

**COST-BENEFIT ANALYSIS OF THE PROPOSED SEWER  
NETWORK AT MORATUWA/RATMALANA IN SRI LANKA AS  
A MEASURE TO PROTECT COASTAL AREAS FROM  
LAND-BASED SOURCES OF POLLUTION**



**South Asia Co-operative Environment Programme - SACEP**



**United Nations Environment Programme - UNEP**

## FOREWORD

UNEP, as the initiator and promoter of the Regional Seas Programme worldwide led the preparation of the South Asian Seas (SAS) Action Plan, in close co-operation with the South Asia Co-operative Environment Programme (SACEP). It was formally adopted at the Meeting of Plenipotentiaries held in New Delhi on the 24<sup>th</sup> of March 1995, marking the culmination of a long drawn out process of consultations and negotiations.

In the Action Plan of the South Asian Seas Programme, one of the priority areas of activity identified was the "Protection of the Marine Environment from Land-based Activities." At the South Asian Workshop on the GPA, sewage was identified as one of the major pollutant from land-based sources.

The Twentieth Session of UNEP Governing Council requested the Executive Director to explore the feasibility for UNEP to convene a global conference to address sewage as a major land-based source of pollution affecting human and ecosystem health. The Regional Co-ordination Units of UNEP's Regional Seas Programme were identified as playing an important role in the implementation of the Action Plan.

SACEP as the Secretariat for the South Asian Seas Programme is happy that they have been associated with UNEP/GPA Coordination Office in the development of a Strategic Action Plan on Sewage to meet the above requests. The inventory for socio-economic opportunities and the identification of the socio-economic benefits related to sewage are important components of this Strategic Action Plan.

I consider it my duty to thank the consultants Dr. B. M. S. Batagoda, Ms. Erandathie Lokupitiya & Ms. Nelum Dorabawila for their efforts in the preparation of this report and Ms. Chandima Jayasuriya, Secretarial Assistant, SACEP for her help in compiling this document.

SACEP whilst thanking GPA Co-ordination Office for its support this exercise seeks the assistance of the bi-lateral and multi-lateral donor community in supporting the activities related to this Priority Area of activity.

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## EXECUTIVE SUMMARY

Due to various human-mediated activities, the coastal and marine environment in the world, particularly South Asian region is continuously getting degraded. Therefore a Global Programme of Action (GPA) was adopted by representatives of 108 governments and European Commission for protection of the marine environment from land-based activities, at an intergovernmental conference held in Washington, D.C., USA from Oct. 25- Nov. 03, 1995. The aim of the Global Programme of Action is to facilitate member states to preserve and protect the marine environment from land based activities. In order to facilitate implementation of the GPA, United Nations Environment Programme (UNEP) as Secretariat of the Programme of Action has organized a series of regional workshops of Government-designated experts, and relevant international representatives as a means of strengthening national and regional capacities in this field. At the regional workshop for the implementation of GPA in South Asia, held in 1997, it was decided that National Action Plans should be developed by all South Asian Nations to implement the GPA indicating the assessment of the problem, priorities, and management strategies to be adopted. At this workshop most country delegations had the view that domestic and urban sewage is one of the major threats to the coastal and marine pollution. The waste water- related problems throughout coastal areas of the world are significant. Therefore, domestic wastewater discharges are considered one of the most significant threats to coastal environments worldwide. Environmental effects associated with domestic wastewater discharges are generally local with transboundary implications in certain geographic areas. Therefore marine environment can be significantly improved by managing land-based activities.

The pollution of marine ecosystem directly affects the socioeconomic activities associated with the coastal ecosystem such as coastal tourism, recreation use, fisheries and associated activities. These potential economic benefits present some solution to protect marine system from land based activities, because the economic value will justify the investment in the marine pollution prevention measures. It was therefore, suggested to review the possibility of using socioeconomic approach including private sector involvement for the domestic and urban sewerage management as a measure to address marine pollution problem in the South Asian region. Therefore, South Asian Cooperative Environmental Programme (SACEP), with the assistance of GPA, carried out a review on potential socioeconomic opportunities in the region of South Asian Seas affecting the marine and coastal environment with special reference to urban and domestic sewage. This review has recommended that there is significant socioeconomic potential to protect marine environment from land based activities. Promotion of private sector investment is one of the major recommendations.

The objective of this paper is to study the economic feasibility of investment in the wastewater management projects in order to investigate possible private sector investment in this field. This study was done for evaluating the costs and benefits of establishment of a wastewater/ sewer network for protection of major water bodies (i.e. Lunawa Lagoon, Bolgoda Lake and Bellanwila- Attidiya marsh) in Moratuwa/ Ratmalana, an industrial area in the coastal zone of Sri Lanka, an island- country in the Indian Ocean.

The case study area has been badly polluted. Point and non-point sources of pollution in the water bodies of Moratuwa/ Ratmalana area include effluents from more than 200 industries and domestic wastewater/ sewage generated by a population of 367,830. Major industries in the area include Textiles and Garments, Chemicals (paints and printing), Metal finishing, Food, Asbestos products, Cottage and small scale industries, Rubber products, Plastic and Aluminum products, etc. The domestic sewage and wash water generation in the project area have been estimated to 771.26 m<sup>3</sup>/ day and 1247.59 m<sup>3</sup>/ day, respectively. The total wastewater generated in the area is 5037 m<sup>3</sup>/ day. The total BOD load that has potential impact on the marine system in Sri Lanka has been estimated as 597696 kg BOD/ day. Based on this, the estimated BOD generated from sewage in the area is 34847 kg BOD/ day. A projection revealed that this BOD level can increase up to 36989 kg BOD/ day within the next five years.

Currently there is no proper sewer network in Moratuwa/ Ratmalana area and the treated (at a very low efficiency) and untreated sewage is being discharged into the main water bodies in the area, namely, Lunawa Lagoon, Bolgoda Lake, and Bellanwila-Attidiya marsh. Ground water in the area is also contaminated due to seepage from domestic septic tanks and soakage pits. Such pollution problems from the industries and septic tanks or soakage pits are common in the area. The water bodies (mainly Lunawa Lagoon) are significantly polluted with sewage, damaging the water quality and causing various impacts on human health and environment.

The proposed sewer network is supposed to collect both domestic and industrial wastewater, and it extends within an area of 40 sq. km in Moratuwa/ Ratmalana. This network will have a capacity of 15380 m<sup>3</sup>/ day. This capacity would remove 93% of all domestic and industrial wastewater produced in the area. The sewage collected through the system will be connected to the existing sea outfall at Wellawatte, Colombo, to discharge sewerage to the deep sea. Currently only about 40% of the urban population has been connected to the existing sewerage system which was built in 1916, and it is connected to the sea outfalls at Wellawatte and Mutwal. The proposed sewer network will be connected to Wellawatte sea outfall, which still has room for discharging a load of sewage far greater than what is been generated in Moratuwa/ Ratmalana area. Therefore this case study was carried out with the objective of investigating whether or not investment in the sewerage management can be justified by its benefits from protecting the marine and coastal system.

The study used Total Economic Value (TEV) model coupled with cost/ benefit analysis methodology. Pressure-State- Response model was used to conceptualize the valuation exercise. Due to time and resource constraints, secondary data and results from studies done in other countries were used in this analysis through benefit transfer method. Benefits of with project scenario and without project scenario were estimated separately. Benefits of the study area under normal condition or assuming no pollution damage were estimated as with-project benefits. It was assumed that pollution has reduced normal benefits up to present level, which were estimated as without-project benefits. The difference between with-project benefits and without-project benefits was considered as environmental cost caused by the present level of pollution, and this was assumed as the project benefits. Both with-project and without-project benefits were discounted at 5% discount rate.

The associated benefits of the implementation of this sewer network include the direct use values such as fishing and food production, agriculture productivity, tourism, and recreation, etc. The indirect use benefits of the project include water quality regulation, flood control, waste treatment, and refugia functions. Non-use values, both option and existence values were also considered. These values were estimated for both with-project and without-project scenarios and global and local nature of these benefits were also considered.

Environmental damage includes the loss of tourist revenue, Loss of fisheries output, Degradation of the beach, Human health hazard, Recreational losses, and Loss of indirect benefits such as water quality regulation, etc, economic values of which were estimated. Damage to human health could not be estimated due to non-availability of data.

The total direct use benefits under with-project scenario were estimated as US\$ 34.8 million, and the total indirect and non- use benefits under with-project scenario were estimated as US\$ 228.8 million. The net present value (NPV) of the total benefits of with- project scenario for 30-year period was estimated to be US\$ 122.5 million at 5% discount rate.

The total direct use benefits under present (without-project) scenario were estimated as US\$ 2.87 million, and the total indirect and non- use benefits under present scenario was estimated as US\$ 21.8. million. The net present value of the total benefits of without project scenario was estimated to be US\$11.1 million.

The net present value of the total benefits from the project was estimated by taking the difference of benefits between with project and the without project scenario (i.e. 122.5-11.1) as US\$ 111.4 million (NPV) which is equal to the total environmental damage in the area.

The total cost of the project is US\$ 75.6 million, which includes the capital, maintenance costs and pretreatment cost. Even though the project has not envisaged to undertake pretreatment, estimated pretreatment cost was included. The present value of the total cost including pretreatment cost discounted at the 5% discount rate was estimated to be around US\$ 49 million.

Based on these, the benefits/ cost ratio of the project was estimated as 2.27, which significantly justifies the economic feasibility of this project.

#### **Monetized environmental effects/ damage of the study area in comparison to GDP**

Monetized effects	111.4 million US\$
NPV of project cost for sewer network	49 million US\$
Benefit/cost ratio	2.27
GDP of the Country	15 billion US\$
Total estimated environmental damage in the whole country (in all sectors) as % of GDP	2% (Munasinghe et al., 1998)

\*Monetised effects as a percentage of GDP

This case study clearly demonstrates that the investment in wastewater management in coastal cities can be economically justified by the benefits of the coastal and marine protection itself. Lack of sewerage management facilities would lead to degradation of the inland water bodies and subsequently coastal and marine eco-system, damaging most ecological functions. Therefore, in order to protect coastal and marine system in the South Asian seas, measures should be taken to address the problem of wastewater management particularly in coastal cities.

This is the first case study of this kind conducted in Sri Lanka. The results of this study clearly encourage the governments to pay serious attention to the management of wastewater. According to this benefit/ cost analysis, public or private investment in this field can be both economically and socially justifiable. However, since the governments of developing countries have other priorities such as poverty alleviation food, national security, etc., sewerage problem can be solved efficiently if sufficient funding is available from private sector or global environmental agencies.

If the total benefits including non-market benefits of coastal and marine system are considered, the wastewater management can be an economically feasible business enterprise that attract both public and private sector funding. However, global community should take a proactive role in investing in sewerage management in coastal zones and take all possible measures to attract private sector investment in this field in order to protect global goods of coastal and marine resources. According to the results of this study, investment in wastewater management is environmentally and economically beneficial for both local and global sustainability.

## 1.0 BACKGROUND

Degradation of marine environment has been a great concern of the global community during the recent years. Reaffirming the Rio Declaration on Environment and Development the representatives of 108 Governments and the European Commission adopted the Global Programme of Action for the Protection of the Marine Environment from Land Based Activities (GPA) at an Intergovernmental Conference held in Washington, DC, USA from 23 October to 03 November 1995. The goal of the Global Programme of Action (GPA) is to prevent degradation of the marine environment from land-based activities by facilitating the realization of the duty of States to preserve and protect the marine environment. The aim of the Global Programme of Action therefore, is to facilitate states to preserve and protect the marine environment from land based activities. It is designed to assist states in taking actions individually or jointly within their respective policies, priorities and resources, which will lead to the prevention, reduction, control and or elimination of the degradation of the marine environment as well as to its recovery from the impacts of land-based activities.

The Washington Conference designated the United Nations Environmental Programme (UNEP) as Secretariat of the GPA, and requested the UNEP to a) promote and facilitate implementation of the Programme of Action at the national level; b) promote and facilitate implementation at the regional, including sub-regional level through, in particular a revitalization of the Regional Seas Programme; and c) play a catalytic role in the implementation at the international level with other organizations.

In order to facilitate implementation of the GPA, UNEP as Secretariat of the Programme of Action has organized a series of regional workshops of Government-designated experts and relevant international representatives as a means of strengthening national and regional capacities. At a similar workshop on the implementation of GPA in the South Asian region comprising of India, Bangladesh, Maldives, Pakistan, and Sri Lanka held in 1997, it was decided that National Action Plans should be developed by all South Asian Nations to implement the GPA, indicating the assessment of the problem, priorities, and management strategies to be adopted. The Governments, therefore, should develop in accordance with their policies, priorities and resources, their national programmes of action when appropriate and take forward the action to implement these programmes.

The Global Programme of Action has identified pollutant sources and proposed methods and recommendations to alleviate and reduce the level of pollution in the areas of Sewage, Persistent organic pollutants (POP), Radioactive substances, Heavy metals, Nutrients, Sediment mobilization, litter and the physical alteration and destruction of habitats. Activities and pollutants that affect the productive areas of the marine environment including estuaries and near-shore coastal waters are municipal, industrial and agricultural wastes, run-offs and atmospheric deposition. These also threaten human health and living resources and are transported long distances by watercourses, ocean currents and atmospheric processes.

At the South Asian workshop, most country delegations were of the view that domestic and urban sewage is one of the major threats to the coastal and marine pollution. Environmental effects associated with domestic wastewater discharges are generally local with transboundary implications in certain geographic areas. The commonality of sewage-related problems throughout coastal areas of the world is significant. Consequently, domestic wastewater discharges are considered one of the most significant threats to coastal environments worldwide. Recognizing variation in local conditions, domestic wastewater improperly discharged to freshwater and coastal environments may present a variety of concerns. These are associated with (a) pathogens that may result in human health problems through exposure via bathing waters or through contaminated shellfish; (b) suspended solids; (c) significant nutrient inputs; (d) biochemical oxygen demand (BOD); (e) cultural issues such as taboos in some areas; (f) plastics and other marine debris; (g) ecosystem population effects; and (h) heavy metals and other toxic substances e.g hydrocarbons, in those cases where industrial sources may have discharged effluent to municipal collection systems.

The pollution of marine ecosystem directly affects the socioeconomic activities associated with the coastal ecosystem. Major economic activities affected include coastal tourism, recreation use, fisheries and associated activities. The potential benefit from these economic activities itself presents some solution to protect marine system from land based activities, because the economic value will justify the investment in the marine pollution prevention technology. It was therefore, suggested to review the possibility of using socioeconomic approach including private sector involvement in the domestic and urban wastewater management as a measure to address marine pollution problem in the South Asian region.

Therefore, a review on potential socioeconomic opportunities in the region of South Asian Seas affecting the marine and coastal environment with special reference to urban and domestic sewage was carried out by the SACEP with the assistance of GPA. It was decided to present several case studies to illustrate the recommendations made by the socioeconomic review; this is one such case study.

## 2.0 INTRODUCTION

Coastal zones are highly dynamic and 'open' combined natural and socioeconomic systems. A significant proportion of social and economic welfare depends directly or indirectly on the availability of environmental goods and services provided by marine and coastal systems. Coastal zones represent the narrow transition zone between terrestrial and oceanic systems. They are also characterized by highly diverse ecosystems, with the result that a large number of functions are performed over a relatively small area. This concentration of functions, together with their spatial location, makes these zones attractive areas for people to live and work in.

Many coastal zones provide a significant proportion of Gross National Product (GNP) of countries. The maintenance of the proper functioning of the marine and coastal zone system is therefore of critical economic importance. Policies and practices, which maximize short-term financial returns, should not be given priority over longer-term, economically beneficial sustainable resource uses, unless resource substitutions are available and are practicable propositions.

This study addresses the issues related to Indian Ocean. The geographic scope of the area of Indian Ocean has been defined to include the marine and related coastal environment of Bangladesh, India, Maldives, Pakistan, and Sri Lanka. Two major basins included within these limits are the Bay of Bengal and the Arabian Sea. The area covered by these boundaries is the order of 70 million square kilometers and the average depth of the ocean is 3800 meters (UNEP 1982). The Northern Indian Ocean has low oxygen value, which can reach as little as < 0.05 ml/l. The north Indian Deep Water is poor in oxygen and forms an oxygen minimum layer between the oxygen rich bottom and intermediate water masses down to 40 S.

Biological Oxygen consumption rates estimated in different areas of the Indian Ocean show that the center of the North Indian deep water, from 600 – 1200m, to have the highest consumption rate at 1.5 – 2.0 ml/l. The biological oxygen consumption rates of all equatorial regions, 100-300 m deep, the Antarctic shelf, 0-400 m deep, and the North Indian Bottom Water more than 2000 m deep were valued at 1.5ml/l, 0.37ml/l and 0.04ml/l respectively.

Development activities in the coastal area lead to industrial pollution, domestic and municipal source pollution, siltation and erosion, radioactive and thermal wastes, siltation, sedimentation and reclamation. One of the other identified major causes of environment degradation is the negligence of the people in these countries of the need for environment protection and the ignorance of the importance of protecting the environment. This fact is highlighted in the Annual Report of the Asian Development Bank for 1997, which state: "Asia's environment has become so polluted and degraded that it poses a threat not just to the quality of life of its people but also to economic growth. The costs of this environmental neglect are massive". It has been identified that urban and domestic wastewater is the major source of pollution in the South Asian Seas.

In Sri Lanka only 63 percent of the population of rural sector have suitable sanitary latrines. Urban population, 80 percent have the access to basic sanitation. Only limited number of urban population has been connected to wastewater system, which was built in 1916. It is not anticipated to provide piped wastewater system to cities in the near future except where no on-site alternatives are possible. In the coastal region in Sri Lanka, where about 24% of the country's population live, sanitation and wastewater facilities are not adequate. However, presently, government is giving high priority for sewage management. The question is whether there is an economic justification for investment in the field of sewerage, particularly as a solution for the protection of marine system. Since sewage is the major marine pollution source, it is worth testing the economic case for investment in sewage management.

Under the Colombo Environmental Improvement Project, wastewater/ sewer network have been proposed for Moratuwa/ Ratmalana and Ja-Ela/ Ekala industrial areas which are in the coastal zone of Sri Lanka. Of these two projects, Moratuwa/ Ratmalana (Fig. 2.1) was selected as a case study to investigate the economic case for investment in sewerage management considering the importance of this area.

Moratuwa- Ratmalana area which is concentrated with various industries, was chosen for this study, and a cost-benefit analysis of the implementation of a sewer network (to collect both industrial and domestic wastewater) to protect the water bodies in this coastal area, was carried out.

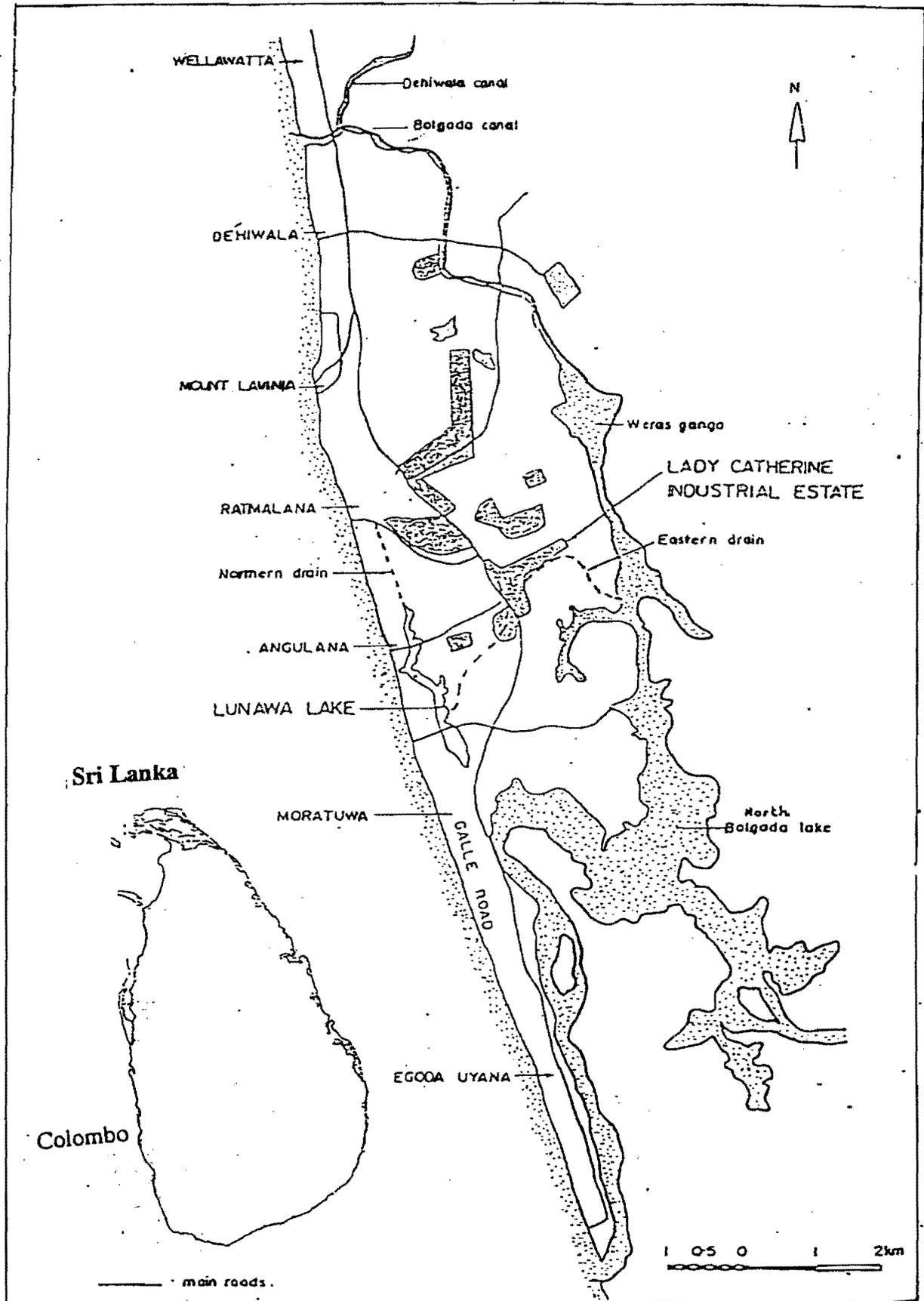
This study analyzes the costs and benefits of implementing a pragmatic system to manage sewage that currently flows into the major water bodies in the Moratuwa/ Ratmalana area. The analysis focuses on a collection network for all-possible sewage flows and industrial wastewater and thus finally discharging the sewage to the deep sea via the existing ocean outfall at Wellawatte, Colombo without treatment. It is expected that industries will undertake pretreatment before connecting sewage to the network. However, pretreatment should be included as a component of the project, to achieve environmental benefits.

The considered sewerage system covers a route connecting de Soyza sewage treatment unit and other domestic sewer network to two main pumping stations, one at Telewala Road and another at Bada Owita in Ratmalana. The main pumping station in Ratmalana will pump the wastewater via a force main to the main pumping station at Bada Owita and from there again via a force main to the existing junction box at the sewerage outfall pumping station at Roxy Lane, Wellawatte. The coastal route extends one kilometer into the Indian Ocean to reach the discharge outlet, from the Roxy Lane pump station.

At present the waste load carried by this sea outfall is released to the deep sea without treatment assuming that it does not include significant amounts of hazardous waste material such as heavy metals, POPs, etc, since pretreatment is expected to be undertaken at industrial level. This sewer network was designed primarily for domestic and urban waste disposal.

The proposed Moratuwa-Ratmalana sewer network that carries some industrial waste may include some heavy metals. It is expected recover these heavy metals at pretreatment stage. Sri Lanka has completely phased out the use of POPs way back in 1986. Therefore the question of releasing POP to the sea does not arise.

Fig. 2.1 The Study Area: Moratuwa Ratmalana Industrial Zone



Since the proposed sewer network is planned to be connected to the existing Wellawatte sea outfall, a pre-treatment of the industrial waste has to be done before being connected to the Wellawatte outfall, in order to avoid releasing substances to the sea. However, the project proponents are not planning any such pre-treatment facilities, because they expect the industries to have their own pre-treatment facilities. Therefore, for this analysis we have included estimated cost of the pretreatment plant, assuming such a facility is included in the project to avoid under representation of the cost.

Wastewater is transported up to the ocean outfall through a marine discharge line, which extends up to a distance of 1243.5 m into the sea at a depth of 10m. The mixing due to the dispersion effects at the outfall will dilute the pollutants, eliminating the need for secondary treatment prior to disposal.

The Wellawatte sea outfall and the associated sewerage system was developed and completed in 1985 to service 18 drainage areas of Colombo South. Today only 3 drainage areas are served and connected to the outfall, bringing a load of 45000 m<sup>3</sup>/day.

The Wellawatte ocean outfall (according to 1981- 1985 environmental analysis) was designed to handle a wastewater load of 218000 m<sup>3</sup>/day, (National Water Supply and Drainage Board, 1996b). In 1996, 45000 m<sup>3</sup>/day of wastewater flowed in to the system from the 3 drainage areas that are connected. This means the system has over-capacity for 173000 m<sup>3</sup>/ day. If we consider a 100% increase (45000x2 = 90000 m<sup>3</sup>/day) of the wastewater load from the already connected areas, this would reduce the available space in the system up to 128000 m<sup>3</sup>/day. The proposed Beira Project will add a flow rate of 6500 m<sup>3</sup>/day under dry conditions and 39000 m<sup>3</sup>/day (dry flow rate x 6 = wet flow rate) under wet conditions. This would leave a balance space of 89000 m<sup>3</sup>/day in the outfall system. This is significantly more than the estimated total wastewater load of 5037 m<sup>3</sup>/ day (which includes a domestic sewage load of 771.26 m<sup>3</sup>/ day) from Moratuwa/Ratmalana area (DHV 1996). This unused capacity in the existing outfall system can be effectively used to prevent wastewater discharging on lakes and lagoon in the area.

The wastewater/ sewer network proposed under the Colombo Environmental Improvement Project will have a capacity of 15380 m<sup>3</sup>/ day consisting of a gravity network force mains and pumping stations for Moratuwa/ Ratmalana area. This capacity would provide the potential for some 200 industries to connect and would remove 93% of all domestic/industrial wastewater produced in the area of Ratmalana/ Moratuwa. Capacity reserve is allowed for the residential community living within the project area to discharge their sewage and wastewater through the sewer network (325 ha), be it by construction of additional sewers at a later stage.

It is important to address the existing crucial issue of protecting these water bodies than saving room in the outfall system indefinitely for those fifteen unconnected drainage areas in the region. Most logical step would be to develop a wastewater management plan immediately all balance fifteen drainage areas as originally planned to be connected to the outfall at a later stage. The Moratuwa/ Ratmalana wastewater management project presents a good case study for marine pollution prevention via wastewater management.

## **Objective**

The objective of this case study is to investigate whether or not investment in the wastewater management can be justified by its benefits from protecting the marine and coastal system, in order to promote private sector investment in this field. This study is relevant since it has been widely accepted that the sewage is the major cause of marine pollution. In Sri Lanka, marine resources make significant contribution to the national economy. Investment in wastewater management can enhance the benefits from marine system, and might be economically justified.

Cost-benefit analysis of the proposed sewerage management facilities at Moratuwa/Ratmalana area (which is one of the drainage areas planned to be connected to the existing Wellawatte sea outfall) was carried out taking it as a measure to prevent pollution in Lunawa Lagoon, Bolgoda Lake, and Bellanwila- Attidiya marsh.

This case study addresses the following major issues specifically, focusing on

- Land-based sources of pollution and activities in coastal areas contributing to the degradation of the marine and coastal terrestrial environment with an analysis of the sewage sources contributing to the degradation of the marine and coastal environment
- Overall environmental and health damage of sewage pollution.
- An analysis of the actual and potential social and economic costs of pollution by sewage expressed in monetary terms
- Indirect impacts due to loss or depreciation of natural resources, or due to effects in human health
- An analysis of costs and benefits of additional measures (legal, administrative, economic, fiscal, technological, institutional) which would have to be introduced in order to protect marine and coastal areas and to ensure their sustainable development and use
- An evaluation of the costs and benefits in non-monetary terms related to sustainable development and the quality of life of populations, including those largely outside the monetary economy.
- An analysis of the costs and benefits from measures which have been introduced to control pollution by sewage in coastal areas
- Net present value of the benefits of wastewater management facilities.
- Recommendation whether wastewater management can present a strong economic case in terms of the benefits of marine pollution prevention.

### **2.1 Methodology and framework for the cost-benefit analysis**

Socioeconomic analysis of the protection of marine environment from land-based activities, can be done using Pressure-State-Response framework (Figure 2.2) together with total economic value (TEV) model (Turner et al. 1998). The pressure-state-response framework helps us understand the relationship between human and natural system. The TEV model actually quantifies the benefits and cost of the process using standard economic approach.

Under this concept what we really measure in terms of money is the human preference for the marine environment. Within this approach important distinctions are made between use values and non-use values. The latter cover a number of motivations that individuals might hold, not in relation to present resource use, but relating to the mere knowledge that certain resources are conserved and will continue to be so in the future. These are known as existence and bequest values.

Particular areas of the coastal zone may be subject to one or more uses at any time, and the range of uses can change over time. Multiple use conflicts have become commonplace in coastal zones. Under general economic development pressure, short-run financial gains from the heavy exploitation of direct use values provided by coastal zone resources, have often taken precedence over long-term sustainable utilization and ecosystem conservation practices and policies (Turner and Adgar 1996).

Many coastal zones provide a significant proportion of countries Gross National Product (GNP). The maintenance of the proper functioning of the marine and coastal zone system is therefore of critical economic importance. Policies and practices, which maximize short-term financial returns, should not be given priority over longer-term, economically beneficial sustainable resource uses, unless resource substitutions are available and are practicable propositions.

Many of the functions and services provided by coastal wetlands, for example, are non-market goods and therefore do not carry appropriate market prices and value. It is also the case that while coastal wetlands are capable of yielding a range of goods and services, some uses preclude others, and so some caution is necessary when total economic value estimates are utilized. Published estimates of the total economic value of wetland functions vary from US\$ 1.5 million/km<sup>2</sup> per year to US\$ 13 million/km<sup>2</sup> per year but the average is between US\$ 2-5 million/km<sup>2</sup> for OECD countries and US\$ 1.25 million/km<sup>2</sup> for developing countries (Fankhauser, 1995). The Broadlands coastal wetland in England, for example, is estimated to provide recreation and amenity benefits of around US\$ 5 million per year (Bateman et al., 1995).

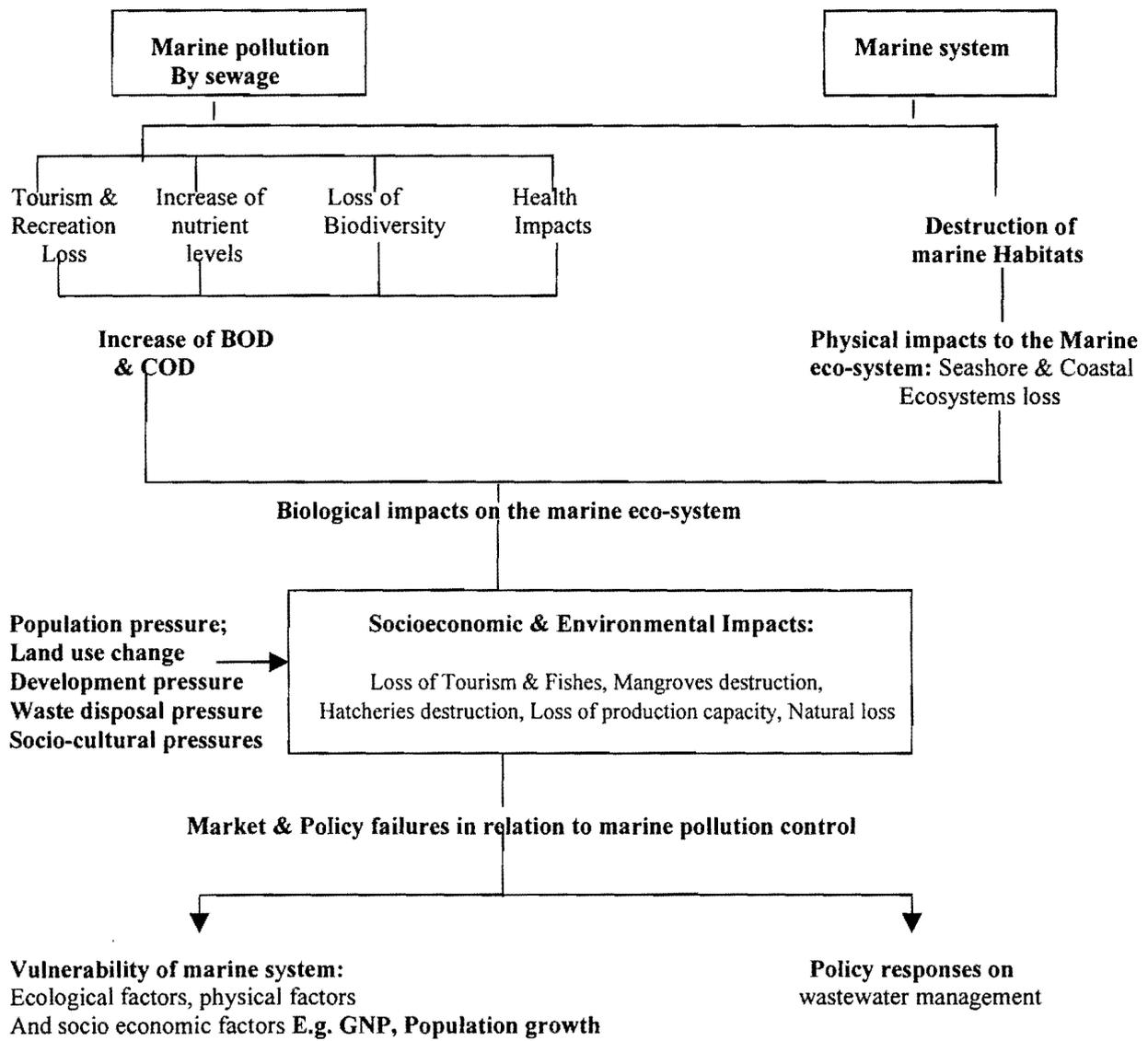
### **Total Economic Value (TEV)**

The monetary measure of a change in an individual's well being due to a change in environmental quality is called the **Total Economic Value** of the change in the environmental quality. It is not environmental quality, per se, that is being measured, but people's preferences for changes in that quality. Valuation, as such, is anthropocentric, in that it is of preferences held by people, and, the value of something is established by an exchange transaction.

In order to ensure that the full economic significance of marine ecosystems is taken into account, the concept of total economic value need to be adopted in the valuation (Figure 2.3). The TEV of the marine ecosystems is the sum of direct use value, Indirect use value, Option value, Bequest value and Existence value:

- Direct Use Values (DUV) are defined as goods where an individual makes actual use of a facility, for example visiting a recreation area to do fishing, and/ or willing to pay for this use. Direct values include raw materials and physical products that can be bought, sold and consumed directly, such as recreation, foods, building materials, fuel and handicrafts which are obtained from marine ecosystems and the species found in them.
- Indirect Use Values (IUV), are indirect benefits derived from ecosystem functions. Indirect values include services and functions provided by marine ecosystem which maintain and protect natural and human systems such as coastal protection, storm control, carbon sequestration and the provision of breeding grounds and habitat for marine fish, bird and mammal species.

**Fig. 2.2 Marine System Pressure - State-Response framework**



- Option value (OV), is an individual's willingness to pay for the option of safeguarding a facility, such as the already mentioned recreation area, for use at some future date. Option value includes the premium placed on maintaining marine ecosystems and their component species for future possible uses, some of which may not even be known now, such as extractive and tourism opportunities, pharmaceutical and industrial applications.
- Bequest Value (BV) measures an individual's willingness to pay to ensure that their heirs will be able to use a resource in the future. Bequest values include benefits accruing to any individual from the knowledge that others might benefit from the conserved resource in the future.
- Existence Value (EXV) measures willingness to pay for a resource for some 'moral', altruistic or other reason and is unrelated to use or option value. In other words, the existence value is the value derived from the knowledge that the ecosystem exists

In view of these the Total Economic Value (TEV) model can be presented as;

$$TEV = UV + NUV = (DUV+IUV+OV) + BV + EXV$$

### **Cost-benefit analysis methodology**

The following general equation for NPV was considered in the present cost benefit analysis.

$$NPV = Bd + Be - Cd - Cp - Ce$$

Where NPV = net present value

Bd = direct project benefits

Be = external (and/or environmental) benefits

Cd = direct project costs

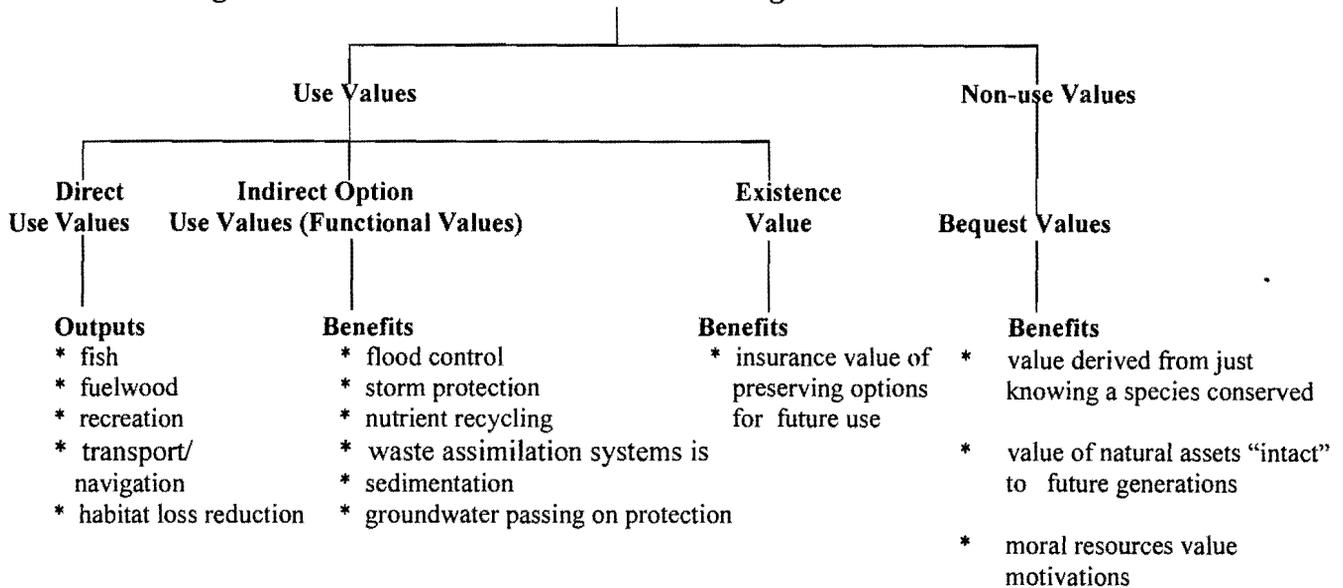
Cp = environmental protection costs

Ce = external (and/or environmental) costs

These values were discounted using the following procedure.

All terms on the right hand side of the equation were discounted in present values. The present value of any future receipt or expenditure was calculated by multiplying it by  $1/(1+d)^t$  where  $d$  is the percentage rate of discount and  $t$  is the number of years ahead. By the process of discounting expenditures and receipts, costs and benefits, which occur at different times throughout the construction and operation of the project, were all revalued to make them comparable to present expenditure and receipts. Since the rate of discount was a crucial element in the evaluation, we used 5% as a more conservative value. The government discount rate for short-term projects is 7%. Since this project is a relatively long-term project, a little lower discount value was selected.

**Figure 2.3 - Total Economic Value - Valuing coastal zone benefits**



**Valuation Methods    Valuation Methods    Valuation Methods    Valuation Methods**

Market Analysis; Other non-market Valuation methods (TCM, CVM, HPM) (IOC); (IS); (Replacement costs)	Damage Costs avoided; Preventive Expenditures; Value of changes in productivity: (Relocation costs): (Replacement costs):	CVM	VM
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Notes: Market Analysis: based in market prices; HPM= hedonic pricing, based on land/property value data; CVM = contingent valuation method based on social surveys designed to elicit; Willingness to pay values; TCM = travel cost method, based on recreationalist expenditure data; IOC = indirect opportunity cost approach, based on options foregone; IS = indirect substitute approach  
(Source: Turner, 1988; Barbier, 1989)

**2.1.1 Approach used in the present study**

This paper did not employ any empirical survey or analysis to gather original data. Secondary data were used. The analysis followed the above framework particularly to assess a first rough estimate of the marine and coastal system. Various benefits of the marine system were presented in order to compare such benefits with potential of having proper wastewater system in place. Only if the benefits of having proper wastewater system are higher than the cost of such system, the political support for higher investment for wastewater management facilities can be obtained. Therefore attempt was made to present different benefit categories of coastal and marine system. The assumption made in this study was that domestic and urban sewage causes significant level of pollution to the marine system.

In the analysis of land-based sources of pollution and activities in coastal areas contributing to the degradation of the marine and coastal terrestrial environment, the following specific items were considered:

- (i) Point and non-point sources of pollution and activities were estimated.
- (ii) An estimate of the type and amount of pollutants reaching the coastal environment from land-based sources and activities either through direct discharges or indirectly through atmosphere or riverine transport, including assessment of the relative importance of individual sources, activities and pollutants.
- (iii) Calculation of the present pollution load, and future projections.
- (iv) An analysis was done to express the actual and potential social and economic costs of pollution from land-based sources and activities in coastal areas, in monetary terms. Indirect impacts due to loss, depletion or depreciation of natural resources or their quality, or due to effect on human health were also evaluated.
- (v) An analysis of the costs and associated benefits, expressed in monetary terms, from the proposed sewer network (as a means of controlling pollution from land-based sources or activities in coastal areas) was carried out.
- (vi) Costs and benefits of additional measures (legal, administrative, economic, fiscal, technological, institutional) which would have to be introduced in order to protect the marine and coastal areas and ensure their sustainable development and use, were also considered.
- (vii) All costs associated with the measures were identified and quantified; Such costs included:
  - Investment or capital cost of equipment construction and land:
  - Sewer network
  - Sewage collection system including pumping station, etc.
  - Construction of sea outfalls.
  - Operation and maintenance costs:
  - All costs associated with the operation and maintenance of capital equipment; they included
    - wages and salaries,
    - materials cost,
    - energy costs;
    - other routine operation not necessarily associated with significant capital equipment such as routine collection of waste on harbor shores

(viii) Analysis of Benefits/Reduced Losses:

(a) **Identification of benefits**

- change in outputs such as food production, tourism, recreation;
- changes in health conditions, reduced mortality and morbidity;
- change in environmental functions; flood control, storm control;
- changes in environmental quality and consequential changes in values
- maintenance and conservation of natural resources; habitats, biodiversity.

(b) **Quantification of benefits:**

- quantity of food, number of tourists or tourist/days, number or recreationist or recreation/days;
- health conditions; reduced number of working days lost, reduction in the number of death;
- reduced quantity of crop lost, reduced number of houses or property lost
- the area of land where values increased;
- number of endangered species saved; quantity of natural resources conserved

(c) **Valuation of benefits:**

Benefits were expressed in economic terms (excluding subsidies, etc.) in constant base year prices. The quantified benefits were valued differently according to the nature of benefits.

- additional output to be valued in market prices(e.g. market price of fish); market prices were adjusted for distortions such as subsidies or taxes;
- additional tourist days valued in daily expenditures;
- additional recreational benefits valued in travel costs;
- reduced material losses valued in replacement costs;
- health benefits valued in reduced loss of earnings or life earnings in case of death;
- reduced losses from natural disaster valued in market values;
- increased land values valued in market prices adjusted for monopoly pricing practices;
- endangered species valued by various methods

However, data availability restricted the use of all those activities in this study, as planned.

## **Organisation of the report**

The report was organized in nine sections. The first and second sections provide background and introduction respectively. The third section describes the study area. Fourth section reviews the land-based sources of pollution and activities in coastal areas contributing to the degradation of marine and coastal terrestrial environment. This section reviews quantitatively the type of point and non-point sources of sewage, domestic and urban centers, and the environment impacts on the marine environment from sewage. Fifth section reviews overall environmental and health damage, while the sixth section deals with the cost benefit analysis. Section seven discusses the limitations of the present case study and ways of addressing them. Section eight gives the concluding remarks. Section nine reveals the emerging points.

### 3.0 THE STUDY AREA

#### 3.1.1 Physical environment: setting and resources

Moratuwa/ Ratmalana is located south of Colombo in the wet zone of Sri Lanka (Figure 3.1) as a part of the coastal plain, with predominantly flat topography (1-7 m above MSL). This area is affected by South West monsoons, and the typical rainfall for the wet zone ranges from 2000- 2500 mm/ year. The highest daily maximum temperature for Colombo, is recorded to be 31.5 °C in April and 22.3 °C in January.

Although it is considered an industrial area, it is not exclusively an industrial zone. The area is interspersed with residential, commercial and agricultural developments.

Seepage from domestic septic tanks and soakage pits is prevalent in the area, resulting in fecal contamination of ground water. Pollution problems from the industries and septic tanks or soakage pits prevail in the area. Due to unplanned building construction, there is flooding problem, as well.

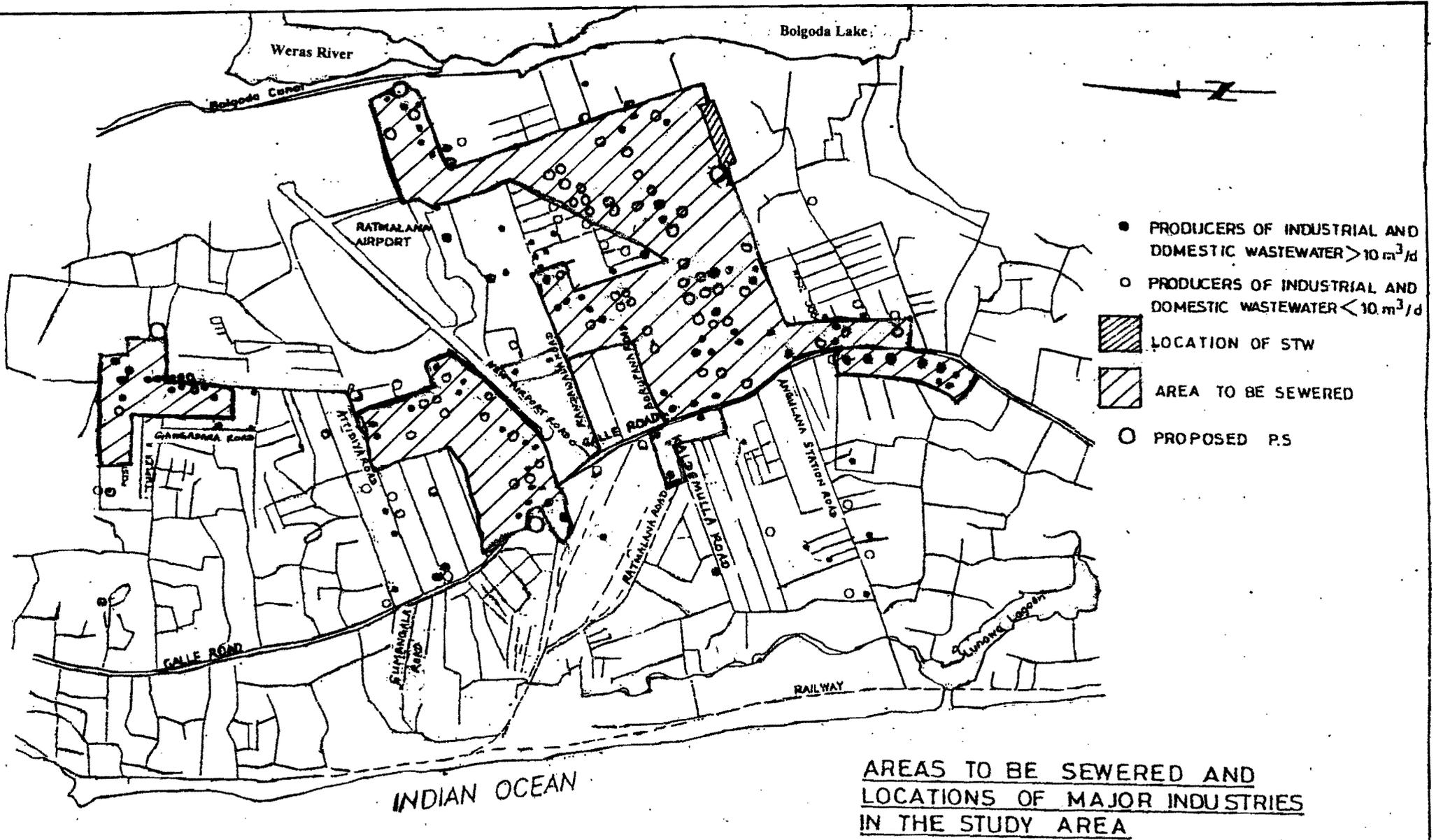
The area of this study is the project area of the proposed wastewater/ sewer network in Moratuwa/Ratmalana (Fig.3.1). This covers an area of about 40 sq. km. At present there are approximately 225 industries intermixed with residential and commercial establishments. The predominant industries include textiles, garments, chemical, metal finishing, food and asbestos products. However, there are no sanitary sewers for wastewater collection and disposal, and the untreated industrial wastewater is discharged into nearby road drains which eventually flows into near by marine water bodies. Domestic sewage is generally disposed of in septic tanks and soakaways. Approximately 368,000 (Table 3.1) residents live within the project area.

**Table 3.1.**

**Population projections** (for several years)- Population density in the area in 1996 was 350,000. The following table shows the population projections from 1996, to 2005

Year	Growth rate*	Population
1996	1.1	350,000
1997	1.2	354,200
1998	1.2	358,450
1999	1.4	363,468
2000	1.2	367,830
2001	1.2	372,244
2002	1.2	376,711
2003	1.2	381,231
2004	1.2	385,806
2005	1.2	390,436

\*- Growth rates for the country (Annual Report, Central Bank of Sri Lanka, 1999); From 2000 – 2005, an annual growth rate of 1.2% was approximated, as that is the average population growth rate given the Human Development in South Asia 1999 – The Crisis of Governance.



**FIG. 3.1** RATMALANA / MORATUWA PROJECT AREA

STW- Sewerage Treatment Works; P.S- Pumping Station

The project area includes three major water bodies, namely, Bellanwila- Attidiya marsh, Bolgoda Lake, and Lunawa Lagoon which are linked together ecologically. Economic outputs (Direct use values) from resources received from these areas include fish, fuelwood, recreation, transport/ navigation, habitat loss reduction. Other benefits include (Indirect use values) benefits of flood control, storm protection, nutrient recycling, waste assimilation system, sedimentation, and ground water regulation.

Out of the main water bodies in the area Lunawa Lagoon and Bolgoda Lake are highly polluted due to domestic and industrial wastewater and sewage coming through the canals and streamlets opened to them. The proposed sewerage system project area encompasses the southern portion of the Dehiwala Mount Lavinia Municipal Council and northern part of the Moratuwa Urban Council, covering the surroundings of the major water bodies in the area. Proposed network would help reduce the mass of sewage added to these water bodies from people who do not have laterines in the surrounding area, and inefficiently treated sewage from the De Zoysa Housing Scheme which is currently connected to Lunawa lagoon [(Although there is a treatment plant at this housing scheme, currently its efficiency and functioning has become very low); Ratnayake and Bhuvendralingam, 1993]]. Details related to these main water bodies are given below.

### **Lunawa Lagoon**

Lunawa Lagoon is located on the western side of the Galle Road in Ratmalana, and is separated from the sea by a sand bar formation at the sea outlet. The surface area of the lagoon is 87 ha (Coast Conservation Department, 1997).

This water body is heavily polluted and the pollution problems are aggravated by the limited supply of fresh water to flush the lagoon waters into the sea. Some drains directly discharge onto the beach, causing pollution, especially during the rainy seasons.

The lagoon once had a variety of aquatic life, including estuarine fish. Currently the lagoon is completely devoid of estuarine fish, as a result of pollution. This has caused economic and health impacts on the neighboring community. It has adversely affected the lives of the neighboring fishermen. Presently, large areas of the lagoon are covered by various aquatic plants, mainly water hyacinth, due to high nutrient content. The electrical conductivity (which is a surrogate measure of salinity), taken recently from all accessible points in the lagoon, together with the presence of extensive stands of typically freshwater aquatic macrophytes, indicate that a fresh or slightly brackish condition exists currently in the whole lagoon from upstream reaches to immediately behind the sand bar on the beach (Tyler and de Silva, 1999).

### **Bolgoda Lake**

Bolgoda Lake and its catchment is situated in the eastern side of the Galle Road and drains into the sea at the Panadura river mouth and through Dehiwala canal. A third outlet is located further south of Panadura. Surface area of the lake is 763 ha (National Water supply and Drainage Board, 1996b). Bolgoda Lake has a low lying catchment area, and the lake has been known from the past for economic and recreational activity. Traditional Ja-kotu fishing is prominent close to the lake outlet into the sea (Pananura river). The lake still remains an ecologically significant water body, although salt-water intrusion and pollution prevail within it.

### **Bellanwila- Attidiya marsh**

This wetland has been identified as a potential recreational zone. Bellanwila- Attidiya marsh comprises of shallow water ponds, marshes and seasonally flooded grasslands with scattered pockets of shrub and small trees. Surface area of the marsh is 60 ha (Central Environmental Authority, 1993). The low-lying, swampy marsh acts as a flood retention marsh and it falls within the upper catchment of Bolgoda river basin. The Bolgoda canal runs through the marsh. Fishing for finfish and shrimps, livestock grazing (water buffalo and cattle), and cutting reeds and shrubs for fuel are the uses of this marsh. The 60 ha core area of the marshland is enclosed within the 392 ha of declared sanctuary, (Central Environmental Authority, 1999). The bird sanctuary is particularly rich in waterfowl, including many migratory species.

The marsh which provides leisure and nature experience to the society is presently threatened with encroachment and pollution, mainly as a result of dumping solid waste and effluent discharge from a nearby garment factory, resulting in large fish kills. Sri Lanka's endemic species, *Aplocheilus dayi* and *Ehirawa fluviatilis*, and economically important freshwater shrimp *Macrobrachium rosenbergii*, have been almost exterminated in the marsh. The very high number of Coliform bacteria (>2400 mpn/ 100 ml) is indicative of the degree of contamination caused by human and animal feces.

### **3.2 Development trends: Population, economic activities**

Population in Moratuwa/ Ratmalana area has increased dramatically over the last two decades with the increasing employment opportunities through increased industrial and other commercial establishments. The population increase from 1996 to 2000 is about 17,000 (Table 3.1). The increased population has increased the need for proper disposal of sewage, most of what is currently being discharged to the nearby water bodies treated (but at a very low efficiency) or untreated.

Urban development activities take place both legally and illegally. Illegal activities are common in the surrounding areas of the aquatic ecosystems mentioned above. The first form of encroachment is deliberate anthropogenic "reclamation" of small parcels of land by householders and sawmill operators. Illegal dumping of sawdust from sawmills to the nearby water bodies (e.g. Lunawa Lagoon), is a common problem. In the case of householders the process starts with the dumping of fill, frequently noxious garbage, into the edge of the water bodies followed by fencing of the in filling area and consolidation of land and possession by planting. The area acquired by a single tenancy may not be great and we must presume that sufficient numbers of people are doing it for it to be of concern. Illegal houses (squatters) probably discharge untreated effluents to the water bodies, which is very much evident in the Lunawa lagoon. One can observe small plumes of effluents issuing from individual houses, the ceramic channels coated in a gray coat with all the appearance of the "sewage fungus" *Sphaerotilus*, the water surface betraying the plume with a greasy scum. An ancillary issue concerning the proposed wastewater/ sewer network is that wastewater will be pumped out to the sea, not discharged to the water bodies, as at present. This will help change the hydrological circumstances of these aquatic ecosystems.

## 4.0 LAND-BASED SOURCES OF POLLUTION AND ACTIVITIES IN COASTAL AREAS CONTRIBUTING TO THE DEGRADATION OF THE MARINE AND COASTAL TERRESTRIAL ENVIRONMENT

### 4.1 Sources of pollution

#### Point and non-point sources of pollution

Through the proposed project, wastewater generated from about 214 industries in Ratmalana/ Moratuwa area are planned to be connected to the ocean outfall system at Wellawatte (DHV, 1996). Some of the predominant industries in the area include

- Textiles and Garments
- Chemicals (paints and printing)
- Metal finishing
- Food
- Asbestos products
- Cottage and small scale industries
- Rubber products
- Machinery
- Plastic and Aluminium products
- Electronic parts/ Assembly of parts

#### Wastewater generation in the area

The total wastewater generated (industrial wastewater and domestic wastewater) in Ratmalana/ Moratuwa area is 5037.65 m<sup>3</sup>/ day (DHV 1996). This includes domestic sewerage water generation in the project area (771.26 m<sup>3</sup>/ day) and domestic wash water generation (1247.59 m<sup>3</sup>/ day), and process wastewater generated by relevant industries is 3018.8 m<sup>3</sup>/ day (DHV,1996). Process wastewater from industries include wash water and cooling water. Wash water is high volume and low strength wastewater generated from equipment maintenance and repair and technical institutions. Cooling water generated by many industries in the area is generally clean and hence can be directed to the surface drainage system if not specially contaminated.

Process wastewater loading in the study area as estimated by the National Water Supply and Drainage Board (1996a) are given in Table 4.1.



(a)



(b)

Two Pictures illustrating the point of outlet (a) and the flow of waste stream directly to the sea (b) from a hotel establishment in Sri Lanka

**Table 4.1: Process Wastewater Loadings in the Study Area**

**PROCESS WASTEWATER LOADING CURRENT ESTIMATE**

Constituent	Textile Manufacturing	Metals Fabricating	Food & Beverages	Chemical & Pharmaceutical	Printing	Plastic & Other Industries	Total
Flow(m <sup>3</sup> /d)	2,652	1.55	283	112	25	45	3,272
BOD5	1,522	3.72	125	22.3	7.50	0.675	1,681
COD	3,368	206	188	62.9	16.8	3.60	3,846
Total suspended Solids	318	6.20	28.3	11.20	1.88	1.80	368
Total Kjeldahl Nitrogen	385	1.55	9.91	1.68	0.375	0.540	399
Total Phosphorus	9.28	0.078	1.02	0.235	0.375	0.023	11
Oils and Greaso	61.0	1.55	2.83	0.224	0.375	0.180	66

\* All units are expressed as kilograms/day unless indicated otherwise

(Source: National Water Supply and Drainage Board 1996b)

Estimated COD discharges from some industrial firms are given in Table 4.2.

**Table 4.2. Estimated COD discharges MT/ yr. of fifteen industrial firms**

Industrial Sector	Load Discharged to the environment (MT/ yr.)
Woven fabric finishing	443533.91
Cotton fabric finishing	103603.43
Knit fabric finishing	278825.33
Garment finishing	256111.38
Carpet finishing	25031.76
Motor vehicle repair	694550.84
Food manufacture	43326.41
Metal product manufacture	20479.42
Total of 15 firms	1865462.00
Average of 15 firms	124364.20

(Source: Moonamale et.al., 1999)

Table 4.3 gives the pollutant loading in the generated domestic wastewater as estimated for a population of 112700 by a preliminary analysis. Table 4.4 shows the impacts from major pollutants in the water bodies in Moratuwa/ Ratmalana area, and the benefits from the proposed waste water/ sewer network. These pollutants, sources, impacts and responses can be used to estimate the cost and benefits of the project.

**4.2 An analysis of sewage sources contributing to the degradation of the marine and coastal environment**

In Colombo area there is an existing sewerage system, which caters to about 40% of the urban population. The system was set up in place at the beginning of 1916 and some renovations had been done recently. The system is badly in need of extension and expansion. The collected sewage is pumped out to the sea without any treatment, using two sea outfalls (Wellawatte and Mutwal).

Sewage pollution in the marine system can cause disastrous impact on the ecosystem as well as human health. Increased BOD level in the marine system will lead to the destruction of biological system in the marine environment. In South Asian region, with high rate of population growth, the impact on sewage on the marine system can be great. Data availability on waste discharges to sea is scarce.

In Sri Lanka, the total BOD load generated from sewage that has potential impacts on the marine system has been estimated as 597696 Kg BOD per day. The total BOD from sewage generated by population in Sri Lanka is 1.8 million Kg BOD per day and the total BOD load from sewage that has potential impacts on coastal and marine environment in Sri Lanka is 0.6 million Kg BOD (Batagoda et al., 2000).

The population living within the extreme boundaries of project area is 367,830 in year 2000. Based on the total population in the area, potential BOD from the sewage in the area was estimated as 34847 kg per day. The projected future sewage pollution in terms of BOD values is given in Table 4.5.

**Table 4.3. Domestic Wastewater Loading in the Study Area**

<b>Constituent</b>	<b>Residential</b>	<b>Commercial</b>	<b>Industrial</b>
Service Population	53,000	2,200	57,500
Flow of total waste water (m <sup>3</sup> /d)	7,155	110	2,875
BOD <sub>5</sub>	2,915	55	1,438
Suspended Solids	2,915	55	1,438
Nutrients			
Ammonia Nitrogen	1,060	22	575
Organic Nitrogen	2,915	55	1,438
Total Kjeldahl Nitrogen	3,975	77	2,013
Organic Phosphorus	530	11	288
Inorganic Phosphorus	1,060	22	575
Total Phosphorus	1,590	33	863

\*all units are expressed as kilograms/day unless indicated otherwise. In the area used for preliminary analysis, the service population in residential, commercial and industrial sectors are 53,000, 2,200 and 57,500 respectively. The total population living in the extreme boundaries of the project area is 367830 in year 2000.

(Source: Preliminary Analysis conducted by Associated Engineering for the Project Feasibility Study)

The wastewater/ sewer network proposed under the Colombo Environmental Improvement Project will have a capacity of 15380 m<sup>3</sup>/ day consisting of a gravity network force mains and pumping stations for Moratuwa/ Ratmalana area. This capacity would provide the potential for some 200 industries to connect and would remove 93% of all domestic/industrial wastewater produced in the area of Ratmalana/ Moratuwa. Capacity reserve is allowed for the residential community living within the project area to discharge their sewage and wastewater through the sewer network (325 ha- 30,000 population), be it by construction of additional sewers at a later stage.

**Table 4.4. Major pollutants in the water bodies in Moratuwa/ Ratmalana area**

Pollutants	Source	Impacts	Losses due to pollution	Control Action	Benefits due to pollution control
Sewage- Domestic and Industrial	Low-income houses, Encroachments, Seepage from septic tanks Housing schemes	Deterioration of the quality of the ground water and major aquatic ecosystems, health impacts, bad odor	Cleanliness of water, Deterioration of aquatic life (including food organisms), recreational amenities	Connection to the wastewater and sewer network for discharge through Wellwatte sea outfall	Improved health, increased recreation Expansion of aquatic biodiversity (at least to a certain extent)
Nutrients (nitrates, phosphates, etc.)	Domestic and industrial effluents, and other wastes (e.g. agricultural)	Eutrophication, water quality deterioration, health impacts	Recreational amenities, aquatic life including fisheries	Pre-treatment at industrial level and connection to the wastewater and sewer network for discharge through Wellwatte sea outfall	Increased recreation, Water quality improvement and resultant expansion of expansion of aquatic biodiversity
*Solid waste – biodegradable and non-biodegradable	Houses, Industries, shops, etc.	Deterioration of water quality, breeding of disease vectors- mosquitoes and other insects, rodents, etc., bad odor	Recreational amenities, cleanliness of the water and environment, deterioration of aquatic life		
Metals (Chromium, copper, cadmium, lithium, arsenic, barium)	Industries	Deterioration of aquatic life and overall water quality, health impacts	Recreational amenities, aquatic life and water quality	Pretreatment at industrial level and connection to the wastewater and sewer network for discharge through Wellwatte sea outfall	Improved water quality and aquatic life, Improved health

\*- pollutants not related to the project activity

**Table 4.5. Projected pollution from sewage generated within the area in terms of BOD**

Year	Population	BOD from sewerage kg/ day
1996	350,000	33158
1997	354,200	33556
1998	358,450	33958
1999	363,468	34433
2000	367,830	34847
2001	372,244	35265
2002	376,711	35688
2003	381,231	36117
2004	385,806	36550
2005	390,436	36989

## **5.0 OVERALL ENVIRONMENTAL AND HEALTH DAMAGE**

The environmental and health damage caused within the area is due to pollution of the three major water bodies described above. Due to heavy loads of pollutants generated as a result of rapid industrialization and population increase in the area, the natural assimilative capacity of the water bodies have exceeded causing various ecological and health damage.

In addition to the destruction of the aquatic ecology and bio-diversity as a result of increased levels of pollutants as described before, nutrient nature of certain pollutants (including sewage) and stagnation of water have created ideal environment for the process known as eutrophication in these water bodies (mainly in the Lunawa lagoon and Bolgoda Lake).

The low flow and no flow conditions thus created have given rise to various health hazards such as providing breeding grounds for mosquitoes and rodents that are vectors for various diseases. Normally aquatic food chain and health are maintained when the natural bio-diversity is existing. In the past, the mosquito populations in these water bodies were controlled naturally due to feeding of mosquito larvae by fish. The loss of fish and other aquatic life has destroyed this natural balance, and this has led to increased spread of vector-borne diseases. The obnoxious odor emanating from certain parts of these water bodies has destroyed the pleasantness of their surrounding environment.

### **5.1 Major environmental issues in relation to the proposed wastewater & sewer network**

Major benefits include public health, productivity (avoided costs to agriculture, other water intake gain of land for housing and other development, etc.), amenity (recreation, and wildlife). If water is polluted, it is not possible to use it in agriculture or other domestic needs.

Major environmental costs include public health risks from leaks, overflows, and ground water contamination, hazards to sewage operatives, contamination from sludge disposal, amenity losses from location of sewage treatment works, productivity losses in agriculture, fisheries, tourism due to sludge disposal.

## **6.0 COST-BENEFIT ANALYSIS OF THE PROTECTION OF LUNAWA LAGOON, BOLGODA LAKE AND BELLANWILA-ATTIDIYA MARSH THROUGH THE PROPOSED SEWER NETWORK PROJECT**

### **6.1 Valuation Issues**

Investment on pollution control of coastal water bodies by waste water and wastewater management should also be carried out based on firm economic grounds as for any other investment. Cost-benefit analysis (CBA) is an accepted method throughout the world today, for investment decision making. While a financial analysis estimates the net benefit accruing to the project-operating entity, CBA measures effect of the project on society as a whole taking the environmental factors into consideration. This requires the quantification and valuation of the environmental benefits and damages in economic terms.

The monetary valuation of environmental damage is a very complicated issue requiring deep investigation, conceptual clarification, time and preparation of indicators enabling approximate values to be placed on environmental quality/damage. On the other hand, it is not impossible or inappropriate to estimate approximate monetary values for environmental damage using indirect methods when the derivation of such indirect measures of social costs and benefits is feasible given available data. This does not mean to say that it is always possible to monetise environmental impacts. Many impacts are qualitative and concern intangible effects. The valuation itself consists of a series of steps involving manipulation of prices and data in the light of a broad understanding of the social institutions of the country to arrive at the likely estimate of the monetary value of impacts.

The first step in the valuation process is a matter of observation that is to identify an environmental damage tracing its origin to an activity (or set of activities). The second step is investigation, that is to assess the importance of that activity and its spatial pattern and linkages to see how it operates in the economy and its interactions with the environment. The third step is conceptualization of the investigated impacts. This step, to examine if there is a real or a notional market for the observed environmental damages or impacts. It is necessary to examine what the society is losing from the damage. This is open to many questions and uncertainty. Finally a value can be placed on the activity or the damage based on the people's preference.

### **6.2 Anticipated benefits and costs of the project**

In overall valuation exercise, type of uses and the impacts of environmental factors on coastal habitat should be investigated. The following tables present such information relevant to the case study area briefly.

**Table 6.1 Typical uses of estuaries and lagoons in Sri Lanka**

<b>Type of use</b>	<b>Specific use/benefit</b>
<b>Non-extractive</b>	<ul style="list-style-type: none"> <li>a. Anchorages for trading and fishing vessels</li> <li>b. Tourist recreation (Negombo, Bentota)</li> <li>c. Research and education</li> <li>d. Raft culture of mussels and oysters (Trincomalee Bay, Puttalam Lagoon, Ratgama Lake and Mirissa Harbor)</li> </ul>
<b>Extractive</b>	<ul style="list-style-type: none"> <li>a. Fishing, full or part-time, employment of 30,000 in 1993</li> <li>b. Sandmining, direct employment for about 2,900 in 1991</li> <li>c. Seedfish/shrimp collection, demand is increasing with more aquaculture</li> <li>d. Ornamental fish collection (Negombo Lagoon, Bolgoda Lake, Trincomalee Bay)</li> </ul>
<b>Transformative</b>	<ul style="list-style-type: none"> <li>a. Use for desalination research (Thondaimannar Lagoon)</li> <li>b. Landfill (Negombo Lagoon)</li> <li>c. Pond aquaculture (Puttalam and Negombo Lagoons, Bolgoda Lake)</li> <li>d. Sewage disposal</li> </ul>

**Table 6.2. Typical uses of mangroves**

<b>Type of Use</b>	<b>Specific Use/Benefit</b>
<b>Non-extractive</b>	Science and education for research and tourism; Universities of Colombo, Kelaniya and Peradeniya, as well as NARA and the Forest Department are engaged in mangrove related research
<b>Extractive</b>	Mangrove harvest for subsistence and commercial uses; domestic use includes house construction and firewood (bakeries, kilns and illicit distilleries)
<b>Transformative</b>	Mangrove conversion for aquaculture, coconut, paddy, housing and urban expansion

**Table 6.3. Environmental Impact and Damage due to marine pollution that can be Monetised**

Impact categories	Sewage related pollution and human activities			
	Sewage	Nutrient	Sediment	Metal
Tourism losses	\$	\$	\$	
Recreational losses	\$	\$	\$	
Dredging cost	\$		\$	
Sanctuary losses				
Fishing losses	\$			\$
Ground water losses	\$	\$	\$	\$
Agriculture productivity losses	\$		\$	\$
Aquaculture loss	\$	\$	\$	\$
Human health loss	\$	\$		\$
Surface water losses	\$		\$	
Biodiversity losses	\$	\$	\$	\$
Residential value losses	\$	\$	\$	\$

**Note:** Impacts on each category can be monetarily estimated when \$ mark is given.

### 6.3 Assessment of monetised benefits

The broad approach adopted in this case study for the identification and estimation of benefits is given below citing the framework within which the benefits are classified and analyzed (Table 6.4). Due to the absence of primary data, estimates were done using the results of studies done in other countries. If the project area is not polluted all the benefits referred to in this table 6.4 can be obtained. In other words, in pollution free situation, the project area provides the benefits included in the table 6.4 entirely. However, due to pollution the study area does not provide these services and benefits fully. It was assumed that these benefits could be obtained after successful implementation of the project. Therefore the values in Table 6.4 are considered as the benefits of the project scenario, since after the project the ecological services in the project area are expected to function well.

**Table 6.4. Monetised Benefits of Lunawa Lagoon, Bolgoda Lake and Bellanwila-Attidiya marsh**

<b>Economic Benefits</b>	<b>US \$ yr<sup>-1</sup></b>
<b>Direct Use Values</b>	
Fishing & food	
Lagoon	74,559 <sup>1</sup>
Lake	64,855 <sup>2</sup>
Agriculture	33,000 <sup>3</sup>
Recreation	72,857 <sup>8</sup>
Tourism	485,714 <sup>9</sup>
<b>Indirect Use Values</b>	
<b>Nutrient cycling</b>	
Water quality regulation	
Lagoon	4,230,835 <sup>11</sup>
Marsh	900 <sup>10</sup>
Flood control	34,580 <sup>6</sup>
Sink(waste treatment):Lagoon & Lake	Industrial
Domestic	510,000 <sup>4</sup>
Sink waste treatment: Marsh	2,125 <sup>5</sup>
	4,680 <sup>7</sup>
Refugia	18,240 <sup>12</sup>
<b>Non-use Value</b>	
Existence values and optional values	8,823 <sup>13</sup>

<sup>1</sup> Calculated transferring the results of Negombo Lagoon Study (Samarakoon 1994) which valued annual fish productivity in the Negombo Lagoon to be US \$ 3 million for the area of 3500 ha, to Lunawa Lagoon which is around 87 ha.

<sup>2</sup> Calculated transferring the value for the lake fisheries of US \$ 85 ha<sup>-1</sup>yr<sup>-1</sup> to the total Bolgoda Lake area of 763 ha (Batagoda et al. 2000)

<sup>3</sup> Calculated transferring the value of the contribution to agriculture from mangroves and lakes of US \$ 165 ha<sup>-1</sup> yr<sup>-1</sup> to the total agriculture area of 200 ha in the project area (5%) (Batagoda et al. 2000)

<sup>4</sup> Calculated benefits for industrial waste sink value of lagoon and lake of US \$ 600 ha<sup>-1</sup> yr<sup>-1</sup> to total lake and lagoon area of 850 ha in the project (Batagoda et al. 2000)

<sup>5</sup> Calculated benefits of domestic & municipal waste sink value of lagoon and lake of US \$ 2.5 ha<sup>-1</sup> yr<sup>-1</sup> to total lake and lagoon area of 850 ha in the project (Batagoda et al. 2000)

<sup>6</sup> Calculated the benefits of storm water damage value of US \$ 38 ha<sup>-1</sup> yr<sup>-1</sup> for the total lake area, lagoon area, and marsh area of 910 ha in the project (Batagoda et al. 2000)

<sup>7</sup> Calculated the benefits of storm water damage value of US\$ 78 ha<sup>-1</sup> yr<sup>-1</sup> for the marsh area of 60 ha. (Batagoda et al. 2000)

<sup>8</sup> Calculated transferring the results of the Negombo Lagoon Study which valued annual recreation values for boating and wind surfing to be US \$ 0.3 million for the area of 3500 ha to the Lunawa Lagoon (763 ha) and Bolgoda Lake (87 ha ) area which is around 850 ha. (Samarakoon 1994)

<sup>9</sup> Calculated transferring the results of the Negombo Lagoon Study which valued annual amenity values as site for star class hotels overlooking the lagoon to be US \$ 2 million for the area of 3500 ha to the Lunawa Lagoon (763 ha) and Bolgoda Lake (87 ha ) area which is around 850 ha. (Samarakoon 1994)

<sup>10</sup> Transferred the water regulation value of wetland US \$ 15 ha<sup>-1</sup> yr<sup>-1</sup> estimated by the study done by Costanza et al. (1997) to 60 ha of marsh land in the study area.

<sup>11</sup> Transferred the water regulation value of lakes US \$ 5545 ha<sup>-1</sup> yr<sup>-1</sup> estimated by the study done by Costanza et al. (1997), to 763 ha of lake in the study area.

<sup>12</sup> Transferred the Refugia value of US \$ 304 ha<sup>-1</sup> yr<sup>-1</sup> estimated by the study done by Costanza et al. (1997)

<sup>13</sup> Transferred from the WTP (Existence) value of US \$ 10.38 estimated based on Debt for Nature Swaps for International Conservation Finances by Tajbakhsh (1993).

In using Total Economic Value (TEV) model, particularly in valuing indirect use benefits of marine system, the double counting problem is a serious issue. Therefore benefit categories were selected in this study to avoid double counting problem as much as possible. In this study, recreation benefits were calculated using the benefit of boating and wind surfing. The tourism benefits were calculated valuing the amenity value, which was calculated by estimating the lagoon- and lake- overlooking benefits of the star hotels located in the area. The nutrient cycling value, for example, was not considered since refugia, agriculture and waste sink functions include nutrient cycling function.

We assumed that the values of the lake, lagoon and the marsh have been reduced by almost 100% in some functions or services while some ecological functions still provide benefits at lower rate. The table 6.5 presents the estimated value of each benefit category under both present scenario and project scenario. These values were derived adjusting the possible benefits by the pollution factor of the study area. In some functions the present benefit is zero. For instance, fishing does not occur in Lunawa Lagoon anymore due to pollution. Similarly, all environmental benefits have been presently deteriorated. The study assumed that implementation of the sewer network project for 30 years would improve the environmental quality of the area up to normal level which will provide maximum benefits.

**Table 6.5. Benefits/ avoided losses in Lunawa Lagoon, Bolgoda Lake and Bellanwila- Attidiya marsh due to sewerage management**

Economic benefits	US\$ per year	
	Present scenario	Project scenario
<b>Direct Use Values</b>		
Fishing & food		
Lagoon	0 <sup>1</sup>	74,559 <sup>1</sup>
Marsh & Lake	6486 <sup>2</sup>	64,855 <sup>2</sup>
Agriculture	1650 <sup>3</sup>	33,000 <sup>3</sup>
Recreation	3643 <sup>4</sup>	72,857 <sup>8</sup>
Tourism	48,571 <sup>5</sup>	485,714 <sup>9</sup>
<b>Indirect Use Values</b>		
Nutrient cycling		
Water quality regulation		
Lagoon	423,083 <sup>6</sup>	4,230,835 <sup>11</sup>
Marsh	225 <sup>7</sup>	900 <sup>10</sup>
Flood control	8645 <sup>8</sup>	34,580 <sup>6</sup>
Sink(waste treatment):Lagoon & Lake		
Industrial	0 <sup>9</sup>	510,000 <sup>4</sup>
Domestic	0 <sup>9</sup>	2,125 <sup>5</sup>
Sink waste treatment: Marsh	468 <sup>10</sup>	4,680 <sup>7</sup>
Refugia (habitats for wildlife)	1824 <sup>11</sup>	18,240 <sup>12</sup>
<b>Non-use Value</b>		
Existence values and optional values	8,823 <sup>12</sup>	8,823 <sup>13</sup>

<sup>1</sup>Currently fishing in lagoon is zero.

<sup>2</sup>It was assumed that fishing at the lake and marsh has been reduced to about 10% of the potential capacity.

<sup>3</sup>Agricultural benefits were assumed to be reduced to 5% due to water pollution.

<sup>4</sup>Recreation benefits were assumed to be reduced to 5%.

<sup>5</sup>Tourism benefits are reduced to 10%.

<sup>6</sup>Water quality regulation function of the lagoon has been reduced to 10% due to sedimentation.

<sup>7</sup>Water quality regulation function of the marsh has been reduced to 25% .

<sup>8</sup>Flood control benefits have been reduced by 25%, due to sedimentation.

<sup>9</sup>Waste treatment function of the lagoon and lake have reached the maximum capacity, so that the system cannot take any more waste without damaging the environment.

<sup>10</sup>Waste treatment capacity of the marsh has not reached the maximum yet, and it is assumed this potential has been reduced to 10%.

<sup>11</sup>The ability of the system to provide refuge for different species has been reduced to 10% due to pollution and eutrophication.

<sup>12</sup>The existence values and option values in the area were assumed to be the same.

The values of present benefits are given under the present scenario column, while the improved benefits after 30 years implementation of the project are given under the project scenario in table 6.6. This means the present scenario is without project and the project scenario is with the project situation.

#### **6.4 With project benefits/ Project scenario**

The project benefits were estimated for 30 year period. Assuming that the inflation rate in the country is constant at 3% for the entire project period of 30 years, The potential benefits of Lunawa Lagoon, Bolgoda Lake and the Bellanwila-Attidiya marsh were estimated. The total direct use benefits of the project for 30 yr. period were estimated as US\$ 34.8 million (Table 6.6). The indirect and non-use benefits of the project area were estimated as US\$ 228.8 million (Table 6.7). Therefore the total benefits were compounded at 3% for 30 year period to estimate annual benefit flow of the project.

With project benefits were discounted at 5% discount rate and given in table 6.8. Thus the net present value (NPV) of total benefits of with project scenario was estimated for 30-year period to be US\$ 122.5 million.

#### **6.5 Without project benefits/ Present Scenario**

Given the data and time constraints, without project benefits were estimated by multiplying the with-project benefits by a pollution factor of respective environmental functions of the area. For example, if a particular function is completely degraded the with-project benefits were multiplied by 0%, and if 10% of the activity of the function still remains, with project benefits were multiplied by 10%. Then the benefit stream for the 30 year period was estimated assuming the pollution level will not further deteriorate, for the purpose of this analysis, even though this might be quite unrealistic.

This assumption, however, can qualify due to the fact that there is a huge public concern on the pollution level of the area, so that even without the project it is unlikely that the pollution level will further increase. These benefits were also compounded at 3% discount rate to adjust for inflation. The total direct use benefits of the present scenario were estimated as US\$ 2.87 million (Table 6.9). The total indirect and non-use benefits of the present scenario were estimated as US\$ 21.1 million (Table 6.10).

Benefits of present scenario were discounted at 5% discount rate and given in Table 6.11. The net present value of the total benefits of without project scenario was estimated to be US\$11.1 million (NPV).

## **6.6 Net present value of the total Environmental Damage and total project benefits**

It was assumed that the difference between with project benefits and without project benefits is the total environmental damage occurred in the area. The assumption was that this damage is avoided by the project.

The net present value (NPV) of total benefits of with project scenario was estimated for 30-year period at 5% discount rate to be US\$ 122.5 million. The net present value of the total benefits of without project scenario was estimated to be US\$11.1 million (NPV). The difference of benefits between with project and the without project scenario is about US\$ 111.4 million (NPV), which is the total environmental damage occurred or environmental benefits of the project.

The net present value of total project benefits = with project benefits US\$ 122.5 - without project benefits US\$ 11.1 million = US\$ 111.4 million

## **6.7 Assessment of Project cost**

The National Water Supply and Drainage Board (NWSB) estimated the capital cost of this project in 1996. Accordingly, the capital cost of proposed wastewater management facility for the period of 1998-2002, has been estimated to about US\$ 14 million (table 6.12). Since the proposed sewer network is planned to be connected to the existing Wellawatte sea outfall, a pre-treatment of the industrial waste has to be done before being connected to the Wellawatte outfall, in order to avoid releasing substances to the sea. However, the project proponents are not planning any such pre-treatment facilities, because they expect the industries to have their own pre-treatment facilities. However, benefit cost analysis of this type of a project without pre-treatment cost is incomplete. Therefore, for this analysis we have included the estimated cost of the pre-treatment assuming that the project includes pre-treatment component.

Wastewater is transported up to the ocean outfall through a marine discharge line, which extends up to a distance of 1243.5 meters into the sea at a depth of 10m. The mixing due to the dispersion effects at the outfall will dilute the pollutants, eliminating the need for secondary treatment prior to disposal, since pretreatment will be done before connecting to the sewer network. The study assumed that the facility would last for more than 30 yrs. The annual maintenance cost was estimated to \$ 0.067. The total pre-treatment cost for 30 year was estimated to US\$ 75.6 million. The total expected cost of two major activities according to the National Water Supply and Drainage Board, are given in Table 6.12.

**Table 6.6. Direct use benefits from Lunawa Lagoon, Bolgoda Lake and Bellanwila- Attidiya marsh in US\$ under project scenario**

Year	Fishing & food		Recreation	Tourism	Agriculture	Total
	Lagoon	Lake				
1998	74559	64855	72857	485714	33000	730985
2027	175703	152835	171692	1144617	77767	1722614
Total (for 30 yrs.)	3547175	3085504	3466202	23108045	1569989	34776915

**Table 6.7. Indirect and non-use benefits from Lunawa Lagoon, Bolgoda Lake and Bellanwila-Attidiya marsh in US\$ under project scenario**

Year	Water quality Regulation		Flood control	Sink waste treatment: lagoon & lake		Sink waste treatment		Existence & optional values	Total
	Lagoon	Marsh		Industrial	Domestic	Marsh	Refugia		
1998	4230835	900	34580	510000	2125	4680	18240	8823	4810183
2027	9970240	2121	81490	1201848	5008	11029	42984	20792	11335512
Total (for 30 yrs.)	201283734	42818	1645158	24263462	101098	222653	867776	419758	228846457

**Table 6.8. Discounted benefits in US\$ under project scenario**

Year	Fishing & food		Recreation	Tourism	Water quality Regulation			Sink waste treatment: lagoon & lake		Sink waste treatment		Existence & optional values	Agriculture	Total
	Lagoon	Lake			Lagoon	Marsh	Flood control	Industrial	Domestic	Marsh	Refugia			
1998	71009	61767	69388	462585	4029367	857	32933	485714	2024	4457	17371	8403	31429	5277304
2027	40654	35363	39726	264839	2306889	491	18855	278081	1159	2552	9945	4811	74063	3077428
Total (30yrs.)	1634282	1424549	1600314	10668772	92930851	19769	759554	11202218	46676	102797	400644	193798	1495227	122479451

**Table 6.9. Direct use benefits from Lunawa Lagoon, Bolgoda Lake and Bellanwila- Attidiya marsh in US\$ under present scenario**

Year	Fishing & food		Recreation	Tourism	Agriculture	Total
	Lagoon	Lake				
1998	0	6486	3643	48571	1650	60350
2027	0	15285	8585	114461	3888	142219
Total (30yrs.)	0	308574	173317	2310786	78499	2871176

**Table 6.10. Indirect and non-use benefits from Lunawa Lagoon, Bolgoda Lake and Bellanwila-Attidiya marsh in US\$ under present scenario**

Year	Water quality Regulation		Flood control	Sink waste treatment: lagoon & lake		Sink waste treatment		Existence & optional values	Total
	Lagoon	Marsh		Industrial	Domestic	Marsh	Refugia		
1998	423083	225	8645	0	0	468	1824	8823	443068
2027	997023	530	20373	0	0	1103	4298	20792	1044119
Total (30 yrs.)	20128350	10704	411289	0	0	22265	86778	419758	21079144

**Table 6.11. Discounted benefits in US\$ under present scenario**

Year	Fishing & food		Recreation	Tourism	Agriculture	Water quality Regulation		Flood control	Sink waste treatment: lagoon & lake		Sink waste treatment		Existance & optional values	Total
	Lagoon	Lake				Lagoon	Marsh		Industrial	Domestic	Marsh	Refugia		
1998	0	6177	3470	46258	1571	402936	214	8233	0	0	446	1737	8403	479445
2027	0	3537	1986	26484	3703	230689	123	4714	0	0	255	995	4811	277297
<b>Total (30yrs.)</b>	0	142466	80019	1066868	74761	9293074	4942	189889	0	0	10280	40064	193798	11096161

**Table 6.12 Expected budget for the implementation of sewer network to protect the Lunawa Lagoon, Bolgoda Lake and Bellanwila, Attidiya Marsh**

Activity	Total capital Cost \$ million
Sewer network and pumping stations – 21 km sewers and 4 sewerage pumping stations*	6.67
Wastewater disposal system- 2 sewage pumping stations and 10 km long pumping main*	7.33
Maintenance/ yr	.067
Estimated pre-treatment cost assuming project will include pre-treatment	0.46 in 1998 (estimated for 30 years assuming 1.1% increase of load per year)

The Project cost stream estimated for 30 years, discounted at 5% discount rate is given in table 6.13.

### 6.8 Net Present Value of the cost

The project has been planned to be completed in five years. The capital cost of the project was estimated to be around US\$ 14 million, the present value of which at the 5% discount rate is about US\$ 12 million. Expected maintenance cost after the completion of project is US\$ 0.067 per annum, and the total maintenance cost for the 30 yr. period is US\$ 1.675. Pre-treatment cost of the project for 30 years was estimated to US\$ 75.6 million. The total cost (capital , maintenance and pre-treatment cost) was estimated as US\$ 106.7 million. The present value of the total cost discounted at the 5% discount rate, was estimated to be around US\$ 49 million.

### 6.9 Comparison of costs and benefits/ Cost benefit ratio

The NPV of the difference between with project benefits and without project benefit, that is the total project benefits, were estimated to US\$ 111.4. The net present values of different environmental functions are given in table 6.14. This shows that the net present value of the project benefits (US\$ 111.4 million) in comparison to the net present value of the cost of the pollution control measures proposed for the project area, which is US\$ 49 million is significantly high.

This gives the benefit cost ratio of 2.27 (Table 6.15)

**Table 6.13. Lunawa Lagoon, Bolgoda Lake and Bellanwila- Attidiya marsh – Cost of pollution control (Figures in US\$Million)**

Year	Capital cost		Pre-treatment cost *	Operating & maintenance	Total	Discounted cost stream
	Sewer network	Wastewater disposal through the sea outfall				
1998	1.33	-	0.459626		3.119626	3.119626
1999	2.66	2.0	0.505589		9.825589	2.963645
2000	2.0	2.0	0.556148		8.556148	2.815462
2001	0.67	2.0	0.611763		5.951763	2.674689
2002		1.33	0.672939		3.332939	2.540955
2003			0.740233	.067	0.874233	2.413907
2004			0.814256	.067	0.948256	2.293212
2005			0.895682	.067	1.029682	2.178551
2006			0.98525	.067	1.11925	2.069624
2007			1.083775	.067	1.217775	1.966142
2008			1.192152	.067	1.326152	1.867835
2009			1.311367	.067	1.445367	1.774444
2010			1.442504	.067	1.576504	1.685721
2011			1.586754	.067	1.720754	1.601435
2012			1.74543	.067	1.87943	1.521364
2013			1.919973	.067	2.053973	1.445295
2014			2.11197	.067	2.24597	1.373031
2015			2.323167	.067	2.457167	1.304379
2016			2.555484	.067	2.689484	1.23916
2017			2.811032	.067	2.945032	1.177202
2018			3.092136	.067	3.226136	1.118342
2019			3.401349	.067	3.535349	1.062425
2020			3.741484	.067	3.875484	1.009304
2021			4.115632	.067	4.249632	0.958838
2022			4.527196	.067	4.661196	0.910897
2023			4.979915	.067	5.113915	0.865352
2024			5.477907	.067	5.611907	0.822084
2025			6.025697	.067	6.159697	0.78098
2026			6.628267	.067	6.762267	0.741931
2027			7.291094	.067	7.425094	0.704834
Total	6.66	7.33	75.60577	1.675	106.9358	49.00067

**Note: Discounted at 5% discount rate.** \*Total annual load of 5037 m<sup>3</sup> was compounded by 1.1% to estimate future wastewater load. The pretreatment cost of 1 m<sup>3</sup> = US\$ 0.25 (NWSDB 1996). + - Operating and maintenance cost was assumed to remain the same, since its value is relatively very low.

**Table 6.14. Discounted benefits of sewerage management at Lunawa Lagoon, Bolgoda Lake and Bellanwila-Attidiya marsh**

Economic benefits	NPV in US\$		
	Present scenario	Project scenario	Environmental damage/ project benefit
<i>Direct Use Values</i>			
Fishing & food			
Lagoon	0	1634282	1634282
Lake	142466	1424549	1282083
Agriculture	74761	1495227	1420466
Recreation	80019	1600314	1520295
Tourism	1066868	10668772	9601904
<i>Indirect Use Values</i>			
Nutrient cycling			
Water quality regulation			
Lagoon	9293074	92930851	83637777
Marsh	4924	19769	14845
Flood control	189889	759554	569665
Sink(waste treatment): Lagoon & Lake			
Industrial	0	11202218	11202218
Domestic	0	44676	44676
Sink waste treatment: Marsh	10280	102797	92517
Refugia	40064	400644	360580
<i>Non-use Value</i>			
Existence values and optional values	193798	193798	0
Total	11.1 million	122.5 million	111.4 million

\* Discounted at 5% for 30 year period.

Note: The Total Economic Value (TEV) model can always have double counting problem if value categories are not properly defined. For example, recreation value and amenity value can always be double counted, if they are not properly defined. In this study, recreation benefits were calculated using the benefit of boating and wind surfing. The tourism benefits were calculated valuing the amenity value which was calculated by estimating the lagoon- and lake- overlooking benefits of the star hotels located in the area. The nutrient cycling value, for example, was not considered since water regulation and waste sink functions include nutrient cycling function.

**Table 6.15. Benefit / Cost Ratio**

NPV of benefits/ avoided Environmental damage	111.4 US\$ million
NPV of project cost for sewer network	49 US\$ million
Benefit/cost ratio	2.27

## 6.10 Discussion

This study is one of the first studies of this kind conducted in Sri Lanka. Valuation of environmental damage in Sri Lanka is a broad approximation and is meant to be interpreted as a general order of magnitude due to unavailability of data. In this study, the monetised effects were estimated with sensible manipulation of existing information and judgement. The Environmental damage/ effects were estimated according to three major groups:

Direct use effects, Indirect use effects, Non-direct use effects. All these categories cannot be estimated in monetary terms.

The estimated monetised effects/damage of the study area amounts to approximately about US\$ 111million. The estimated Gross Domestic Product of Sri Lanka is roughly US\$ 15 billion. Therefore the avoided environmental damage of the study area is about 0.74%. Although this is relatively low as a percentage, it can be considered a significant contribution to the national economy.

According to this study, loss of tourist revenue is the largest direct effect from land-based sources of pollution in the study area. It was estimated to amount to about \$ 9.6 million (NPV). This damage reflects loss of tourist revenue calculated on the basis of estimates of decline in hotel bed space turnover relating to the pollution threat from land - based sources. In 1999, the tourist arrival in Sri Lanka is 436440. Gross earning from tourism is about US\$ 274 million in 1999. Of the total international tourist arrival, about 40-60% are eco-tourists. The tourist arrivals are expected to grow by an average of 4% per annum during the next two decades. The eco-tourism is expected to grow by 10-15%. Therefore expected tourism benefits in the project area are significant.

Recreational or amenity value in the area is also significant. The residential amenity value including recreation of the area was estimated to US\$ 1.52 million (NPV). Residential amenity is a qualitative concept but some indirect monetary estimates of amenity may be derived through an assessment of the changes in property values, isolated as much as possible from other influences, due to environmental damage. This impact was estimated indirectly by assessing the reduction in the rate of appreciation of property in selected area with potential environmental threats such as those due to liquid waste disposal. It took into account properties that are retained for residential use whose owners are indifferent to capital gains from potential change of use (tourist, restaurant, etc). Recreation losses occur because the people in the area do not have sufficient places for recreation purposes. Every year residents in the area as well as people from out side areas travel to this area for recreation purpose. The recreation value was estimated transferring the result of study done at Negombo lagoon, which estimated it to be US \$ 0.3 million per year.

The water quality regulation function of the lagoon and the marsh has been reduced significantly due to serious pollution. Once the pollution level increases, the natural water regulation capacity cannot clean the water. The reduction of pollution level to levels that can be treated naturally is expected by the project. Pollution of ground water can be attributed to leakage from tributaries, domestic waste water, solids, surface wastewater and interference of sea water. Sewerage system would greatly reduce or damage the ground water. Reduction of pollution in the area with the help of sewerage system and separate industrial treatment would reduce to the groundwater pollution. This study estimated the water quality regulation damage to be US\$ 83.6 million (NPV).

Bellanwila- Attitidiya marsh, which is located within the project area, belongs to one of the declared bird sanctuaries in the country. The marshland, which is situated in a relatively urban area, is about 60 ha. This area is inhabited by large number of migratory birds of different species. Sewage pollution can significantly influence the degradation of the sanctuary. The refugia function was estimated to be US\$ 0.4 million (NPV), as a proxy for the benefits of the bird sanctuary benefits.

Fishing losses are due to the pollution in the area. This include loss of Shellfish and Finfish. Pollution in the lagoon and the lake has also created unsuitable conditions for aquaculture. Both quantity of fish and variety of fish basis declined due to the pollution. The maximum capacity of fish productivity of these water bodies would have been extremely high if not for the degradation due to industrial pollution. Considering the fish productivity at medium level and which could be compared to Negombo Lagoon of similar ecosystem, the fish productivity is US \$ 857.00 per ha. Nursery function related to fish produces an income of US \$ 571.00 per ha. Ornamental fish extraction for exportation had been a high source of income though it does not exist as an industry. This study estimated the fishing losses as US\$ 16.4 million.

The damage to human health occurs from the lake water based activities, such as swimming, bathing, boating and fishing. However, at present only boating and fishing occur but no swimming or bathing can be done due to pollution. Mosquito breeding in polluted, stagnant water (specially in Lunawa Lagoon) is another health hazard, since mosquitoes are vectors of certain diseases. Due to unavailability of data, this function was not estimated.

It is unrealistic to attempt to monetise all environmental threats and damage. Some, if not many, impacts on the environment cannot be measured in money values because they are intrinsically qualitative and people cannot express how much a particular resource (beauty, coastal amenity, walk along the beach, etc) is worth to them. In extreme cases it should be possible eventually to assess how much the residents of Moratuwa/Ratmalana would be willing to pay to protect or keep a particular part of the coast in its natural state, or to assess how much the population would be willing to accept as compensation for a given damage or loss of amenity or loss of option to enjoy open landscape, views, etc. The preferences of future generations are unknown at present but sustainable development required strategies to allow future generations to enjoy the environment and exercise their options.

In Sri Lanka these qualitative effects are particularly important because the small size of the island renders the coastal environment part of everybody's daily life and changes to the environment have qualitative impacts on the whole community. Links with the past and images of the city and its seafront environment are quality notions affected by tourism. Th historical heritage of Sri Lanka and the high standard of aesthetic and cultural criteria prevailing in Sri Lanka indicate evident sensitivity to qualitative effects and appreciation of environmental beauty. People place existing values for eco-systems such as Lunawa Lagoon, Bolgoda Lake and Bellanwila-Attidiya marsh for their resources as well as visual attraction. People also can put values for the biodiversity in the area. Existing value can be estimated through survey in a Willingness to Pay (WTP) study.

The present study was carried out within a relatively short period of time (within a few months). Due to inadequate data availability in Sri Lanka in the field of wastewater management as well as economic benefit evaluation of coastal and marine systems, this study had to rely on the secondary data and the results transferred from the studies done in other countries. Ideally, the relevant data should have been collected through an on-site field survey. This will require more resources and time. So far no proper study has been done with respect to the benefits and cost associated with important functions in coastal zone of Sri Lanka, in relation to wastewater management. Therefore this is the first study of this kind in the country.

This situation can be improved by investing more on research in environmental economics, particularly valuation of environmental functions of different ecosystems. If such value estimates are available, this type of short-term benefit-cost analysis can effectively use such values. Therefore, it is recommended that more focus should be given to research to monetary estimation of most non-market benefits of various ecosystems, particularly coastal and marine, and forest ecosystems.

## 7.0 CONCLUDING REMARKS AND RECOMMENDATIONS

Providing proper wastewater facilities to the people is essential to improve the quality of life. This also helps to eradicate poverty of the people. Addressing sanitary and sewerage management issues directly impacts on the natural system, particularly on coastal and marine resources, since it reduces the pollution. This also directly impacts on the improving human health. Reduction of health cost will improve the poverty problem in the society, which will subsequently help improve the environment. Poverty has been recognized as one of the major causes of environmental degradation. In the South Asian region, the impact of land-based activities, particularly urban and domestic sewage on marine system is significant.

Most developing governments are not in a position to allocate their limited budget for wastewater system development since they have other priorities. Traditionally, only public funds have been invested in the sewer network development. This has not been the lucrative business for the private sector. It is now realized that without effective private sector participation, providing sewerage facilities to the people in developing countries will not improve. In other words, without private sector investment, pollution of coastal and marine system from land-based activities cannot be effectively managed. Therefore this study investigated whether investment in sewer network is an economically viable venture in order to promote private sector investment in this field.

This study analyzed the proposed sewer network at Moratuwa/ Ratmalana area in Sri Lanka that costs US\$ 14 million. This sewer network is supposed to connect to the existing sea outfall at Wellawatte. This project was proposed particularly to protect the Lunawa Lagoon, Bolgoda Lake, and Bellanwila-Attidiya marsh, and associated marine ecosystem.

However, this project could not be implemented yet due to non-availability of funding. Part of the reason for this is that international funding agencies do not consider wastewater management as a priority area. They have not realized the global benefits of the wastewater management, particularly through the protection of coastal and marine ecosystem and prevention of possible transboundary health hazards.

This case study clearly demonstrates that the investment in wastewater management can be economically justified by the benefits of the coastal and marine protection itself. The coastal and marine eco-system provides myriad of direct, indirect and non-use benefits for the humanity. Lack of wastewater management facilities would lead to degradation of the inland water bodies and subsequently coastal and marine eco-system, damaging most ecological functions. Therefore, in order to protect coastal and marine system particularly in the South Asian seas, the major measures that should be taken include addressing the problem of sewerage management.

In view of these, investment in wastewater management is necessary not only for local sustainability but also for global sustainability. Neglecting wastewater issues will destroy coastal and marine biology not allowing future generation to exercise their options.

This study suggests that investing in wastewater management is economically viable when its entire benefits, including global benefits are taken into account. According to this study, the net present value of the cost of sewer network was US\$ 11.1, while the net present value of the project was about US\$ 111.4 million. The benefit/cost ratio of the sewer network project by way of coastal and marine protection benefit, was estimated to be 2.27. This benefit/cost ratio is economically highly significant.

Therefore investing in wastewater management can be considered as an economic activity if a proper mechanism is developed to capture total benefits of the protection of marine and coastal system, including direct use, indirect use, and non-use benefits. This can promote private sector participation in the field of wastewater management.

In conclusion, this study indicates that wastewater management can be a viable private sector investment if its benefit on marine protection is taken into project analysis. If government recognizes the non-market benefits of the protection of coastal and marine system, the private sector can be attracted for investing in the sewer management.

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