of large tracts of land due to mined pits along the river. Mining activities affect water quality, lower the water table, impact infrastructure and cause the intrusion of saline water (Athukorala and Navaratnem, 2008), and these impacts have been observed in the Maha Oya. Even more devastating is its impact on the coast between the Maha Oya mouth and the Deduru Oya mouth in Chilaw. The river provides sediment to replenish the sand eroded by wave action along the coast. Excessive mining has resulted in this sediment load being prevented from reaching the coast, creating a deficiency of sand leading to severe erosion (ADB, 1999; CZMP, 2006). Many tracts of beach, settlements, infrastructure and fisheries activities have been impacted, and the situation is being mitigated by expensive coastal protection structures (ADB, 2009).

Decision-makers currently know little about the costs and benefits of Maha Oya and its ecosystems, and do not tend to factor these values into their decisions. This has served to undermine conservation and sustainable use when land, resource and investment decisions are made. Although there is some control of mining now, which is coupled with coastal protection, much of the degradation has already occurred with mitigation activities being implemented.

1.2 The study area

The valuation study was carried out in a part of the Maha Oya river (the study area), and its results therefore refer only to this area. The area falls within the Gampaha and Puttalam Districts. The study area is mapped in Figure 1. More specifically, the area includes the riverine area from the mouth of the Maha Oya to Mukkama in the North Katana Grama Niladari (GN) Division, which is a distance of approximately 7.5 kilometres (as the crow flies), the study also includes the GN divisions that are adjacent to the river. The coastal stretch from the Maha Oya mouth to the Katuneriya area of the Nattandiya Divisional Secretariat spans a distance of about 25 kilometres.

Figure 1: Map of the study area in relation to Sri Lanka



Source: Google Earth

1.3 The team

The design and planning of the study occurred during mid 2010, with questionnaires and data collection beginning in November 2010. The following team was involved in the ecosystem valuation study:

Team composition	Name
Core study team	Manishka De Mel and Chamila Weerathunghe
External technical review	Lucy Emerton
Scientific advisor	Dr. Nalin Wikramanayake
Extended study team	Shamal Ranasinghe, Tiran Abeywardana, Ruzmyn Vilcassim and Dinushika Senavirathna
Data collection and entry	Buddhika Nuwan Sameera, Buddhika Sampath Abeygunawardana, Viraj Kanishka Madanayaka, Asanga Malith, Samitha Jayawardana, Chathuranga Darshana, T B S Muthunayaka, P U Wewalwala, Gimhan Sooriyabandara, Maneka Gunasinghe, Priyanka Mudalige and Dushani Kularathna

2. Scope, Approach and Techniques

2.1 Aims and parameters of the study

The aim of this study was to estimate the economic value of the ecosystem services of the Maha Oya and associated ecosystems, with a view to justifying conservation and restoration, so as to safeguard its hydrological, ecological and socio-economic benefits.

In order to achieve these objectives, the valuation study included the following components:

- Valuing the economic benefits associated with the goods and services provided by the Maha Oya ecosystem, and the distribution of these values between different sectors and groups.
- Valuing the economic costs of ecosystem degradation, and the distribution of these costs between different sectors and groups.
- Valuing the economic impacts of ecosystem restoration, and the distribution of these values between different sectors and groups.

2.2 Valuing the goods and services provided by the Maha Oya ecosystem

The study was based on a 'total economic value' approach, which is widely used by environmental economists to identify, categorise and quantify in monetary terms the benefits associated with ecosystems. This is defined as the sum of direct, indirect, option and existence values (Emerton, 2005). This also corresponds to the framework for ecosystem services provided by the Millennium Ecosystem Assessment (MEA, 2005), of provisioning, regulating, supporting and cultural services.

The time and resources available for the study were limited; there are also few or no data on the value of the Maha Oya ecosystem. For these reasons, the study focuses on quantifying direct use values, with some consideration of indirect values. Due to lack of data, option and existence values are not calculated.

The analysis values direct and indirect benefits overall, and also looks at how they are distributed between different sectors and groups:

- *Direct values or provisioning services:* these values include benefits from the raw materials and physical products which are used directly for consumption and sale including water supply, mineral resources, fisheries and recreation among others. The study has been able to quantify the monetary value of many of these direct benefits.
- *Indirect values or regulating/supporting services:* the ecological functions which maintain and protect natural and human systems through services such as maintenance of water quality, flow and storage, flood control and storm protection, salinity control, pollution control and micro-climate stabilisation. Due to insufficient data, it has not been possible to value most of these indirect benefits. Many are, however, at least partially reflected in the direct values that are generated by the Maha Oya (for example water, fisheries and recreation). Likewise, the study was not able to value option and existence values or cultural services.
- *Stakeholders:* the Maha Oya study focuses on the benefits to local communities (households), resource extractors and hotels in the area (business and industry), and the government.

Information was collected using structured questionnaires, interviews with key informants and published and unpublished information.

It should be emphasised that this study aimed to generate broad estimates of the value of Maha Oya and associated ecosystems, to be used for management and decision-making purposes. The figures are a preliminary indication of the broad magnitude of the benefits and costs, and should not be taken as exact or indisputable values. They rely on limited data collection, and on the information and reports available at the time. Much of this data is approximate or incomplete. Additionally, the study was carried out within the project area and the results are reflective of this area only.

Some economic benefits that depend directly on the Maha Oya and associated ecosystems*

- Provision of mineral resources and construction materials such as sand and clay
- Fishing area and fish stocks, used both for trade and for home consumption, in the river, estuary and canal
- Water supply for domestic use, regional distribution of water, cultivation and industrial use
- Ground water supply and maintenance of groundwater levels
- Breeding sites and habitat for fisheries
- Maintenance of biodiversity and habitats
- Water transport along the river and canal
- Enhanced dry season surface water supplies (wells)
- Provision of wildlife, fish and migratory bird habitat and breeding grounds
- Control of groundwater salinity and regulation of salinity in the river
- Pollution control and flushing of pollutants
- Flood control

* Not all of these values were assessed by the study.

2.3 Valuing the economic costs of degradation of the Maha Oya ecosystem

Analysis is based on quantifying the direct and indirect costs of ecosystem degradation. The unsustainable extraction of mineral resources such as sand and clay have led to the severe degradation of the Maha Oya and associated ecosystems. Additionally the impacts are seen kilometres away where coastal erosion has been exacerbated and severe due to insufficient replenishment of sand in the coastal area, as the river no longer carries sand to the coast. Specifically:

- The degradation of the Maha Oya, associated ecosystems and the coastal area are significant (CZMP, 2006; Nianthi and Shaw, 2007). Degradation of ecosystems, both riverine and coastal has resulted in several mitigation and restoration efforts. Mitigation methods used in the coastal area include groynes, revetments and sand replenishment. Along the river some mined areas have been filled, banks strengthened and vegetation grown as mitigation and restoration methods. In order to restore and mitigate effectively, much more investment will be required than what has currently been carried out.
- Land degradation and complete loss of land has occurred along the river and in coastal areas. Along the river mining has resulted in the collapse of banks, while adjacent to the river sand and clay pits have been completely mined. These water filled pits are now connected to the river and according to the interpretation of the State Land Ordinance (Karunaratne, 2011) it can be considered to be a part of the river and cannot be claimed by its original owners. Along the coast, severe erosion has resulted in hundreds of settlements and many hundred square meters of land being lost.
- Land degradation in the coastal and riverine areas has affected infrastructure such as roads, houses and have threatened bridges, water storage tanks etc. If degradation continues there is great danger to many of the infrastructure.

The analysis values these costs overall, and also looks at how they are distributed between different sectors and groups.

In addition to the direct use of market prices, three main methods (Emerton and Kekulandala, 2003) are used to value these costs:

- *Mitigative/avertive expenditures* look at the expenditures that have been made by the government and affected individuals to mitigate, avert, offset or remediate the effects of ecosystem degradation. It primarily relates to the protective measures that have been necessitated to cope with the effects of coastal and riverbank erosion.
- *Effect on production* looks at how ecosystem degradation has impacted on land and river productivity, affecting economic output and consumption.
- *Damage costs* looks at the losses to infrastructure, land and other fixed assets.

Some of the economic costs caused by the degradation of the Maha Oya and associated ecosystems*

- Loss of land and degradation (river and coast)
- Restricts sustainable (unsustainable) long-term supply of mineral resources such as sand and clay
- Decline in biodiversity
- Damage to infrastructure such as roads and bridges
- Decline of fisheries due to loss of breeding grounds, boat landing areas
- Loss of aesthetic value
- Salinity intrusion
- Livelihood loss – coastal population
- Costs of resettling due to coastal erosion
- Costs of coastal mitigation/restoration
- Costs of river mitigation/restoration
- Death and injury associated with mining
- Health impact to miners

* Not all of these values were assessed by the study.

2.4 Valuing the economic benefits and impacts of restoration

This component involved constructing ‘Business as Usual’ (BAU) and ‘Ecosystem Restoration and Sustainable Management’ (ESRM) scenarios for the Maha Oya ecosystem, covering a period of 25 years. Key assumptions and parameters for each of the scenarios are defined, and actual data used to model future streams of costs and benefits as identified above. From this scenario modelling, net present values and other indicators show the overall economic impacts of the two scenarios, and express the gains and net value added by ecosystem restoration and sustainable management.

The scenarios are summarised in Table 1.

Table 1: Summary of the scenarios

	Business as Usual (BAU)	Ecosystem Restoration and Sustainable Management (ERSM)
Changes in river water direct use	Number of households increases with population, but declines due to salinity and pollution	Number of households increases with population, but declines by number of additional people connected to the mains
	Per capita consumption remains the same	
	Tariff increases due to higher costs of clean up	Tariff increases less than BAU due to less clean up
	Due to increasing salinity and pollution, reduction in use	Slight increase in use due to lower salinity and pollution
Changes in river water use for water supplies	Number of households increases with population, and additional connections are added each year	
	Per capita consumption increases over time	
	Tariff increases due to higher costs of clean up	Tariff increases less than BAU due to less clean up
	No reduction in use due to salinity and pollution	
Changes in river fishing	Consumption/fishing will decline due to degradation	Consumption/fishing will increase slightly due to availability of fish (but slight increase as fishing will be restricted)
	Value of fish will increase over time	
Changes in sand mining	Unit cost/market value of sand will increase	
	Sand mining will reduce due to lack of sand (but more mining than ERSM)	Sand mining will reduce due to lack of sand and controlled mining (less mining than BAU)
	Some illegal mining will occur	There will be no illegal mining
Changes in clay mining	Currently no legal clay mining in project area	Currently no legal clay mining in project area
	Some illegal mining will occur	There will be no illegal mining
	Unit cost/market value of clay will increase	
Changes in tourism	Tourism will increase, as per general trends	
	Tourism will reduce due to bad environment	Tourism will increase due to good environment
Change in riverine management expenditures	Will decrease	Will increase
Change in riverine land loss	Land loss will decrease as mining will decline due to the lack of sand and clay availability	
Change in coastal land loss	Will decline as coastal protection structures are being built	
Change in coastal restoration expenditures	Will increase	Will be reduced gradually over time
	Sand nourishment needed for some years will be constant	Sand nourishment needed for some years will decline due to less mining
Change in damage cost to infrastructure	Will increase and then be constant	Will increase during the first few years due to existing damage and then cease
Change to the displacement of coastal population	Will decrease due to coastal protection	Will decrease due to coastal protected (in a slightly shorter time than in BAU)
	Costs of resettlement, loss of fixed assets, reduced income and production opportunities will increase over time	

As above, the analysis values these benefits and costs overall, and also looks at how they are distributed between different sectors and groups.

2.5 Study process

The design and gathering information for the study included 10 iterative steps, which have been detailed in Table 2.

Table 2: Stages of the study

Activity	Description
1. Field visits to observe ground situation	Field visits were carried out especially to focus on the ecosystem valuation component. The Technical Advisor (Environmental Economist), Scientific Advisor and the study team participated in the field visits.
2. Brainstorming sessions to design study	Several brainstorming sessions were held with the study team, the larger project team, the Scientific Advisor and Technical Advisor to design the study and identify ecosystem services, check feasibility and review available information.
3. Field information	Field information was collected prior to designing questionnaires. Additionally key informants including government officials (Grama Niladari etc) were identified and background information was collected.
4. Designing questionnaires and information list	Three questionnaires were designed to collect information for the valuation and to obtain additional socio-economic information. Additionally a comprehensive list of questions and information to be collected was designed and possible sources of information, which included key informants and published information, were identified.
5. Questionnaire for riverine communities	A questionnaire was designed for riverine communities to identify direct and indirect values. A total of 113 questionnaires, covering 11 GN divisions were carried out in February and March 2011.
6. Questionnaire for hotels	A questionnaire was also designed for hotels that benefit from ecosystem services. Of the four medium-large sized hotels in the area, full information was provided by one hotel and partial information by the other three hotels. Data was collected during the period November 2010 to May 2011.
7. Questionnaire for coastal communities	A questionnaire was designed to collect information from those bearing the costs of coastal erosion. A total of 50 questionnaires were carried out in May and June 2011.
8. Published information and key informants	Information was collected from these sources during the February to September 2011.
9. Data entry	Carried out during the period March to August 2011.
10. Analysis of data and report on ecosystem valuation	Carried out during the period August to November 2011.

2.6 Application of valuation techniques

As already mentioned above, the limited information, time and other resources available for this study made it impossible to value every economic benefit and cost arising from Maha Oya and its associated ecosystems. For these reasons, this study excludes some economic values associated with the study area including option and non-use values. To make quantitative estimates of these categories of environmental economic benefits typically requires a large amount of original data, and involves long and complex survey work and analysis. Additionally only some of the indirect values such as ecological functions were valued due to insufficient scientific information to quantify its value. Thus the study will only show a minimum value of the ecosystems associated with Maha Oya. Table 3 shows the scope of the study in terms of the application of valuation techniques to ecosystem goods and services.

The simplest and most straightforward way of valuing certain goods and services is to look at their *market prices*. In this study, market price techniques were applicable to sand, clay, water supply and fish.

However in some cases the goods and services associated with the Maha Oya ecosystem have no market in the local area, or are subject to prices that are distorted. As mentioned above, for the benefits and costs that could not easily be valued through the application of market prices, three additional techniques have been used to value benefits:

- *Effect on production*: Other economic processes often rely on ecosystem resources as inputs, or on the essential life support provided by its services. Where they have a market, it is possible to value ecosystem goods and services in terms of their contribution to the output or income of these other production and consumption opportunities. In this study, effect on production techniques are used to value fishing benefits.
- *Replacement cost:* Even where ecosystem 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 the value of ecosystem goods and services, although usually represent only partial estimates, or under-estimates. In this study, replacement costs are used to value water for domestic use.
- *Mitigative or avertive expenditure techniques:* It is almost always necessary to take action to mitigate or avert the negative effects of the loss of ecosystem goods and services, so as to avoid economic costs. These mitigative or avertive costs can be used as indicators of the value of conserving ecosystem resources in terms of expenditures avoided. In this study, mitigative expenditures are used to value the provision of stability to coastal and riverine areas, prevention of salinity intrusion benefits for riverine communities and for domestic supplies.

Table 3: Valuation techniques used in the study

Economic benefit/cost	Type of value	Coverage of study	Valuation technique
Economic benefits			
1. Surface water supply for domestic use	Direct	Covered	Valued using replacement cost for domestic water supplies.
2. Surface water for industries	Direct	Insufficient data	
3. Surface water supply for cultivation	Direct	Insufficient data	
4. Surface water supply for distribution	Direct	Covered	Valued using market cost for water distribution.
5. Fisheries for domestic use	Direct	Covered	Valued at market prices for obtaining fish for domestic use from river and canal.
6. Fish trading	Direct	Covered	Valued at market prices for traders selling fish from river and canal.
7. Fish breeding and habitat	Indirect	Covered (as a part of 5 and 6)	Reflected in effect on production of fisheries (to avoid double counting)
8. Provision of sand as a construction material	Direct	Covered	Valued at market price for the provision of sand.

Economic benefit/cost	Type of value	Coverage of study	Valuation technique
9. Provision of clay as a construction material	Direct	Covered	Valued at market price for the provision of clay.
10. Groundwater salinity control	Indirect	Insufficient data	
11. Maintenance of groundwater levels	Indirect	Insufficient data	
12. Pollution control	Indirect	Insufficient data	
13. Regulation of salinity in the river	Indirect	Covered	Valued at damage costs avoided: covered under costs below, as salinity intrusion is mitigated.
14. Micro-climate regulation	Indirect	Insufficient data	
15. Transport	Direct	Insufficient data	
16. Flood control	Indirect	Insufficient data	
17. Cultural	Non-use	Insufficient data	
18. Aesthetic	Non-use	Insufficient data	Reflected in tourism values.
19. Option values	Option	Insufficient data	
20. Other non-use values	Non-use	Insufficient data	
Economic costs (of degradation and conservation)			
1. Infrastructure damage		Covered	Valued using damage cost techniques for infrastructure damage.
2. Livelihood loss – coastal population (if degradation continues)		Covered	Valued using effect on production for households suffering from coastal erosion due to mining.
3. Land degradation/loss of land (if degradation continues)		Covered	Valued using damage cost techniques for land degradation/loss.
4. Decline in fisheries		Insufficient data	
5. Salinity intrusion		Covered	Valued using the mitigative cost of salinity intrusion.
6. Costs of resettling (due to coastal erosion)		Covered	Valued using the mitigative cost of resettlement.
7. Costs of coastal mitigation/restoration		Covered	Valued using the mitigative/avertive expenditure of coastal restoration.
8. Costs of river mitigation/restoration		Covered	Valued using the mitigative/avertive/restoration expenditure of river restoration.
9. Death and injury associated with mining		Insufficient data	
10. Health impact to miners		Insufficient data	
11. Biodiversity loss		Insufficient data	
12. Loss of aesthetic value		Insufficient data	

2.7 Information collection and administration of surveys

The design and planning stage included several brainstorming sessions. The study team, the larger project team, the Scientific Advisor and Technical Advisor (Environmental Economist) discussed the design of study and identified ecosystem services, checked feasibility and reviewed available information. Many visits to the field were made to find out background information and availability of information. This information was also essential for the designing of questionnaires.

Information necessary to carry out the study included various sources, and was collected from these sources during November 2010 to August 2011.

Literature review and secondary data
Existing data and historical information were collected through published and unpublished reports and documents. A comprehensive list of questions and information to be collected was designed and possible sources of information were identified. This included government reports and various studies.

Questionnaire for hotels
A questionnaire was designed for hotels that benefit from ecosystem services. Of the four medium-large sized hotels in the area, full information was provided by one hotel, namely Ranweli Holiday Village. Data was collected during the period November 2010 to May 2011.

Questionnaire for households along the river
A questionnaire was also designed for riverine communities to identify direct and indirect values. A total of 113 questionnaires were administered, of which 111 were used as two were discarded due to insufficient information. The questionnaire was carried out in Grama Niladari (GN) divisions adjacent to the river from the estuary to the North Katana Division, and covered 12 GN divisions. The survey was carried out in February and March 2011. These included 4 GN divisions in the Katana Divisional Secretariat (DS) Division, Bambukuliya, Manaweriya, North Katana, Muruthana in the Gampaha District, and 8 GN divisions in the Dankotuwa and Wennappuwa DS divisions in the Puttalam District. These include Kammala/Kammalthota, Sindarthiya, Thoppuwa and Kochchikade in Wennappuwa DS division and Matikotuwa, Thambarawila, Morukkuliya and Etiyawala in Dankotuwa DS division**.** Sample selection was done by dividing the survey area in to transects, and choosing five households at random from each transect grid.

Questionnaire for displaced families along the coast
A questionnaire was designed to collect information from those bearing the costs of coastal erosion. An initial site visit was carried out to get the information on displaced families due to coastal erosion. The total number of questionnaires was set at 50, and the households surveyed were selected to keep a consistent proportion of populations in each GN division. A total of 50 questionnaires were carried out in May and June 2011. These included five from the Wennappuwa DS division, Bolawatte, Kammala South, Kammala, Kadawatha, Kolinjadiya and two from the Nattandiya DS division, Mudukatuwa and Katuneriya. Both DS divisions are situated in the Puttalam District.

Key informants
Additionally, key informants including government officials from administrative and government departments and subject experts were identified and background information was collected.

3. Results and Discussion

3.1 Current value of the goods and services provided by the Maha Oya ecosystem

The study assessed the values associated with water use, fisheries, sand and clay extraction, and tourism values. It found that the value of these goods and services generated by the Maha Oya ecosystem was more than LKR 1.7 billion in the current year (details in Annex 1).

Table 4: Value of the goods and services provided by the Maha Oya ecosystem

Type of ecosystem service	Value (LKR mill/year)
Direct use of water for domestic drinking	0.02
Direct use of water for domestic bathing	0.92
Direct use of water for domestic washing	0.49
Direct use of river water for domestic cooking	0.10
River water supply	435.77
Domestic fisheries (river)	7.28
Commercial fisheries (river)	86.18
Sand mining	506.63
Illegal sand mining	398.06
Illegal clay mining	40.76
Tourism	257.35
Total Value (LKR mill/year)	**1,733.56**

Direct water use from the river
A considerable number of families depend on the river partially or solely for washing, bathing, cooking and even drinking.The numbers of households using water was extrapolated from the survey sample. It is estimated that a total of 214 people depend on the river for drinking, generating an annual value of LKR 0.02 million, while 3,859 people use the river for bathing, which generate a value of LKR 0.92 million annually. The river is used for washing purposes by 3,055 which has an annual value of LKR 0.49 million. A total of 643 people depend on the river for water for cooking purposes, valued at LKR 0.10 annually.

River water supply by the National Water Supply and Drainage Board (NWSDB)
An intake of the NWSDB is situated in Bambukuliya, which provides water for domestic, industrial and commercial users. A total of 17,605 households, 4 industries, 91 schools/religious institutions and 1,400 commercial institutions/hotels depend on the Bambukuliya water intake, while the Board of Investment zone also gets its water from this intake. This adds up to 1,642,500 units of water annually, totalling LKR 435.77 million.

Fisheries for domestic and commercial use (river)
There are 296 households that use the river for fishing for domestic use, and this value is estimated to be worth LKR 7.28 million a year. Commercial fisheries are carried out by a total of 296 families, valued to be LKR 86.18 million a year.

Provision of sand – legal and illegal mining
A total of 50,622.5m^3 of sand is extracted legally, totalling LKR 506.63 million per year; while an estimated 39,805.25m^3 of sand is extracted illegally, and is valued at LKR 398.06 million per year.

Provision of clay – illegal mining
There is no legal clay mining allowed currently in the project area, but it is estimated that a total of 16,303m^3 of clay is extracted illegally, valued at LKR 40.76 million per year.

Tourism
It is estimated that a total number of 5,634 tourists stayed an average of 11.5 days a year in hotels within the project area, generating income and revenues worth LKR 257.35 million.

Distribution of values between various groups

Local communities (households) obtain the least benefits from the Maha Oya ecosystem, totalling LKR 98.25 million per year, from direct water use from the river and fishery activities. The Government obtains benefits from water supply from the river, mining royalties and tourism, which add up to LKR 248.38 million per year. Business and industry obtain the highest benefits by far, from the water, fishing, mining and tourism sectors, which add up to approximately 1.4 billion. This value is about four times more than the benefits derived by the local communities and government sectors put together, indicating the inequitable sharing of resources from the Maha Oya and associated ecosystems.

Table 5: Distribution of values between various groups

Sector	Community	Government	Business/industry
Water	90.97	217.18	129.15
Fishing	7.28		86.18
Mining		5.47	939.97
Tourism		25.73	231.61
Total value (LKR mill/ year)	**98.25**	**248.38**	**1,386.91**

3.2 Value of the economic costs of degradation of the goods and services provided by the Maha Oya ecosystem

The study assessed the economic costs associated with land degradation, costs of coastal protection, river rehabilitation and displacement of people. It found that the conomic cost of ecosystem degradation and loss was some LKR 1.2 billion in the current year (details in Annex 2).

Table 6: Value of the economic costs of degradation of the goods and services provided by the Maha Oya ecosystem

Type of ecosystem service	Cost (LKR mill/year)
Mitigative and avertive expenditures	
Expenditures on coastal protection	430.89
Expenditures on maintaining existing coastal structures	160.00
Expenditures on riverine environmental management	0.59
Damage costs	
Damage to infrastructure	105.25
Displacement of coastal population	21.02
Loss of land along river	456.32
Loss of land along coast	18.88
Total Value (LKR mill/year)	**1,192.95**

Mitigative and avertive expenditures associated with ecosystem degradation

Coastal protection for eroding areas
Coastal protection can be done in many ways, such as revetments that protect the coast but prevent beach from forming. The cost of coastal protection in this case is for protection of coast while maintaining beach values. This method is a combination of several coastal protection methods; emergency protection, revetments, offshore breakwaters, groynes and sand nourishment. The entire coastal stretch from the Maha Oya to Deduru Oya mouth is approximately 35 kilometres. Of this, the southern most 10 kilometres, just north of the Maha Oya estuary has already been protected – thus this area will only require sand nourishment. There is a need to protect an additional 15 kilometres to prevent loss of settlements and beach values, while there are no plans to protect the northern section. Therefore the study has accounted for the cost of protecting these 15 kilometres. The total cost of coastal protection is LKR 430.89 million a year for new protection structures.

Coastal protection for existing areas
Currently 10 kilometres of coast, just north of the Maha Oya estuary has been protected. However there is a maintenance cost associated with this, in order to retain beach values for fishery activities, tourism and aesthetic values. This is an annual cost of LKR 160 million.

Riverine environmental management
There is currently an almost negligible amount of investment in riverine management. This value is LKR 0.59 million per year.

Damage costs associated with ecosystem degradation

Damage to infrastructure
Coastal erosion and mining activities have resulted in the damage of bridges and roads adjacent to the river and coast. The costs of damage to roads were not available, and thus only costs for bridges were obtained and therefore an underestimation of costs. This is a total of LKR 105.25 million annually.

Displacement of coastal population
Annually an average of 23 houses are lost due to coastal erosion, along with this are costs associated with resettlement, loss of fixed assets and reduced income and production

opportunities for those displaced. The cost of land loss has not been included as land degradation is valued separately below. Thus the cost of displacement of coastal settlements (excluding land lost) is LKR 21.02 million per year.

Loss of land along river and coast
On average a total of 14.72 hectares of land is lost along the river due to mined pits and is valued at LKR 456.32 million per year. Along the coast, approximately 1.18 hectares of land is lost each year, this cost is estimated to be LKR 18.88 million per year.

Distribution of costs between various groups

The government sector bears the biggest costs, totalling to LKR 697.08 million a year, followed by the community with a total of LKR 495.87 million. The sharing of costs is inequitable, as business and industry do not bear any costs at all.

Table 7: Distribution of costs between various groups

	Community	Government	Business/industry
Costs (LKR)	-495.87	-697.08	0
Total value (LKR mill/year)	**-495.87**	**-697.08**	**0**

3.3 The economic value-added from ecosystem restoration and sustainable management

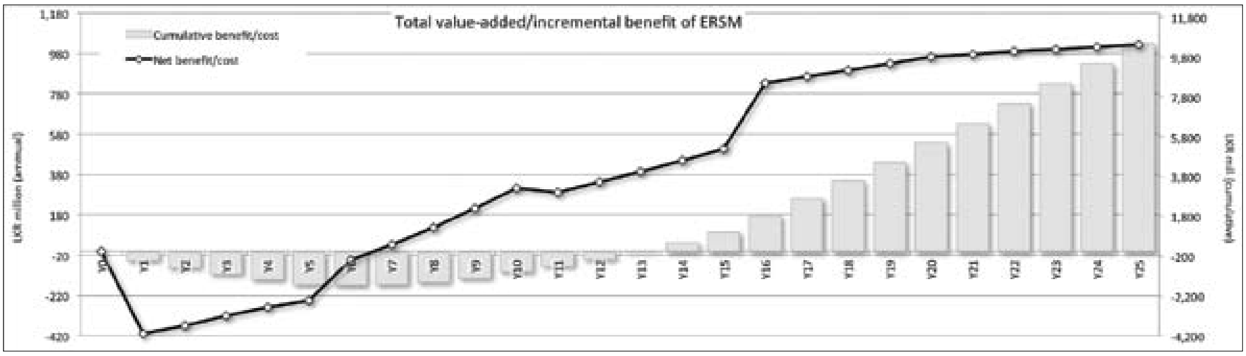
The study assessed the costs and benefits of restoring the degraded ecosystems, under 'Business as Usual' (BAU) and 'Ecosystem Restoration and Sustainable Management' (ESRM) scenarios.

Overall, there is a clear economic gain from ecosystem restoration and sustainable management as compared to a continuation of business as usual (Figure 2; detailed tables in Annex 3). Calculated over 25 years, it yields an incremental benefit of LKR 849 million: the net present value of ERSM (LKR 7.6 billion) is clearly higher than that of BAU (LKR 6.8 billion). ERSM leads to a significant reduction in the damage costs associated with ecosystem degradation and loss, while maintaining (and even in some cases increasing) the economic values generated from the sustainable use of land and resources. Under BAU, costs are incurred to all groups as ecosystem service provision declines, undermining income and employment as well as giving rise to a range of physical expenditures and losses.

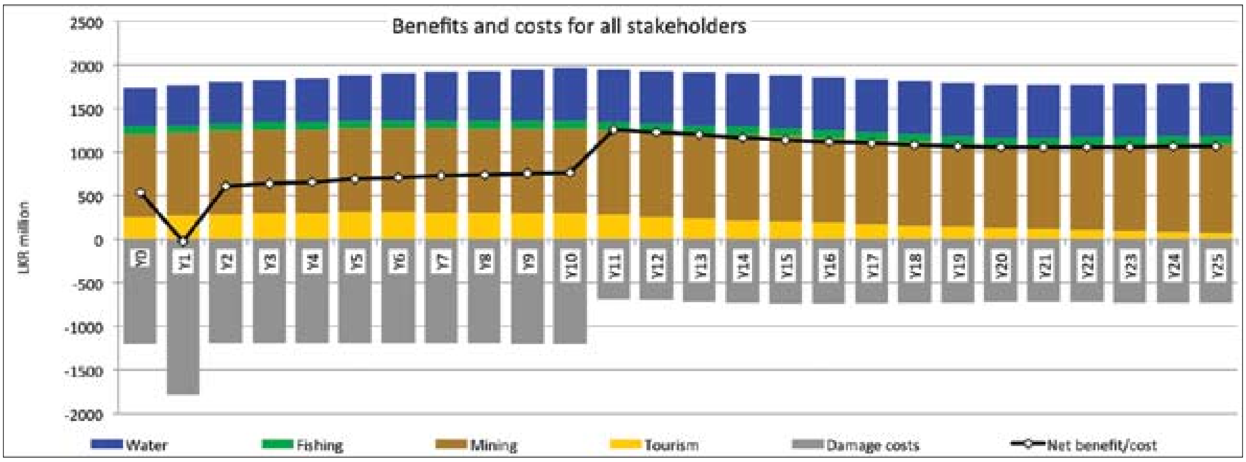
Table 8: Summary of the economic impacts of BAU and ERSM for stakeholders

Stakeholder group	Net Present Values under BAU			Net Present Values under ERSM			Impact of ERSM
	Benefits	Costs	Net impact	Benefits	Costs	Net impact	
Local communities	1,068	-3,525	-2,457	1,152	-3,175	-2,023	434
Business / industry	13,089	0	13,089	12,098	0	12,098	-991
Government	2,756	-6,620	-3,864	2,991	-5,449	-2,458	1,406
Total (LKR mill)	**16,912**	**-10,145**	**6,767**	**16,241**	**-8,624**	**7,617**	**849**

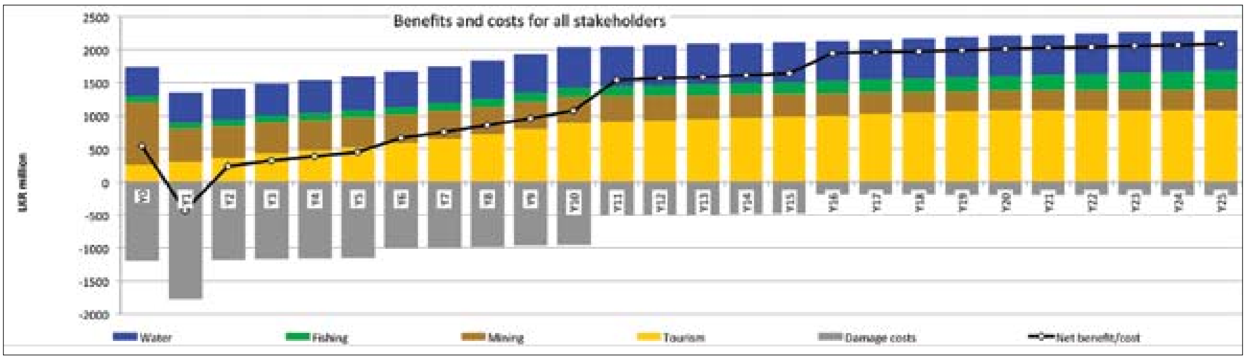
Figure 2: Overall impacts of BAU and ERSM scenarios



Business as Usual



Ecosystem Restoration and Sustainable Management



3.4 How different groups stand to gain from ecosystem restoration and sustainable management

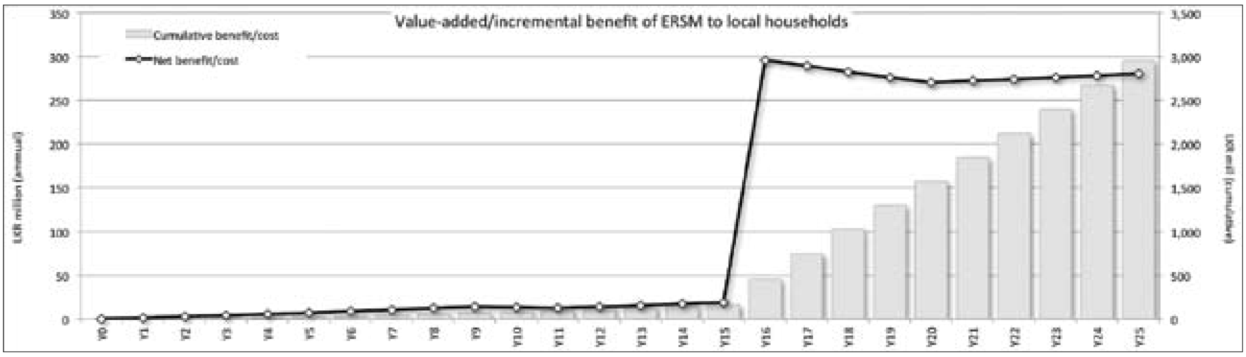
Economic impacts on local communities (households)

ERSM leads to substantial gains for local communities (households): a cumulative benefit of almost LKR 3.3 billion over 25 years, with a NPV of LKR 434 million (Figure 3; detailed tables in Annex 4). These gains build up gradually. Initially, in the first 15 years, the gains from ERSM remain relatively small (although increase steadily). This is because initially under both scenarios there is a significant cost associated with coastal restoration as the Coast Conservation Department has plans for mitigation activities (irrespective of scenario), with the entire area estimated to be protected by year 15. The net benefit from ERSM rises steeply in year 16, because the coastal area within the project area is mitigated, significantly reducing costs (and thus increasing benefits), and is maintained thereafter.

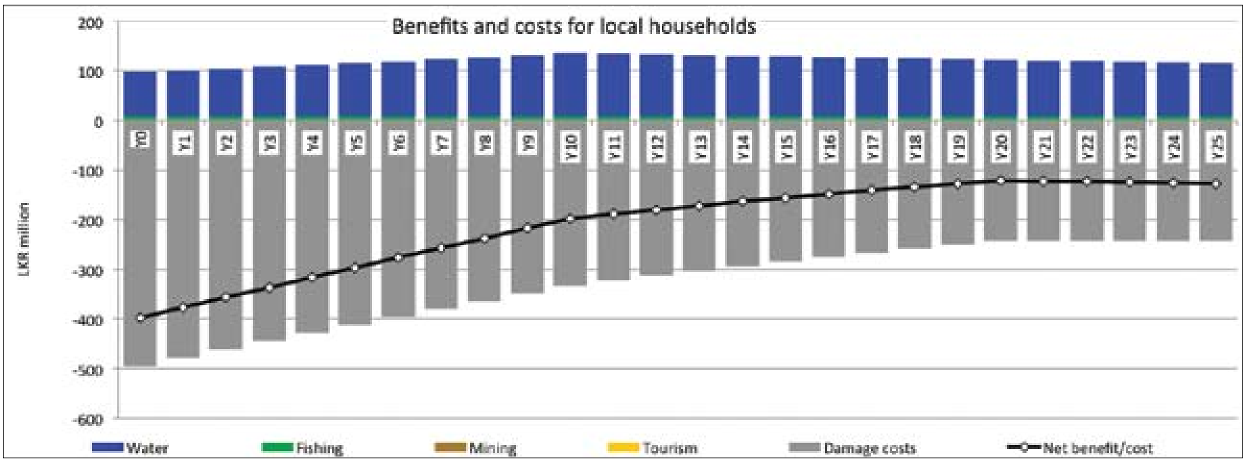
Overall, local communities (households) stand to lose out under a 'Business as Usual' scenario. The net present cost of BAU is LKR -2.5 billion. This is because local households bear many of the damages incurred as a result of ecosystem degradation, and these outweigh the livelihood benefits gained from the continued use of natural resources. Over time, the annual value of natural resource use (mainly fishing and water for bathing, washing, drinking and cooking) is slowly eroded, as the environment is degraded and the flow of ecosystem services decreases. Meanwhile, the damage costs arising from coastal erosion, land degradation along the river and displacement of coastal populations are very high in the early years, as mining is sustained at high levels, before eventually levelling off due to the collapse of sand mining activities. Under this scenario, coastal mitigation activities are completed by year 15 reducing damage costs, however cost continue due to land degradation along the river. Low levels of investment in environmental management and ecosystem restoration would serve to control degradation to some extent, although would not be sufficient to mitigate or remediate it effectively.

In contrast, an 'Ecosystem Restoration and Sustainable Management' scenario leads to a net gain to local communities (households). The net present value of ERSM is LKR -2.0 billion. Initially, the continued damage costs that arise from environmental degradation and the loss of ecosystem services will outweigh the benefits from sustainable land and resource use. It will take some time for environmental mitigation and remediation measures to take effect. From year 15, there will be a sharp decline in ecosystem-related damage costs, and the value of ERSM will become positive at the local community level.

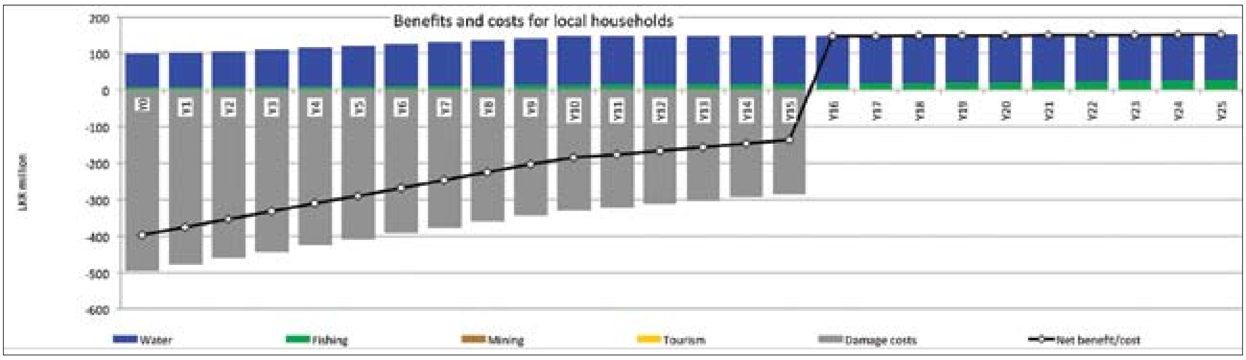
Figure 3: Impacts of BAU and ERSM scenarios for local communities (households)



Business as Usual



Ecosystem Restoration and Sustainable Management



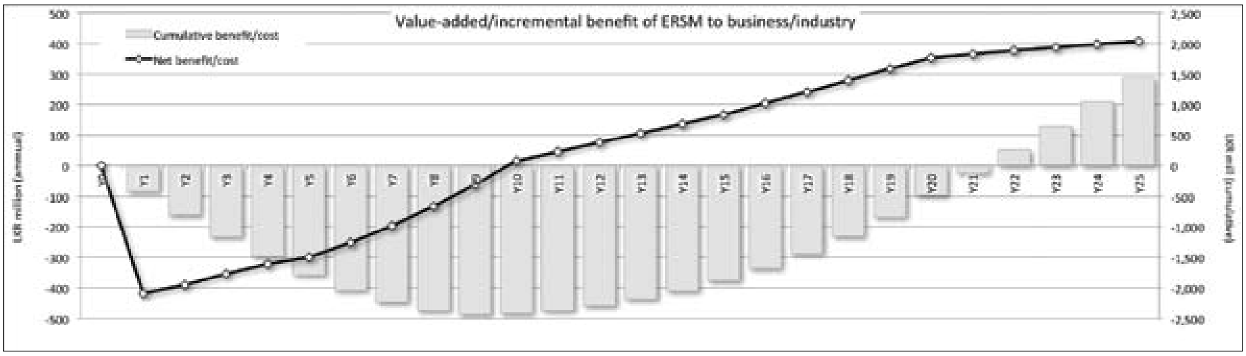
Economic impacts on business and industry

ERSM leads to gains for business and industry: a cumulative benefit of around LKR 2 billion over 25 years, with a NPV of LKR -991 million (Figure 4; detailed tables in Annex 5). These gains build up gradually. Initially, in the first 9 years, business and industry suffers a net loss from ERSM. This is mainly because of the control of illegal mining activities, and consequent loss of income. From year 10, the additional gains from sustainable land and resource uses outweigh these losses, and in year 22 the cumulative benefits offset the overall loss of mining income.

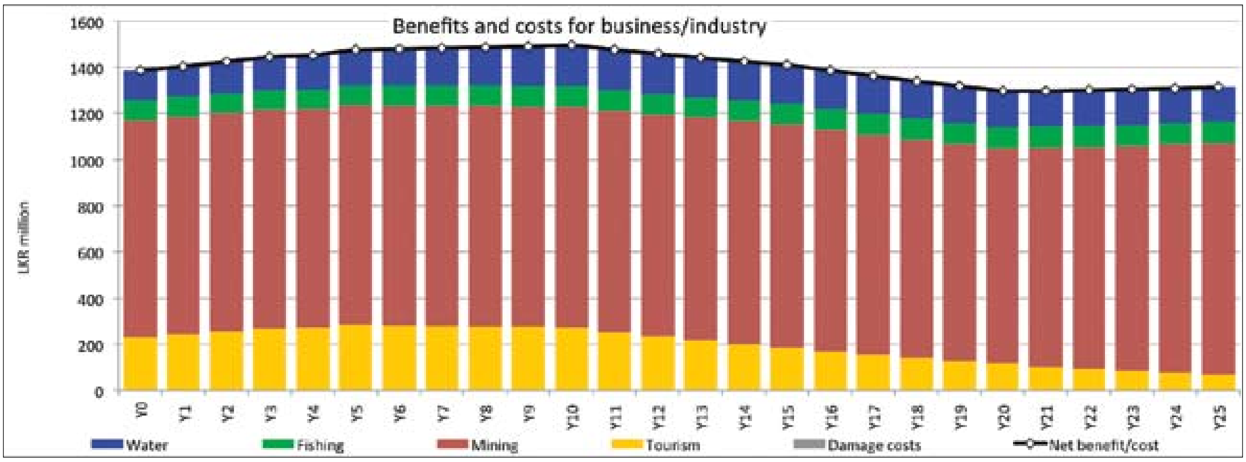
Overall, business and industry stands to gain under a Business as Usual scenario. The net present value of BAU is LKR 13.1 billion. As business and industry does not bear any of the direct damage costs and expenditures associated with environmental degradation, the flow of benefits remains positive. It should however be noted that income and earnings will gradually decline over time, largely due to a reduction in the profitability of tourism.

An Ecosystem Restoration and Sustainable Management scenario also yields a net gain to business and industry. The net present value of ERSM is LKR 12.1 billion. Although there is an immediate drop in income (as illegal mining activities are curtailed), the value of sustainable land and resource uses continue to rise thereafter. In particular, tourism shows a steady growth, which is associated with improving environmental quality and ecosystem service provision.

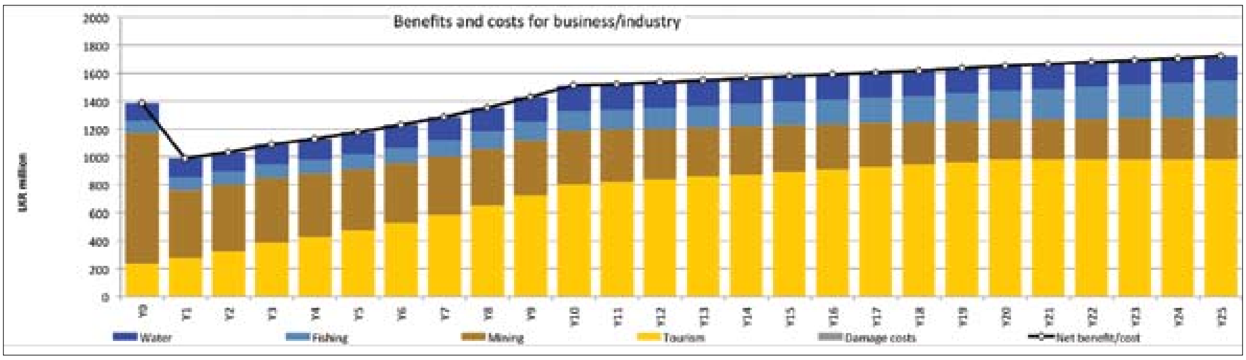
Figure 4: Impacts of BAU and ERSM scenarios for business and industry



Business as Usual



Ecosystem Restoration and Sustainable Management



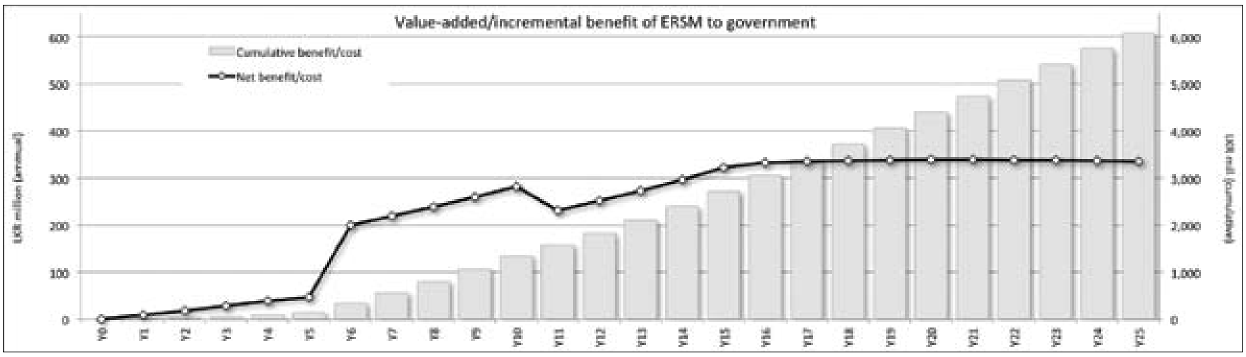
Economic impacts on government

ERSM leads to significant gains for government: a cumulative benefit of more than LKR 6 billion over 25 years, with a NPV of LKR 1.4 billion (Figure 5; detailed tables in Annex 6). These gains build up gradually. Initially, in the first 5 years, the gains from ERSM remain relatively small (although increase steadily). This is because there are damage costs associated with coastal erosion, land degradation and infrastructure damage along river. The net benefit from ERSM rises steeply in year 6, because after year 5 the costs associated with infrastructure damage along the river cease reducing costs significantly and benefits are maintained thereafter.

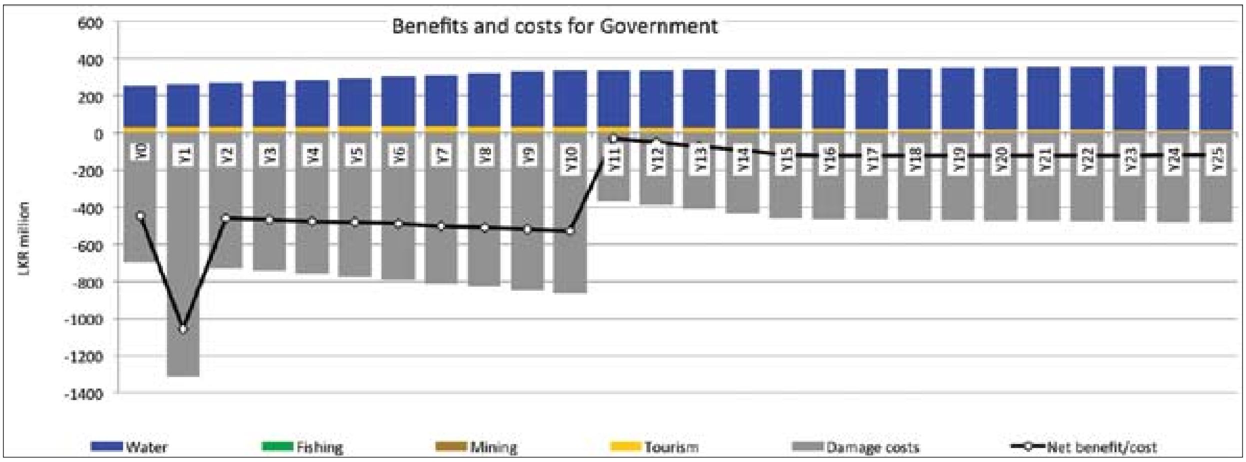
Overall, the government stands to lose out under a 'Business as Usual' scenario. The net present cost of BAU is LKR -3.9 billion. This is because the government bears the bulk of the costs associated with the civil works and infrastructure investments that are required to mitigate or remediate the effects of environmental damage, and these outweigh the public revenues earned from the use of the land and natural resources of the Maha Oya. Over time, the public revenue base (mainly from water tariffs and tourism-related taxes, with a very small contribution from mining royalties) is slowly eroded, as the environment is degraded and the flow of ecosystem services decreases. Meanwhile, expenditures on remediating and mitigating environmental damage costs remain high, especially in the early years, before levelling off. As noted above, low levels of investment in environmental management and ecosystem restoration would serve to control degradation to some extent, although would not be sufficient to mitigate or remediate it effectively.

In contrast, an 'Ecosystem Restoration and Sustainable Management' scenario leads to a net gain to government. The net present value of ERSM is LKR -2.5 billion. Initially, the high damage costs that arise from environmental degradation and the loss of ecosystem services will outweigh the revenues earned from sustainable land and resource use. It will take some time for environmental mitigation and remediation measures to take effect. From year 10, there will be a sharp decline in ecosystem-related damage costs, and the value of ERSM will become positive for government.

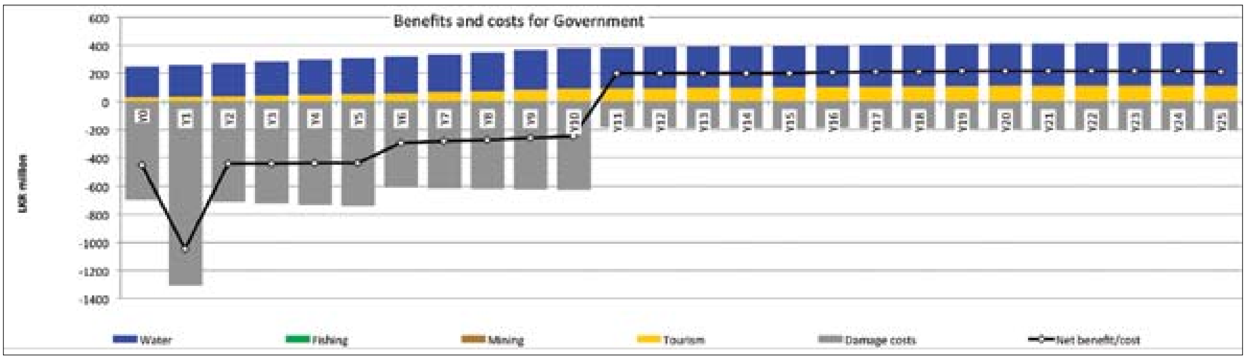
Figure 5: Impacts of BAU and ERSM scenarios for government



Business as Usual



Ecosystem Restoration and Sustainable Management



4. Conclusions

The study has estimated that the current economic benefits generated by those ecosystem services that could be valued for the Maha Oya is LKR 1.7 billion per year. Meanwhile, degradation of the Maha Oya ecosystem is estimated to have incurred economic costs of LKR 1.2 billion in the current year.

Analysis shows that there would be a clear economic gain from investing in ecosystem restoration and sustainable management, as compared to a continuation of the *status quo* under business as usual. The incremental gains over the next 25 years are estimated at LKR 849 million, yielding a net present value higher than that generated by BAU. Ecosystem restoration and sustainable management leads to a significant reduction in the damage costs associated with ecosystem degradation and loss, while maintaining (and even in some cases increasing) the economic values generated from the sustainable use of land and resources. Under business as usual, costs are incurred to all groups as ecosystem service provision declines, undermining income and employment as well as giving rise to a range of physical expenditures and losses.

It is notable that under the ERSM scenario, all stakeholders benefit; while in the BAU scenario, the government and local communities lose out, while business and industry (who are the main actors driving ecosystem degradation and loss) continue to benefit from the goods and services associated with the Maha Oya.

This is not only inequitable, it is economically inefficient: the current situation is not in the broader public economic interest; it is only benefiting some groups. Poor local communities and the government are bearing the costs of the environmental degradation that is being caused by sand and clay mining, costs that they can ill afford to bear.

Such findings have major policy implications, as the stakeholder groups that are driving ecosystem degradation and loss are not bearing its costs. These costs accrue as externalities to society and the broader economy. For reasons of social equity, economic efficiency and environmental sustainability, these externalities need to be internalised so that those who cause environmental degradation bear the economic consequences and costs of their actions, those who are negatively impacted by environmental degradation are adequately compensated for their losses, and those who take action to safeguard the environment are rewarded for their efforts. A range of economic instruments can be used to these ends, including the imposition of penalties for those causing environmental degradation, and the provision of fair compensation for those suffering from its impacts. It is also essential to reward the groups that are responsible for generating ecosystem services and maintaining environmental quality in the Maha Oya region.

5. Recommendations

According to the findings of the study, the following actions are recommended:

- Prepare a Management Plan and an Action Plan for the management, conservation and restoration of the Maha Oya and its associated ecosystems, focusing on ecosystem restoration and sustainable management.
- A multi-stakeholder approach to problem solving, including the effective coordination and cooperation between responsible government agencies such as the Geological Survey and Mines Bureau, Irrigation Department, Coast Conservation Department and local administrative bodies.
- Enforcement of existing laws and policies to minimise illegal activities that exacerbate the externalities of environmental degradation.
- Penalise those whose activities contribute to the degradation of ecosystems. These penalties can be used for compensation, restoration activities and to overcome damage costs.
- Prepare a compensation scheme for those in riverine and coastal areas that suffer from the impacts of environmental degradation.
- Ensure that adequate economic incentives are provided to those who contribute towards ecosystem conservation and restoration, through the provision of funding, livelihood support and other rewards.

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Annexes

Annex 1: Value of the goods and services provided by the Maha Oya ecosystem

Table 9: Direct water use from the river: drinking

Description	Value
Number of people using water	214
Water consumption m^3 per capita per year	1.83
Water value per m^3 - tariff (expenditures saved for consumer)	31.00
Water value per m^3 - costs of supply (costs avoided for government)	12.50
Water value per m^3 - willingness to pay (WTP)	62.00
River water - domestic use - drinking, consumer expenditures saved (LKR mill)	0.01
River water - domestic use - drinking, government costs avoided (LKR mill)	0.00
River water - domestic use - drinking, government revenues lost (LKR mill)	-0.01
River water - domestic use - drinking, consumer surplus (LKR mill)	0.01
Value (LKR mill/year)	**0.02**

Table 10: Direct water use from the river - bathing

Description	Value
Number of people using water	3,859
Water consumption - m^3 per capita per year	5.47
Water value per m^3 - tariff (expenditures saved for consumer)	31.00
Water value per m^3 - costs of supply (costs avoided for government)	12.50
Water value per m^3 - willingness to pay (WTP)	62.00
River water - domestic use - bathing, consumer expenditures saved (LKR mill)	0.65
River water - domestic use - bathing, government costs avoided (LKR mill)	0.26
River water - domestic use - bathing, government revenues lost (LKR mill)	-0.65
River water - domestic use - bathing, consumer surplus (LKR mill)	0.65
Value (LKR mill/year)	**0.92**

Table 11: Direct water use from the river - washing

Description	Value
Number of people using water	3,055
Water consumption - m^3 per capita per year	3.65
Water value per m^3 - tariff (expenditures saved for consumer)	31.00
Water value per m^3 - costs of supply (costs avoided for government)	12.50
Water value per m^3 - willingness to pay (WTP)	62.00
River water - domestic use - washing, consumer expenditures saved (LKR mill)	0.35
River water - domestic use - washing, government costs avoided (LKR mill)	0.14
River water - domestic use - washing, government revenues lost (LKR mill)	-0.35
River water - domestic use - washing, consumer surplus (LKR mill)	0.35
Value (LKR mill/year)	**0.49**

Table 12: Direct water use from the river - cooking

Description	Value
No of people using water	643
Water consumption - m^3 per capita per year	3.65
Water value per m^3 - tariff (expenditures saved for consumer)	31.00
Water value per m^3 - costs of supply (costs avoided for government)	12.50
Water value per m^3 - willingness to pay (WTP)	62.00
River water - domestic use - cooking, consumer expenditures saved (LKR mill)	0.07
River water - domestic use - cooking, government costs avoided (LKR mill)	0.03
River water - domestic use - cooking, government revenues lost (LKR mill)	-0.07
River water - domestic use - cooking, consumer surplus (LKR mill)	0.07
Value (LKR mill/year)	**0.10**

Table 13: River water supply by the National Water Supply and Drainage Board (NWSDB)

Description	Value
Increased costs of water costs of supply per unit (government costs)	0.13
Domestic - connections	17,605
Domestic - units per year	4,225,200.00
Domestic - unit cost LKR	20.00
Domestic - willingness to pay (WTP)	40.00
Industrial - connections	4.00
Industrial - units per year	2,160.00
Industrial - unit cost LKR	45.00
Industrial - willingness to pay (WTP)	90.00
Schools/religious - connections	91.00
Schools/religious - units per year	81,036.00
Schools/religious - cost per unit	53.00
Schools/religious - willingness to pay (WTP)	106.00
Commercial/hotels - connections	1,400
Commercial/hotels - units per year	840,000.00
Commercial/hotels - cost per year	50.00
Commercial/hotels - willingness to pay (WTP)	100.00
BOI - units	1,642,500.00
BOI - cost per unit	53.00
BOI - willingness to pay (WTP)	106.00
River water - Water Board, domestic consumer surplus (LKR mill)	84.50
River water - Water Board, industrial consumer surplus (LKR mill)	0.10
River water - Water Board, schools/religious consumer surplus (LKR mill)	4.29
River water - Water Board, commercial/hotels consumer surplus (LKR mill)	42.00
River water - Water Board, BOI consumer surplus (LKR mill)	87.05
River water - Water Board, government revenues (LKR mill)	217.95
River water - Water Board, increase in government supply costs (LKR mill)	-0.13
Value (LKR mill/year)	**435.77**

Table 14: Fisheries for domestic use (river)

Description	Value
Number of households fishing	296
Kilograms (kg) of fish consumed/households/year	123.00
Fish value per kg	200.00
River fish - domestic use (LKR mill)	7.28
Value (LKR mill/year)	**7.28**

Table 15: Commercial fisheries (river)

Description	Value
Number of households fishing	296
Kilograms (kg) of fish caught/fisher/year	794.00
Fish value per kg (local sale price)	366.67
River fish - commercial use (LKR mill)	86.18
Value (LKR mill/year)	**86.18**

Table 16: Provision of sand – legal mining

Description	Value
Quantity of sand extracted m^3/year	50,662.50
Sand - value per m^3 (royalties)	108.00
Sand - value per m^3 (sale price)	10,000.00
Sand - legal mining, government revenues (LKR mill)	5.47
Sand - legal mining, gross production value (LKR mill)	501.15
Value (LKR mill/year)	**506.63**

Table 17: Provision of sand – illegal mining

Description	Value
Quantity of sand extracted m^3/year	39,806.25
Sand - value per m^3 (sale price)	10,000.00
Sand - illegal mining, gross production value (LKR mill)	398.06
Value (LKR mill/year)	**398.06**

Table 18: Provision of clay – illegal mining

Description	Value
Quantity of clay extracted m^3/year	16,303.00
Clay - value per m^3 (sale price)	2,500.00
Clay - illegal mining, gross production value (LKR mill)	40.76
Value (LKR mill/year)	**40.76**

Table 19: Tourism

Description	Value
Number of tourists	5,634
Average length of stay (days)	11.50
Value per tourist day (LKR expenditures)	3,972.00
Value of tourists (taxes and public revenues)	397.20
Tourism - government revenues (LKR mill)	25.73
Tourism - gross value to hotels (LKR mill)	231.61
Value (LKR mill/year)	**257.35**

Annexes

Annex 2: Value of the economic costs of degradation of the goods and services provided by the Maha Oya ecosystem

Table 20: Expenditures on coastal protection

Description	Value
Emergency protection - km per year	1.50
Emergency protection - investment costs per km (LKR)	13,625,000.00
Revetment - km per year	1.50
Revetment - cumulative km per year	1.50
Revetment - investment costs per km (LKR)	54,500,000.00
Revetment - maintenance costs per km per year (LKR)	817,500.00
Offshore breakwaters/groynes - km per year	1.50
Offshore breakwaters/groynes - cumulative km per year	1.50
Offshore breakwaters/groynes - investment costs per km (LKR)	110,000,000.00
Offshore breakwaters/groynes - maintenance costs per km per year (LKR)	1,650,000.00
Sand nourishment with structures - volume per year (maintenance) m^3	200,000.00
Sand nourishments - costs per m^3	800.00
Costs of expenditures on coastal protection (LKR mill)	430.89
Cost (LKR mill/year)	**430.89**

Table 21: Expenditures on maintaining existing coastal structures

Description	Value
Sand nourishment m^3	200,000.00
Sand nourishments - costs per m^3	800.00
Costs of expenditures on existing coastal structures (LKR mill)	160.00
Cost (LKR mill/year)	**160.00**

Table 22: Expenditures on riverine environmental management

Description	Value
Annualised investment costs per year (LKR)	566,666.00
Maintenance costs per year (LKR)	28,333.30
Expenditures on riverine environmental management (LKR mill)	0.59
Cost (LKR mill/year)	**0.59**

Table 23: Damage to infrastructure

Description	Value
Costs of repairing and replacing bridges per year (LKR)	105,252,617.00
Damage to infrastructure (LKR mill)	105.25
Cost (LKR mill/year)	**105.25**

Table 24: Displacement of coastal population

Description	Value
No of households/year	23
Costs of resettlement (average LKR per household)	15,000.00
Loss of fixed assets (average LKR per household)	200,000.00
Reduced income and production opportunities (average LKR per household per year)	698,793.00
Displacement of coastal population - costs to government (LKR mill)	-0.35
Displacement of coastal population - costs to landowner (LKR mill)	-20.67
Cost (LKR mill/year)	**-21.02**

Table 25: Loss of land along river

Description	Value
Area of land lost (ha/year)	14.72
Value of land (LKR market price/ha)	31,000,000.00
Loss of land along river - cost of land lost (LKR mill)	-456.32
Cost (LKR mill/year)	**-456.32**

Table 26: Loss of land along coast

Description	Value
Area of land lost (ha/year)	1.18
Value of land (LKR market price/ha)	16,000,000.00
Loss of land along coast - cost of land lost (LKR mill)	18.88
Cost (LKR mill/year)	**-18.88**

Annex 3: The economic value-added from ecosystem restoration and sustainable management

Table 27: Total value for the incremental value of ERSM for all stakeholders

	Y0	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10	Y11	Y12	Y13	Y14	Y15	Y16	Y17	Y18	Y19	Y20	Y21	Y22	Y23	Y24	Y25
Water	-	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1
Fishing	-	4	8	12	17	22	27	32	38	44	50	57	63	71	78	86	94	103	112	122	132	142	153	165	177	189
Mining	-	-454	-468	-483	-497	-510	-524	-537	-549	-562	-574	-586	-598	-609	-620	-631	-636	-640	-644	-647	-650	-660	-670	-680	-690	-700
Tourism	-	34	76	128	173	207	270	339	416	501	595	635	673	711	748	783	821	858	893	928	962	974	986	996	1,005	1,014
Damage costs	-	7	14	21	28	36	184	198	213	228	240	185	203	223	244	268	552	544	536	528	520	520	520	519	519	519
Net benefit/ cost	-	-409	-370	-321	-278	-246	-43	33	117	211	312	291	343	396	450	506	833	865	898	931	964	977	990	1,001	1,013	1,023
Cumulative benefit /cost (LKR mill)	**-**	**-409**	**-778**	**-1,099**	**-1,377**	**-1,622**	**-1,665**	**-1,632**	**-1,515**	**-1,305**	**-993**	**-702**	**-360**	**36**	**486**	**992**	**1,825**	**2,690**	**3,588**	**4,519**	**5,483**	**6,460**	**7,450**	**8,452**	**9,464**	**10,487**

Table 28: Total value for all stakeholders for the BAU scenario

	Y0	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10	Y11	Y12	Y13	Y14	Y15	Y16	Y17	Y18	Y19	Y20	Y21	Y22	Y23	Y24	Y25
Water	437	452	467	482	498	514	531	549	567	585	605	605	605	605	605	605	605	605	605	605	605	605	604	604	604	604
Fishing	93	94	94	95	95	95	96	96	96	97	97	97	98	98	98	98	99	99	99	99	100	100	100	100	101	101
Mining	945	947	949	950	952	954	956	957	959	961	962	964	966	968	969	971	964	956	948	941	933	947	962	976	991	1,006
Tourism	257	271	285	300	301	318	315	311	308	304	301	279	259	240	222	206	188	172	157	143	130	118	106	96	87	78
Damage costs	-1,193	-1,790	-1,189	-1,187	-1,187	-1,187	-1,188	-1,190	-1,192	-,1195	-,1,199	-690	-701	-714	-729	-747	-740	-733	-727	-721	-715	-717	-719	-721	-723	-724
Net benefit/ cost (LKR mill)	**541**	**-27**	**606**	**639**	**659**	**694**	**709**	**723**	**738**	**752**	**767**	**1,255**	**1,226**	**1,196**	**1,165**	**1,133**	**1,115**	**1,098**	**1,082**	**1,067**	**1,053**	**1,053**	**1,054**	**1,056**	**1,060**	**1,065**

Table 29: Total value for all stakeholders for the ERSM scenario

	Y0	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10	Y11	Y12	Y13	Y14	Y15	Y16	Y17	Y18	Y19	Y20	Y21	Y22	Y23	Y24	Y25
Water	437	452	467	482	498	514	531	549	567	586	605	605	605	605	605	605	605	605	605	605	605	605	605	605	605	605
Fishing	93	98	102	107	112	117	123	128	134	141	147	154	161	168	176	184	193	202	211	221	231	242	253	265	277	290
Mining	945	493	480	468	455	444	432	421	410	399	388	378	368	359	349	340	328	316	305	294	283	288	292	296	301	305
Tourism	257	305	361	428	474	525	584	650	723	805	896	914	932	951	970	989	1,009	1,029	1,050	1,071	1,092	1,092	1,092	1,092	1,092	1,092
Damage costs	-1,193	-1,783	-1,174	-1,166	-1,159	-1,152	-1,004	-992	-979	-967	-958	-505	-498	-491	-485	-479	-188	-190	-191	-193	-195	-197	-199	-201	-203	-205
Net benefit/ cost (LKR mill)	**541**	**-436**	**236**	**319**	**381**	**448**	**666**	**756**	**855**	**963**	**1,078**	**1,546**	**1,569**	**1,592**	**1,616**	**1,640**	**1,948**	**1,963**	**1,980**	**1,998**	**2,017**	**2,030**	**2,044**	**2,058**	**2,072**	**2,088**

Annex 4: Economic impacts on local community (households)

Table 30: Values for the incremental value of ERSM - community

	Y0	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10	Y11	Y12	Y13	Y14	Y15	Y16	Y17	Y18	Y19	Y20	Y21	Y22	Y23	Y24	Y25
Water	-	0	1	2	2	3	3	4	5	6	6	7	8	9	9	10	11	12	12	13	14	15	16	16	17	18
Fishing	-	0	1	1	2	2	3	3	4	4	5	6	6	7	8	9	9	10	11	12	13	14	16	17	18	20
Damage costs	-	0	1	1	2	2	3	3	4	4	2	0	0	0	0	0	276	267	259	251	243	243	243	243	243	243
Net benefit/cost	-	1	3	4	5	7	9	10	12	14	13	13	14	16	17	19	296	289	283	276	270	272	274	276	278	280
Cumulative benefit/ cost (LKR mill)	-	1	4	8	13	20	29	40	52	66	79	92	106	122	139	158	454	743	1,025	1,302	1,572	1,845	2,119	2,395	2,673	2,953

Table 31: Values for the BAU scenario - community

	Y0	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10	Y11	Y12	Y13	Y14	Y15	Y16	Y17	Y18	Y19	Y20	Y21	Y22	Y23	Y24	Y25
Water	91	94	97	101	104	108	111	115	119	123	128	126	125	124	122	121	120	118	117	116	114	113	111	110	108	107
Fishing	7	7	7	7	7	7	7	7	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
Damage costs	-496	-478	-461	-445	-428	-412	-396	-380	-364	-348	-333	-323	-313	-303	-294	-285	-276	-267	-259	-251	-243	-243	-243	-243	-243	-243
Net benefit/cost (LKR mill)	-398	-377	-357	-337	-316	-297	-277	-257	-237	-218	-198	-189	-180	-172	-164	-156	-148	-141	-134	-127	-121	-122	-124	-125	-126	-128

Table 32: Values for the ERSM scenario - community

	Y0	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10	Y11	Y12	Y13	Y14	Y15	Y16	Y17	Y18	Y19	Y20	Y21	Y22	Y23	Y24	Y25
Water	91	95	98	102	106	110	115	119	124	129	134	134	133	132	132	131	131	130	129	129	128	128	127	126	126	125
Fishing	7	8	8	9	9	10	10	11	11	12	12	13	14	15	15	16	17	18	19	20	21	22	23	25	26	27
Damage costs	-496	-478	-461	-443	-426	-409	-393	-376	-360	-344	-331	-323	-313	-303	-294	-285	0	0	0	0	0	0	0	0	0	0
Net benefit/cost (LKR mill)	-398	-376	-354	-333	-311	-289	-268	-246	-225	-204	-184	-176	-166	-156	-146	-137	148	148	148	149	149	150	150	151	152	152

Annex 5: Economic impacts on business and industry

Table 33: Values for the incremental value of ERSM - business/industry

Business/ industry	Y0	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10	Y11	Y12	Y13	Y14	Y15	Y16	Y17	Y18	Y19	Y20	Y21	Y22	Y23	Y24	Y25
Water	-	1	1	2	3	4	5	5	6	7	9	9	10	11	12	13	14	15	16	17	18	20	21	22	23	24
Fishing	-	4	7	11	15	20	24	29	34	40	45	51	57	64	70	77	85	93	101	109	118	128	138	148	159	170
Mining	-	-454	-468	-482	-496	-510	-523	-536	-549	-561	-573	-585	-597	-608	-619	-630	-634	-639	-642	-646	-649	-658	-668	-678	-689	-699
Tourism	-	31	69	115	156	186	243	305	374	451	535	571	606	640	673	705	739	772	804	835	866	877	887	897	905	913
Damage costs	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Net benefit/ cost	-	-419	-391	-354	-322	-300	-251	-196	-134	-63	16	47	77	107	136	166	204	241	279	316	354	366	377	388	398	408
Cumulative benefit/ cost (LKR mill)	**-**	**-419**	**-809**	**-1,163**	**-1,485**	**-1,785**	**-2,036**	**-2,233**	**-2,366**	**-2,430**	**-2,414**	**-2,367**	**-2,290**	**-2,183**	**-2,047**	**-1,881**	**-1,677**	**-1,436**	**-1,157**	**-841**	**-487**	**-121**	**256**	**644**	**1,042**	**1,449**

Table 34: Values for the BAU scenario - business/industry

	Y0	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10	Y11	Y12	Y13	Y14	Y15	Y16	Y17	Y18	Y19	Y20	Y21	Y22	Y23	Y24	Y25
Water	129	133	138	142	146	151	156	161	166	171	177	175	173	171	170	168	166	164	162	160	158	156	154	152	150	148
Fishing	86	87	87	87	88	88	88	89	89	89	89	90	90	90	91	91	91	91	91	92	92	92	92	92	93	93
Mining	940	942	944	945	947	949	951	952	954	956	958	960	962	964	965	967	960	952	945	937	930	944	958	972	987	1,002
Tourism	232	244	256	270	271	286	283	280	277	274	271	251	233	216	200	185	169	154	141	129	117	106	96	86	78	70
Damage costs	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Net benefit/ cost **(LKR** mill)	1,387	1,405	1,424	1,444	1,452	1,474	1,478	1,482	1,486	1,491	1,495	1,476	1,458	1,441	1,426	1,411	1,386	1,362	1,339	1,318	1,297	1,298	1,300	1,304	1,308	1,314

Table 35: Values for the ERSM scenario - business/industry

	Y0	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10	Y11	Y12	Y13	Y14	Y15	Y16	Y17	Y18	Y19	Y20	Y21	Y22	Y23	Y24	Y25
Water	129	134	139	144	149	155	160	166	172	179	185	184	184	183	182	181	180	179	178	178	177	176	175	174	173	172
Fishing	86	90	94	99	103	108	113	118	123	129	135	141	147	154	161	168	176	184	192	201	210	220	230	240	251	263
Mining	940	488	475	463	451	439	428	417	406	395	385	375	365	356	346	337	325	314	302	292	281	285	290	294	299	303
Tourism	232	274	325	385	427	472	526	585	651	725	806	823	839	856	873	890	908	926	945	964	983	983	983	983	983	983
Damage costs	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Net benefit/ cost (LKR mill)	**1,387**	**987**	**1,034**	**1,091**	**1,130**	**1,174**	**1,227**	**1,286**	**1,352**	**1,427**	**1,511**	**1,523**	**1,535**	**1,548**	**1,562**	**1,577**	**1,589**	**1,603**	**1,618**	**1,634**	**1,651**	**1,664**	**1,678**	**1,692**	**1,706**	**1,721**

Annex 6: Economic impacts on government

Table 36: Values for the incremental value of ERSM - government

	Y0	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10	Y11	Y12	Y13	Y14	Y15	Y16	Y17	Y18	Y19	Y20	Y21	Y22	Y23	Y24	Y25
Water	-	-1	-2	-4	-5	-6	-8	-9	-11	-13	-15	-16	-18	-20	-21	-23	-25	-26	-28	-30	-32	-34	-35	-37	-39	-41
Mining	-	0	0	0	0	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-2	-2
Tourism	-	3	8	13	17	21	27	34	42	50	59	63	67	71	75	78	82	86	89	93	96	97	99	100	101	101
Damage costs	-	7	13	20	27	34	181	195	209	224	238	185	203	223	244	268	277	277	277	277	277	277	277	277	277	277
Net benefit/ cost	-	9	18	29	39	47	200	219	239	260	282	231	251	273	297	322	333	335	336	338	340	339	338	338	337	335
Cumulative benefit/cost (LKR mill)	**-**	**9**	**27**	**56**	**95**	**142**	**342**	**561**	**799**	**1,059**	**1,342**	**1,573**	**1,824**	**2,097**	**2,394**	**2,716**	**3,049**	**3,383**	**3,720**	**4,058**	**4,398**	**4,737**	**5,075**	**5,413**	**5,749**	**6,085**

Table 37: Values for the BAU scenario - government

	Y0	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10	Y11	Y12	Y13	Y14	Y15	Y16	Y17	Y18	Y19	Y20	Y21	Y22	Y23	Y24	Y25
Water	217	224	232	239	247	255	264	273	282	291	300	303	307	310	313	316	319	322	325	329	332	335	339	342	346	349
Mining	5	5	5	5	5	5	5	5	5	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Tourism	26	27	28	30	30	32	31	31	31	30	30	28	26	24	22	21	19	17	16	14	13	12	11	10	9	8
Damage costs	-697	-1,312	-727	-743	-759	-776	-793	-810	-828	-847	-866	-368	-388	-411	-436	-462	-464	-466	-468	-470	-472	-474	-476	-478	-480	-482
Net benefit/ cost (LKR mill)	**-449**	**-1,055**	**-462**	**-468**	**-477**	**-483**	**-492**	**-502**	**-511**	**-521**	**-531**	**-32**	**-52**	**-73**	**-96**	**-122**	**-123**	**-123**	**-123**	**-123**	**-123**	**-123**	**-123**	**-122**	**-122**	**-121**

Table 38: Values for the ERSM scenario - government

	Y0	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10	Y11	Y12	Y13	Y14	Y15	Y16	Y17	Y18	Y19	Y20	Y21	Y22	Y23	Y24	Y25
Water	217	223	229	236	242	249	256	263	271	278	286	287	289	290	292	293	294	296	297	299	300	302	303	305	306	308
Mining	5	5	5	5	5	4	4	4	4	4	3	3	3	3	3	3	3	2	2	2	2	2	2	2	2	2
Tourism	26	30	36	43	47	52	58	65	72	81	90	91	93	95	97	99	101	103	105	107	109	109	109	109	109	109
Damage costs	-697	-1,305	-714	-723	-732	-742	-611	-615	-619	-623	-627	-183	-185	-188	-191	-195	-188	-190	-191	-193	-195	-197	-199	-201	-203	-205
Net benefit/ cost (LKR mill)	**-449**	**-1,046**	**-443**	**-440**	**-438**	**-436**	**-293**	**-283**	**-272**	**-261**	**-248**	**199**	**200**	**200**	**200**	**200**	**210**	**212**	**213**	**215**	**216**	**216**	**216**	**215**	**215**	**214**

About the project

Increasing the resilience of coastal and riverine communities to climate change and other threats by conserving the ecosystems of the Maha Oya and associated coastal wetlands in Sri Lanka

Mangroves for the Future (MFF) is a unique partner-led initiative to promote investment in coastal ecosystem conservation for sustainable development. It was established following the impacts of the December 2004 Tsunami to provide support to vulnerable countries in south and south east Asia to address future threats of climate change and other natural disasters. MFF supported EFL to implement a 2-year project to protect and conserve the Maha Oya and its associated coastal and riverine ecosystems.

The project took an integrated approach with a focus on strong scientific, advocacy and community components, with the aim of social and economic empowerment of communities and human wellbeing through ecosystem conservation. Project outcomes include influencing policy and decision making for ecosystem conservation, generating scientific data, ecosystem restoration, community empowerment through alternative livelihood training, capacity buildingof stakeholders and sensitising school children towards environmental conservation.

About the organisation

Protecting and conserving Sri Lanka's environment

Environmental Foundation (EFL) is one of Sri Lanka's oldest public interest organisations working in environmental conservation and protection. Established in 1981 EFL is engaged in conservation through legal and scientific means, and supports poor and disadvantaged communities defend their rights to a clean and healthy environment. The organisation implements donor funded projects, disseminates information on conservation related topics and lobbies for better policies to support a sound environment.

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