An overview of socio-economic opportunities related to the protection of coastal and marine environment from land based sources of pollution particularly urban and domestic sewage in the South Asian Seas Region

Report submitted to
The South Asia Cooperative Environment Programme (SACEP)

April 2000

An overview of socio-economic opportunities related to the protection of coastal and marine environment from land based sources of pollution particularly urban and domestic sewage in the South Asian Seas Region

Report submitted to
The South Asia Cooperative Environment Programme (SACEP)

B.M.S. Batagoda
Ajith de Alwis
Prasanthi Gunawardena
Asitha Senevirathne
Devika Karunaratne

Contents

		Page No.
1.0	Background	1
2.0	Inaugural Session	1
3.0	Technical Sessions	9
4.0	Group Discussions	26
5.0	Concluding Session	34

Annexes **35**

Annexure i

.....Tentative Agenda

Annexure ii

.....List of Participants

Table of contents

Page

Executive Summery

Chapter 1 *Introduction*

1.1	Background		1
1.2	Methodology		3
1.3	Report organization		3
1.4.	Introduction to the Indian Ocean		4

Chapter 2 *Types and quantities of point and non-point sources of sewage from domestic and urban centers affecting coastal and marine eco-systems*

2.1.	Introduction		8
2.2.	Current situation of wastewater in the South Asian region		8
	2.2.1.	Pakistan	8
	2.2.2.	Bangladesh	9
	2.2.3.	India	9
	2.2.4.	Sri Lanka	10
2.3.	River bodies, drainage basins and openings to the sea		11
2.4.	Drainage/run-off into surface and groundwater bodies		12
2.5.	Surface water pollution		14
2.6.	Water quality standards		14
2.7.	Present activities with impacts on the coastal environment		16
2.8.	Future developments that affect wastewater management		19
2.9.	Estimated Sewage load for South Asian countries		20

Chapter 3 *Review of plans programme & projects of wastewater management that has an impact on coastal and marine system in the South Asian Sea*

3.1.	Introduction		22
3.2.	Projects and plant in Sri Lanka		23
	3.2.1.	Beira Lake Restoration Project	24
	3.2.2.	Major activities under the Beire lake project	26
3.3.	Relocation and Modernization of Tanneries Project- Bata atha, Sri Lanka		27
3.4.	Clean Settlement Project		29
3.5.	Cleaning of sewage system/net work		29
3.6.	San Sebastian canal Project		30
3.7.	Review of the role of local governments		31
3.8.	Coastal Management Plans - 1996		32
3.9.	Ja-ela/Ekala wastewater management project		33

3.10. Ratmalana/Moratuwa wastewater management project 34
3.11. Regulatory framework related to Coastal Protection 34
3.12. Responsible Institutions for coastal and Marine Resources 38

Chapter 4 *Identification of the Economic Sectors Making Use of Coastal and Marine Environment*

4.1. Introduction 41
4.2. Coastal based tourism sector in South Asia 42
4.3. Coastal based industrial sector in South Asia 42
4.4. Coastal based fisheries sector in South Asia 44
4.5. Coastal based ports and harbours sector in South Asia 47
4.6. Coastal based Sanitation and sewerage sector 49
4.7. Coastal Agriculture 49

Chapter 5 *Quantitative Assessment of the Economic Benefits of coastal and Marine Environment*

5.1. Introduction 51
5.2. Benefits of the coastal and marine environment 52
5.2.1. Coral Reefs 52
5.2.2. Estuaries and Lagoons 53
5.2.3. Mangroves 55
5.2.4. Seagrass Beds 55
5.2.5. Salt Marshes 56
5.2.6. Barrier Beaches, Spits and Dunes 57
5.3. Economic cost of degradation of the coastal and marine environment in relation to specific economic activities 58
5.4. Quantitative assessment of the economic benefits - Theoretical Framework 59
5.4.1. The total economic value of marine ecosystems 59
5.5. Techniques for quantifying economic values of marine ecosystems 61
5.5.1. Techniques for quantifying direct values 61
5.5.2. Techniques for quantifying indirect values 61
5.5.3. Techniques for quantifying non use values 62
5.6. Quantitative estimates of the coastal and marine environmental benefits 62
5.6.1. Economic estimates of corals 62
5.6.2. Economic estimates of lagoons 63
5.6.3. Economic estimates of mangroves 64
5.6.4. Economic estimates of estuaries 67
5.6.5. Summary of economic estimates of coastal and marine system 67
5.6.6. Limitations to valuation 71

Chapter 6 *Potential public - Private Partnership in Sewerage Management*

6.1. Introduction 73
6.2. Sewerage infrastructure need in South Asian Countries 73
6.3. Private sector investment opportunities 74
6.4. Private sector investment experience in the sewerage sector 75
6.5. Expenditure on sewerage management in SAARC region 76
6.6. Investment in sewerage management in Bangladesh 79
6.6.1. Privatization Policies of Bangladesh 80
6.7. Investment in sewerage management in India 80
6.8. Investment in sewerage management in Pakistan 81
6.9. Investment in sewerage management in Sri Lanka 81
6.10. Justification for private sector involvement in sewerage management 83
6.11. Opportunities of privatization in sewerage management 83
6.12. Types of Public Private Partnership (PPP) options in the sewerage management 85
6.12.1. Service agreements 86
6.12.2. Leasing 86
6.12.3. Built-Operate-Transfer (BOT) 87
6.12.4. Turnkey 87
6.12.5. Franchise 87
6.12.6. Concession 88
6.12.7. Full Private Company 88
6.12.8. Public Private partnership 88
6.13. Stakeholders in private sector involvement in water supply and sanitation 89
6.14. Risks involved in private sector sewerage management 90
6.15. Planning private sector involvement in sewerage sector 90
6.16. Recommendation for private sector involvement for the protection of coastal and marine system through investment in sewerage management 91

Chapter 7 *Summary conclusions and recommendations*

7.1. Introduction 93
7.2. Sewage as a pollutant to marine system 93
7.3. Economic Assessment 95
7.4. Development plans 97
7.5. Private Partnership (PPP) for sewage management 97
7.6. Conclusions recommendations 100

References 101

Executive Summery

The Global Programme of Action (GPA) for the protection of marine environment from land based activities has identified the domestic and urban sewage as one of the major pollutants in the South Asian Seas. Countries in the South Asia are also of the view that domestic and urban sewage is one of the major threats to the coastal and marine pollution in the India Ocean. Environmental impacts associated with domestic sewage and wastewater discharges are generally local but has trans-boundary implications in certain geographic areas through pollution of marine environment.

Many countries in the South Asian region have several large rivers flowing through their land mass which have become badly polluted due to increased human activities. The volume of sewage in the region is constantly on the increase due to increasing urbanization. Sewage and industrial waste in these countries, either untreated or partially treated are allowed to be discharged into the rivers and seas. It is estimated that about 111 million gallons of sewage per day is generated in the city of Karachchi, Pakistan from domestic and urban source. The total BOD load from the domestic waste in the Chittagang area in Bangladesh is estimated as some 3.5 tons per day. Nearly 20% of the population of India live within 40 Km from the coastal sea. The sewage generated in these coastal cities and towns are directly disposed off into the sea through creeks or through rivers. In Sri Lanka, the total BOD load generated from sewage, that have potential impacts on the marine system has been estimated at 597696 Kg BOD per day. Sewage generated by entire population in Maldives has potential impacts on the marine environment.

This study estimated the total BOD from sewage generated by the population in the South Asian countries as 1.8 million Kg BOD per day in Sri Lanka, 98.7 Million Kg BOD per in India, 15.3 million kg BOD per day in Pakistan, 12.8 million Kg BOD per day in Bangladesh and 0.28 million Kg BOD per day in Maldives. As estimated by the study, the total BOD load from sewage that has potential impacts on the coastal and marine environment for each country are 0.6 million Kg BOD per day (30% of population) in Sri Lanka, 19.7 million Kg BOD per day in India (20% of population), 1.2 million Kg BOD per day in Bangladesh (10% of the population), 2.3 million Kg BOD in Pakistan (15% of the population) and 0.028 million Kg BOD per day in Maldives (100% population). Accordingly, the study estimated total BOD load of sewage from South Asian countries that have potential impacts on the Indian Ocean as 23.9 million Kg BOD per day.

Sewerage pollution can cause disastrous impacts on the marine system as well as human health. Increased BOD level in the marine system will lead to the destruction of marine biological system. In the South Asian region, given high rate of population increase, the impact of sewage on the marine system can be great, if proper management system is not introduced.

National and sub-national development plan related to the sewage management as well as coastal and marine environmental protection will also have significant positive or

negative impacts on the marine environment. Beira Lake restoration plan, relocation and modernization of tanneries project at Bata Ata, and Ja-Ela, Ekala and Moratuwa, Ratmalana common treatment plants in Sri Lanka are some examples. The costs of these development plans can be economically justified by the potential benefits of the marine environment as well as the economic opportunities of use of sewage for commercial activities.

Marine and coastal systems have been the foremost economic base for the coastal population in the world. The economic activities of marine ecosystem are largely based on two economic functions viz. as a resource supplier and as a waste assimilator. According to the recent estimates, lagoons have the total economic value of US$ 2000 $ha^{-1} y^{-1}$. Carbon sequestration benefits of coral reefs have been estimated to US$ 50,000 per square meter coral reef in terms of the global warming damage avoided. The value of marine and estuarine fisheries is about US$ 85 $ha^{-1} y^{-1}$. Protection from storm damage offered by mangrove has been valued at about US$ 38 $ha^{-1} y^{-1}$. Contribution to the agriculture from mangroves has been estimated to US$ 165 $ha^{-1} y^{-1}$. Potential economic value of shrimp farming is about US$ 2106 $ha^{-1} y^{-1}$. Aesthetic value of the coastal and marine environment has been estimated to be US$ 230 $ha^{-1} y^{-1}$.

The cost saving from coastal wetland for treatment of wastewater range from US$ 78 to 3470 per acre of wetland use for treatment. The value of lagoon as sink for untreated industrial waste is estimated as US$ 600 $ha^{-1} y^{-1}$. The value of lagoon as sink for domestic and municipal waste has been estimated as US$ 2.5 $ha^{-1} y^{-1}$.

Proper management of domestic and urban sewage and sanitation is the only solution to protect the marine system from sewage pollution and its socio-economic opportunities. However, at the rate of progress, the investment for the provision of suitable managed sanitation will be insufficient to satisfy very large number of population in the region. Given the prevailing economic condition in the South Asian countries, the public funds are not sufficient to manage sewerage system. Therefore private sector investment in the sewerage management has been encouraged not only as a measure to improve health condition but also to protect the marine and associated fresh water system from sewage pollution. However many governments in the South Asian region have failed to attract private sector investors into the sanitation and sewage management.

During the period from 1990 to 1994, the number of people without access to adequate sanitation increased by 171 million from 234 million in the Asia Pacific. The number of urban dwellers in Asia without access to sanitation reached to 371 million in 1994. Only 15 percent of rural Asian population had access to sanitation, which is only 332 million. The Asian and Pacific region needs about US$ 80-100 billion in investments in order to solve water supply and sanitation problem. The expenditure levels on wastewater management in the Asia and the Pacific varies from less than US$ 0.01 to over US$ 200 per Capita per annum. The minimum investment required for meeting the basic sanitation in India would be Rs 10.4 - 43.4 billion. The proposed investment for sanitation programme in Pakistan is about Rs. 7.8 billion. In Sri Lanka to meet proposed sanitation target, Rs. 1.6 billion is required annually.

This amount of money cannot be expected to come from traditional government sources and other development assistance. Therefore a large share of sewerage sector investment has to be obtained from private sector both domestic and foreign. Private Sector investment should be encouraged not only to raise investment capital, but also to increase financial efficiency and quality of services. All South Asian countries in principle have accepted the need for private sector investment in the sewerage sector. Therefore, sanitation and sewage infrastructure development in the region provides unprecedented business opportunities for the private sector, since public capital becoming increasingly limited.

The type of Private Public Partnership (PPP) available for sewerage management includes service agreements, leasing, Built-Operate-Transfer (BOT), Built-Own-Operate-Transfer (BOOT), turnkey, franchise and full private company. Among them, private public partnership (PPP) combining the government and private sector in a joint operation is the most acceptable approach for sewerage management in the South Asian region.

Although, sewage can be used as economic resources to generate income to the private sector through re-use of treated water for industrial and agriculture purpose, sales of bio-gas generated from sewage and sales of sludge for fertilizers, these incomes is not sufficient for viable private sector venture. Therefore governments should provide sufficient incentives to attract private sector for investment in the sewerage sector. The cost of incentive package to the government can be well justified by the benefits of the protected coastal and marine environment in the South Asian seas alone with the improved health condition of the public.

In summery following recommendations are made to promote sewage management in the South Asia in order to protect coastal and marine environment of South Asian seas;

1. Since sanitary facilities in the South Asian Region is poor, both domestic and urban sewage pause considerable pressure on the coastal and marine eco-system in the Indian ocean.
2. The total sewage generation in Sri Lanka has been estimated to 7244800 kg per day (as average sewage gives about 250 mg/l BOD and assuming a density of 1000 kg/m3) and 1811200 kg BOD load per day. Of this, the total load on the coastal zone (from 1/3 of population) has been estimated to 597696 kg BOD per day.
3. According to this approach, the BOD load from sewage on the coastal zone of South Asian Region has been estimated to 23.9 million kg BOD per day. This consists of 0.6 million kg BOD from Sri Lanka, 19.7 million kg BOD from India, 1.2 million kg BOD from Bangladesh, 2.3 million BOD from Pakistan, and 0,028 million kg BOD from Maldives.
4. National and sub-national development plans that address the domestic and urban sewerage will have significant in fact on the marine system i.e. Beira Lake restoration plan, Ja-Ela, Ekala sewerage system development plans in Sri Lanka.

5. The coastal and marine system provide great deal of socio-economic opportunities that include tourism, nature based tourism, provision of construction material, corals, agriculture, fisheries etc.
6. Domestic sewerage management itself is an economic activity i.e. re-use of treated water, bio-gas generation from sewerage etc. that will help to protect marine system.
7. It is inevitable that the growing demands for sewerage facilities for the population can not be met with the public investments. The Asia Pacific region requires about US$ 80 - 100 billion in investments in order to ease water supply and sanitation problem. The minimum investment required for meeting the basic sanitation in India would be Rs.10.4 - 43.4 Billion. The proposed investment programme of sanitation in Sri Lanka and Pakistan are Rs. 1.0 billion and Rs. 7.8 billion respectively. Therefore private sector involvement in the sewerage management sector is necessary in order to protect the marine environment from sewerage pollution.
8. The type of private sector involvement options in the sewerage management includes services agreement, leasing, Built-Operate-Transfer (BOT), Turnkey, Franchise, Concession, Built-Own-Operate-Transfer(BOOT) and full private company
9. Experience in the world has demonstrated the viability of private sector involvement in the sewerage management.
10. It is recommended that Public Private Partnership (PPP) in the sewerage management in South Asian Region can improve the quality of sanitation facilities available for the people while protecting the coastal and marine system in the Indian ocean from domestic and urban sewerage pollution.
11. However since sewerage management sector is not yet attractive to the private sector investment, governments in the South Asian Region should provide attractive incentive packages for private sector that involve in the investment in sewerage management activities. The cost of incentive package to the government can be well justified by the benefits of the protected coastal and marine system in the South Asian region alone with the improved health condition of the public.

Chapter 1

Introduction

1.1 Background

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 3 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 action 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 states 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.

In order to give effect to the objectives, the Global Programme of Action recommends combining five elements in the development of national programmes. They are a) Identification of the nature and severity of the problem; b) Contaminants; c) Physical alteration, including habitat modification and destruction in areas of concern; d) Sources of degradation and e) Areas of concern.

The long – term objective of national programmes of action should be to develop integrated strategies and programmes to address all action in relation to impacts upon the

marine environment form land-based activities. In order to make the Global Programme of Action more effective states should ensure that there are administrative and management structures necessary to support the national programme of action.

Apart from national programmes, the Global Programme of Action identifies the necessity for regional and sub-regional co-operation in order to strengthen and where necessary create new regional cooperative arrangements and joint action to support effective action, strategies and programmes.

It has also, identified the need for international cooperation for cost-effective implementation of the programme, by capacity building, technology transfer and cooperation and financial support. Review and implementation of the programme and its further development and adjustment must be at a global level.

The Global Programme of Action has identified pollutant sources and proposed methods and recommendations to alleviate and reduce the level of polluting in the areas of Sewage, Persistent Organic Pollutants (POP), Radioactive substances, Heavy metals, Nutrients, Sediment mobilization, litter and the physical alteration and destruction of habitants. 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 and 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 waster-water 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 to the socio-economic activities associated with the coastal ecosystem. Major economic activities affected include coastal tourism, recreation use, fisheries and associated activities. These potential economic benefits itself present 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 socio-economic

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.

The objective of this paper is therefore, to review potential socio-economic opportunities in the region of South Asian Seas affecting the marine and coastal environment with special reference to urban and domestic sewage. The paper addresses the following major issues specifically.

1. Review economic sectors making use of coastal and marine environment and national and sub-national plans.
2. Review quantitatively the type of point and non-point sources of sewage domestic and urban centers.
3. Quantitative assessment of economic benefits of use of coastal and marine environment using total economic valuation framework.
4. Review the environment impact on the marine environment from sewage.
5. Review the potential investment from public – private partnership in sewage management.

1.2 Methodology

This paper did not employ any empirical survey or analysis to gather original data. Secondary data were used. The Total Economics Value (TEV) framework was used for this analysis particularly to estimate the total benefits of the marine and coastal system (Chapter 5 presents detailed TEV mpdel). Various benefits of the marine system were presented in order to compare such benefits with potential of having proper sewerage system in place. Only if the benefits of having proper sewerage system is higher than the cost of such system, the political support for higher investment for sewerage management facilities can be obtained. Therefore attempt was made to present each benefits categories of coastal and marine system.

The assumptions made in this study were that i) domestic and urban sewerage cause significant level of pollution to the marine system; ii) without properly managing the wastewater and sewage in the region, it is difficult to protect coastal and marine environment in the South Asian seas; and iii) without effective public – private partnership, required investments for sewage management cannot be expected . Therefore the study also reviewed potential public private partnership for the sewerage management assuming that public fund will not be sufficient to provide better sewerage facilities in the South Asian region.

1.3 Report organization

The report was organized in five sections. The first section provides introduction, overview, background and of the study. The second section reviews quantitatively the type of point and non-point sources of sewage domestic and urban centers and also the review the environment impacts on the marine environment from sewage. National and sub-national plans with regard to potential pollution and benefit to the coastal and marine

environment, particularly in relation to Sri Lanka were reviewed in the third section. Forth section reviewed potential economic sectors making use of coastal and marine environment in order to assess economic benefits of the sector. Fifth section attempts to quantitatively assess the economic benefits of use of coastal and marine environment using total economic valuation framework. Potential public – private partnership in sewage management were discussed at the sixth section. The seventh section concludes the report with summary and conclusions.

1.4 Introduction to the Indian Ocean

This report addresses the marine and related coastal environment of Bangladesh, India, Maldives, Pakistan, and Sri Lanka (figure 1.1). From this region, 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 the center of the North Indian deep water, form 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. Nitrite Maxima of 110 – 220 mg/m, with an overall maximum value of 320 mg/m at 12 S in the North Indian Deep Water. This BOD concentration is partly due to domestic and urban sewage in the area.

The tropical Indian Ocean is considered rich in shallow tropical marine fauna. The least productive of the ocean area is the South Central Indian Ocean which is oligotrophic as compared to the rest of the ocean area which is fairly eutrophic. The Indian Ocean has a lower biological productivity than the Pacific or Atlantic Oceans due in part, to its relatively smaller continental shelf area. The shelves off India, Sri Lanka and Pakistan are prominent on the western coast whereas the eastern coasts and East Africa have narrow shelves fringed with mangroves and coral reefs. The region of maximum biological use to man is found in the continental shelf area. The islands have volcanic and coral type reefs. The Arabian Sea has the potential of being an exceptionally fertile area, especially during the southwest monsoon, due to upwelling induced by wind stress. In the Ras Hafun area, upwelling results in water rich nutrients with temperatures well below 20 C but lacking in the fertility apparent in more stable upwelling areas. Turbulence results in replenishment of nutrients and waters rich in plankton. Some regions of the Arabian sea are very fertile due to the discharge from various rivers, for example at the mouth of the Indus, as well as from upwelling. High concentrations of phosphates are recorded here and large precipitation accumulations may be found.

The effect of river discharge is also important in the Bay of Bengal for example, there is a high inflow of mud from the Ganges river. The discharge from the turbid rivers is picked up by the Northeast Monsoon Current and taken along the East Coast during the Northeast Monsoon. The Southwest Monsoon, with its heavy rains, causes and increasing flow of fresh water from the rivers with an increased sediment load entering the water.

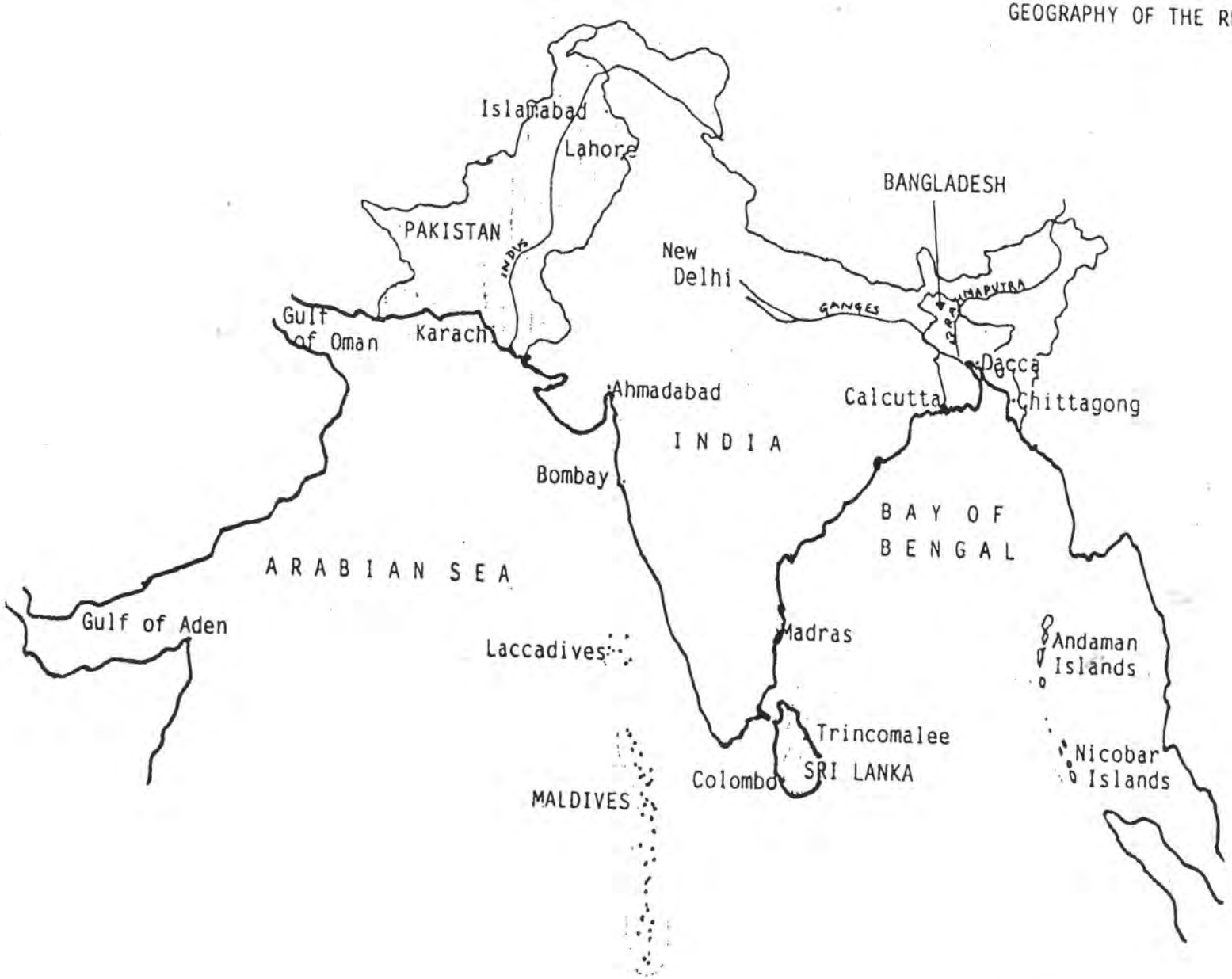


Figure 1.1 Geography of the region

Increased sediment reduces light penetration and transparency and results in a decrease of plankton as measured in dry weight per m (cube). The sharply stratified low salinity at the surface, due to high fresh water from the Ganges and Irrawaddy rivers, is the cause for the relatively poorer fertility seen in the Bay of Bengal as compared to the Arabian Sea (table 1.1).

Table 1.1 -Conditions of some waters of the Indian Ocean.

Water Masses	Latitude	Depth (m)	PH	Phosphates (mg at/m)	Silicates (mg at/m)
Subtropical surface		(Surface) 200		0.8 – 0.15 1.0	
Subtropical sub surface	40-16 S		8.0 – 8.1		
Equatorial surface		(Surface) 100		0.2-0.1 1.2	
Equatorial water	6-10 S	120 – 300 300 – 500	7.81 – 7.86		 25 - 30
Equatorial Bottom Antarctic surface		 0 -100	 7.93 – 7.98		100 – 110 35 - 70
Antarctic surface convergence				1.5 – 1.9	
Antarctic Intermediate		Upper band Middle band Lower band		1.2 – 1.3 1.8 – 1.9	15 25 – 45 67 – 70
Antarctic bottom					110 - 190
Central		800			
Circumpolar				1.8 – 2.2	
North Indian deep				2.6 – 3.1	
Deep					70 - 120

From: The Encyclopaedia of Oceanography
R W Fairbridge (1966)

The microbial distribution is greater in the northern parts of the Bay of Bengal and Arabian Sea and off the Indian Coast at Goa. Detritus is found in large quantities near the coast and is especially abundant near the river mouths due to run-offs. The increased quantity of organic matter accounts for the high bacterial counts found in the northwestern parts of the Arabian Sea. These bacteria are mainly proteolytic types with about 10% being of the luminescent variety.

The bio-chemical condition of the Indian Ocean can be defined as a product of economic, social and demographic condition causes significant impact on the marine biological system.

Table 1.2 - Population figures for the countries of the Indian Ocean basin (1999)

COUNTRY	POPULATION IN MILLIONS				AREA (KM^2)
	1996	1997	1998	Annual Population growth rate(%) 1995-2000	
Bangladesh	123	125	128	2.2	142,776
India	953	969	987	1.8	3,287,593
Maldives	.26	.27	.28	3.2	298
Pakistan	145	148	153 *	2.7	803,941
Sri Lanka	22	19	19	1.2	65,610

From: The Human Development in South Asia 1999 – The Crisis of Governance
* According to the 1998 census conducted in Pakistan the total population of the country is approximately 131 million with an annual growth rate of 2.6%.

The population in the region, Bangladesh, India, Maldives Pakistan and Sri Lanka are directly dependent on this marine area. The land area of these countries and the population figures are given in table 1.2. The average population density is 193 KM. Thus, on an average 22.8 % of the world population lives in this region which is around 11.6% of the total land area.

These countries have over the last three years grown at a GDP rate of 6.6 for 1997, 3.7 for 1998 and 5.3 for 1999. The countries are into development activities and industrialization. The economic activities the countries indulge in are industrialization, tourism, mining on land, agriculture, fishing and infrastructure development activities. This increases the need for more sanitation facilities.

These development activities lead to industrial pollution, domestic and municipal sources 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.

In the South Asian region sanitation and sewage facilities are not adequate. However, presently, governments are giving high priority for sewage management. Pakistan government has given high priority for the provision of drinking water and sanitation facilities. In Pakistan proper sanitation facilities are available about 32 percent of the population. This consists of 60 percent of urban at 17 percent of the rural population. The government has launched a Social Action Programme (SAP) for provision of social services including sanitation. The programme had planned to provide sanitation facilities to additional population of 19 million during the period from 1993-1998.

In Bangladesh sanitary latrines are mostly private. In rural, there are around 700 private producers of latrine components with annual capacity of 140,000 latrine units. Grameen Bank (one banking organization) provides loans to interested villagers to install water supply and sanitation facilities.

India possesses about 4 percent of runoff the river in the world. It also has about 15 percent of world's population. The urban population which was 19 percent of population of 361 million in 1951 increased to 27 percent of the total population of 930 million in 1994. Provision of sanitation in India both urban and rural is unsatisfactory. A total of 611 million rural population that is 95 percent of the total rural population has not been provided basic sanitation. At the same time about 115 million urban population have no access to basic sanitation. In India total population that has no access to sanitation has been estimated to 754 million.

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 sewerage system, which was built in 1916. It is not anticipated to provide piped sewerage system to cities in the near future except where no on-site alternatives are possible.

Chapter 2

Types and quantities of point and non-point sources of sewage from domestic and urban centers affecting coastal and marine eco-systems

2.1 Introduction

The assessment of socio-economic opportunities that present in the sewage management can be done only after studying the types and quantities of point and non-point source wastewater in the area. In studying, point and non-point sources of pollution on marine coastal areas, the future development scenarios should be taken in to account. Therefore, the first step of this section attempts to assess the current situation (baseline situation) of the wastewater pollution in the region. Then, taking *sewage* as the main factor of importance, wastewater pollution in the marine system in the region will be discussed based on the future development possibilities.

2.2. Current situation of wastewater in the South Asian region

Due to increasing urbanization throughout the region, the volume of sewage is constantly on the increase. Many countries have several large rivers flowing through their landmass, but because of increased human activities around them many of these rivers have become badly polluted. These two human activities also contribute quite substantially to the degradation of the adjoining seas. Sewage in these countries, either untreated or partially treated, are allowed to be discharged into the rivers and seas.

2.2.1. Pakistan

There are very limited facilities available for the coastal cities of **Pakistan** for disposal of human excreta or wastewater. They use open spaces or semi enclosed spaces near the sea, creeks as toilets. The coastal towns do not have any sewerage system and hence use the local ground depressions, storm water drains or adjacent seasonal rivers and creeks for disposal of untreated liquid domestic and urban wastes. This type of sewage disposal is practiced in Jiwani, Gwanar, Pasni, Ormara, Hub and Gandani on Balochistan coast. Similar arrangements are in place at coastal towns of Sindh such as Mripur Sakro, Shah Bandar, Jati and Badin. However, at Keti-Bunder, due to low ground levels the disposal of waster waters to the adjacent creek is difficult during high tide. In the city of Karachi in Pakistan, it is estimated that about 262 million gallons per day (MGD) of swage is generated in Karachi and adjacent areas from domestic and industrial sources. Of these 111 MGD is generated form municipal and the remaining from industrial sources (6000 industrial units). The industrial wastewater and sewage are discharged into the two seasonal rivers: Lyari river and Malir river of Karachi. These rivers act as main open sewers for the liquid waste disposal from the city. The Lyari and Malir rivers are thus contributing about 59% and 25% of the total pollution load of the Karachi City respectively, while 15% of the pollution load is directly discharged into the adjacent open sea coast or to the Gizri, Korangi and Gharo Creeks. Only 25% sewage is treated. Most sewage is disposed into the city's watercourses without treatment.

2.2.2. Bangladesh

The townships and human settlements in the coastal areas of **Bangladesh** do not have any domestic waste treatment facilities and therefore effluents either directly or indirectly find the way untreated into the rivers and hence to the Bay of Bengal. A survey report of a waste water expert mission and DEPC data show that the two populous coastal cities of Chittagong and Khulna have poor sanitary conditions owing to a lack of sanitation facilities or the improper functioning of existing facilities. It is common practice to dump excreta in drains and canals, which go to nearby rivers. The rivers including the Karnaphuli and Passur, directly receive raw excreta daily form a vast number of people living on both sides of them.

The flow of the river varies form 11,200 m^3 /sec in the rainy season to 113 m^3/ sec in the dry season. During the dry season the river loses most of its capacity to purify itself of the biodegradable wastes. The total BOD load from the domestic waste in the Chittagong area is estimated as some 3.5 tons/day. The domestic waste load in the Khulna and Mongla port areas may be estimated to be approximately 2.2 tons BOD/Day. Source: National Programme of Action (Bangladesh) for the implementation of the Global Programme of Action for the Protection of the Marine Environment from Land Based Activities. (1999).

In Bangladesh the townships and human settlements do not have any domestic waste treatment facilities and the effluents, either directly or indirectly, find their way into the water bodies.

2.2.3. India

Nearly 20% of the population of **India** live within 40 km form the coastal sea. The constant increase of population and rapid industrialization in the recent years have led to the generation of enormous wastes in the coastal cities and towns. These wastes, both domestic and industrial in nature are directly disposed off into the sea through creeks or through the rivers situated in these coastal cities and towns. A variety of contaminants ranging from purified organic matter, pathogenic bacteria and heavy metals reach the marine environment from these sources. The details of these contaminants are given in Table 2.1. It is difficult to target sewage separately as industrial wastes also reaches the same rivers and streams.

Organic pollution originating form human settlements is increasing with expanding populations and urbanization. Even large rivers are becoming polluted due to the level of human activity along their banks. Sewage treatment is virtually non existent in the area. In the littoral states of the Indian Ocean, most of the effluent from municipal and domestic sources is released untreated into natural waters. There are few sewage treatment plants in the region and where they are present they are often overloaded and in bad working order. Stabilization (oxidation) ponds are an ideal way of treating sewage as the climatic conditions of the area are suitable for this form of treatment. Furthermore, they require little trained personnel or finance as it is a natural treatment method.

Table 2.1 - Characteristics of a typical domestic sewage mixed with effluents from small and medium scale industries

Parameter	Mumbai (µg/1)
Dissolved Solids	1450000
Suspended solids	245000
BOD	258000
Sulphate	75000
Nitrogen	35000
Phosphorus	6000
Chloride	587000
Manganese	507000
Iron	2529
Cobalt	30
Nickel	81
Copper	110
Zinc	251
Lead	11

From: National Action Plan for Protection of Marine Environment form Land – Based Activities – By Integrated Coastal and Marine Area Management Project Directorate, Department of Ocean Development, Chennai. (October 1999).

2.2.4. Sri Lanka

The coastal area is of much importance to Sri Lanka. One third of the population and two-thirds of the urbanized land are today within the coastal region. In addition two thirds of the factory industrial output and 80 per cent of the tourism-related infrastructure and sites are in the coastal region. With growth in population the importance along with the stresses on the coastal region is bound to increase. All these should have an impact on the immediate marine environment and the identification of impacts is essential in formulating a management plan.

Sri Lanka has a high urban population density. With an average population density of 278 persons per sq. km. Sri Lanka has the 21st highest density of population in the world, with the average in the western province riding the highest at 1296 per sq. km. An acute land problem is building up in Sri Lanka.

Sri Lankan city and town planners and housing and construction sectors have not yet adopted the common sewer concept, which developed countries systematically developed from an early stage knowing that pollution upon urbanization has a significant negative environmental impact. The two common systems widely used in human waste management in Sri Lanka are the pit latrines and septic tanks. These invariably cause groundwater contamination. The only large conventional sewerage system within Colombo urban area is the area served by the Colombo Municipal Council (CMC), with main sewer extensions to parts of Kolonnawa and to the Dehiwala-Mt. Lavinia MC. The

performance of the present sewerage system is quite unsatisfactory, as it is overloaded as well as in a quite neglected condition. The original system for Colombo was constructed in 1902 to cater to an estimated 1951 population. Presently about 482,000 people are connected to the sewerage system with others having on-site excreta management facilities. However, 40 per cent of the city area is not served by the sewer system. However, the present system, built between 1906-1916, is in dire need of extensive repair and rehabilitation. Recent research indicates that a number of sewerage networks are on the brink of collapse.

A few sewer systems serve some housing and industrial schemes (i.e. Soysa Pura flats at Ratmalana operated by the National Water Supply and Drainage board and in two industrial zones at Biyagama and Katunayake). Two large-scale housing schemes maintained by National Housing Development Authority (NHDA) have their own collection network and treatment plant to treat the sewage and wastewater generated within the housing schemes. Raddoluwa housing scheme at Seeduwa employs an extended activated sludge process, while the De Soysa housing scheme at Ratmalana has a trickling filter to treat their generated liquid waste. The treated waste is discharged to Dandugam oya in the case of Raddoluwa and to Lunawa lagoon in the case of De Soysa housing scheme.

It is estimated that about 15% of the total population in the Colombo Urban Area have no sanitation facilities at all, primarily in low-income areas. The sewers only pump the waste into the open sea without any treatment using two sea-outfalls at Welawatte and Modara, a method that one cannot approve of. This practice of sending sewage to sea via ocean outfalls was earlier accepted as it was assumed that raw sewage sent down a long enough pipeline would be harmless, with all bacteria dead, by the time it washes onshore. But new research in USA has shown that seawater does not, kill all bacteria but only make them dormant.

2.3. River bodies, drainage basins and openings to the sea

The radial drainage pattern carries surface water into 103 river basins. The general pattern of stream flow could be considered broadly radial – a notable exception being Mahaweli - with the mean length of a stream being about 135 km.

As in UK when the Royal Commission developed the BOD test they arrived at the conclusion that all UK rivers considering the flow the maximum number of days away from the sea to be 5 days. Such data are not yet available for Sri Lanka. However, this drainage pattern is important as being a small island nation activities in the interior could well get drained to the sea after a short time period. Much of the pollution coming to the marine environment is contributed by this drainage as much of the economic activities are connected to water sources and in many cases these very sources act as sinks as well. Important sources of pollutants relevant to this assessment are Sewage (the principal component for this presentation) and leachate from municipal waste streams.

In assessing the impact value both the quantity (flow rates) and the quality (i.e. composition) are of importance. Kelani ganga – industrial waste and sewage (Kelani

ganga is by far the most polluted river in Sri Lanka). This drains an area of 2,278 km^2 in the wet zone (includes the CMR). Emptying into the Indian ocean at a flow rate of 213.8 m^3 sec^{-1} . The estimated BOD to the river from the is industry 8%. In San Sebestian canal, the estimated BOD load is daily 1800 kg (industry factor 10%) the rest is sewage related load.

Muthurajawela Marsh-Negombo Lagoon estuarine system: Approx 6232 ha is situated in the highly urbanized Colombo Metropolitan area. This is an area subject to impacts from population pressure, unintegrated land uses and pollution. The area supports a fisher population of 3000. There is an existing ICM plan prepared in 1991 based on an ecological survey. The lagoon (3,164 ha) is connected by a single narrow opening with the sea, the channel section situated in the Negombo town. The marsh (3,068 ha) extends southward. The main inflowing river Dandugam Oya drains a catchment of 727 km^2 and discharges at the junction of the lagoon and the marsh. All untreated waste from the Ekala-Jaela industrial estate at present discharged into Dandugam Oya which subsequently delivered this load into Negambo lagoon. Immediate impacts of this situation are fish stocks in the Negambo lagoon and inability to provide different job opportunities to that of fisheries sector due to poor literacy and educational background and increase in labour force (expected 500,000 by the year 2001).

Sewer outfalls from Mutwal and Wellawatta simply pumped out waste. No prior treatment is done. Mutwal outfall releases around 67,500 – 90,000 m^3 of sewage daily [This was earlier released into the Kelani river]. Initially there was a sewage treatment facility when the sewage was discharged to Kelani but now it has been abandoned.

Wellawatta outfall is used to manage stormwater runoffs and canal outlets. Galleface outfall has point activities with immediate access to sea.

There are about 50000 hotels, guest houses and resorts in the coastal zone and majority of them discharge their waste without treatment to the coastal marine system.

2.4. Drainage/run-off into surface and groundwater bodies

All wastewater from the Colombo Metropolitan area (CMA) and from the Kelani Ganga catchment area, with the exception of wastewater infiltrating the solid, is finally discharged into the ocean. Discharge points are Kelani Ganga two ocean sewerage outfalls (Wellawatte and Modara) and some minor outlets, including Colombo harbour, Beira Lake, Wellawatte and Dehiwela, Canals, Lunawa Lagoon and Bolgoda Lake, as well as Negombo Lagoon, Ja-Ela, Kalu-Oya, Muthurajawala and Danugam- Oya rivers. There are also some minor discharges of sewerage from communities living along the coast.

Water pollution within urban areas such as Colombo in Sri Lanka, is due to a combination of factors such as the discharge of domestic effluents, discharge of urban drainage/ surface run- off water, discharge of industrial wastewater, inadequate maintenance and cleaning of sewerage systems, and or the dumping of solid waste into water courses.

The major source of water pollution within the Colombo Metropolitan Region is domestic wastewater. Within the Greater Colombo area, it has been estimated that 7, 150 m/day of residential domestic wastewater is discharged. In fact, domestic wastewater accounts for nearly 66% of total wastewater that is generated in this region (Associated Engineering, 1994).

The main reason for this high domestically induced water pollution is the discharge of untreated faecal pollution into surface water bodies. The only large conventional sewerage system within Colombo Metropolitan Area (CMA) serves part of Colombo MC, with main sewer extensions to parts of Kolonnawa UC , with main sewer extensions to parts of Kolonnawa UC and Dehiwela-Mt Lavinia UC . A few small systems serve some housing schemes. However, the present system, built from 1906-1916 is in dire need of extensive repair and rehabilitation, with recent research indicating that a number of sewerage networks on the brink of collapse. In Sri Lanka only 63 percent of the population of the rural sector have suitable sanitary latrines while urban population about 80% have access to basic sanitation.

Currently, only 80% of the total population of the CMC, approximately 300,000, are connected to the sewerage system. The area serviced by a sewerage network is about 3600 ha, which corresponds to 80% of the total CMC land area. The rest of the population within the larger Greater Colombo Area (total population, approximately 1.2 million) make use of septic tanks, river and canal banks , the seashore and open land.

It has also been estimated that about 15% of the total population of CMA, primarily in low-income areas, have no sanitation facilities at all. Furthermore, about 50% of the population in the CMA belong to the low-income category and live in semi-permanent dwellings, where high population densities strain existing waste disposal infrastructure and also result in the placement of septic tanks near drinking water sources .

A study done in 1997 by NREPP project, Ministry of Forestry and Environment showed sparkling revelations about the extent of pollution due to illegal sewage connections to the St. Sebastian canal and eventually to Kalani river. All these automatically flow to the ocean and the study further illustrated the critical importance in investing in Sewage treatment.

The analysis done in relation to St. Sebastian Canal suggests that it is technologically beyond the capacity of the industries currently located on the Canal to reduce their BOD loads sufficiently to bring the ambient water standard below the minimum desired level. Even at rapidly rising marginal costs, industries can remove only 200 tons/ year, yet the excess load of 357 tons/ year is beyond the technical capacity of the firms. The total daily load of BOD in the San Sebastian Canal is 1,800 Kg/day and the industry accounts for only 10 percent of this total load. Thus even if industries were to stop producing BOD altogether, it would have a minimal impact on the total BOD in the Canal.

Households, on the other hand, account for more than half of the total load in the San Sebastian Canal A sewage treatment system has the potential for reducing loads in the

San Sebastian Canal by an amount greater than the excess load and thus returning the Canal's ambient water quality to an acceptable level.

2.5. Surface water pollution

As table 2.2 illustrates, within the Colombo Municipal Council, the entire canal system has degenerated into a virtual open sewer. The Beira Lake in central Colombo suffers from high eutrophication and elevated levels of faecal coliform. The Lunawa lagoon is biologically dead. Although Bolgoda Lake has not been polluted to the same extent, there is rising concern that the long term impact of the continued discharge of industrial and urban pollution into the catchment area will compromise its economic and ecological value. The Kelani river waterway, which drains an area of 2278 Km in western Sri Lanka, also contains some of the most densely populated districts. The water quality here is of particular concern as Colombo' s water supply source is located upstream at Ambatale. The rover receives wastewater from some of the most densely populated urban settlements, a considerable number of industries (including a large textile processing plant in Pugoda) and agricultural run-off. It should be emphasized that the water quality of the Kelani River is much worse during its flow through the CUA, where large volumes of urban run-off water and wastewater are discharged into it

Table 2..2 - Ambient Concentration of key water pollutants

	Bolgoda Lake	**Kelani (dry season)**	**Kelani (wet season)**	**Kelani**
Pollutant	Monitored	Estimated	Estimated	Monitored
BOD	5	5.8	0.9	3
Suspended solids	33	13.8	1.7	6
Oil & Petroleum		0.7	0.09	
Total Nitrates & Ammonia	5	1.2	0.2	1
Chlorine		0.28	0.05	

2.6. Water quality standards

CEA standards for effluent quality are less stringent than those of Singapore and almost identical to India's standards in most areas, including COD and BOD (see table 2.3 which compares Sri Lankan standards with Singapore and India). However, there are no standards set for the ambient water quality for surface waters or for ground water in Sri Lanka (table 2.4).

Table - 2.4 Present Status of Water Bodies compared to the proposed standards							
Water bodies		**BOD (mg/l)**	**COD(mg/l)**	**DO (mg/l)**	**P (mg/l)**	**N (mg/l)**	**CL (mg/l)**
	Standard	**10-55**	**1-20**	**3.7-8.8**	**0-0.15**	**0-2.1**	**5-120**
Beira Lake		15-80	30-440		0-90	30-455	
Physical/biological condition : Eutrophication, High faecal coliform , siltation, smell anaerobic (dry season) water hyacinthe growth							
San Sebastian Canal		320		0			
Physicalcal /biological condition: Anaerobic,blockage by solid waste, foam on surface, embankment erosion, offensive smell							
Wellawatte Canal							
Physical/biological condition: anaerobic, solid waste, blockage of outlet, embankment erosion							
Heen Ela		15		2			
Physical/biological condition Smell, blockage by water , hyacinth growth							
Kimilapone Canel		18-380		0-4			
Physical/biological condition: Anaerobic, solid wastes, embankment erosion,							
Dehiwela Canal							
Physical/biological condition: Anaerobic, solid wastes, embankment erosion, blockage of outlet							
Wears Canal			830			150	1055
Physical/biological condition: Anaerobic,water hyacin growth							
Bolgoda Lake			300-400			140-360	8000-15000
Lunawa Lagoon			180-200			115-215	4000-6500
Physical/biological condition: Anaerobic, offensive smell, siltation, brackish water, nearly void of aquatic life							

Source World Bank 1995

Table -2..3 Comparison of effluent standards in countries in the region				
	Sri Lanka	**India**	**Singapore**	
			Water Course	**Controlled Water Course**
PH	6.0-8.5	5.5-9.0	9.9	6.9
Temperature	<40C	<40C	45C	45C
BOD, at 20 C	30	30	50	20
COD	250	250	100	60
Total Suspended Solids	50	100	50	30
Oils and grease	10.0	10.0	10.0	5
Phenolic Compounds	1.0	1.0	0.2	0.1
Cyanides	0.2	0.2	0.1	0.1
Sulfides	2.0	2.8	0.2	0.2
Arsenic	0.2	0.2	1.0	0.05
Cadmium	0.1	1.0	0.1	0.01
Chromium	0.1(total)	2.0	1.0	0.05 Trivalent & Hexavalant
Lead	0.1	0.1	0.1	0.1
Nickel	3.0	3.0	1.0	0.1
Selenium	0.05	0.05	0.5	0.01
Zinc	5.0	5.0	1.0	0.5

2.7. Present activities with impacts on the coastal environment

The Beira Lake in central Colombo suffers from high eutrophication and elevated level of faecal coliform. Beira lake is an artificial lake in the heart of the Colombo city which is grossly polluted. Many families (approx 2000 people) live in squatter settlements along the banks of the Beira lake. For most of them it acts as an open sewer and a garbage disposal site.

The Lunawa lagoon is biologically dead. Although Bolgoda Lake has not been polluted to the same extent, there is rising concern that the long term impact of the continued discharge of industrial and urban pollution into the catchment area will compromise its economic and ecological value.

Taking all canal ways into account in the city of Colombo low income settlements closer to these are estimated to be about 60,000. It is these numbers that have given rise to the sustainable townships program described later. An example of a highly polluted canal way at present is the San Sebestian canal where many settlements exist alongside industries.

Two main industrial areas are located at Ratmalana-Moratuwa and Ekala-Jaela. There are few small clusters of industry elsewhere though these two are the most significant.

The Ratmalana area covers the southern part of the Dehiwela-Mt. Lavinia Municipal Council. The Moratuwa area lies within the Moratuwa Urban Council. The area covers about 40 sq. km. The area is characterized by mixed land-use with approximately 225 industrial establishments. These areas are not dedicated industrial areas but mixed residential areas. No sewers exist in these areas and normally mixed wastewater discharges occur.

Table 2.5 Per capita domestic wastewater generation (Ratmalana-Moratuwa area)

	Residential	Commercial	Industrial
Flow (litres per capita/day)	135	50	50
BOD (gm per capita/day)	55	25	25

The load can be calculated using the population figures for this area (table 2.5). At the time of this study (i.e 1995-6) the figure has been estimated to be 3,50,000.

Much of these waste find their way to the coast due to the close proximity.

Ja-ela area covers a total land area of 65.3 sq. km., and contains about 135 industrial establishments. The main industrial area is in Ekala (Ekala Industrial Estate). There are some other industrial areas interspersed among residential and agricultural areas.

Bolgoda lake located in the south of Colombo is one of the largest and most scenic natural lakes in the country. However, it is now receiving many pollution loads from activities surrounding it. This has implications to the 300 native and migratory bird species that is supposed to add diversity to the beauty of that lake. Encroachment, reclaiming land with gravel fill etc. and silting are also problems brought about by unchecked human activities. Bolgoda lake joins Kaluganga at Anguruwatota and flows into the Indian Ocean at the estuary near Panadura.

Shrimp farming has being an on-going activity on the north-west coast of Sri Lanka since 1985. There are about 500 shrimp farms operating in the area surrounding the Dutch canal from Deduru Oya to Mundel lake. However, this are also receives considerable amount of sewage and other effluents. Wastes from shrimp farms are discharged without any treatment. The following waste materials are introduced

- residual of fertilizers and supplementary feed
- acidic discharges from new ponds constructed at potential acid sulphate soil
- chemicals used for water treatment
- chemicals used for insect control
- chemicals used for predator fish control
- chemicals used for fish health control (Malchate green)

BOD values up to 42 mg/l had been noted in the Dutch canal. There are about 5000 hotels and other related places along the coastal belt and most of them do not have any waste treatment system.

Urban runoff is a major source of pollution. The Colombo metropolitan area receives an average 2400mm of rainfall each year. The Kalu Ganga and Kelani are noted for flood hazards in their lower reaches. The Colombo canal system includes the Main Drain, Mahawatta Ela, Dehiwela canal, Bolgoda canal, Wellawatte canal, Dematogoda Ela, Torrington Canal, Beira Lake and St Sebastion Canal. In the Muthurajewela area the two main canals are the Hamilton and Old Dutch canals. However, despite this network of canals, there is a frequent occurrence of flooding, which in addition to the risks that it poses by itself, in terms of damage to property also results in the additional effect of polluting groundwater and surface water sources.

There is no organized storm water drainage system though in the western coastal belt it is possible to identify some major outlets. All wastewater from the CMA and from the Kelani Ganga catchment area, with the exception of wastewater infiltrating the soil, is finally discharged into the ocean. Discharge points are Kelani Ganga, two ocean sewerage outfalls (Wellawatte and Modara) and some minor outlets, including Colombo harbour, Beira Lake, Wellawatte and Dehiwela Canals, Lunawa Lagoon and Bolgoda Lake, as well as Negombo Lagoon, Ja-Ela, Kalu-Oya, Muthurajawala and Dandugam -Oya rivers. There are also some minor discharges of sewerage from communities along the coast. Compositional data on these are not available, as these non-point sources have received less attention.

(i)

(ii)

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

2.8. Future developments that affect wastewater management

Construction of housing under the sustainable townships program (Ministry of Housing and Urban Development). These housing schemes aimed at providing better accommodation for the slum and shanty dwellers in the city would have more organized sewage handling mechanisms thus reducing the present problem to a great extent. The idea of these high rises by town planners is to provide homes for people and land for development. Assuming on average a family of 4 the housing should provide better waste management services to 4 x 66,000 people. The latter number is the number of houses intended in the first phase of the program. This phase is expected to be completed in mid-2001.

Ekala-Jaela system is expected to be discharged to the Dandugam Oya and then finally to the ocean. It is important to note that this are is not at present served with piped water nor with sewerage.

Ratmalana-Moratuwa system is expected to be connected to the Wellawatta sea out fall. Ratmalana-Moratuwa area has piped water though the total resident population is not using the facility with many dependent on well water as well. This is mainly due to cost of connection to the Water Board's supply.

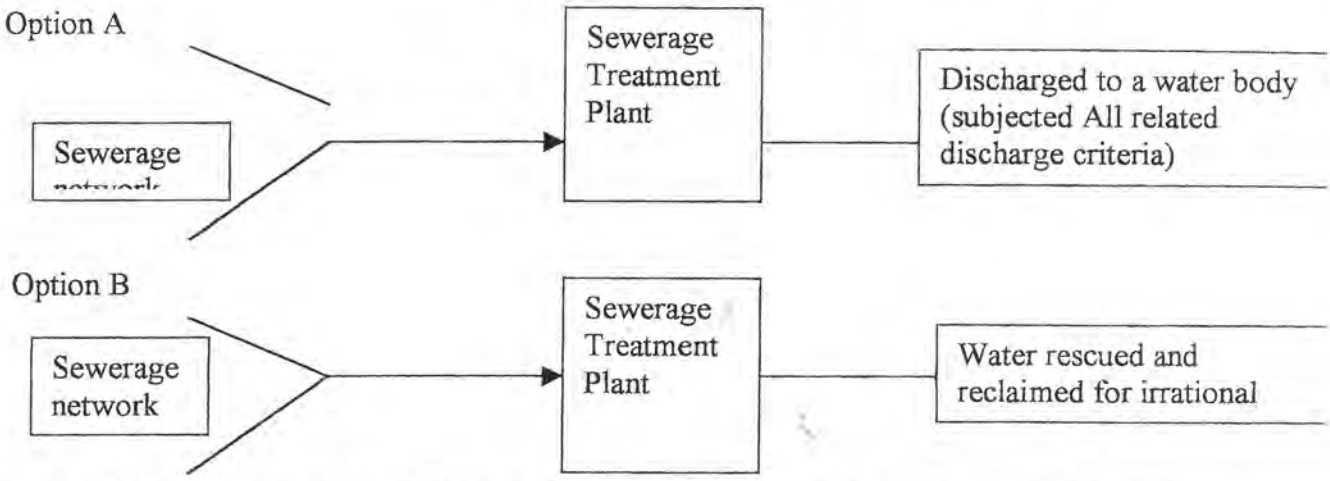
In both these systems planned for Ratmalana and Ekela both industrial wastewater and sewage are expected to be collected. The sewerage systems are planned in stages. The situation at present is these projects have halted after some preliminary work and has raised many problems in the mind of citizens.

The following development scenarios could result in future. If the development is seriously pursued it is inevitable that some of these should take place;

(1) Implementation of sewerage systems to urban and semi-urban clusters. These systems would enable the collection of generated sewage. Depending on the location the following two situations could result

- the sewerage units associated with areas in the coastal belt could have the option of discharging to sea using sea outfalls with or without any treatment. The latter option has already being studied in detail for implementation at Ratmalana-Moratuwa area.

- Sewerage systems situated in the interior may follow either of the following options:



Current scientific studies have revealed that one should not discharge untreated sewage into the sea. Hence untreated sewage disposal via ocean outfalls should not be considered as a long-term option. The impact of following the scheme as in Option A is that marine coastal zone would receive an enhanced pollution load though in a controlled manner. The Option B would not allow for an extra load on the marine environment as a result of activities in the interior of the country.

2.9. Estimated Sewage load for South Asian Countries

Sewage load for all South Asians countries were estimated using following sequence developed based on Sri Lankan data.

Total Population: 18,112,000 (With population growth at 1.4%, an annual addition of 200,000 is expected to this figure.)

Generation data: With waste generation potential per person at 0.4 kg
(literature varies on this figure up to 1 kg per person per day)

Sewage 7244800 kg (as average sewage gives about 250 mg/l BOD and assuming a density of 1000 kg/m^3)
BOD load per day - 1811200 kg BOD

The load on the coastal zone (from 1/3 of population) in Sri Lanka = 597696 kg BOD per day

Based on this method, the total BOD from sewage generated by the population in the South Asian countries were estimated as 1.8 million Kg BOD per day in Sri Lanka, 98.7 Million Kg BOD per in India, 15.3 million kg BOD per day in Pakistan, 12.8 million Kg BOD per day in Bangladesh and 0.28 million Kg BOD per day in Maldives. As estimated by the study, the total BOD load from sewage that has potential impacts on the coastal and marine environment for each country are 0.6 million Kg BOD per day (30%

of population) in Sri Lanka, 19.7 million Kg BOD per day in India (20% of population), 1.2 million Kg BOD per day in Bangladesh (10% of the population), 2.3 million Kg BOD in Pakistan (15% of the population) and 0.028 million Kg BOD per day in Maldives (100% population). According to the study estimated total BOD load of sewage from South Asian countries that have potential impacts on the Indian Ocean as 23.9 million Kg BOD per day.

Chapter 3

Review of plans programme & projects of wastewater management that has an impact on coastal and marine system in the South Asian Sea

3.1 Introduction

Coastal areas in Asia are faced with unprecedented problems with the population growth, continuous immigration and the damaging effects on marine coastal waters through land based and other sources. It continuously effects the coastal eco systems, some of the South Asia's largest cities such as Bangkok, Jakarta, Manila, Singapore, Karachchi Culcatta, Chennai and Colombo are coastal. The changes to coastal eco system was by intensifying human activities are remarkably similar through out Asia. (Olson & Christian, 2000) There are rapid population growth and organization and poverty within the coastal zone and water bodies and land areas adjacent to the coastal waters.

Most Asian countries have passed national environment policies and have signed national treaties to protect and conserve coastal environment. However, fragmented policy interventions with conflicting institutional mandates have effected their implementation. Conflicts between national government policies and programmes in coastal management and economic development, the discrepancies between national government policies and programmes with local government initiatives in relation to coastal management are some of the draw backs. It amply illustrate with the following statement.

The few developing countries address coastal management through a holistic national policy and legal framework. Fragmented national legislation has resulted in devolution of responsibility for coastal management between multiple government agencies, opened with overlapping functions.

In relation to Sri Lanka too a sum with similar situation exist. However, in some countries including Philippines, Indonesia and the Peoples Republic of China responsibility for total coastal management had largely devolved with the local government. In those countries the local government institutions has jurisdictions over the marine coastal waters thus making plan by such institutions on effects to the marine coastal waters become legally possible. In the Philippines the management of municipal waters to 15 k.m. from show line was mandated to municipalities and cities. The similar situation exists in other countries too. Coastal management programmes in those countries vary considerable from one municipality to another.

As far as Sri Lanka is concerned its evident, there has been several projects enacted to arrest the degradation of marine coastal waters and several projects initiated to control pollution in water bodies adjacent to coastal waters. As stated above the ideal situation would be to give the municipalities in South Asian countries the responsibility for coastal management. Even in Sri Lankan context, if large municipalities are given that power, it could be easy to them to handle since pollution of coastal marine waters through land based sources are very much connected to the local government system. This would

enable municipality to be more remarkable and get involved with the private sector and community organization in implementing such programmes. Otherwise the local geo political boundaries of the local government institutions do not coincide with coastal eco system bound. This will have to be rectified in the first instances if an effective programme is to be launched.

In the South Asian region sanitation and sewage facilities are not adequate. However, presently, governments are giving high priority for sewage management. Pakistan government has given high priority for the provision of drinking water and sanitation facilities. In Pakistan proper sanitation facilities are available about 32 percent of the population. This consists of 60 percent of urban at 17 percent of the rural population. The government has launched a Social Action Programmes (SAP) for provision of social services including sanitation. The programme has planned to provide sanitation facilities to additional population of 19 million during the period t from 1993-1998

In Bangladesh sanitary latrines are mostly private. In rural, there are around 700 private products of latrine components with annual capacity of 140,000 latrine units. Grameen Bank provides loans to interested villagers to install water supply and sanitation facilities.

India possesses about 4 percent of runoff the river in the world. It also has about 15 percent of world's population. The urban population, which was 19 percent of population of 361 million in 1951, increased to 27 percent of the total population of 930 million in 1994. Provision of sanitation in India both urban and rural is unsatisfactory. A total of 611 million rural populations that is 95 percent of the total rural population has not been provided basic sanitation. At the same time about 115 million urban populations have no access to basic sanitation. In India total population that has no access to sanitation has been estimated to 754 million.

3.2 Projects and Plans in Sri Lanka

In Sri Lanka, there have been Several Plans, Programmes & Projects addressing the issue of sewage management that affects coastal and marine ecosystem. Some of them have been Master Plans and most of them include a donor funding component. These include.

(1) Implementation of Wastewater treatment facilities to service the Jaela- Ekala, Industrial Zone under BOT Terms.
(2) Design Environment Assessment and Supervision of Implementation of Sewerage systems at Jaela/Ekala and Moratuwa/ Ratmalana Area.
(3) Colombo Metropolitan Regional Structure plan – Vol (I) Syathesis
(4) CMR structure plan Vol (II) Plan
(5) Lunawa Lagoon rehabilitation plan (Rs. 250 Mn)
(6) Kalutara Lagoon Management Plan
(7) Bentota Estuary Master Plan
(8) Weras Ganga, Bolgoda Lake catchment Master Plan and remadial projects Rs. 250Mn
(9) Assessment of wastewater outfalls into ocean – Rs 13Mn – MPPA

(10) Marine Drive project – Stage (I) – Rs 1000 Mn
(11) Establishment of a Storm Water Management Agency
(Projects 5-11 are componants of the CMR Structure plan)
(12) Hikkaduwa Coastal Zone Waste Management Project
(13) Amended Coastal Zone Management Plan
(14) Fullestorn Industrial Estate – ELA study ERM
(15) Bataatha reocation and modernization of tanneries project.
(16) - do – Study on establishment of CETP & Chrome recovery plants
(17) Beira Lake Restoration study - Vol (I) – Environment Impacts
(18) Beira Lake Restoration Study - Vol – (II) Restoration Project & Action Plan
(19) Colombo Port Rules 1936
(20) Off shore sand mining for Colombo Port expansion – (IEE report)
(21) Coastal Environmental profile & plan of Hikkaduwa area
(22) Coastal Environmental profile & plan Rekewa Lagoon
(23) Environmental guidelines for coastal tourism Development in Sri Lanka
(24) Sewage Infrastructure for Sri Jayawardenapura Kotte
(25) Flood Control & Environmental Improvement Project – Greater Colombo
(26) Improvements of Sea Outfalls (Dehiwela & Wellawatta)
(27) Rehabilitation of Colombo Putlam Canal
(28) Clean Settlements Project

These projects Plans consist of most of the information connected to pollution of coastal seas from land based activities and the steps taken to control that situation. Most of these plans are being implemented at present at a slow pace and with limited monitoring hence the exact impact of restoration cannot be measured. Review of some of these plans provides an idea about activities going on in the South Asian region.

3.2.1 Beira Lake Restoration Project

The Beira Lake is located in the heart of the city of Colombo in Sri Lanka, and has an highly urbanised catchment of 432 ha that is mostly flat, with ground levels ranging from less than 1m to 6m above mean sea level. The Lake covers 65.4 hectares and has a mean depth of 2.0m. It comprises four main basins; the East Lake, the Galle Face Lake, the West Lake and the South West Lake. The East is the largest and deepest basin (43.2ha,)max. Depth of 5.6m),while the other three basins are much smaller and shallower (total of 22.2 ha,max depth of 3.4m)

The water quality of Beira Lake has deteriorated to the extent that bathing or practice of recreation sports involving water contact may present a health hazard to the local population. The optical, physics-chemical, and bacteriological characteristics of the lake limit its use for these activities, and reduce the capacity of the lake to support aquatic organisms. The water quality of the West and South West Lakes has deteriorated to a greater extent than that of the East and Galle Face Lakes. When compared to adjacent water bodies, the water quality of the Beira lake is worse than that of the St.Sebastian Canal and the Kelami Ganga (listed in increasing order of water quality).

The cost of the restoration of Beira lake was enormous. However, the restoration of Beira lake directly benefited the purification of the coastal waters in and around Colombo since the Beira was the major pollution of the marine coastal waters in and around Colombo. When talking about pollution of Beira lake what matters was not the pollution of the lake itself but the culmination of pollution sources in and around Colombo. With 7,000 illegal connections to the Beira lake it signifies the majority of polluted water and sewage in the city of Colombo and suburbs. All these finally end up in the marine coastal waters.

The cost of the environment management strategy of the Metropolitan Environment Improvement Programme was US$ 350,000 while Beira lake restoration study was US$ 500,000. The restoration of the Beira lake Phase I had cost Rs.1185Mn. This is without taking the Phase II cost into consideration. It signifies the numerous cost that had to be burned for cleaning of an exercise for pollution cost by sewage and storm water. In fact all this could have been avoided if proper care was taken by the municipality, local government and government authorities at the correct time. This could be an object lesion for any local authority with a large water board which leads towards marine coastal waters.

3.2.2 Major activities under the Beire lake project

(i) Disconnection of Unauthorised Sewer Lines: A survey proved conclusively that the storm-water network brings sewage into the lake. It was assumed that this was a result of unauthorised connections of sewage lines to the storm-water network. A field survey was carried out to validate this assumption by a Colombo municipal engineer who studied the storm-water network of five major outfalls, draining 7 out of the 24 sub-catchment areas. The survey showed conclusively that this was indeed the case, and by extrapolation of the results to the entire catchment, it was estimated that there were some 7,254 unauthorised connections. Required interventions are identification and disconnection of all unauthorised sewage and sludge connections, including public water stand-post outlets and redirection of waste waters to the sanitary sewer network.

(ii) Reduction of Frequency of Sanitary Sewer Overflows: Colombo's sewer network is over ninety years old and at present its capacity is inadequate and in need of rehabilitation. The ultimate disposal of sewage, which takes place with only primary treatment, is through two 1,500 millimetre ocean outfalls - a northern one off Mutual which is 2,053 meters long, and a southern one off Wellawatte which is 1,394 meters long .The network has occasional overflow connections to the storm-water network. This is to prevent the backing up of sewers in the event of their failure during periodic pump house maintenance and the overloading of the sewerage system during excessive rainfall. However, because of small gradients in the sewerage system, excessive silting, and the frequent maintenance required to this aging system and pump houses, such overflows are becoming increasingly frequent. This probably contributes far more pollutants than all the individual unauthorized connections. The required interventions involve plugging up the overflow connections, de-silting the network serving the catchment and rehabilitating the existing pump stations

(iii) Reduction of Industrial Effluent Loading: Only one major food processing plant has any outfalls into Beria Lake. This industry has already diverted its most polluting outfalls into the sanitary sewer network and has installed grease traps. The intervention required involves monitoring closely the effluent of this industry and the installation of more effective oil and grease separators. The other major source of pollutants is the General Hospital which discharges its waste water into a major storm-water drain (Norris Canal) which ends up in Beira Lake. This could be remedied by diverting all waste water into the sanitary sewer system.

(iv) Connection of Septic Tanks and Soakage Pits to Sanitary Sewer System: The entire Beira Lake perimeter is not served by a sanitary sewer network. One example is that part of the East Lake perimeter is served by septic tanks and soakage pits which often overflow and discharge their effluent, either directly into or so close to the lake that the pollutants do not degrade before reaching the water. The intervention recommended here is the development of a new sewer network to serve these areas with a new or upgraded pump station facilities designed to accommodate the increased flows.

(v) Upgrading of Squatter Settlements: The number of inhabitants in squatter settlements in Beira Lake margins has been estimated at 2,347. Discharge of raw sewage directly into the lake, from open latrines in close proximity to their dwellings, contributes to the overall faecal contamination of the water. Although it is by no means the largest overall contributor, its localized nature would constitute a health hazard to the inhabitants, especially the children who often swim in the vicinity. As a measure of improving the situation of these individuals, proposal has been made to relocate the squatter dwellers to an area within the catchment itself where they would be given rehabilitated housing facilities.

3.3 Relocation and Modernisation of Tanneries Project - Bata atha, Sri Lanka

This project is promoted by the Ministry of Industries along with the private sector organization of Sri Lanka Association of Tanners presently operated in an around Colombo, Central location, Bata atha, Ambalantota with facilities for treatment of affluent discharged from the tanneries to the relevant standards described by the CEA. It also includes the 2 chrome recovery plants, it is already established in Ragagiriya and Handala. One of the major characteristics of this environmental project is the contribution for the government sector private sector and the donor community.

The major outputs of this project are:

(a) Establishment of a common affluent plant designed to meet all discharging standards.
(b) Pilot demonstration of re-use of treatment affluent based on on-going worldwide research.
(c) Establishment of a safe land fill to store tannery solid waste and solid waste disposal.
(d) Establishment of a laboratory to monitor CETP results and effectively operate the CETP.

(e) The detailed project report for utilization on version of tannery solid waste project based on on-going results under the UNIDO regional programme.

(f) Once established this would be the most modern CETP for tannery industry in the South East Asia.

For this aspect a memorandum of understanding has been signed and the responsibilities of the Sri Lanka Association of Tanners as well as individual tanneries have been clearly spelt out. This is an attempt of a private sector and public sector collaborated environmental projects. The responsibilities of relevant stakeholders are given below.

a) The project proponent demonstrates by an adequate and credible study acceptable to this Authority that the full water demand of 2025 m3 / day could be extracted from the Kalametiya Lagoon and that all the relevant authorities such as Irrigation Department, Mahaweli Authority of Sri Lanka and the Department of Wildlife Conservation have granted written approval for such extraction.

b) The treated effluent is discharged to the sea following an adequate and credible study acceptable to CEA, Coast Conservation Department (CCD) and other relevant authorities which should include a dispersion study model demonstrating that the effluent will not be detrimental to existing fishery and other sensitive eco-systems. We have been advised by the technical evaluation committee (TEC) that the claim made by the project proponent that all the treated effluent can be recycled and used as a process water, is not feasible. No part of the project is commenced or implemented until condition a) and b) above are fulfilled and written and written approval is obtained from the CEA, CCD and other relevant authorities.

In view of the analysis, it has been envisaged in the project report for CETP prepared by UNIDO to opt for sea discharge in which case dilution by more than eight times is assured. As can be seen from a comparison of the two tables, the treated effluent will meet the national standards for discharge in margin areas. Following further discussions between CEA and SLAT (Pvt) Ltd , it has been agreed by CEA not to insist on a dispersion model.

It can therefore be safely stated that provided the treatment plant is operated and maintained properly the pollutant discharge standards will be met. This implies that training of the personnel needed to operate and maintain the treatment plant should from an integral part of the implementation of the project.

It also has to be acknowledged that worldwide experiments and trials are ongoing to reuse part of the treated tannery effluent either in the process or in the cultivation of certain tree/ plant species. Though initial results are promising, at this stage it is too early to confirm suitability of treated tannery effluent for the two above said purposes keeping in mind longer term implications. However, UNIDO's Report recommends that a provision may be made for this purpose under controlled and closely monitoring conditions on a small pilot scale. In the event of satisfactory reuse/recycle system for treated effluent becoming established and available and acceptable to the CEA before the complex is ready, at that stage, the CEA

may reconsider if this alternative could be adopted on lieu of sea-discharge of treated effluent. Finally the discharge of treated effluent to the marine coastal waters was accepted

3.4. Clean Settlement Project

The clean settlement programme and its pilot project that were undertaken in 1992 also focused on establishing a healthy environment for slum dwellers. A storm water and sewage management was one of the foremost programme of this project and upgrading 135 family settlement in the municipal council area through a local NGO was one of the initiatives in this project.

The project area was divided into three Community Development Council (CDC) areas, and each CDC had the responsibility for implementation in its area. Sevanatha a non governmental organization served as the facilitator in organizing activities and linking local government and other agencies with the CDCs. The action plan developed contained both short and long term solutions. The former would be executed by the community without external assistance. Examples of these activities included repair of damaged common toilets, water taps, and drains. Long term solutions included actions taken by the communities in partnership with external actors, using external assistance. These solutions were more permanent remedies to environmental problems.

Strengthening local government institutions is crucial because they play a central role in managing the urban environment, through for example, provision of city services and land use planning. When services break down or environmental conditions deteriorate, they are often the first to be blamed. If the marine coastal waters are to be protected the local government institutions especially the Municipal council will have to play a major role.

In many cities, local capacity to generate revenues is limited. This inability to raise funds contributes to the failure of local authorities to properly operate and maintain environmental infrastructure, such as water supply, drainage, sewerage, and solid waste management. Capacity building for urban planning and governance at the local level must include enhancing local revenue resources such as property taxes, business or motor service charges for environmental infrastructure.

3.5. Cleaning of sewage system/ net work

Available data indicates that, in an area with approximately 500,000 households, there are approximately 300,000 sewerage connections. Consequently, a significant proportion of households rely on the use of septic tanks, which if not constructed or sited properly (particularly) in areas where the water table is high), will only compound the problem of urban water pollution.

In addition, the highly polluted state water bodies in the Colombo, such as the Beira Lake, is directly the result of, among other things outlined above, the lack of or, inadequate maintenance and cleaning of sewerage systems in the city. The overloading

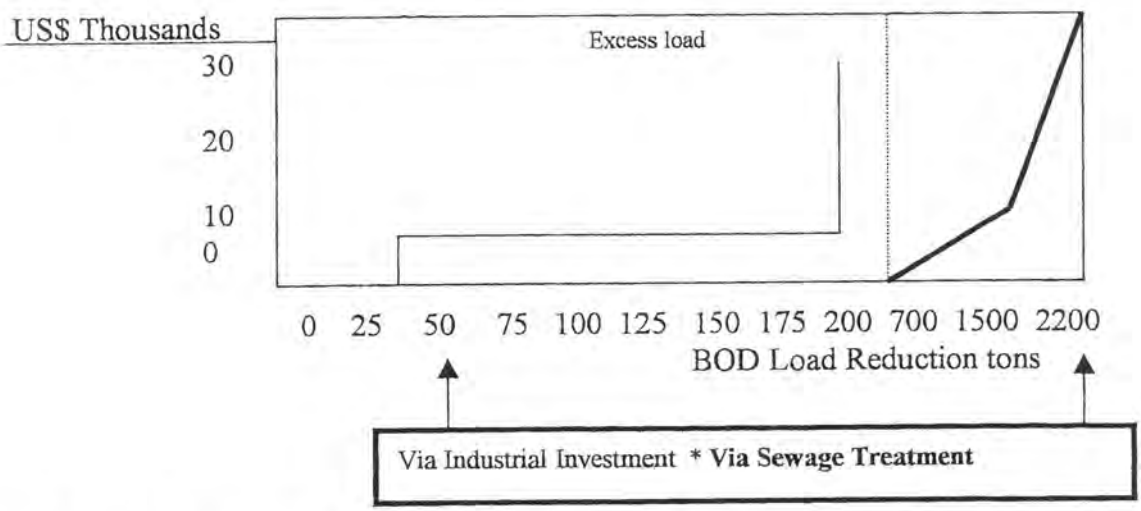
of the existing network as well as poor planning has led to the discharge of, among other things, domestic wastewater into the lake such that it has reached a deplorable state. The current World Bank, project to clean up the Beira Lake (which is illustrated elsewhere) by addressing the root cause the upgrading of sewerage networks.

3.6. San Sebastian Canal Project

San Sebastian Canal is part of the Colombo canal system and it discharges storm water, industrial effluent, and sewerage collected from a large urban area into the Kelani River via the north lock situate just upstream of Victoria Bridge. The land adjoining the canal is home to a huge shanty settlement. Where people live in conditions where sanitary and waste disposal facilities are non- existent. A large number of industries are present along the canal banks, utilizing the canals for liquid waste disposal. The collective result of this influence makes the San Sebastian Canal the most polluted water body in the city of Colombo. Households, on the other hand, account for more than half of the total load in the San Sebastian Canal.

The marginal costs for BOD reduction via investments in sewerage treatment are shown on the right-hand side of figure 3.1. Clearly, investment in a sewage treatment system has the potential for reducing load in the San Sebastian Canal by an amount greater than the excess load and thus returning the Canal's ambient water quality to an acceptable level.

Figure 3.1 - Exhibit Marginal Cost of Controlling Pollution in San Sebastian Canal



This study and other analyses clearly demonstrate that wastewater & sewage is the most significant factor contributing to the pollution in this area. It further illustrates that it was through investment on sewage greatest potential of returning those water bodies ambient water quality to acceptable levels. This would have a direct impact on coastal waters. As all these water bodies in and around the Capital city either falls to the Beira Lake or the

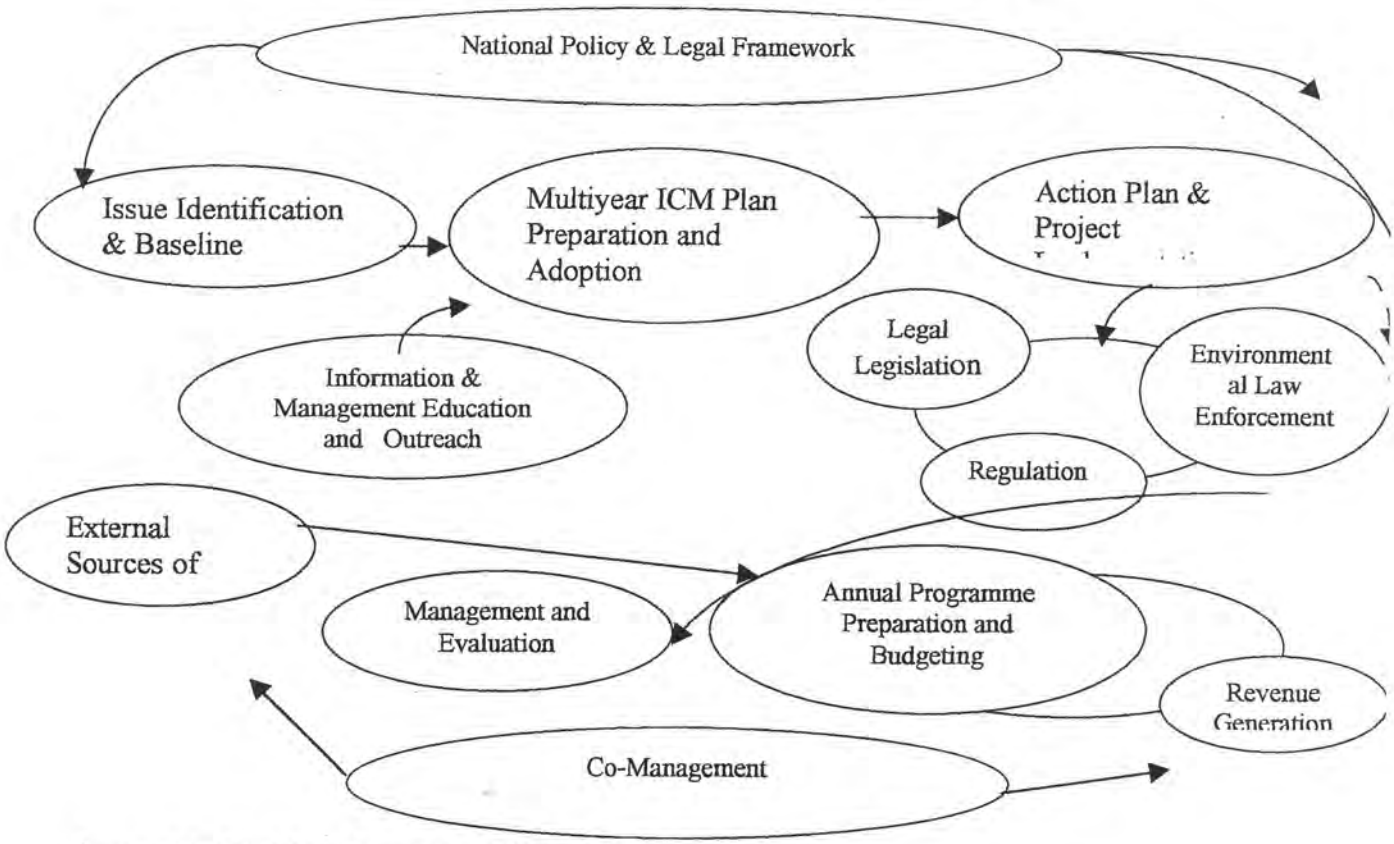
Kelani River at Points which is less than 1 kilometer to the sea. Therefore purifying these water bodies as well as the Beira Lake would have a lasting impact on the ocean.

3.7. Review of the role of local governments

Local government can play a pivotal role as both a front-line steward and as a last safety net for the recovery and sustainable use of coastal resources (Courtney and White 2000). The process of devolving coastal management responsibilities to local government may take different forms and cover different mandates and geographic areas. As a basic service of local government, however, coastal management should incorporate local government powers and responsibilities for planning, protection, legislation, regulation, revenue generation, enforcement, intergovernmental relations, extension services, and technical assistance.

Figure 3.2 shows the coastal management process as a basic service of local governments guided by national policies and laws. Community-based approaches that directly involve coastal stakeholders and NGOs are of paramount importance in the devolved functions, as are other co-management mechanisms with neighboring local governments, national governments, and other sectors.

Figure 3.2 - Coastal Management as a Basic Service of Local Government



Source: Modified from Courtney and White 2000

Joint venture between national and local government with the private sector and community based organization collaboration is an effective way of implementing these programmes. As mentioned earlier the cleaner settlement project and involvement of Sevanatha Foundation is an example. Simply mandating coastal management as a matter of policy is not sufficient to arrest environmental degradation. There should be a strong local mechanism to handle it. The units at local government level should be strengthened and they should be given the autonomy to liaise and get the assistance of all stakeholders in the execution process. Community based natural resources management is also promoted as a more environmental sustainable and socially equitable alternative by existing resource management regimes. Such a programme too could be implemented if an integrated programme is worked out with local government authorities getting authority over coastal marine waters.

3.8. Coastal Management Plans – 1996

The Cabinet of Ministers in April 1990 approved the Coastal Zone Management Plan and decided that the plan should be updated every 4 years. In 1993, a Coastal Protection Unit was established under Sri Lanka Ports Authority.

According to the revised coastal zone management plan 1996, in order to arrest the deterioration of the water quality of coastal water and to mitigate impacts on discharge of wastes to coastal water it was suggested that,

(a) All activities and discharges along coastal zone should conform to the CEA standards for coastal and seawaters.
(b) To co-ordinate with all other relevant organizations to formulate economic incentive schemes for controlling waste discharges to coastal zones.

Coastal zone Management Planning seeks to define the issues, policies and actions for long term planning and management of the coastal region which has a unique identity. The Sri Lanka Coastal Zone Management Plan addresses the issues of shoreline erosion and the loss and degradation of natural coastal habitats, as well as of recreational, cultural and scenic sites. Appraisal of development project proposals within the broad mandate given in the Coastal Zone Management Plan involves consideration of the needs of the people as well as the condition of the ecosystems in a manner a project based EIA cannot adequately accomplish.

The management of coastal resources involves many government institutions, as in the case of other natural resources in Sri Lanka. Responsibilities are sometimes overlapping and/or conflicting, and in other instances responsibilities are unclear. The primary management responsibility, however, rests with the Coast Conservation Department (CCD) presently placed within the Ministry of Fisheries and Aquatic Resources Development (MFARD). CCD is responsible for:

* Formulating and implementing coastal protection and management activities;

* Regulating development within the prescribed "coastal zone" (see below) through permits;
* Evaluating development project impacts through discretionary environmental impact assessments;
* Preparing and implementing the Coastal Zone Management Plan; and
* Conducting surveys in co-operation with other agencies.

To assist with management decisions and recommendations, the Coast Conservation Advisory Council advises the Director of Coast Conservation on all development activities in the coastal one. This council reviews the Coastal one Management Plan (CZMP), environmental impact assessments (EIAs) and requests for variances on permits. The CMP, which was approved by the Cabinet of Ministers in 1990, provides the framework to manage resources in the coastal one.

One main constraint faced by the CCD is its limited legal jurisdiction. CCD's jurisdiction is restricted to the "coastal Zone", which is defined as the area 2 km out to sea, 300 m inland, and 2 k inland for rivers, lagoons and estuaries. CCD and other agencies also face the more common problems of lack of financial resources, equipment and trained personnel.

Unlike other Government agencies, CCD's mandate is more farsighted in that it was designed to help co-ordinate the sectoral management authority of other agencies. Thus far, CCD's coordinating role has been on a more informal basis. There is a need for CCD to place greater emphasis on interagency co-ordination. To help accomplish this, more formal interagency coordinating mechanisms, such as Memoranda of Understanding, may be needed.

In the case of Rekawa, CCD plays a leading role in coordinating management activities within the SAM area. This situation is a test of CCD's broad interest n coastal one management, as envisaged in Coastal 2000 Central to this process is the concept of Special Area Management.

3.9. Ja-Ela/Ekala wastewater management project

A piped collection system has been found to be economically feasible in the main industrial area in Ekala only. A few establishments with more than nominal waste generation outside Ekala will have to transport their effluent by trucks to the (proposed) central treatment plant (5 industries).

The proposed collection system will potentially serve a total of 101 (projected) industrial and commercial establishments and will remove 98.8% of all domestic/industrial wastewater produced in the area. The proposed network will be dimensioned for a total flow of 5270 m3/day and includes capacity reserve for the ultimate connection of approximately 98 ha of residential development (2700 population).

3.10. Ratmalana/Moratuwa wastewater management project

The proposed sewer network will have a capacity of 15380 m3/day consisting of gravity network force mains and pumping stations for the Ratmalana/Moratuwa area. This capacity which would provide the potential for some 200 industries to connect and would remove 93% of all domestic/industrial wastewater produced in the area. As in the Ja-Ela/Ekala one, in 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-30000 population), be it by construction of additional sewers at a later stage.

As above this area too is a part of the coastal plain with a predominantly flat topography. The land elevation varies between 1 to 7 metres above MSL. Relatively, Ratmalana/Moratuwa industrial one is closer to the sea than the Ja-Ela/Ekala zone.

Seepage from domestic septic tanks and soakage pits is prevalent in the project area, resulting in faecal contamination of ground eater. Chemical contamination by seepage of industrial effluent also affects groundwater quality. In addition, the ground water quality is affected by saline intrusion, particularly in the land strip nearer to coast between the Galle road and the sea. Such problems are particularly prominent during the dry weather period (January to April).

3.11. Regulatory Framework related to coastal protection

Coast Conservation Act: The Coast Conservation Act No 57 of 1971 stipulates that a permit must be obtained from the Director of Coast Conservation to engage in any development activity within the coastal zone. The Act defines the "Coastal Zone" as the "area lying within a limit of 300 meters landward of the mean high water line and a limit of two kilometers seaward of the mean low water line and in the case of rivers, streams and lagoons, or any other body of water connected to the sea, either permanently or periodically. The landward boundary extends to a limit of two kilometers perpendicular to the straight base line drawn between the natural entrance points thereof and includes the waters of such rivers, streams and lagoons, or any other body of water so connected to the sea." Fishing is the only " prescribed" activity in the coastal zone permitted without an EIA.

Centralised Sewerage System: Sewerage systems are only classified as Prescribed Projects, under the National Environmental Act (NEA), and require formal environmental assessment if the wastewater is toxic or hazardous. There is no toxic or hazardous substance involved in the proposed project.

The operation of the project will include discharges into the environment by way of treated effluent from the system and dried sludge. Consequently, an Environmental Protection Licence (EPL) will be required as a prerequisite to system operation. The EPL is issued by the CEA and generally contains operating standards for the system including specification of national standards for system discharges into the environment.

The EPL is required to be renewed annually and conditions for renewal are based on the environmental performance of the system in the previous year.

Sewer Pipe Laying: The NEA lists pipe laying exceeding 1 kilometre as a prescribed project. Since the proposed project is likely to involve pipe (sewer) laying exceeding 1 kilometre, and significant disruption to traffic if laid along Galle Road is inevitable, then an Initial Environmental Examination (IEE) will be required. The CEA will issue the Terms of Reference for the IEE upon submission of sewer layouts.

Location of the Sewage Treatment Plant: An environmental examination will be required if the proposed site is located in a sensitive area. The sensitive areas that are relevant to the present Project are;

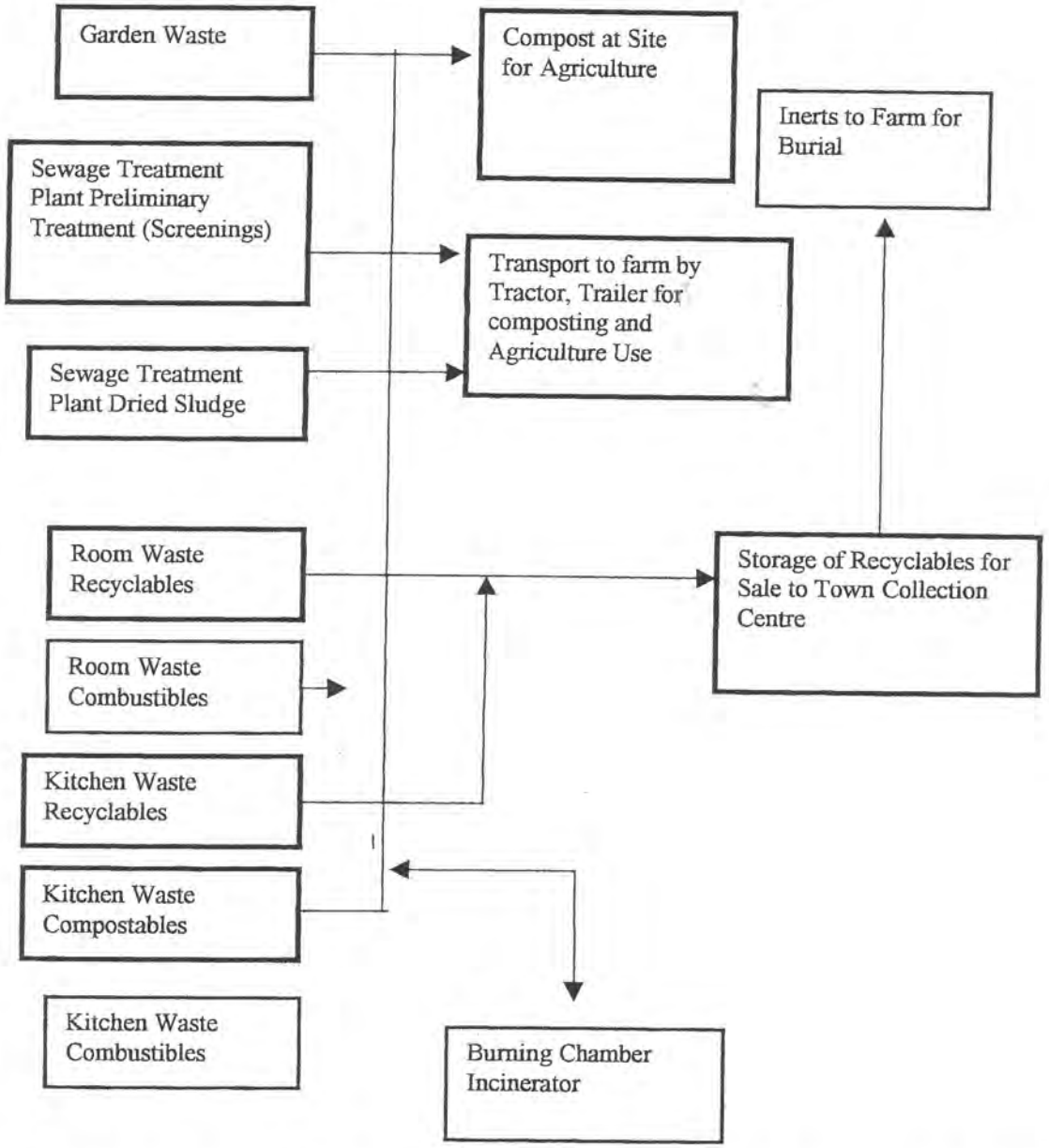
(a) 60 metres from the bank of a public stream having a width more that 25 metres at any point of its course
(b) within 100 metres from the boundaries of, or within, any area declared as a sanctuary under the Fauna and Flora Protection Ordinance
(c) within 100 metres from the high flood level contour of, or within, a public lake.
of the above, (b) is particularly relevant if a sea outfall is envisaged.

If the proposed system is not within a sensitive area but within 300 metres from the high-water line of the beach, then the jurisdiction of the project approval will come under the Coast Conservation Department (CCD) under the Coast Conservation Act. In that case, a permit from the CCD will be required to construct and operate the system. The CCD will issue such a Permit subject to an Initial Environmental Examination (IEE).

Location of Final Effluent Disposal Point: The EPL, as previously mentioned in will specify the effluent characteristics to suit the receiving water body. In the event that a sea outfall is envisaged, permission from the CCD based on an environmental assessment will become necessary.

Environmental Guidelines: When comparing the sectors in Sri Lanka it is the Coastal Zone where some regular system of management is in operation. It covers areas such as wastewater, storm water, sewage collection, sewage disposal, septic systems, among other things. Coastal zone structures specially hotels has been subjected to heavy systematic control by the department of Coastal Conservation and Ceylon Tourist Board. Although all hotels and Guest house are subjected to adhere to management plans, in order to control Coastal pollution from land based sources it is only some of the major hotel groups such as John Keels, Aitken Spence and Confifi Group have come out with a prudent waste management plan (Figure 3.3)

Figure 3.3 - Waste Disposal Plan for Aitken Spence (Hotels) in Coastal Zone



Apart from the regulations of CCD of Ceylon Tourist Board. The Institutions Constructions Training and Department (ICTAD) has prepared Guidelines for Potable Water Supply, Wastewater and Storm Water Drainage, Domestic Sewage Disposal and Solid Waste Management.

These guidelines are basically connected to collection of disposal and include the diameter of pipe as well as slope. The slope of the pipes must be maintained at a self-cleansing velocity. Sri Lanka Building standards provide for slopes as low as 1:130 for 100 millimeter (mm) diameter pipes and 1:200 for 200 millimeter diameter pipes. These

national standards do not have local variations. The recommended minimum pipe diameter is 75mm.

Wastewater disposal systems are listed below in order of heir desirability.

1. Diversion for use in agricultural lands or for lawn watering
2. Disposal to a common sewer if one exists.
3. Connection to septic tank system soakage pit if the system and the soil are capable of absorbing the extra liquid.
4. If the above are not feasible, the following may be considered depending on soil conditions, availability of space, and depth of the water table.
    a. Soakage pit if the soil percolation is adequate;
    b. Soakage field if the percolation rate is inadequate;
    c. Evapotranspiration mound if rock or clay exists at a shallow Depth and the water table is high; and
    d. Under-drain filter if due to soil conditions, all of the above are unsuitable options.

The Coastal area especially for areas where tourism is dominant the regulatory framework is supervised and effected by the Ceylon Tourist Board. Even the implementation of guidelines issued by ICTAD and other agencies are regulated through this mechanism. This at least give some guarantee that pollution of coastal seas from this sector is somewhat checked and controlled. Since these are point sources and subjected to licensing from the Department of Coast Conservation and the Ceylon Tourist Board the sector is rather streamlined. However even within this area it is the unauthorized dwellings and shanties who thrive from forward and backward linkages of the industry who engage in pollution of coastal waters.

Storm Water collection Systems: Storm water collection systems should be designed according to the desired velocity of the flow and for ease of maintenance. Closed drains should be provided only if;

- Road width is limited
- Where drains are deeper than 0.75 meters
- Where open drains are not aesthetically appropriate

Storm water from the collection system should be discharged through outfalls to natural water courses, to larger drains or canals, to retention ponds or marshes, or to a soakage system. The discharge through the outfall should be via a silt trap and screen to prevent debris collected in the open drains from being discharged through the outfall. The placement of the outfall pipes into natural waterways should be in areas with large amounts of flushing and away from coral reefs and other coastal habitats which may be damaged by the outfall.

Sewage disposal : Sewage comprises the waterborne wastes of a human community carried in a sewer system normally containing animal or vegetable matter in suspension or solution, excluding sludge. Sewage can carry human diseases through viruses and bacteria that are pathogenic to humans. Untreated or improperly treated sewage is a health hazard and can contaminate drinking water sources and coastal waters. Contaminated coastal waters are not suitable for swimming and other recreation activities, resulting in not only environmental degradation, but economic losses from tourist declines and increasing health costs of residents.

Large hotels of more than 100 rooms are required to install waste water treatment facilities. A "Biofilter Sewage Treatment Plant" has recently been installed in the Eden Hotel which offers cost effective treatment and recycling for sewage and wastewater. Traditional treatment mechanisms are more costly and expensive to maintain.

Permit Procedures for Coastal Developers: Coastal tourism developers until 1993 had to obtain project approval/ clearance from each government agency. The application procedure has been changed to allow developers to make only a single application to the Tourist Board. Applications for projects to be located in the Coastal Zone are then referred to the CCD for their observations. The present application form includes questions covering the interests of all concerned agencies.

The Coast Conservation Department may require the project proponent to submit an Initial Environmental Examination Report (IEE) or an Environmental Impact Assessment (EIA) Report before a permit is issued.

All proponents of tourist development (as well as other developers) are required by the Environmental Act to submit within a specified time an IEE report, or, in the case of a hotel or holiday resort or project which provides recreational facilities exceeding 99 rooms or 40 hectares, as the case may be an EIA report. The IEE or EIA report is made available during a period of 30 days for public comment. These comments are studied by the project approving agency and its decision is then published in the Government Gazette. The overall EIA process is described in a booklet by the Central Environmental Authority.

A permit from the Director of Coast Conservation is mandated by the Coast Conservation Act No. 57 of 1981 for conducting any development activity in the Coastal Zone.

3.12 Responsible Institutions for Coastal and Marine Resources

The Ceylon Tourist Board assists with the development of tourism, enabling the country to enjoy the benefits of increased foreign exchange earning and providing support to the service industries and the traditional cottage industries. The Ceylon Tourist Board Act No. 10 of 1966 requires The Tourist Board as part of its special duties to:

(a) prepare schemes for the establishment, regulation, supervision, development and control of : tourist resorts, tourist services and the employment of persons in tourist services; and to

(b) formulate a national plan or policy, outlining general proposals for the regulation,supervision, development and control of tourism.

The Tourist Development Act No.14 of 1968 mandates the formulation of a Tourist Hotels Code. The Tourist Development (Amendment) Act No. 2 of 1987 requires that no person without authorized approval within a declared tourist development area shall:

(a) "construct or erect any building or structure; or
(b) re-erect, alter or convert any existing building or structure; or
(c) set up or carry on any establishment or business, for the purpose of providing any tourist facilities and services within such (a) tourist development area."

The Central Environmental Authority (CEA) administers the National Environmental Act and its regulations. It has designated the Tourist Board as the Project Approving Agency for Tourist Hotels, where such projects are to be located outside the Coastal Zone which is the domain of the Coast Conservation Department.

Tourist hotels are also subject to the National Environment Act of 1988 (Amendment) mandate which states that "no person shall discharge, deposit or emit waste into the environment which will cause pollution except: (a) under the authority of license issued by the Authority (CEA); and (b) in accordance with such standards and other criteria as may be prescribed under this Act."

The National Environmental Act as amended in 1988, mandates that developers must have a permit from the Central Environmental Authority before discharging any effluent or solid waste material into the environment. This Act also specifies tolerance limits for industrial and domestic effluents discharged into marine coastal areas. The revised Coastal Zone Management Plan of 1996 strengthens the Coast Conservation Department role in monitoring and controlling discharges, solid or liquid, in the coastal zone.

The Coast Conservation Department (CCD) has jurisdiction over two kilometres of coastal sea and a 300 metre strip of land measured from the high water level, as well as 2 kilometres of coastal waterways measured perpendicularly from the seashore. The major concerns of the CCD are prevention of coast erosion, the protection of coastal habitats such as coral reefs, seagrass beds, mangroves and other shoreline vegetation and the prevention of pollution.

The Coast Conservation Department's regulatory policy includes the reservation of setbacks or land where building activity is prohibited or severely restricted. The extent of the setbacks was Management Plan of 1990. The setback distances have been revised on the basis of improved information available after several years of implementing the Coastal Zone Management Plan regulations. The setback area in the Coastal Zone Management Plan of 1996 is divided into a strict "reservation or no build" zone adjoining

the beach and a "restricted or soft zone" on the inland side, where limited development may be allowed.

The Ministry and Department of Fisheries and Aquatic Resources Development are concerned with coastal tourism development in areas that have been traditional fishing sites such as Tangalla and Negombo. The right of public access to the beach, particularly of fishermen, has been denied in several areas, leading to user conflicts. The Ministry is the watchdog of the traditional rights of fishermen to beach their boats, to engage in beach seine (medal) fishing and provision of space for fishermen to hang nets to dry.

The Urban Development Authority has authority over all urban areas. In the case of coastal areas this authority extends up to one-kilometer inland. UDA is concerned with: the location of hotels (away from schools, places of religious worship); infrastructure facilities (water supply, sewage disposal, garbage disposal, storm water drainage, electric power, and fire protection).

The Urban Development Authority, under its Planning and Building Regulations (1986), in the interest of harmonizing development with the surrounding (urban) development, can request the developer to make modifications as it deems necessary in the height, architecture, architectural features or façade of any building. The Authority may also direct a developer to landscape the development site and maintain it with planting in a stipulated manner.

Chapter 4

Identification Of the Economic Sectors Making Use Of Coastal And Marine Environment

4.1 Introduction

Marine and coastal ecosystems have been the foremost economic base for the coastal population in the world. The economic activities of the marine eco-system are largely based on the two economic functions of the marine environment viz., as a resource supplier and as a waste assimilator. These activities range from direct uses such as fish production to recreation benefits and indirect benefits such as maintaining biodiversity, nutrient cycling and hydrological functions. It is therefore important to recognise at the outset the specific type of contributions made for each sector from marine and coastal environment.

Coastal economic activities play a significant role in the South Asian economies. The major economic sectors making use of the coastal and marine environment in the South Asian region includes: tourism, fisheries, industries, transportation, ports and harbours and waste disposal.

In the **Maldives**, dredging and reclamation activities in the lagoons for development activities contributes to the problem of erosion. This has happened around the airport island of Hulule, where extensive reclamation was undertaken by dredging the surrounding lagoon in order to extend the airport runway for modern jumbo jets. This is now causing beach erosion problems in some parts of the island mainly due to changed current patterns. Many island resorts also suffer from beach erosion problems especially when landing jetties affect and change the course of the local currents.

Industrialization in the some identified countries are rapid and has more recently being congregated into sites and locations in order to provide the industries with better and required facilities and the fact that these industries will be placed away from human habitat areas.

In **Pakistan** there are three identified industrial sites. The SITE AREA (Sind Industrial Trading Estate) covers about 4,000 acres of land and has 300 major and 900 minor industries of which the textile industry is the largest (60% of the total). Other industries are: battery, cement, chemicals, electroplating, electricity generating plants, food and beverages, heavy engineering works, tanneries, meat, oil refining, paints and dyes, paper, pesticides, pharmaceuticals, plastic and rubber, tobacco, and vegetables.

In the LITE AREA (Landhi Industrial Trading Estate; includes Korangi) has fewer industries such as textiles, meat, fish – meal and soda ash factories. A recent trend in the greater Karachi area is the upsurge in the development of the poultry industry particularly in the area between Karachi and Hyderabad. Small and large units of this industry are scattered in both SITE and LITE areas.

On both the eastern and western coasts of India, there are regions of intense industrial development. One of the most important in the east coast is the Hooghly Estuary region. The lower part of the estuary has multifarious industries: paper, textiles,

chemicals, pharmaceuticals, plastics, shellac, food, leather, jute, tyres, and cycle rims. Between the 92km from Dumurdaha to Birlapore, 95 factories are found of which 55 are jute mills.

4.2 Coastal based tourism sector in South Asia

As in the other parts of the world, the common feature of the tourism is its dependence on beaches, sea, or other water bodies for recreation and relaxation. It is thus highly sensitive to water quality and the cleanliness and appearance of beaches, and there is a risk of uncontrolled and careless development spoiling those very assets on which it depends.

Emphasis is laid on the tourism services sector, more recently on eco-tourism. As a result too many large hotels are being constructed along the beaches. As discussed earlier, land based pollution particularly, due to domestic and urban sewage is causing significant threat to the coastal tourism sector in the South Asian region. Wastes from these hotels are very often a serious threat to the adjacent marine habitat. In some countries garbage and other wastes from these hotels have spoilt the beauty of the beaches and let to contamination of the environment and generation of hydrogen sulphide in the water.

One of the countries that have a concentrated development plan for tourism is the Republic of **Maldives**. Tourism is island resort type, where the entire island is developed into a resort. There is only one resort on one island that is usually on few hectares only. The Government of Maldives has designated islands on selected atolls for such development, and these islands are leased to the resort to developers for a specific period. The Government however, aims to limit tourism development to a specific zone through the control of limiting resort building on identified atolls.

Tourism has expanded considerably in the Maldives. Tourist arrivals increased by 9% over 1997 to 2100000. The sharp increase in tourism has also stimulated economic activity in the construction, distribution and transportation sectors.

4.3 Coastal based industrial sector in South Asia

The coastal region comprises 24 percent of the land area of Sri Lanka but economic activities in the region account for 40 percent of the gross domestic product. Industrial development constitutes a significant portion of increased economic activity. Ninety percent of industrial units are located in coastal areas. Three products accounted for 72 percent of total industrial employment in 1989: (1) food, beverages and tobacco; (2) clothing and leather products; and (3) chemicals, petroleum, coal and plastic products.

In view of the government's industrial development policies and the attractiveness of Sri Lanka for foreign industrial investment, managing urban and industrial wastes are of increasing importance. Urban pollutants-heavy metals, petrochemicals, sediments and fecal matter-degrade marshes, estuaries, lagoons and coral reefs and threaten the sustainability of near shore fisheries. Increasingly polluted river and ground water also increases exposure to water-borne pathogens. Increasing urbanization and

industrialization have combined to make water quality an important issue to be addressed by coastal managers and others.

Coastal and marine areas of the South Asian region often bears many mineral resources. For example, Sri Lankan beaches have illmenite, monezite bearing beach sands, limestone, copper magnetite and peat. Sand mined from Sri Lanka's coastal areas and rivers is used by the construction industry. Sand mining in a river lowers its bottom, causes bank erosion and reduces the supply of sand to the coast. The riverbed and the banks will show continuous erosion when the extraction rate nears or exceeds the natural productions. In these circumstances there may be a sharp drop in supply to the coast. The reduction of supply to the coast and direct mining from the beach lead to recession of the coast, gradually spreading from the river mouth and the locations of beach mining. The effects of mining combines with the effects of sea level rise. Any volume of sand extracted from the active parts of the rivers and the coast is lost to the entire system. No natural process can replace it.

Excessive mining and inappropriate location of sand mining operations contribute to shoreline erosion and beach retreat by cutting the sand supply to can contribute downdrift beaches. The erosion of the riverbanks and coast can be prevented by protection work. It has been estimated that the damage, in the form of land loss and/or protection comes to Rs. 25 to 30 million per annum or Rs. 9.00 per m^3 of sand mined. The ongoing recession and depletion of sand in the riverbeds and along the coast will cause deepening of the rivers and estuaries; enlargement of the mouths of rivers and other coastal inlets, and the creation of new inlets by breaching of the coastal barrier. These processes will allow:

* The sea (tides, saline water) to intrude deeper in to the coastal plains;
* Increased flooding originating from the sea;
* Disappearance of coastal vegetation;
* Salt intrusion, especially during dry seasons; and
* Changing water quality causing negative impacts on aquatic fauna and habitats.

A survey of the location, extent and socioeconomic issues related to coastal sand mining from Puttalam to Dondra Head conducted by the CCD in 1984 was updated in 1991. This area includes most of the major sand mining locations in Sri Lanka. The 1991 study revealed that approximately 576,938 cubes (1,633,700 cubic meters) of sand were mined from the coastal region. This indicates a 14 percent or 69,072 cube increase in 1991 over 1984. The number of sand miners had increased from 1,762 in 1984 to 2,891 in 1991

Coral is the principle source of lime for Sri Lanka's construction industry, supplying approximately 90 percent of the lime used. Coral is also used as an inexpensive source of soil ameliorant which reduces acidity in agricultural lands. In certain parts of the southwestern coastal sector, coral has been mined for almost four hundred years. Traditionally, only relic reefs behind beaches were mined. The growth of the construction industry since the late 1960's has stimulated the coral mining industry and led to the destruction of living reefs that serve as natural barriers against wave attack on these coasts.

Types of coral extraction in Sri Lanka include reef breaking, collection of coral rubble from the beach, and back beach mining. Reefs are also blasted to provide navigation access to fishing boats. Both coral collection from the beach and the reef breaking aggravates erosion. Besides destroying the ecologically valuable reef habitat, reef breaking reduces the size of the fringing reef and its natural ability to absorb the energy of breaking waves. Without reefs, the full force of waves strikes the shore, thus increasing the rate of erosion.

Coral rubble is one source of beach material in Sri Lanka. By collecting large amounts of coral rubble from the beach, the amount of material available for beach nourishment is reduced, accelerating erosion either locally or downdrift. Coral rubble also assists in reef building through consolidation by binding organisms which leads to new reef formation.

Table 4.1 Coral collected from Sri Lanka's southwestern coastal sector, 1984 and 1994

Location	Amount (tons) 1984	Percent of total	Amount (tons) 1994	Percent of total
Inland	10,400	58	15,800	80
Sea corals	7,659	42	4,020	20
Total	18,059	100	19,820	100

In 1984, an excess of 18,000 tons of coral 1985 was extracted in the coastal reach between Ambalangoda and Dickwella. By 1993 sea corals removed from the coastal zone declined to an estimated 4,020 tons per annum, a 48 percent decrease from 1984 (Table 4.1). This has resulted from the enforcement of regulations under the Coast Conservation Amendment Act of 1984. However the sea coral supply to the market has been supplemented by mining of inland coral deposits outside the coastal zone. The amount of inland coral mining has increased 52 percent from 10,400 tons in 1984 to 15,800 tons in 1994. In 1994 a total of 1473 persons were directly engaged in mining, collecting and transporting of sea corals while another 800 persons were engaged in inland coral mining activities.

4. 4. Coastal based fisheries sector in South Asia

The Indian Ocean contains between 3000 and 4000 species of fish. Owing to the area being rich in chlorophyll, nutrients, organic production and zooplankton, biomass should sustain large stocks of fish. Most fishing methods used here fairly simple and fishing by large vessels using advanced technology is somewhat restricted to the foreign presence in the area. The main species of fish found in the Indian Ocean are listed in tables 12 and 13. The distribution of fish larvae in the Indian Ocean is shown in figure 16. As the countries are in stages of development, have large numbers of people living close to the sea and making their living from the coast. These people have traditional rights of access to fish and other marine resources.

The Exclusive Economic Zone (EEZ) of **Bangladesh** encompasses an area of around 768000 km (square) and is a potential form of fish and shell fish (Shaffi and Quddus 1992). Fisheries sector for Bangladesh is second to agriculture in terms of economic activity engaging over 5 million people especially in the coastal wetland areas and contributing 6% to Gross Domestic Product (GDP) and 12% export earning.

The total harvest of Finnish, crustaceans and frogs in Bangladesh is now estimated at about 675,000 –725,000 tonnes per year. In the Sundarbans, 185,000 people were engaged in fishing over the period 1971 – 1983 and the average number of boats employed was 54,000. fishery production in this areas have increased from 640 Mt. In 1971/72 to 14,000 mt in 1982/83. The average annual yield over this 12 –year period was 7,160 mt although ESCAP (1988) gives figures of about 9,999 tons. The main catches are hilsa and prawns, the former for local consumption, the lette export. The estuaries and shelf waters are very rich in prawns and shrimps, notably Macrobrachium, Penaeus, Metapenaeus, Parapenaeopsis and Palaemon.

Table 4.2 - Province-wise nominal catch of fish and shellfish - in metric tones

AREA		1997	1998
Pakistan		589,731	596,980
Marine		422,201	433,456
Finfish		387,647	394,265
	Sindh	252,739	257,973
	Balochistan	129,025	129,465
	EEZ	5,883	6,827
Shell Fish		34,554	39,191
	Sindh	33,028	37,675
	Balochistan	1,381	1,334
	EEZ	145	182
Inland			
Fresh Water Fish		167,530	163,524
	Sindh	102,508	106,611
	Punjab	61,098	53,924
	N.W.F.P	743	840
	Northern Area	110	83
	Dams	3,071	2,066

Source: Pakistan's National Programme of Action under the Global Programme of Action for the Protection of the Marine Environment form Land Based Activities – December 1999.

The directorate of fisheries of Bangladesh and the Bangladesh Fisheries Development Corporation are undertaking projects to develop coastal marine fisheries in the Bay of Bengal with financial assistance from the International Bank for Resource Development ad the Asian Development Bank

Pakistan is a net exporter of shrimps, lobsters, crabs, mollusks, fish which year and fishing products. A total of 83,183m tones were exported which fetched Rs 7,27

billion. The total landing for small pelagics, large pelagics, dmersal fish and shellfish I 1998 accounted for 433,456m tons.(Table 4.2)

In the **Maldives** fishing (especially Tuna) from sailboats using live-baits constitutes the traditional fishery. Mechanization of the fishing crafts has only very recently been introduced and popularized. There are unconfirmed reports in recent years of some decrease in commercial tuna populations in certain areas and seasons at certain depths in the fishing grounds, but this has yet to be scientifically investigated and confirmed. Considering the low intensity of fishery so far, the chances for such a decrease, if at all true, being caused by overfishing is very remote.

Fisheries provide direct employment to more than 22,000 people. Estimates indicate that the total fish catch grew by about 3% in 1998 to more than 110,000 tons.

In **India** with a coastline of 5650km, the major fishing ground lies off Kerale followed by Maharashtra and Tamil Nadu. Major potential still exists for catches of catfish along the northwest coast and the upper continental coast; deep sea lobsters from the southwest coasts along and upper continental slope off Quiland; squid off the southwest and southwest coasts along Gujarat and Maharashtra. Lantern fish (Myctophedae), a mesopelagic species providing vitamin A and about 110 litres of oil per ton, are found off the Bombay shelf and Angina Baks. Grenediers (Lut janidae) and macurids are found off the west coast; swimming crab off the northeast and east coast and prawns off Kakinada.

India has extensive molluscan resources that are neglected in some regions and overexploited in others. The more important species are mussels, oysters, clams, pearl oysters, squids, cuttlefish and sacred chank (gastropod). Indian mussels attain sexual maturity very early and grow rapidly to marketable size and they should, therefore, be profitable. However, there is little demand in India for edible bivalves, although pearl culturing is viable cephalopods, too are still underfished.

Bottom trawling provides an average of 200 kg per hour of which 24% are elasmobranches, 17% conges, 14% catfish, 16% croakers and 5% pomfret (Stromateidae). Pelagic trawling is most profitable off Dwarka followed by Veranal and Goa. Here 834 kg per hour has been recorded (60% horse mackeral, 18% ribbon fish (Trachipteridae), 5% elasmobranches 3% catfish, 8% pomfret and 2% eels. In each case the remaining percentage is made up of diverse other species.

According to recent assessment the annual potential yield of marine fishery resources in the Indian Exclusive Economic Zone is 3.92 million tones, about 65% of this potential is already being tapped. The annual catch as of 1997-98 is 2.95MT at an estimated value of Indian Rs 44,250 million. While resources upto a depth of 50m are fully exploited, resources available beyond this depth still offer scope for increasing the level of exploitation through the introduction of a judicious mix of resource-specific small and large fishing vessels.

About 80% of the present level of marine fish production comes from within a depth of 50m and about 20% from depths up to 200m. traditional and mechanized sectors

contribute almost 98% of this production. The deep sea fishing sector contributes a mere 2% of total production.

Table 4.3 - Estimated Fishery Potential in the Indian EEZ

Region	0-50m depth	Beyond 50 m depth	Oceanic	Total
Northwest Coast	866.7	567.0		1433.7
Southwest Coast	565.5	357.3		922.8
Lower East Coast	401.3	100.9		502.2
Upper East Coast	423.7	164.2		587.9
Andaman & Nicobar	22.5	139.0		161.5
Lakshadweep	-	63.0		63
Residual in 300-500m depth	-	4.0		4
Total	2279.7	1395.4	246	3921.1

Source: National Action Plan for Protection of the Marine Environment form Land Based Activities – Integrated Coastal and Marine Area Management. - October 1999.

Out of the available potential of 1.4 mt in the offshore region it is estimated that only 1.13mt is of commercial value. About 86% of this potential is estimated to be of low commercial value, while only 14% is of medium to high value. Even this could yield over Rs 7200 million as foreign exchange through export.

The major commercial fishing ground for fish and shellfish in **Pakistan** extend from Sindh Coast stretching from Hub River to the Indian boarder and Makran coast wet of Karachi along the Balochistan coast to the Iranian boarder.

The present fish production form Pakistan waters is about 0.5 Million metric tones. It is expected that fish production can be increased substantially by taking appropriate conservation measures for renewed sustainable development.

The commercially important marine fisheries resources of Pakistan are composed of about 350 different species. Some 240 are demesal fish, 50 are small pelagics, 10 are medium sized pelagics and 18 are large pelagics fish in addition, there are 15 species of shrimps, 12 of squid/cuttlefish/octopus and 5 species of lobsters.

Even though, fisheries is the most important economic activity along the Pakistan coast, they have undergone a period of decrease in exports especially to the European Union owing to the unhygienic conditions at landing sites. As a result, fish harbours have drastically reduced fish and shrimp exports to the European Union.

4. 5 Coastal based ports and harbours sector in South Asia

This section deals with various kinds of structures at the interface between sea and land. Although most of them are involved in maritime transport, many other coastal developments are not, e.g. sea-walls, housing, tourist buildings and structures, promenades, coastal roads, etc.

The environmental impact of coastal developments depends on a variety of factors, which can be simplified as scale, location and function. Scale is vital. At one extreme, major ports are sizeable industrial settlements in their own right, or else vital parts of large cities, and their environmental impact is hard to disentangle from that of the whole metropolitan area or industrial estate. At the other extreme, individual wharf or jetties serving local or specialised functions will have effects limited to their immediate vicinity, and involving such local issues as coastal stability and amenity. Location is also vital. Certain specialized ports (e.g. for minerals or oil) are located well away from major population centres, whereas others are in downtown areas (e.g. Bombay, Rio de Janeiro). A given environmental effect (e.g. pollution) is a graver risk if it occurs in proximity to large settlements. Another important distinction is between ports located in estuaries and those in bays. The former tend to affect a wider range of economic activities, such as artisanal fisheries, salt reclamation, aquaculture, dredging of sand and gravels, mangrove exploitation, as well as tourism. Ports in embayments, on the other hand, tend to have fewer such activities, and are less susceptible to siltation and industrial water pollution.

The major environmental effects will obviously arise during the course of putting the basic infrastructure in place. Recurring environmental effects will arise mainly from dredging, discharges, spillages and waste from visiting ships, and any water pollution from the port activities or associated industrial processes.

Non-port coastal structures are a large category that takes in a variety of residential, commercial, transport, tourist and amenity developments. All involve modifying the natural coastline in various ways and increasing the intensity of its use. The creation (or destruction) of amenity, the increase in household or municipal effluent and other water pollution, and interference with reefs, Cliffs, mangroves, beaches, etc. are all likely to be relevant environmental issues.

The main environmental effects can be classified as: land-use conflicts, interference with natural processes, and man-made pollution. Certain problems may appear m port areas, but be due to agents elsewhere, e.g. industrial effluent, household sewage. Certain effects will be more prominent during initial construction than during subsequent operation (e.g. land-use conflicts, as opposed to pollution).

Land-use conflicts involves interruption to fisheries, fish breeding grounds, aquaculture; displacement of sand, aggregate mining; preempting wetlands; disruption of tourism and recreation; interference with traditional shipping.

Interference with natural processes involves effects on beach material, longshore drift, siltation; destruction of reefs, sandbanks; riverbed shifts; altered configuration of seabed; loss of original vegetation, e.g. rare flora; destruction of natural habitats for birds, fish, animals; excavation of construction materials, e.g. sand, landfill. Pollution impacts are petroleum and chemical spills from vessels and shore-based operations; risks from storage of hazardous materials; discharges from vessels.

4. 6 Coastal based Sanitation and sewerage sector

The safe disposal of excreta is now possible using a variety of low-cost techniques - e.g. dry, pour-flush, Ventilated Improved Pit, or conventional WC latrines linked to pits, septic tanks or mains sewers. Provided they are properly installed, used ' emptied and serviced they would normally score environmental benefits over the systems they replace. These qualifications are, however, important and often not realized. Leaks into groundwater and freshwater systems are a perennial hazard in areas of high population density. Programs of advice and education on household hygiene are usually necessary to get the full benefits from sanitation projects.

Sewerage projects can be divided into those involving collection, treatment and disposal of sewage.

A) Collection: Septic tanks are serviced and emptied by fleets of vehicles, with minor environmental disturbance. The construction and operation of underground sewers can, on the other hand, entail major disruptions during construction, and thereafter have potential effects on groundwater movements and quality. Leaks and temporary overflows can cause localized risks to public health, and damage to agriculture.

B) Treatment. There are various degrees of treatment, depending on the volumes, the human environment, and whether the water is to be recycled. Sewage treatment works are invariably intrusive, and damage local amenity, though these effects need to be offset against those of the system they replace, especially the disposal of untreated sewage into the sea or inland water bodies, or the use of human waste as fertilizer.

C) Disposal of the treated waste water and residual sludge may pose problems for public health, agriculture and fisheries, though again such problems have to be compared with those from alternative systems of disposal.

4. 7.Coastal agriculture

Historically, agriculture was the main economic activity in these identified countries. In the recent past these countries have changed the development strategies to industrialization. These countries however still, use quantities of insecticides, fertilizers and pesticides such as DDT, aldrin and endrin in the agricultural activities.

Fertilizers, pesticides and insecticides are used in agriculture, pest control and vector control. The quantities of pesticides and insecticides used every year vary widely between these countries. In many countries, however, organochlorine pesticides are either prohibited or are gradually being replaced by organophosporous and carbamate pesticides. Very little study on their accumulation and harmful effects has been carried out. However, a recent survey has shown that plankton in the Arabian sea, off the west coast of India, has a DDT concentration ranging from 0.05 – 3.21 ppm wet weight.

India's agricultural sector rebounded in 1998, this increase in agricultural income is providing a boost to domestic demand, and with exports also recovering industrial production has begun to increase. The consumption of pesticides is estimated at 0.45 kg per hectare. These pesticides are in liquid formulation and are sprayed using

mechanical sprayers. Since, mostly organic solvents are used in the pesticides formulation, the fraction of pesticides in the vapour component remains less. Very low levels of pesticides have been detected in the atmosphere adjoining to agricultural fields.

With the growing population in **Bangladesh** land is fast becoming a scarce commodity. The extent of government owned land is decreasing annually. The coastal area of Bangladesh is given below. Their use of pesticides and the effect to the environment is not available. The annual catch as of 1997-98 is 2.95MT at an estimated value of Indian Rs 44,250 million. While resources upto a depth of 50m are fully exploited, resources available beyond this depth still offer scope for increasing the level of exploitation through the introduction of a judicious mix of resource-specific small and large fishing vessels.

About 80% of the present level of marine fish production comes from within a depth of 50m and about 20% from depths upto 200m. traditional and mechanized sectors contribute almost 98% of this production. The deep sea fishing sector contributes a mere 2% of total production.

Chapter 5

Quantitative Assessment of the Economic Benefits of Coastal and Marine Environment

5.1 Introduction

The coastal zone is a complex ecosystem under the influence of physical, chemical and biological processes. Under natural conditions these processes interact and maintain equilibrium in the coastal ecosystem. Man makes a variety of important uses of coastal resources, as explained in the previous chapter. However, man's extensive use of the ocean introduces factors, which bring about an imbalance in the natural processes, and may result in harmful and hazardous effects to life hindering further use (Ngoile and Horrill, 1993).

Marine ecosystems provide basic support to economic activities by yielding raw materials, supporting and protecting natural and human systems and maintaining options for future economic production and growth, and providing non use values - to households, to businesses, to governments and to the global community. Economic analysis helps to understand and quantify both the value of these benefits, and the costs associated with their loss, and thus provides a justification for conservation of the environment.

Marine degradation has direct links with economic factors. Production and consumption activities impact directly on marine ecosystems through using up non-renewable resources, converting resources and habitats to other uses and adding wastes and effluents to the air, land and sea. In addition, there are ranges of broader economic factors that permit the activities to occur, including macroeconomic and sectoral policies, social and economic conditions. Economic analysis aims to identify these activities and to predict the underlying root causes of marine degradation and loss.

In line with these links, the prevention of marine degradation depends to a large extent on integrating economic concerns into the management of coastal and marine resources. For example, economics is useful in assessing the suitability of a waste treatment plant to protect the coastal and marine environment in order to safeguard the various functions and values of the ecosystem. Economics provides a range of tools and measures, which can be used to address these issues of equity, efficiency and sustainability and to support marine area management including,

- demonstrating the high economic values associated with marine conservation and the significant and wide-ranging costs associated with marine degradation

- providing incentives for conservation by ensuring that adequate economic benefits accrue from conservation and sustainable use to groups who have the potential to impact on marine resources and ecosystems through their economic activity

- identifying sustainable sources of funding and financing mechanisms for preventing marine pollution at community, private sector, government and international levels.

5.2 Benefits of the coastal and marine environment

In the past, the coastal region has played a central role in the development of the South Asian countries. Economic activities such as fishing, tourism, industry and agriculture have sustained rapidly growing economies in the coastal provinces of these countries. Most of the population of the South Asian countries live in the coastal districts, and the number of inhabitants per km^2 is very high in many of these areas. High population pressure in combination with some of the human activities result in increasing pressure on the environment, and signs of serious degradation of some of the habitats in the coastal zone are now obvious.

Coastal habitats considered in this report are coral reefs, estuaries and lagoons, mangroves, seagrass beds, salt marshes, barrier beaches, spits, sand dunes. While the six coastal habitats are discussed separately, this does not imply they are independent units. Natural coastal habitats are linked together by a complex web of direct and indirect interactions. Land use practices in river basins, which empty into coastal waters also, have major impacts upon coastal habitats. However, successful management of coastal habitats will require coordination with authorities responsible for upland activities.

It is important to understand the complex linkages among human activities and changes within a natural system. In the discussion of individual habitat types that follow, the known uses of the six coastal habitats are classified under each habitat type as non-extractive, extractive and transformative to facilitate discussion and public awareness with respect to conflicts among them. Non-extractive uses refer to activities such as recreation, research and education, which do not involve removal of material from the habitats or result in serious impacts. Extractive uses involve removal of renewable materials such as fish or mangrove wood. Transformative uses result in negative changes in habitat characteristics and function. There is a degree of overlap among the uses. For instance, a non-extractive use such as discharge of wastes into an estuary may cause eutrophication and thereby produce a transformation in ecosystem functioning. Similarly an extractive use which causes excessive depletion of renewable resources, such as coral mining results in transformation of a habitat. The following section defines each coastal habitat and its benefits for humans.

5.2.1 Coral Reefs

Coral reefs consist of a large rigid structural mass of calcium carbonate formed by the cemented skeletal remains resulting from the successive growth and development of reef building corals and coralline algae. The corals constitute the more important component since they give vivid color and varied three-dimensional form to the reef.

Both fringing and barrier reefs dissipate wave energy and are important for coastal stability and as a source of beach material. Coral reefs occur in shallow coastal waters that are clear and free from excessive freshwater and nutrients. Growth of corals depends on the presence of microscopic symbiotic plants in their body walls. These plants require sunlight that passes through the clear, shallow water.

Spatial heterogeneity is a key reef characteristic providing diverse living opportunities

for a multitude of plants and animals. This spatial heterogeneity is lost when corals are broken or removed. Loss of spatial heterogeneity inevitably results in a general decrease in the diversity of coral reef organisms. The growth rate of corals is slow and varies between 2 cm per year for the massive brain coral and 10 cm per year for branching corals.

When physical damage occurs, its consequences are rapid and obvious. Coral reefs can become masses of rubble encrusted by algae without the color and productivity that characterizes living reefs. Reef degradation by pollution particularly, by sewage pollution, however, is insidious and the manifestation of damage occurs over a prolonged period. Surveys have recorded 171 species of reef building corals in Sri Lanka waters. Coral reefs offer many benefits, which are briefly summarized in Table 5.1 with proper sewerage management, these coral reef benefits can be protected to some extent.

Table 5.1 Benefits of coral reefs

Type of Benefit	Example
Direct Use Values	
Non-Extractive	a. Tourist viewing generates employment b. Scientific/educational research value
Extractive	a. Coral mining for coral based live ornamental fish and reef products primarily for exports; b. Fishing
Transformative	Anchorages, fisherman sometimes blast channels through reefs to create anchorages
Indirect Use Values	a. Carbon sequestration benefit b. Disturbance regulation function c. Waste treatment function d. Biological control e. Habitat/ refugia value
Non Use Values	a. Existence values b. Bequest values

Source (CCD, 1997), Costanza et al (1997)

5.2.2 Estuaries and Lagoons

An Estuary is a semi-enclosed coastal body of water which has a free connection with the sea, and within which sea water is measurably diluted by freshwater derived from land drainage. The estuaries in Sri Lanka need to be subdivided as basin estuaries and riverine estuaries, since the main management issues for the two types are fundamentally different.

Lagoons are coastal bodies of water containing brackish water which are either

permanently separated from the sea or are connected to the sea only during part of the year.

In most of the South Asian countries, majority of the estuaries is closely linked with the major urban centers along the coast. As populations increase and urban expansion continues, the estuaries, in addition to their natural functions, will be required to support a widening range of human activities. Estuaries support many commercially important organisms that contribute both to estuarine and nearshore fisheries. Some 90 percent of organisms of commercial importance captured in estuaries and lagoons arrive as migrants from the sea. This productivity depends largely on the estuary's mix of fresh and marine waters in providing and renewing nutrients, organic materials and oxygen, and water circulation patterns. Sand transported by rivers into the sea by way of riverine estuaries is important to beach maintenance.

The eventual fate of basin estuaries and lagoons is extinction by sedimentation. This process occurs through the stabilization of shoals by vegetation, barrier formation by longshore drift or opening up to an estuary mouth by erosion to form a bay. The pace of extinction depends primarily upon geomorphology and can be increased by human activities. Estuaries and lagoons have economic significance because of their fisheries which provide employment to the coastal communities. Benefits of estuaries and lagoons are shown in Table 5.2. In most cases, the excessive pollution caused due to wastewater destroys the benefits of estuaries and lagoons.

Table 5.2 Benefits of estuaries and lagoons

Type of Benefit	Example
Direct Use Values	
Non-extractive	a. Anchorages for trading and fishing vessels b. Tourist recreation c. Research and education d. Raft culture of mussels and
Extractive	a. Fishing, full or part-time, employment b. Sandmining, direct employment c. Seedfish/shrimp collection, demand is increasing with more aquaculture d. Ornamental fish collection
Transformative	a. Desalination experiments b. Landfill c. Pond aquaculture d. Sewage disposal
Indirect Use Vlaues	a. Disturbance regulation b. Nutrient cycling c. Biological control d. Habitat/ refugia value e. Cultural value
Non Use Values	a. Existence values b. Bequest values

5.2.3 Mangroves

Mangroves are salt-tolerant, woody, seed-bearing plants ranging in size from small shrubs to tall trees. They occur along sheltered intertidal coastlines, and in association with estuaries and lagoons. Although mangroves occur on saline soils they have the usual plant requirements of freshwater, nutrients and oxygen. There are 14 species of true mangroves and 12 species of mangrove associates in South Asian coast.

The mangrove ecosystem can be a major source of food and nutrients to estuarine, lagoon and near-shore coastal waters, and provides a nursery for the early stages of commercially important crustaceans and fish. Mangroves stabilize shorelines against erosion, both in estuaries as well as along the coast where their presence inhibits wave damage. Mangrove stands also help control runoff thereby reducing siltation in estuaries and seagrass beds. Mangroves support a number of subsistence and commercial uses critical to the welfare of some coastal communities Major benefits supported by mangroves are summarized in Table 5.3. These benefits should be protected from pollution by wastewater and sewage in the South Asian countries.

Table 5.3 Benefits of mangroves

Type of Use	Specific Use/Benefit
Non-extractive	Science and education for research and tourism
Extractive	Mangrove harvest for subsistence and commercial uses; domestic use includes house construction and firewood
Transformative	Mangrove conversion for aquaculture, coconut, paddy, housing and urban expansion
Indirect Use Values	a. Disturbance regulation b. Waste treatment c. Habitat/ refugia value
Non Use Values	a. Existence values b. Bequest values

5.2.4 Seagrass Beds

Seagrass beds are composed of rooted, seed-bearing, marine plants (halophytes). They occur in shallow, nearshore coastal waters that are sheltered from high wave energy, and in estuaries and lagoons. The seagrasses, epiphytes and the abundant detritus found in seagrass beds together comprise a highly productive habitat that supports many commercially important organisms.

Seagrass beds are abundant along South Asian coast although their locations and extent have not been precisely mapped and estimated. They form dense underwater meadows, the edges of which may be glimpsed during low tide. They often occur in association with coral reef ecosystems. Seagrasses allow epiphytic organisms to obtain

sites for attachment and provide nesting habitat and food for a number of species of fish. They also provide habitats and food for the endangered Dugong and Sea turtles. Some herbivorous fish consume the leaves, some juvenile fish feed upon epiphytes and several shrimp species feed upon grass detritus. Lastly, seagrass binds sediment and stabilizes it against erosion.

The major portion of marine fisheries production in South Asian Seas is obtained from the nearshore coastal waters. These are also the areas where seagrass beds are most extensive. The linkage between seagrass beds, coral reefs and fisheries production is direct and critical, but not usually quantified nor always recognized.

Typical uses of seagrass heads shown in Table 5.4. The excessive sewage and wastewater pollution may threaten these benefits.

Table 5.4 Typical uses of seagrasses

Type of Use	Specific Use/Benefit
Non-extractive	a. Sediment stabilization, seagrass foliage decreases peed and prevents sediment displacement b. Research on seagrass ecology and chemical uses
Extractive Uses	a. Polychaete harvests are used as broodstock feed in commercial shrimp hatcheries, harvested from selected seagrass beds b. Fishing c. Fodder at some locations
Indirect Use Values	a. Disturbance regulation b. Nutrient cycling c. Biological control d. Habitat/ refugia value e. Cultural value
Non Use Values	a. Existence values b. Bequest values

5.2.5 Salt Marshes

Salt marshes consist of herbaceous, salt resistant plants growing in sandy or muddy tidal flats in and areas which are periodically inundated by sea water. Salt marshes are common characteristics of coastal areas in temperate climates and they are generally replaced in the tropics by mangroves. Nevertheless, tropical versions of salt marshes occur. In South Asian Region salt marshes occur mainly in regions where the dry season is prolonged.

The major natural functions of salt marshes are to provide nutrients to nearshore coastal waters, provision of bird habitat, supply of seed fish for coastal aquaculture and as a discharge area that can absorb storm water runoff. Salt marshes are not heavily

utilized in South Asia at the present. However, in the future they are likely to be the focus for activities which require habitat conversion (Table 5.5).

Table 5.5 Typical uses of salt marshes

Type of Use	Specific Use/Benefit
Non-Extractive	a. Tourism and bird watching on tidal flats that serve as a habitat for migratory birds
Extractive Uses	a. Grazing on a small scale b. Hunting of waterfowl c. Collection of milk fish from tidal pools
Transformative Uses	a. Construction of salt pans b. Shrimp aqua culture in some areas
Indirect Use Values	a. Disturbance regulation b. Nutrient cycling c. Biological control d. Habitat/ refugia value e. Cultural value
Non Use Values	a. Existence values b. Bequest values

5.2.6 Barrier Beaches, Spits and Dunes

Barrier beaches and spits: Barrier beaches are accumulations of unconsolidated sediment transported ashore by waves and molded into a form that lies across a body of water and isolates it from the sea (Rekawa beach in Sri). Spits are essentially incipient barrier beaches that project from the shore in the direction of dominant drift and are free at one end.

Dunes are wind blown accumulations of sand which are distinctive from adjacent land forms such as beaches and tidal flats. Although they resemble beaches they differ mainly with respect to absence of tidal effect. Dunes are unstable unless covered by vegetation.

Coast protection and sand supply are the major natural functions of barrier beaches and spits. In addition, some segments of beaches serve as nesting areas for sea turtles. The dynamic spits that form seasonally at estuarine inlets obstruct natural water flow patterns, often resulting in the flooding of low-lying and in decreased fishery productivity. For example, fishery yields at Koggala Lagoon in Sri Lanka declined sharply after a spit expanded into a barrier beach and sealed off the inlet. Barrier beaches and dunes are subject to a number of uses as shown in Table 5.6.

Table 5.6 Typical uses of barrier beaches and dunes

Type of Use	Specific Use/Benefit
Non-Extractive	Beach landing of fishing boats, drying of gear on barrier beaches
Extractive	a. Mining of beach sand on barrier beaches and some dunes) b. Grazing on some dunes
Transformative	Construction of housing on dunes
Indirect Use Values	a. Disturbance regulation b. Nutrient cycling c. Biological control d. Habitat/ refugia value e. Cultural value
Non Use Values	a. Existence values b. Bequest values

5.3 Economic costs of degradation of the coastal and marine environment in relation to specific economic activities

The following table illustrates some impacts on these coastal benefits. These impacts need to be properly understood to protect coastal resources from land based pollution. Economic estimates could also be derived from the cost or the economic damages that accrue to the coastal and marine systems which provides an indication of the importance of the protection of the coastal environment from the land based degradation activities.

Table 5.7 Impacts on coastal habitats due to sewage

Coastal Habitat	Potential Impacts
Coral Reefs	Physical damage to coral reefs Increase in sediments Introduction of waterborne pollutants
Estuaries/Lagoon	Changes in sedimentation patterns Changes to the salinity regime Introduction of waterborne pollutants Destruction of submerged and fringing vegetation Inlet modifications Loss of fishery habitat
Mangroves	Changes in salinity regime and tidal flow patterns Excessive siltation Introduction of pollutants

Seagrass Beds	Physical alterations Excessive sedimentation or siltation Introduction of excessive nutrients
Salt Marshes (Tidal Flats)	Degradation of bird habitat or seed fish collection sites
Barrier beaches, Dunes and Spits	Erosion

5.4 Quantitative assessment of the economic benefits - The Theoretical Framework

5.4.1 The total economic value of marine ecosystems

Traditionally, both economists and decision-makers have tended to see the value of marine resources in terms of only raw materials and physical products, especially focusing on commercial fishery activities. This narrow view of economic benefits has often acted to the detriment of the marine ecosystems, since it under-represents their economic importance and value and ignores a large proportion of the goods and services they provide. Marine ecosystems generate economic benefits far in excess of just physical products.

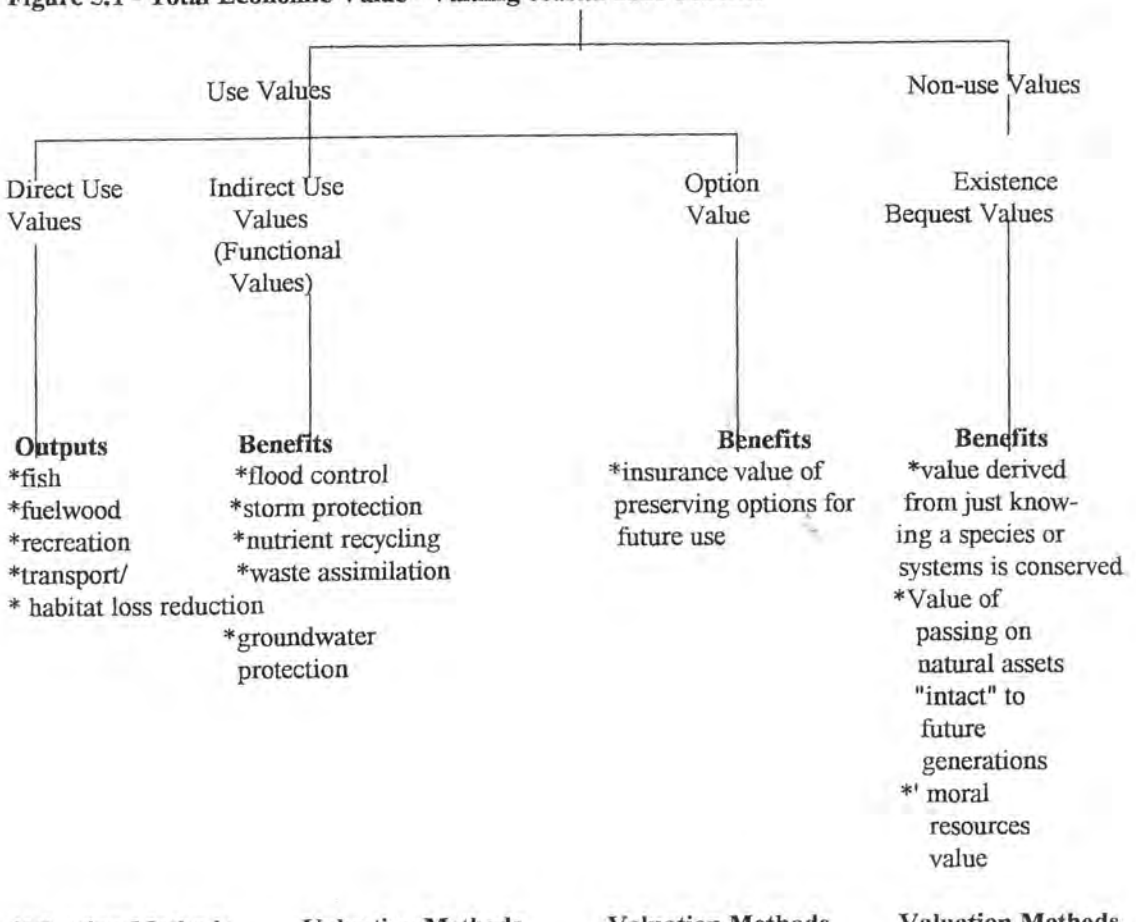
The basic aim of valuation is to determine people's preferences - how much they are willing to pay for, or how much better or worse off they would consider themselves to be as a result of changes in the supply of, different marine goods and services. Valuation provides a means of quantifying the economic costs and benefits that accrue to different people from marine ecosystems, the economic costs arising from their degradation and loss, and the relative profitability of the different economic activities which take place in and around marine and coastal areas. Valuation helps to understand and predict the economic decisions and activities, which impact on the status and integrity of marine areas.

Placing monetary values on marine benefits puts them on an equal footing with other sectors of the economy. It allows marine values to be considered and incorporated, rather than ignored, when planning and management decisions are made.

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.
The TEV of the marine ecosystems is the sum of direct use value, indirect ues value, option value, bequest value and existence value (Figure 5.1).

Direct use 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.

Figure 5.1 - Total Economic Value - Valuing coastal zone benefits



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

Indirect values include services and functions provided by marine ecosystems 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.

Option values include 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 values include benefits accruing to any individual from the knowledge that others might benefit from the conserved resource in the future

Existence values include the value derived from the knowledge that the ecosystem exists

5.5 Techniques for quantifying economic values of marine ecosystems

A wide range of techniques are available for quantifying the economic value of marine ecosystems. The following section describes the available methods for quntifying the economic values of the ecosystems. These techniques can be discussed in three groups: techniques for valuing direct use, techniques for valuing indirect use and techniques for valuing non-use values.

5.5.1 Techniques for quantifying direct values

As illustrated in Table 5.8, a range of methods can be used to quantify the direct values associated with marine ecosystems. Each has varying applicability, and choice of technique will be determined largely by the nature of each value being considered, available information and overall aims of valuation.

Table 5.8: Techniques for quantifying the direct value of marine ecosystems and their applicability

Technique	Applicability
Market prices	Marine products which can be bought and sold directly
Prices of alternatives or substitutes	Marine products which have close substitutes which can be bought and sold
Costs of collection and preparation	Marine products whose collection and preparation requires marketed inputs
Contingent valuation	Marine products whose value is clearly perceived
Participatory valuation	Marine products with a high domestic or subsistence value
Travel costs	Marine tourism and recreation

5.5.2 Techniques for quantifying indirect values

As illustrated in Table 5.9, a range of methods can also be used to quantify the indirect values associated with marine ecosystems. Each has varying applicability, and choice of technique will be determined largely by the nature of each value being considered, available information and overall aims of valuation.

Table 5.9: Techniques for quantifying the indirect value of marine ecosystems and their applicability

Technique	Applicability
Market prices and stated preference	Marine services which can be bought and sold directly, have, substitutes which are marketed, or have a clearly-recognised economic value
Replacement costs	Marine services which can be replaced by artificial means

Effect on production	Marine services which are closely linked to other production activities
Damage avoided/ preventive expenditure	Marine services which protect human systems and economic activities

Since the indirect impact of marine services on production and consumption, as they typically have no market, and due to the fact that they generate wide-ranging off-site economic benefits, it is usually necessary to find additional methods to value marine services

5.5.3 Techniques for quantifying non use values

It is extremely difficult to quantify marine option and existence values, largely because neither have a market or support directly production and consumption activities. Usually the only way to quantify bequest and existence values is to used some kind of method which calculates through indirect means people's stated or observed preference for marine ecosystems - for example by using contingent or participatory valuation, or by assessing the amount of money contributed from outside towards marine conservation. Both types of valuation methods have the disadvantage that they are usually difficult, costly and time consuming to carry out. For this reason, despite their importance and significant economic worth, the option and existence values associated with marine ecosystems often remain unquantified.

5.6 Quantitative estimates of the coastal and marine environmental benefits

The following section presents the economic estimates of the different ecosystems of the above described benefits, estimated using various techniques.

5.6.1 Economic estimates of corals

Economic benefits of coral ecosystems have been estimated by researchers throughout the world using various techniques. Some of the estimates are presented below.

The economic value of corals in Sri Lanka has been calculated according to the value of employment generation. Since live fish trade and coral mining generates employment for 70,000 people in Sri Lanka in a length of 85 km of coral reefs. The daily wage rate is taken as SLRs 100 and the value is US$ 3 million per annum per km of corals (Ohman et al, 1993).

Two forms of corals: coral rag from island sources and living reef coral are mined in Mafia Island, Tanzania. Mafia's residents are entirely dependent on coral for building materials. The value of this coral has been calculated by looking at the price of substitute building materials - cement imported from the Tanzanian mainland - of US$ 140/tonne. (Duivy et al 1995). This value is relevant to this study since Tanzania also borders Indian ocean.

On average, 21.5 million visitor nights are spent in the Barrier Reef region of Australia each year. The average cost per trip is A$ 156 for domestic visitors and A$ 1,121 for foreign tourists. If visitors spend an average of a week on the Barrier Reef, the total

travel costs associated with the marine park may be nearly of A$ 800 million a yea (Craik 1994).

Tourism on the Great Barrier Reef generates $ 1.5 billion in Queensland alone. (Linden and Sporrong, 1999). Using benefir transfer method, (using GNP PPP SAsia as US$ 2000), tourism value for South Asia is calculated. This calculation is based on the fact that although Bangladesh, India, Sri Lanka and Pakistan has many protected coral reefs, proper management is present only in Maldives. Therefore, it is assumed that benefits of one site in Queensland is equivalent to one site (i.e, Maldives) in South Asia.

By absorbing carbon, coral reefs in Djibouti help to mitigate the effects of global warming. Djibouti's coral reefs, with a surface area of at least 6.105 million m^2, are estimated to have a net primary productivity in excess of 2,500 g carbon/m2/year. With the costs of damage arising from global warming estimated at an average of US$ 20/tonne, marine ecosystems in Djibouti may generate economic benefits of over US$ 0.3 million a year in terms of global warming damage avoided (Emerton 1998).

Sedimentation (resulting from logging activities) will have a negative impact on coral cover, coral diversity and fish production in the coastal area of Bacuit Bay and on marine tourism. The dependence of fish on both coral cover and diversity establishes a potential link between forest degradation, ensuing sedimentation of coastal waters, changes in coral diversity and fish biomass. Using regression analysis, Hodgson and Dixon found that 100 million tones per km2 of annual sediment deposition led to one coral sp. Extinction per year. The extinction was in turn correlated with a decrease in fish biomass of 0.8%. the negative impact of 400 million tones per km2 deposition per year on coral cover was calculated to cause a 2.4% decrease in fish biomass. Similarly, as marine tourism is dependent on pristine coral reefs and seas, the decline in coral cover and diversity as well as the increased sedimentation and turbidity in coastal waters is expected to affect tourism revenues drastically.

The economic cost of the extinction of one coral species per year could be approximated as US$ 5 per person per year based on the existence value estimations of a fish species in USA (Heywood and Watson, 1995).

5.6.2 Economic estimates of lagoons

As discussed in the previous section, lagoons provide a range of economic benefits. Some quantitative estimates of lagoon economic benefits as estimated using Negombo Lagoon in Sri Lanka included fishing, anchorage, recreation and sink of waste (Samarakoon 1994).

The fishery productivity of the Negambo lagoon in Sri Lanka which is of 3500ha valued at US$ 3 million provides primary income for 3000 lagoon fisher families (a population of 15, 000). Its nursery function supports the primary income of 400 marine fisherman trawling for penaeid shrimp, while the nutrient interaction entrains small pelagic fish stocks that support the primary income of an additional gill-net, marine fisherman. The annual value of this coastal, marine fishery stock is US$2 million. Should the lagoon lose its existing state of productivity entraining collapse of fishery

stocks, the cost of providing alternative occupations to the fisherman is estimated as US$ 1.8 million.

The anchorage value of Negambo lagoon is US$ 3 million (the cost of constructing a fishery harbour outside the lagoon mouth to accommodate 400 large hulled marine craft and 1000 small marine craft). The paer ha value is US$ 857.

The direct recreation value of the Negambo lagoon only for tourists is US$ 0.3 million, estimated on the basis of the number of tourists who visit lagoon for boating and wind surfing. The per ha value is US$ 85.7.

Amenity value as a site for star class hotels overlooking the Negambo lagoon is US$ 2.0 million (annual income from an existing 120 room hotel). The per ha value is US$ 571.43. Other values of uses such as research and education, settlement expansion are more difficult to estimate.

The sink value for 45 industries that discharge untreated wastes is US$ 6 million (cost of constructing a treatment facility) or US$ 38 per ha per industry. The sink value for domestic and municipal waste for a population of 100,000 is US$ 2.5 million or US$ 7.14 per ha per 1000 population (the cost of construction of an ocean outfall system).

Based on all these estimates, the minimum, total annual value of Negombo lagoon has been estimated to US$ 20 million or US$ 5714 per ha. (Samarakoon 1994)

5.6.3 Economic estimates of mangroves

Among the range of benefits provided by the mangrove ecosystem, food supply, raw material, recreation, transport, disturbance regulation, waste treatment, energy capture, storm damage protection, coastal defence, sediment stabilization, and protection from intrusion are important. These benefits should be considered in the economic analysis of wastewater management since sewage pollution can destroy mangrove ecosystem. Some economic estimates of mangroves briefly presented here in order to highlight the importance of the system.

Value of food production of mangrove has been estimated to US$ 466 per ha per year (Costanza et al. 1997) 1994 prices. Harvesting of crabs, oysters, cockles and mussels from mangrove is traditional throughout the world both for subsistence and commercial consumption. Commercial production of molluscs in Malaysia in 1981 amounted to 71,000 tones and potential value for traditional oyster harvesting in Thailand is US$ 60/ha/yr.The mangrove crab is harvested as a delicacy and is deliberately fattened in mangrove ponds in China, Southeast Asia and Australia. The value of crabs and molluscs depends very much on whether they reach a commercial or export market. Export price is US$ 4.8/ lb. and US$ 1.5 in a semi subsistence market.

Provision of raw materials from mangroves has been valued as US$ 162 per ha per year (Costanza et al. 1997). This value includes value for both tidal marsh and mangroves

Mangrove sites attracts recreation activities such as boat trips, bird watching, wildlife

observation, rambling, shooting, fishing, hunting. The recreation and tourist value for the Trinidad Caroni Swamp Park visited by nationals and foreign tourists alike with the primary attraction being the presence of the rare scarlet ibis *Eudicimus ruber* was estimated at 200 US$/ha/yr in 1978.

Mangrove fringes in estuaries also play a part in maintaining channels both through sediment stabilising and contributing to estuarine circulation patterns. Maintenance of navigable routes in mangrove areas can be very important, given the dominance of water transport in estuarine and delta areas. Also, river channels, sheltered harbours and port facilities can be threatened by sedimentation these services could be valued either through shadow project costing of alternative transport systems or through the mitigating cost of dredging. It is estimated a capita cost of US$ 100m for road building in Sumatra as an alternative to channel dredging to maintain river transport at a capital cost of US$ 6m.

Disturbance regulation function and waste treatment function of mangroves has been valued at US$ 1839 and US$ 6696 per ha per year respectively (Costanza et al 1997).

The role of organic matter production can be valued through the direct use of forest products and the nutrient input to fisheries, which can account for up to 90% of estuarine nutrient input. However, not all of the solar energy captured is readily harvested as consumable products. Also there are energy inputs from wind, tides, rivers and the which contribute through the transport of nutrients and marine life, seed dispersal, river channeling and environmental coupling. Mangrove is often quoted as being potentially one of the most productive ecosystems known producing up to 3kg/m2/yr or 290 kJ/m2/yr. Valuation of the benefits of energy capture, organic matter production and nutrient export could be done by energy valuation method. If we assume that all solar energy capture produces useful products, or contributes to the ecological stability and thus maintenance of functions and life support services, an upper limit on mangrove value can be obtained from energy analysis. This method uses the Gross Primary Production to estimate the energy capture by an ecosystem which is then converted into a fossil fuel equivalent. This is then valued by comparison to the value of fossil fuel energy in economic production using a national energy consumption index. Such an analysis suggests a value of US$ 847/acre/yr or US$ 2000 /ha/yr for brackish marsh in Lousinia in a with - without comparison against brackish aquatic systems, representing an NPV of US$ 10,000 – US$ 20,000 at 8% and 3% discount rates respectively. An average value of US$ 154 for South Asia has been calculated using GNP(PPP) US$ 2000 for South Asia as the valueof the energy capture.

The role of mangroves in coastal protection and prevention of coastal erosion is readily accepted. Although they are unlikely to withstand a dramatic shift in coastal currents or sea level rise, it can be assumed that they contribute to stabilising deposition through energy dissipation and root formation. Most management plans for coastal zones include preservation of a coastal or riverine fringe of mangrove vegetation. The value of coastal protection depends to a large extent on the value of land that is being protected. In the case of agricultural land, settlements or infrastructure such as roads, the cost of loss through erosion can be readily obtained through replacement costs or agricultural rents. Loss of settlements frequently occurs in fishing communities which inhabit each ridges at the outer reaches of the mangrove in order to minimise time and

fuel in reaching coastal fishing grounds. Where such land is lost (often after mangrove clearance for fuelwood for fishing processing) the cost of transport from alternative available sites could be used as a value for the erosion prevention service provided by mangrove.

Where mangrove serves as a protection from seaspray, salt water flooding and storm damage, the effect of this could be calculated through hazard appraisal techniques and valued according to the loss of crops, soil fertility or cost of damage. The main problem is to establish a comparable with – without scenario. Costanza *etal.*, has attempted to estimate the storm protection value of coastal wetlands in USA (Louisiana) using data on previous storms and the damage caused at various distances from the landfall of a hurricane by winds and foods, they established a value for a strip of wetland coastline at US$ 128/acre/yr or on NPV of US$ 1915/ acre at 8% discount rate. An average value of US$ 154 for South Asia has been calculated as the value of the mangroves in prevention of storm damage.

Coastal defences in situations of land reclamation or protection could be used as an alternative cost approach method for valuation. Again these would be subject to hazard appraisal with respect to storm surges and, the impacts associated with sea walls such as shifts in erosion patterns, should be accounted for. Zamali (1991) gives an example of rock bunds in Malaysia built to protect agricultural land which had been abandoned after tidal flooding. The bund cost M$ 1600 per meter. Although the project showed positive economic returns, no value was attached to the loss of mangrove seaward of the bund or of other impacts resulting from the construction.

Wherever erosion occurs there is likely to be an increase in turbidity in the water resulting in possible declines in productivity aquatic systems. Furthermore, sediment redeposition may occur on coral reefs, seagrass beds, or bordering mangrove sites, causing death or reduced productivity for a period of readjustment. Redeposition may also pollute sand beaches, limiting their value for recreation and tourism development. However, no economic estimates are available for these values. The main difficulty in attributing values to such mangrove services lies in the uncertainty surrounding the impact of mangrove loss or degradation or sedimentation. Modeling of circulation patterns, coastal erosion and deposition, coupled with historical information on previous impacts of sedimentation, may allow better estimation of impacts and valuation.

The coastal protection function extends to include the protection of water resources. Fresh water is becoming an increasingly scarce resource in many tropical and sub-tropical countries particularly in coastal areas where human populations are greatest. Mangroves act as a retention basin for freshwater flows and in doing so maintain a pressure of water which prevents intrusion of salt water into coastal groundwater. Also, through stabilising channel banks and holding fresh water, mangroves limit the boundary of saltwater intrusion into river mouths allowing river terrace flooding at high tides by the more buoyant fresh water. This can be important for maintaining fresh water for irrigation, and in protecting fresh water swamp forest on the inland margins of mangroves.

Estimating values for these functions again requires a separation of the mangrove

contribution from other influencing factors such as rainfall, sea level rise, river water abstraction and sedimentation of river channels from upstream sources. Where loss of agricultural productivity occurs, the value of the agricultural rent or productivity would offer a minimum value for the services, alternative costs such as for shipping in freshwater could also be used. The economics of saltwater intrusion will really be dependent on the valuation of water resources in the country concerned and the role of mangrove in maintaining supplies should be identified. The impact of water abstraction and pollution on mangroves in the Indus delta of Pakistan and estimates of the effects of saltwater encroachment as result of sea level rise is discussed in literature. It is estimated that about 80,000 people and 128 km^2 of heavily cultivated land near Karachi would be displaced by sea level rise over the next 100 years. The potential for mangroves to adapt to rising sea levels is reduced by a lack of freshwater and sediment coming down stream and by loss of species diversity through overexploitation. Given the uncertainty surrounding the extent of sea level rise and the future value of freshwater cropland a quasi option value related to water and land productivity could be assigned to the mangrove services.

5.6.4 Economic estimates of estuaries

Estuaries are another types of ecosystem that can be affected by sewage and wastewater pollution. Some of the economic estimates of the functions of estuaries as estimated by Costanza et al (1997) are presented below.

Nutrient cycling and biological control functions of estuaries have been estimated at US$ 21100 and US$ 78 per ha per year respectively. Habitat/refugia value of estuaries has been estimated at US$ 131 per ha per year. Food production value and raw materials value of estuaries were estimated to US$ 521 and US$ 25 per ha per year. Recreation value as estimated by Costanza et al (1997) is about US$ 381 per ha per year.

5.6.5. Summary of economic estimates of coastal and marine system

Table 5.10 illustrates estimated values for some functions of marine environment.

Table 5.10 Economic estimates of coastal and marine ecosystems

Ecosystem	Value type and Example	Method of estimation	Economic value
Coral reef	Extractive use value		
	a. Coral mining and Ornamental fishing	Value of employment generation	US$ 2.65 million per year per km of coral[1]
	b. Building material	Price of substitutes (substitute building material)	US$ 140 per tonne[2]
	Non Extractive use values		
	a. Tourist viewing	Travel cost method	AU$ 800 million per year[3]
		Value of income	US$ 8.7 million

		generation	For the South Asia region[4]
	Indirect use values Carbon sequestration function	Value of Damage avoided method	US$ 20 per Tonne of coral[5]
Lagoon	Extractive use values a. Fishing	Income generation for fisher families	US$ 857.14 per ha[6]
	Non Extractive use values a. Anchorage value	Cost of constructing a fishery harbour	US$ 857 per ha[7]
	b. Direct recreation value	Based on tourist visits	US$ 85.7 per ha[8]
	c. Amenity value	Value of the site for star class hotel	US$ 571.43 per ha[9]
	Indirect Use values a. Sink for industrial waste	Cost of constructing a treatment facility	US$ 38 per ha per industry[10]
	b. Sink for domestic waste	Cost of construction of an ocean outfall system	US$ 7.14 per haper 1000 population[11]
Mangrove	Extractive use values Food production	NA	US$ 466/ha/yr[12]
	Traditional oyster harvesting	Market prices	US$ 60 /ha /yr[13]
	Provision of raw materials	NA	US$ 162/ha/yr[14]
	Non Extractive use values Recreation value	Value of tourist visits	US$ 200 per ha per yr[15]
	Recreation value Value of Navigation	NA	US$ 658 /ha/yr[16]
	Indirect Use values	Cost of road building	US$ 100million[17]
	Disturbance regulation	NA	US$ 1839 per ha per yr[18]
	Waste treatment	NA	US$ 6696 per ha per yr [19]
	Energy capture	Based on Gross Primary Production	US$ 2000/ha/yr[20]

contribution from other influencing factors such as rainfall, sea level rise, river water abstraction and sedimentation of river channels from upstream sources. Where loss of agricultural productivity occurs, the value of the agricultural rent or productivity would offer a minimum value for the services, alternative costs such as for shipping in freshwater could also be used. The economics of saltwater intrusion will really be dependent on the valuation of water resources in the country concerned and the role of mangrove in maintaining supplies should be identified. The impact of water abstraction and pollution on mangroves in the Indus delta of Pakistan and estimates of the effects of saltwater encroachment as result of sea level rise is discussed in literature. It is estimated that about 80,000 people and 128 km^2 of heavily cultivated land near Karachi would be displaced by sea level rise over the next 100 years. The potential for mangroves to adapt to rising sea levels is reduced by a lack of freshwater and sediment coming down stream and by loss of species diversity through overexploitation. Given the uncertainty surrounding the extent of sea level rise and the future value of freshwater cropland a quasi option value related to water and land productivity could be assigned to the mangrove services.

5.6.4 Economic estimates of estuaries

Estuaries are another types of ecosystem that can be affected by sewage and wastewater pollution. Some of the economic estimates of the functions of estuaries as estimated by Costanza et al (1997) are presented below.

Nutrient cycling and biological control functions of estuaries have been estimated at US$ 21100 and US$ 78 per ha per year respectively. Habitat/refugia value of estuaries has been estimated at US$ 131 per ha per year. Food production value and raw materials value of estuaries were estimated to US$ 521 and US$ 25 per ha per year. Recreation value as estimated by Costanza et al (1997) is about US$ 381 per ha per year.

5.6.5. Summary of economic estimates of coastal and marine system

Table 5.10 illustrates estimated values for some functions of marine environment.

Table 5.10 Economic estimates of coastal and marine ecosystems

Ecosystem	Value type and Example	Method of estimation	Economic value
Coral reef	Extractive use value		
	a. Coral mining and Ornamental fishing	Value of employment generation	US$ 2.65 million per year per km of coral[1]
	b. Building material	Price of substitutes (substitute building material)	US$ 140 per tonne[2]
	Non Extractive use values		
	a. Tourist viewing	Travel cost method	AU$ 800 million per year[3]
		Value of income	US$ 8.7 million

		generation	For the South Asia region[4]
	Indirect use values Carbon sequestration function	Value of Damage avoided method	US$ 20 per Tonne of coral[5]
Lagoon	Extractive use values		
	a. Fishing	Income generation for fisher families	US$ 857.14 per ha[6]
	Non Extractive use values		
	a. Anchorage value	Cost of constructing a fishery harbour	US$ 857 per ha[7]
	b. Direct recreation value	Based on tourist visits	US$ 85.7 per ha[8]
	c. Amenity value	Value of the site for star class hotel	US$ 571.43 per ha[9]
	Indirect Use values		
	a. Sink for industrial waste	Cost of constructing a treatment facility	US$ 38 per ha per industry[10]
	b. Sink for domestic waste	Cost of construction of an ocean outfall system	US$ 7.14 per haper 1000 population[11]
Mangrove	Extractive use values		
	Food production	NA	US$ 466/ha/yr[12]
	Traditional oyster harvesting	Market prices	US$ 60 /ha /yr[13]
	Provision of raw materials	NA	US$ 162/ha/yr[14]
	Non Extractive use values		
	Recreation value	Value of tourist visits	US$ 200 per ha per yr[15]
	Recreation value	NA	US$ 658 /ha/yr[16]
	Value of Navigation		
	Indirect Use values	Cost of road building	US$ 100million[17]
	Disturbance regulation	NA	US$ 1839 per ha per yr[18]
	Waste treatment	NA	US$ 6696 per ha per yr [19]
	Energy capture	Based on Gross Primary Production	US$ 2000/ha/yr[20]

	Habitat/ refugia value	NA	US$ 169 /ha/yr[21]
Estuaries	Indirect use values		
	Disturbance regulation	NA	US$ 567/ha/yr[21]
	Nutrient cycling	NA	US$ 21100/ha/yr[21]
	Biological control	NA	US$ 78/ha/yr[21]
	Habitat/refugia value	NA	US$ 131/ha/yr[21]
	Food production	NA	US$ 521/ha/yr[21]
	Raw materials	NA	US$ 25/ha/yr[21]
	Recreation	NA	US$ 381/ha/yr[21]
	Cultural	NA	US$ 29/ha/yr[21]
Sea grass beds	Extractive use values		
	Raw materials	NA	US$ 2 /ha/yr[21]
	Indirect use vales		
	Nutrient cycling	NA	US$ 19002 /ha/yr[21]
Coastal wetlands	Extractive use values		
	Fishing	Value of employment	US$ 18000/per season[22]
	Indirect use values		
	Prevention of storm damage	Cost of damage	US$ 24.7 /ha/yr[23]
	N reduction value	NA	US$ 18.7 /kg N reduction[24]
	Wastewater treatment value	Cost savings	US$ 1962 – 86750 /ha [25]

[1] Coral mining generates employment for 50,000 people in Sri Lanka in a length of 85 km of coral reffs; the daily wage rate is taken as SLRs 100 and value is calculated for per annum per km (Ohman et al, 1993)

[2]This value is derived from the price of substitute building material – cement imported form Tanzania mainland for the residents of Mafia island (Duivy et al 1995)

[3]Based on the value of 21.5 million visitor nights are spent in the Barrier Reef region of Australia each year. The average cost per trip is A$ 156 for domestic visitors and A$ 1,121 for foreign tourists. If visitors spend an average of a week on the Barrier Reef, the total travel costs associated with the marine park may be nearly of A$ 800 million a year. (adapted from Craik 1994).

[4]Tourism on the Great Barrier Reef generates $ 1.5 billion in Queens land alone. (Linden and Sporrong, 1999). Using benefir transfer method, (using GNP PPP SAsia as US$ 2000), tourism value is calculated under the assumption that although Bangladesh, India, Sri Lanka and Pakistan has many protected coral reefs, proper management is present only in Maldives. Therefore, benefits of one site in Queensland is taken as equivalent to one site (i.e, Maldives) in South Asia.

[5]By absorbing carbon, coral reefs help to mitigate the effects of global warming. With

the costs of damage arising from global warming estimated at an average of US$ 20/tonne, marine ecosystems in S Asia may generate huge economic benefits in terms of global warming damage avoided.

[6]The fishery productivity of the lagoon (3500ha) valued at US$ 3 million provides primary income for 3000 lagoon fisher families (a population of 15, 000). Its nursery function supports the primary income of 400 marine fisherman trawling for penaeid shrimp, while the nutrient interaction entrains small pelagic fish stocks that support the primary income of an additional gill-net, marine fisherman (Samarakoon 1994).

[7]The anchorage value is US$ 3 million (the cost of constructing a fishery harbour outside the lagoon mouth to accommodate 400 large hulled marine craft and 1000 small marine craft) (Samarakoon 1994).

[8]The direct recreation value only for tourists is US$ 0.3 million, estimated on the basis of the number of tourists who visit Negombo lagoon for boating and wind surfing.(Samarakoon 1994).

[9]Amenity value as a site for star class hotels overlooking the lagoon is US$ 2.0 million (annual income from an existing 120 room hotel) .(Samarakoon 1994).

[10]The sink value for 45 industries that discharge untreated wastes is US$ 6 million (cost of constructing a treatment facility) (Samarakoon 1994).

[11] The sink value for domestic and municipal waste for a population of 100,000 is US$ 2.5 million (the cost of construction of an ocean outfall system).(Samarakoon 1994).

[12] Potential value for traditional oyster harvesting in Thailand is US$ 60/ha/yr

[13]Mangrove sites are also suitable for recreation development such as boat trips, bird watching, wildlife observation, rambling, shooting, fishing, hunting. The only recreational value for mangroves reported in literature is for the Trinidad Caroni Swamp Park visited by nationals and foreign tourists alike with the primary attraction being the presence of the rare scarlet ibis *Eudicimus ruber*. The recreation and tourist value was estimated at 200 US$/ha/yr in 1978 but did not include the value of employment for 62 full time and 53 part time transport operators.

[14] Maintenance of navigable routes in mangrove areas can be very important, given the dominance of water transport in estuarine and delta areas. These services could be valued either through shadow project costing of alternative transport systems or through the mitigating cost of dredging. It is estimated a capital cost of US$ 100m for road building in Sumatra as an alternative to channel dredging to maintain river transport at a capital cost of US$ 6m.

[15] Based on Costanza et al (1997) 1994 prices; method of estimation has not specified in the paper. This value includes value for both tidal marsh and mangroves

[16] If we assume that all solar energy capture produces useful products, or contributes to the ecological stability and thus maintenance of functions and life support services,

an upper limit on mangrove value can be obtained from energy analysis. This method uses the Gross Primary Production to estimate the energy capture by an ecosystem which is then converted into a fossil fuel equivalent. This is then valued by comparison to the value of fossil fuel energy in economic production using a national energy consumption index. Such an analysis suggests a value of US$ 847/acre/yr or US$ 2000 /ha/yr for brackish marsh in Lousinia in a with - without comparison against brackish aquatic systems, representing an NPV of US$ 10,000 – US$ 20,000 at 8% and 3% discount rates respectively.

[17, 21] Based on Costanza et al (1997) 1994 prices; method of estimation has not specified in the paper.

[23]Based on the estimate of Chinde District in the Zambezi Delta, Mozambique. If rural casual wage rates are some US$ 1 per day, an equivalent of some 18,000 days per season worth US$ 18,000, are expended on fishing activities in Chinde District (adapted from Turpie, Smith, Emerton and Bames, 1998).

[24]Based on estimate of N reduction value of restored wetland in Sweden

[25]Based on estimates of cost savings from using coastal wetlands for substitute treatment in Louisiana, USA. Estimates of discounted cost savings ranged from $ 785 to $ 34700 per acre of wetlands used for treatment (Breaux et al, 1995).

According to the above table it is extremely evident that the coastal and marine environments have large economic values. The economic estimates however, were not available for South Asian area, estimates from other parts of the world are provided here which could at least be taken as a first approximation of the value.

These estimates show the importance of the protection of the coastal and marine ecosystems in particularly from the pollution from the land based activities which can significantly reduce the level of above benefits. Land based pollution, especially, pollution by sewage could incur huge economic costs to the economies of the South Asian countries. Although these costs are not directly felt, their impact will underline most of the major economic activities in these countries.

5.6.6 Limitations to valuation

Valuation is a useful tool for marine protected area management because it highlights a range of costs and benefits which have in the past often been ignored by planners, policymakers and decision-makers. Valuation techniques however only provide tools which help to make better and more informed decisions about marine protected area management they are not ends in themselves, and have a number of shortcomings and weaknesses. There are a number of methodological issues and limitations which should always be borne in mind when carrying out marine valuation:

Marine valuation is usually, of necessity, *partial.* Most quantified estimates of the economic benefit of marine goods and services focus only on selected components of their value. They should be taken as a minimum estimate of the total economic value of marine ecosystems. The *reality of values* is sometimes limited. They are rarely 'real'

values and often do not exist in terms of concrete prices and income. Rather than definitive or binding figures, most values should be seen as indicative estimates which present a guide to what marine protected areas may be worth, for use in planning, decisions and policy. it is always important to make explicit the hypotheses, suppositions and assumptions which have been used in the course of marine valuation.

The value of marine protected areas are *unequally distributed* between people and over time. Most valuation techniques do not take account of this differentiation or variability. Different people have different perceptions of the value of marine resources and ecosystems, and these may vary at different times. Economic valuation is usually based on a particular person's or group's conception of what a particular marine good or service is worth at a specific point in time. It is not necessarily universally valid, or extrapolable between different groups, areas, species or over time.

The loss of marine resources and ecosystems can have *irreversible effects* including the complete collapse of human livelihoods, the permanent loss of consumption and production possibilities or the total extinction of wild species. The full risk or ultimate implications of these losses, or how the loss of one species or habitat may affect other resources or activities in the future, is not known. The final or knock-on effects of marine ecosystem degradation can never be fully quantified or reflected in economic valuation.

Some marine benefits will always be *unquantifiable and unmeasurable* because the necessary scientific, technical or economic data is not available. Other aspects of marine valuation which relate to human life or religious and cultural significance involve ethical considerations, especially when they are used to argue that specific activities or particular people's needs are more desirable or important than others.

Chapter 6

Potential Public - Private Partnership in sewerage management

6.1. Introduction

The United Nations General Assembly at its fifteenth session encourage government to promote private sector participation in the sewage management by adopting the resolution on "Water Supply and Sanitation"(A/RES/5/126). The resolution recognized "that at the current rate of progress, the provision of drinking water will be insufficient to satisfy very large number of people by the year 2000 and that the lack of progress in the provision of basic sanitation services is likely to have dramatic environmental and health consequences in the near future. This indicates the need for new strategies to addresses the water supply and sanitation problem. One of such emerging strategy is the private sector involvement. Therefore the general assembly requested the governments to implement fully the provision concerning water supply and sanitation contained in Chapter 18 of Agenda 21 and to undertake as appropriate, legal, regulatory and institutional reforms designed to bring about the involvement of the private sector. Therefore the private public partnership (PPP) has been internationally recognized. However many governments in the South Asian region has failed to attract private sector investors into the sanitation and sewage management. At the same time, sanitation and sewage infrastructure development in the region provide unprecedented business opportunities for the private sector, since public capital becoming increasingly limited, and investment in the sewage management has been economically justified. This study indicates that the coastal and marine protection benefits of the sewage management itself justify the investment in the field.

Therefore, there is a definite need to develop new strategies to promote public private partnership in the sewage management and so contribute to the formulation of national programmes and policies involving the private sector in the provision of water supply and sanitation. This section of the report review the experience in the South Asian region in the private sector involvement in the sewage management and recommend the potential public private partnership in the sector, as a measure to protect marine and coastal pollution from land based pollution specially from sewage.

6.2. Sewerage infrastructure need in South Asian countries

The magnitude of the sanitation problem in the world was presented in to the fifteenth session of the General Assembly of the United Nations in 1995. According to this estimate since the beginning of the International Drinking Water Supply and Sanitation Decade, 1981 to 1990, hundreds of millions of people in the region had access to water and sanitation. The number of people with access to adequate sanitation in the Asia and Pacific increased by 24 million from 892 million in 199 to 916 million in 1994. During the same period, however the number of people without access to adequate sanitation

increased by 171 million from 2,34 million in 1990 to 225 million in 1994. Of these the South Asia's share is greater than other part of the Asia.

Providing Water Supply and Sanitation to urban areas of Asian Countries is difficult task without private sector contribution, because of high urban population growth. The number of urban dwellers in Asia without access to sanitation reached to 371 million in 1994. This is 39 percent of total urban population. Urban sanitation coverage in Asia and Pacific is given in table 6.1.

Table 6.1. Urban sanitation coverage, Asia and the Pacific, 1990 to 2000

	1990	1994	2000
Urban population, millions	829	955	1178
Number served with sanitary millions	689	805	981
Per cent of population served with sanitary service	83%	84%	83%
Number unserved, millions	140	150	197
Percent of unserved sanitary service	17%	16%	17%

Rural Sanitation Situation in Asia is also similar. In 1994 only 15 percent of rural Asian population had access to sanitation which is only about 332 million (Table 6.2)

Table 6.2 Rural sanitation converge, Asia and the Pacific, 1990, 1994, 2000

	1990	1994	2000
Rural population, millions	2097	2167	2250
Number served with sanitary services millions	379	332	262
% sanitary services provided	18	15	12
Number unserved with sanitary services millions	1718	1834	1988
% sanitary services provided	82	85	88

These data suggest the magnitude of sanitary infra-structure need in the Asian region.

6.3. Private sector investment opportunities

In early 1990, annual global funding commitments for water and sanitation sector in developing countries remain stagnant around US$ 10 billion. Of these around 65 percent came from national sources while rest came form external support agencies (UN 1996). According to Asian Development Bank estimate, the Asia pacific region need about US$ 80-100 billion in investments in order to ease water supply and sanitation problem.

These amounts of money cannot be expected to come from traditional government sources and official development assistance. Therefore a large share of investment has to be obtained from private sector, both domestic and foreign. Private sector investment should be encouraged not only to raise investment capital, but also to increase financial efficiency and improve the quality of services.

In order to make private sector efficient in the sanitation and sewerage management sector governments must regulate the public monopolies of water supply and sewerage networks. Suitable policies should be developed to encourage partnership between the public sector and private sector.

Even with suitable regulations, without strong financial incentives and favorable investments situation, especially sewage management sector cannot attract private sector investors. The main reason for this is that private sector can find other less risky and higher profitable investment than sewerage management.

However private sector involvement in the construction, operation and maintenance of water supply and sanitation networks and treatment plants has began to grow in the Asian region. Typical situation is that facilities owned by municipalities are leased out to private companies to operate and maintain for a certain period. The experiences have already shown that private sector participation in various form ranging from management contracts for part of the operations to full ownership of utilities is efficient and viable.

6.4 Private sector investment experience in the sewerage sector

Private sector participation in the water supply and sanitation is common in the developed world. In the United Kingdom water and sanitation industry was privatized in 1989 under the Water Act (1989). The water and sewerage services performed by 10 multifunctional publicly owned regional authorities were restructured and 10 commercial public limited companies were formed. The share of these companies were floated on the stock market in 1989 sold in the UK, USA, Europe and Japan. With comprehensive system of public regulation, the ownership of these water and sewerage companies were in the private sector by the end of 1989. With the profits and share market capital, these companies are investing rebuilding of new system of sewerage system. These companies also received worldwide contract to build sewerage and water supply facilities.

In the United States only small cities are leasing out publicly owned sewerage facilities to be managed by private companies. Leasing and privatization of sewer management is limited to treatment plants and not the entire sewer systems.

Several countries in Latin America, Argentina, Chile, Mexico and Venezuela and Brazil were able to attract private sector in the water supply and sanitation industry. A British company has entered into a US$ 30 million contract for 10 years to provide water and wastewater services for more than 2 million people in 5 out of 16 municipalities of

Mexico city. These countries long term concessions for the provision of water supply and sewage collection and treatment have been awarded to western country companies.

In the Asia and pacific region Malaysia is leading in private sector involvement in this sector. Malaysia has adopted a plan to modernize its sewerage system through a long-term contract with a group of investors led by a British water company. This project involve investment of around US$ 2,220 million spread over next 25 years. This project is expected to generate revenues around US$ 9000 million. States of Labuan, Ipoh, Johor, Sabah and Selangor have initiated privately funded projects on sewer system and water supply on Build-Operate-Transfer (BOT) basis. Several other states have privatized existing facilities.

In Adelaide, Australia, Public Service contract of US$ 1,100 million has been awarded to a consortium consisting of British and French Company with a 47.5 percent of stake for each and Australian Company with 5 percent stake. This consortium would manage water and sewerage systems in South Australia for 15 years. In Victoria, new three water and sewage licensed operators were established by restructuring Melbourne Water Corporation. In New South Wales, private sector has been invited to proposed US$ 520 million programme to build, own, and operate four water treatment plants in Sydney region.

In China, municipalities in many cities are negotiating with private companies for BOT projects and joint in the water and sewerage sector.

In Papua New Guinea a group of Malaysian companies has been awarded a US$ 122 million concession for 22 years to built and operate a water treatment plant.

In Sri Lanka, wastewater treatment plants in Ratmalana and Ekala/Ja-ela area will be built and operated by a private investors within the framework of the Colombo Metropolitan Area infrastructure development project. The government is fully committed to engaging private sector as an engine of growth for the development of the country. However, only limited functions such as billing out collection, construction and designing of plants have been privatized.

6.5 Expenditure on sewerage management in SAARC region.

Given the size of the population growth, South Asian region has to invest a great amount of money for sewerage management. Expenditure on (wastewater) sewerage management during the past five years in the South Asian countries are given in table 6.3, 6.4 and 6.5.

Table 6.3 - Expenditure on wastewater management during the past five year in SAARC Region

Country	Capital works		Operational maintenance	
	Total US$	US$% per Capita/ year	Total US$	US$ per Capita/ Year
Bangladesh	80,000,000	0.13	-	-
Bhutan	10,000,000	1.10	35,000	<0.01
India	-	-	-	-
Pakistan	-	-	-	-
Maldives	9,500,000	7.22	-	0.09
Sri Lanka	26,320,000	0.27	9,290,000	-

Source: UN 1996

Table 6.4 - Expenditure on wastewater management: most recent financial years in SAARC region

Country	Capital works		Operation and maintenance	
	Total US$	US$/per capita	Total US$	US$/per capita
Bangladesh	56,200,000	0.44	1,540,000	0.01
India	351,200,000	<0.01	122,000,000	20.00
Maldives	920,000	3.51	-	-
Pakistan	-	-	-	-
Sri Lanka	23,220,000	1.18	1,860,000	0.09
Bhutan	0	<0.01	35,000	0.02

Source: UN 1996

Table 6.5 - Projected expenditure on wastewater management: next five years

Country	Capital works		Operation and maintenance	
	Total US$	US$/per capita Year	Total US$	US$/per capita year
Bangladesh	-	-	-	-
Bhutan	1,000,000	0.11	47,000	<0.01
India	4,185,000,000	0.81[2]	-	-
Maldives	-	-	-	-
Pakistan	-	-	-	-
Sri Lanka	59,370,000	0.58	10,060,000	0.10

Source: UN 1996

Expenditure level on wastewater management in the Asia and Pacific varies from less than US$ 0.01 to over US$ 200 per Capita per annum. The common trend for all countries is an annual expenditure per capita for both capital and operational costs and funding the wastewater management predominantly come from public sources. A survey carried out by ESCAP suggests that out of 21 countries in the Asia Pacific region 17 countries believe that funding available was not sufficient to meet wastewater infrastructure development. Table 6.6 present the sources of funding for the sewerage management in the South Asian region.

Table 6. 6 Sources of funds for wastewater management projects

Country	Government budget allocations US$	Charges for wastewater disposal US$	Specific internal and external loans	Bilateral and multilateral grants	Private sector investors
Bangladesh	-	-	-	-	-
Bhutan	20	-	-	80	-
India	100	-	-	-	-
Maldives	-	-	-	54	-
Pakistan	-	-	-	-	-
Sri Lanka	-	-	-	-	-

Source: UN 1996

In the Asian region, charges are levied for domestic wastewater disposal in 15 countries of 21 countries surveyed. Table 6.7 present levy charges for wastewater in the South Asian region.

Table 6.7. Countries levying charges for wastewater disposal

Country	Charges levied for wastewater disposal from		
	Domestic sector	Industry	other sources
Bangaladesh	Yes	Yes	Yes
Bhutan	Yes	Yes	-
India	Yes	-	-
Maldives	No	No	No
Pakistan	Yes	No	No
Sri Lanka	No	No	No

Table 6.8. Private sector participation in wastewater infrastructure

Country	Private sector participation is encouraged for:			
	BOT concessions	Franchised Management of completed projects	On-site treatment of industrial wastewater	On-site treatment of domestic/ municipal wastewater
Bangladesh	Yes/Planned	Yes/Planned	Yes/Planned	Yes/Planned
Bhutan	No	No	No	Planned
India	-	-	-	Planned
Maldives	-	-	-	-
Pakistan	Yes	No	No	No
Sri Lanka	Yes	No	Yes	Yes

Most countries in Asia Pacific encourage private sector participation in wastewater management. Japan does not encourage private investment in this sector. Table 6.8 presents private sector participation in the sector.

Most countries in the region believe that international and regional cooperation is necessary to strengthen the sewerage management capacity in the region (Table 6.9).

Table 6.9. International and regional cooperation in wastewater management

Country	Does cooperation need strengthening in:			
	Training Activities	Information exchange	Technology transfer	Exchange of constancy and expert services
Bangladesh	Yes	Yes	Yes	Yes
Bhutan	Yes	Yes	Yes	-
India	Yes	Yes	Yes	No
Maldives	Yes	Yes	-	Yes
Pakistan	Yes	Yes	Yes	Yes
Sri Lanka	Yes	Yes	Yes	Yes

Source: UN 1996

6.6 Investment in sewerage management in Bangladesh

In most cities in Bangladesh sanitation facilities consist of individual septic tanks and bucket systems. Off set pit latrines are currently being provided to replace bucket system latrines. The Water and Sewerage Authority (WASA) in Dhaka has installed a sewerage system to carry the night soil of the city dwellers, treat them in oxidation ponds and dispose of the effluent in the river Buringanga.

In rural area water-sealed sanitary latrines are being distributed at subsidized cost and home-made pit latrines have been promoted. Even in urban population only small percentage have the access to water borne sewerage system. For example only 15 percent of urban population in Dhaka is served by a conventional water borne sewerage system (6.10).

Table 6.10 - Urban sanitation, Bangladesh, 1990

Area	Percentage of population served by:				
	Sewerage	Septic tank	Pour-flush latrine	Bucket latrine	Unsanitary system
Dhaka	15	40	15	-	30
Chittagong	-	31	5	15	49
District towns	-	22	16	26	36

6.6.1. Privatization policies of Bangladesh

The government intends to privatize water supply and sanitation activities in Bangladesh. Already some functions of sewerage service have been privatized.

Easy loans from the banks are available for installation of water supply and sanitation facilities in rural areas. Some non-government organization also provide sanitation facilities. Sanitary latrines are sold to the beneficiaries at subsidized price.

In Bangladesh sanitary latrines are mostly private. In rural, there are around 700 private producers of latrine components with annual capacity of 140,000 latrine units. Grameen Bank (one banking organization) provides loans to interested villagers to install water supply and sanitation facilities.

However, still in Bangladesh sanitation sector has not able to attract private sector.

6.7 Investment in sewerage management in India

India possesses about 4 percent of runoff the river in the world. It also has about 15 percent of world's population. The urban population which was 19 percent of population of 361 million in 1951 increased to 27 percent of the total population of 930 million in 1994. Provision of sanitation in India both urban and rural is unsatisfactory. A total of 611 million rural population that is 95 percent of the total rural population have not been provided basic sanitation. At the same time about 115 million urban population have no

access to basic sanitation. In India total population that have no access to sanitation has been estimated to 754 million.

The minimum investment required for meeting the basic sanitation would be Rs. 10.4 billion and Rs. 43.4 billion depending on the types of sanitation system used. It is not possible the government alone to meet this requirement. Private sector assistance is important.

The provision of sanitation is a state duty according to the constitution. The local level responsibilities are vested with the urban and rural bodies. In the laws of many states, the obligatory functions of municipalities such as sanitation are prescribed in a manner which precludes private sector entry. If the private sector involvement is necessary it is necessary state government to amend their legislation to enable private sector investment in the sanitation sector. The government should adopt transparent and non-discriminatory policy for attractive private sector investment in the sanitation sector.

6.8 Investment in sewerage management in Pakistan

Pakistan government has given high priority for the provision of drinking water and sanitation facilities. In Pakistan proper sanitation facilities are available for about 32 percent of the population. This consists of 60 percent of urban and17 percent of the rural population. The government has launched a Social Action Programme (SAP) for provision of social services including sanitation. The programme had planned to provide sanitation facilities to additional population of 19 million during the period from 1993-1998. The proposed investment for the sanitation programme was US$ 7.8 billion. The programme expected to provide sewerage facilities for 90 percent of urban population. Government has planned several sewerage management progress; Lahore Water Supply and Sewerage project; Punjab Water Supply and Sewerage Project; Sindh Water Supply and Sewerage Project; MWFP Water Supply and Sewerage Project; and Balukistan Water Supply and Sewerage Project.

In addition to these project the government exempted equipment necessary for water supply and sewerage project from customs duties. Project financing loans both domestic and external sources are made available.

At present private sector is not involved in the sanitation sector. However the government is studying the possibility of promoting private sector investment in the sector.

6.9 Investment in sewerage management in Sri Lanka

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 have been connected to sewerage system which was built in

1916. It is not anticipated to provide piped sewerage system to cities in the near future except where no on-site alternatives are possible.

According to the government plans, to meet the sanitation target Rs. 1.0 billion is needed annually. Master plans for water supply and sanitation were proposed for Greater Colombo in 1991 and 1992 respectively. Cost of the implementation of planned sanitation projects are given in table 6.11.

Table 6.11 - Costs for implementation of the planned water supply and sanitation projects, Sri Lanka

Area	**Project**	**Cost(Rs. million)**
Greater Colombo	Kalu Ganga Water Supply Project	14,500
	Water Supply Project-Phase II	800
	Greater Colombo Sewerage Project	4,000
	Design and Construction of Salinity Barrier	500
Other areas		12,000
Total		31,800

Funding for these projects is expected from external loan and private sector. The Government established the Public Enterprises Reform Commission (PERC) to be responsible for restructuring public enterprises. The task of the PERC is to decide the best form of private sector involvement and carry out necessary policy directives accordingly. Under this programme several utility companies are being privatized or under consideration for privatization. Possible options under consideration are complete privatization, management companies, leasing for a number of years, creation of subsidiary companies. Necessary legal enactment for privatization has been already passed early 1980s.

The National Water Supply and Drainage Board which has the authority on this sector, has some limited private sector participation in its activities such as billing designing etc. Privatization of entire sanitation sector is not in the government's agenda. However opportunities for privatization exist ranging from complete privatization to privatizing existing facilities. Mobilizing private investment for new facilities using Build-Operate-Own or Build-Operate-Transfer method is another possibility.

6.10 Justifications for private sector involvement in sewerage management

The major sanitation utilities in the world are provided by public sector organizations. The reasons for this situation includes, a) sanitation is perceived as a basic needs b) sewerage system are natural monopolies, c). Sewers are buried under road belonging to the government, d). several systems should have the clear ownership. Because of these reasons public sector has continuously provided sewers system as a political priority.

However providing sewerage facilities by the public sector has experienced significant problems in the past. The major problem was the limited funds availability with the government budget to allocate for sewerage management. Similarly most government attempt to keep sanitation charges too low due to political reasons. Therefore public sewerage companies are not financially viable. Another problem of public sewerage companies is that their proponents and the quality of services are not published. Therefore customers satisfaction of the public sewerage system is generally poor.

This situation lead to most governments to consider private sector involvement for the improvement of sewerage management facilities. The advantages of private sector participation in the sewerage management activities includes; a). Private sector can obtain or provide funds through equity or debt in addition to the funds available to a government under ceilings of expenditure. The private sector can collect money commercial terms so that the private sector investments are sustainable; b). Clear regulatory procedures can be introduced when dealing with the private sector; c). Consumers are kept better informed by the private sector publications; d). Private sector companies are more flexible in their approach to solve problems; e) Employers are motivated due to remuneration packages; f).private sector can bring specialist skill to the sector.

Private sector involvement in the sewerage management is not free from disadvantages. Major disadvantages are a). Private sector can develop a monopolistic situation which need some form of correction, b). Regulator can become too involve in day-to-day operation of the company which will reduce the efficiency, c). Duration of contract is always limited, d). Handing over process at the end of private sector arrangement need to be defined, e). Taking over of part of a public services by the private sector will require a well-defined contract in order to safe guard all parties. These are some concern in involving private sector in sewerage management.

6.11 Opportunities of privatization in sewerage management in South Asian region

Public sewerage management is at present a matter for the government. Now attention has been drawn both governments and private sector on the possibilities of using private sector investment in the sector. However, some early sewer systems were installed by commercial venture, which were eventually vested in the government. Now there are range of different options for private sector involvement that are being considered by

various government organizations in the world. Such options available for sewerage management include;

a) New work and major sewerage facilities rehabilitation including planning, design, supply of components and construction supervision of control.
b) Supply and regular servicing of equipment and machinery, computers, photocopiers, vehicle.
c) Communication including postal services for billing, telephone links to control customer services centers and reporting of fault..
d) Revenue collection through commercial banks, postal services for collecting date.
e) Staff catering- canteens social and sports facilities.

Even today major sewerage utilities already rely to a greater or a lesser extent on the private sector for provision of some of these services mentioned above.

Traditionally, the provision of on-site facilities of treatment has been the responsibility of landowner or householders either private or non-private. In the sewerage management sector, collection and treatment of wastewater and sewers is not a commercially viable venture so that traditionally some changes are normally made for the services. However, the treatment process of sewers, can produce methane gas for domestic or industrial use, which can be sold to enhance income. The treated water is suitable for irrigation of parks and recreational areas and for other purposes such as industrial use. The sludge finally can be sold as fertilizer. These sewerage management activities can be implemented as commercially viable ventures. The figure 6.1 diagrammatically present the water supply and water cycle that shows some of the possible points of sale or charges (ESCAP 1997). From this figure the activities which can attract private sector as providers of services and as investors can be identified.

However, we should be realistic about the extent of the profit private sector can earn from this. Some ambitious claim on possible private sector involvement in sewerage management have made the situation verse because sewage management has not yet become a lucrative business. Therefore a realistic approach is essential with sound understanding of the real benefits of mutual partnerships between private and public sector.

In order to yield maximum benefit the most usable activities of the sewerage management for private sector have to be identified. Figure 6.2 illustrates a spectrum of options that may be considered when planning a strategy for involving the private sector sewerage management (UN 1996). Among them some activities and methods used in the private sector can provide greater autonomy with responsibility keeping with the government. On the other hand some options included in the most right side columns indicates full divestiture to private sector leaving little control for the government which has been successfully implemented in water supply and sanitation sector in England Wales in 1989.

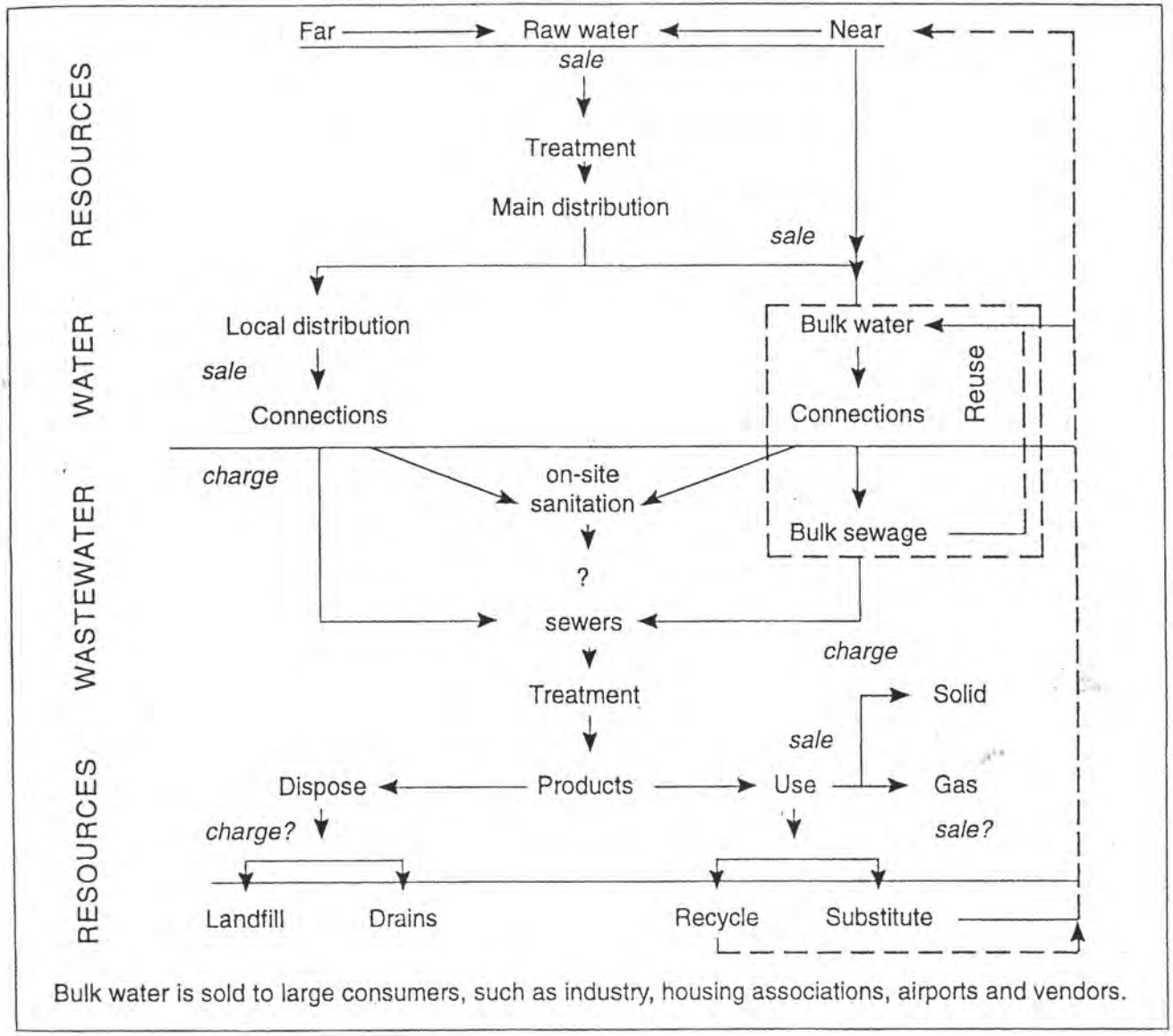


Figure 6.1 Outline of urban water use

The most viable options lies in between these extremes from full government departmental contract and full privatization.

However, when choosing the initial option it is extremely important to make sure that future options were not affected. Therefore initial option should be selected with a view that a gradual transition can be made from minimal private sector involvement to a relatively major hand over of responsibility.

This progressively step by step privatization has some advantages as it allows both private and public sectors to develop management strategies with experience.

The commonly excepted strategies to convent government departments in charge of sewerage activities to corporations or authorities as a first step towards privatization.

Duration of the contract is also important. For the large investments by the private sector, there should have long term duration while small investments may be carried out under short term.

Planners should seriously consider the objective of the swage management and the duration of the contract, short, medium, long be decide accordingly. The management of privatization may be decided as illustrated in figure 6.2. If capital funds are coming from the government and if the operation of a complete system is privatized a lease would be appropriate. Similarly a longer concession can be recommended if capital investments are provided form the private sector. Among them form of public and private partnership (PP) is most practical and acceptable institution that can promote private sector investment.

The criticism leveled against the private sector involvement in sewage management is the possibility of private sector creating a monopoly and exploiting customers setting unreasonable high tariffs. Therefore, whatever the option we use to improve the private sector involvement it is required to introduce some form of regulations and control of standards of service and remuneration earned. Such system should be administered by an independent regulatory body that will operate within a well-defined regulatory framework.

6.12 Types of Public Private Partnership (PPP) options in the sewerage management

The type of public private partnership includes service agreement (contracting out, management contract), leasing, Built-Operate-Transfer (BOT), turnkey, franchise, concession, built-own-operate-transfer (BOOT), full private company.

6.12.1 Service agreements

Some components of sewerage management system can be transferred to the private sector through a service agreement. The government authorities can also employ private organization to assist certain aspects of the sewerage services. For example Bangladesh is experimenting with service agreement for billing and revenue collection. Sri Lanka also has tried contracting out certain functions of utility services. In general when there is no in-house opportunity technical staff to handle specific task the government body can contract out that particular task to private sector. A contract for well-defined work could be a lump some payment could be paid in installments.

To achieve maximum output from a service agreement a flexible contract may be used. Specially for ill-defined, complex or risky tasks can be undertaken under flexible contract terms which can be changed with agreement between both parties.

Management contracts are major type of service agreements used in the sewerage system. Under management contracts private company takes over the particular part o f the system, such as sewerage treatment work or operation and maintains of the entire sewerage system. The company maintains the facility in terms of the management contract. The public authority in this case retains the overall responsibility of the system. In general the private company in charge of the management contract will not share any profit or loss with the government.

6.12.2. Leasing

In the sewerage management sector, leasing can be used for running the entire facility by private sector. Private organizations operating under a lease makes larger financial input to cover the maintenance cost but not the capital cost. The government will have to make necessary capital investment. Leasing contract provides greater degree of autonomy to the private sector compared to service agreements. The main task of the private sector operating under a lease agreement is in operation and routing maintenance. Therefore, in a leasing contract private sector has the greater opportunity for profits. This advantage of lease agreement is that the private sector encourages the government for more investment to expand the capital stock, which will reduce the lessee's operation cost.

Built-operate-transfer agreement, built-owned-operate-transfer, built-transfer-operate, built-lease-transfer are some of the lease agreements that can be used for private sector involvement in sewerage management.

6.12.3. Built-Operate-Transfer (BOT)

Under a leasing agreement of BOT a private company build the facility of sewerage system ,operates it for some time and then hand it over to the government. Under BOT agreement contractor may not provide finances. In such system the company does not

Activity	Privatization level										
	Full government department	Public		Service agreements		Lease			Franchise		Full privatization
		Board	Corporation	Contract out	Management contract (gerance)	Lease	BOT	Turnkey	Concession	BOOT	Divestiture
Legislation	○	○	○	○	○	○	○	○	○	○	○
Regulation (See Note)	○	○	○	○	○	○	○	○	○	○	○
Tariff levels	○	○	○	○	○	○	○	○	○	○	○●
Ownership:											
(a) existing fixed assets	○	○	○	○	○	○	○	○	○	●	●
(b) replacement	○	○	○	○	○	○	○	○	●	●	●
(c) new fixed assets	○	○	○	○	○	○	○	○	?	●	●
Finance:											
(a) expansion	○	○	○	○	○	○	○	○	?	●	●
(b) use of funds	○	○	○	○	○	○●	○	○	○●	○●	●
(c) working capital	○	○	○	○	○	●	●	●	●	●	●
System:											
(a) planning/design	○	○	○	○	○	○●	○●	○	●	●	●
(b) construction	○	○	○	○	○	○	●	●	●	●	●
(c) rehabilitation (long-life assets)	○	○	○	○	○	○	○	○	●	●	●
(d) maintenance (short-life assets)	○	○	○	○	○	●	●	–	●	●	●
(e) operation	○	○	○	?	●	●	●	?	●	●	●
(f) revenue collection	○	○	○	○	●	●	?	?	●	●	●
Risks:											
(a) commercial construction/operation	○	○	○	○	○	●	●	●	●	●	●
(b) legal (main)	○	○	○	?	●	●	●	●	●	●	●
(c) efficiency	○	○	○	●	●	●	●	●	●	●	●
Financial autonomy	NO	NO	YES	YES	YES	YES	YES	YES	YES	YES	YES
Management autonomy	NO	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Duration (years)	–	–	–	2.5	5	7/20	7/20	–	25/30	25/30	25/30

KEY: ○ = Government, non private, ● = Private, ? = Either, ○● = Both

Note: Regulation has to be stronger for greater degrees of private involvement. Public bodies can be partly self-regulating.

Figure 6.2 Responsibilities under private sector involvement options

Activity	Privatization level										
	Full government department	Public		Service agreements		Lease			Franchise		Full privatization
		Board	Corporation	Contract out	Management contract (gerance)	Lease	BOT	Turnkey	Concession	BOOT	Divestiture
Legislation	○	○	○	○	○	○	○	○	○	○	○
Regulation (See Note)	○	○	○	○	○	○	○	○	○	○	○
Tariff levels	○	○	○	○	○	○	○	○	○	○	○●
Ownership:											
(a) existing fixed assets	○	○	○	○	○	○	○	○	○	●	●
(b) replacement	○	○	○	○	○	○	○	○	●	●	●
(c) new fixed assets	○	○	○	○	○	○	○	○	?	●	●
Finance:											
(a) expansion	○	○	○	○	○	○	○	○	?	●	●
(b) use of funds	○	○	○	○	○	○●	○	○	○●	○●	●
(c) working capital	○	○	○	○	○	●	●	●	●	●	●
System:											
(a) planning/design	○	○	○	○	○	○●	○●	○	●	●	●
(b) construction	○	○	○	○	○	○	●	●	●	●	●
(c) rehabilitation (long-life assets)	○	○	○	○	○	○	○	○	●	●	●
(d) maintenance (short-life assets)	○	○	○	○	○	●	●	–	●	●	●
(e) operation	○	○	○	?	●	●	●	?	●	●	●
(f) revenue collection	○	○	○	○	●	●	?	?	●	●	●
Risks:											
(a) commercial construction/operation	○	○	○	○	○	●	●	●	●	●	●
(b) legal (main)	○	○	○	?	●	●	●	●	●	●	●
(c) efficiency	○	○	○	●	●	●	●	●	●	●	●
Financial autonomy	NO	NO	YES	YES	YES	YES	YES	YES	YES	YES	YES
Management autonomy	NO	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Duration (years)	–	–	–	2.5	5	7/20	7/20	–	25/30	25/30	25/30

KEY: ○ = Government, non private, ● = Private, ? = Either, ○● = Both

Note: Regulation has to be stronger for greater degrees of private involvement. Public bodies can be partly self-regulating.

Figure 6.2 Responsibilities under private sector involvement options

own the facility. The facility will be handed over to the authority only when it is operational.

6.12.4 Turnkey

Turnkey contracts are in general similar to the BOT type of agreements except turnkey contractor who does not provide finance. Turnkey contracts are generally entered into design and building constructions. This may also include training of staff of the new projects built over a short period.

6.12.5 Franchise

Franchise is one of the best private public partnerships to increase private investment for possible sewerage management. Franchising involves private sector financing all or most of the investment cost of the sector. Therefore, when government budgets are severely limited for sewerage management franchised private sector involvement can be used as a good option.

However, for franchised investment to survive its income has to be sufficient to cover the capital cost debt repayment and equity returns plus operating and maintaining cost. Therefore, cash flow of the company is critical for a franchise to sustain. As a solution for this governments provides various incentives for the private sector to improve their cash flow. These types of incentives are essential to attract interest of other private sector for franchising even though it is an additional cost to the government. Under franchised common incentives include:

1. Free use of existing facilities
2. An initial grant or soft loan for immediate rehabilitation of existing facilities.
3. Free land provided by the government
4. An explicit subsidiary for the initial year

It is not possible to sell a franchise for sewerage project without any financial incentives. Therefore selling franchise with an up front payment cause problem of financial viability to franchise. The initial payment the franchise would be willing to pay could be very low.

Franchise is one of the best option for promoting public private partnership for sewerage management, possibly by setting up of a jointly-owned special company.

6.12.6 Concession

The concessionaire provide finances for the investment costs, agreed expansion costs and working capital. Concessionaire collect revenue from customers a fee based on the agreed formula by the government. The government of Philippines used this approach to attract private sector for metropolitan waterworks and sewerage system (MWSS) saving the Manila area.

6.12.7 Full Private Company

This approach involves transfer of existing assets from the public to the private sector, which is refused to as divestiture. Under the divestiture option, the private company purchases the right to operate the public services and compensates the government by purchasing the existing works and assets. United Kingdom used this approach for private water supply and sanitation services in England and Wales.

First, the UK government, brought the functions of water supply, sewerage and sewage disposal in England and Wales into ten Regional Water Authorities under the Water Act 1973. As a solution for financial constraints, the government began to explore the possibility of getting private sector involved in this sector in mid 1979s and the early 1980s. In May 987, the UK government transferred to the private sector the functions of water supply, sewerage and sewage disposal, keeping the regulatory and river management functions with the public sector.

6.12.8 Public Private Partnership

Public private partnership is considered to be a joint approach by the government and the private sector. The public and the private sector working together within one organization barring responsibility for all aspects of the operation is the closest partnership. In this process major constrain is in deciding the degree of responsibility that can be given to the private sector. The ideal scenario should be combining the government and the private sector in an join operation.

The company structure e should be a special purpose company that will act as the principal coordinator. The company can consist of all the stakeholders who would corporate and participate in the service process.

Government can participate directly as a stakeholder in the special Purpose Company which is called direct government partnership. In this case around fifty percent of the shares can be held by the government.

Under the public private partnership, sewerage management by the public sector may contribute:

a) control over legislation
b) certain powers such as right of access to and compulsory purchase of land
c) water rights which may reside with the state
d) Provide part or all existing sewerage facilities.

The private sector can contribute

a) rate of autonomy
b) improved skill levels
c) detailed long-term planning
d) greater flexibility in day to day operation

e) more stable budgeting and forward planning
f) greater emphasis on commercial operations
g) improved efficiency and output through incentives

6.13 Stakeholders in private sector involvement in water supply and sanitation

The transfer of sewerage services to the private sector involves numerous stakeholders. Each stakeholder has some role to play in the process. The effectiveness of their involvement will decide the success of the privatization process. The main stakeholders who will be affected are:

a) Government, central and local;
b) Managers;
c) Trade union;
d) Employees;
e) Investors;
f) Bankers;
g) Consumers;
h) Community at large;
i) Regulators, for economic and service level.

Many changes in the privatization process have to be supported by legislations. This is the role of the government. The government should have clear and well defined policy on private sector involvement and should create an enabling environment. The factors that can affect in creating an enabling environment include:

a) Political stability and general political agreement on the privatization strategy. Private sector is cautious on the possible threat to the process by the opposition parties.
b) Well -developed infrastructure and services in other sectors will enable the sewerage sector to operate properly i.e. electricity and other services.
c) A clear distinction between commercial objectives and social aims of the government.
d) Sound economic policies to avoid unforeseen problems such as high import duties, exchange rate fluctuation etc.
e) Effective legal mechanisms for establishing private entities and for settling disputes (setting up arbitration authority).
f) Effective regulation mechanisms with clear guideline from the government for level of services and economic aspects.
g) Availability of capable and responsible private sector.
h) A well-developed capital market and financial institutions.
i) Well informed consumers.

When conditions are attractive, the private sector will develop and expand in order to take the opportunities provided by the government.

6.14 Risks involved in private sector sewerage management

The success of the private sector involvement in the sewerage sector is the handling risks involved. Some of the risks identified in this area include:

a) Political risks caused by complete political framework and climate, particularly on the availability of: a) support for private sector involvement in public services; b) an acceptable approach to social aspects of water supply; c) acceptance of independent regulation; d) commitment of the government for joint participation with the private sector.
b) Construction completion risks connected with a) inadequate knowledge of existing infrastructure; lack of access to land; a choice of too advanced technology; insufficient local construction skills; loose cost control and overruns.
c) Operational risks, i.e. risks of failure to provide the expected service levels for example, associated with: a) insufficient raw water supply; unreliability of raw materials, energy and fuel supplies; poor performance of existing infrastructure; possible government intervention.
d) Financial risks such as risk of collecting insufficient revenue which might be caused by a.) Excessive inflation; b) unfavorable currency exchange rate; c) unreliability of income; d) Poor payment of dues.
e) Legal risk created by the absence of clarity in contract conditions on a) rights and power for raw water, b) discharge of treated sewage; c) resolution of disputes; d) ownership of infrastructure
f) Project specific risk such as revenue risk, lower consumption risk, bad debt etc.
g) Operational risk, mainly lack of raw water, poor quality raw water, interrupted power supply and frequent breakdowns.
h) Legal risk including insufficient rights and powers contract uncertainties and disputes.
i) Implementation risks including political opposition, non-agreement of major consumers, non-availability of local debt funding, lack of competent bidders.

6.15 Planning private sector involvement in sewerage sector

Planning of privatization of sewerage management should follow multi-faceted process involving key stakeholders. The process need broad knowledge of the technical, financial and political issues, professional skills to develop realistic compromises to satisfy all stakeholders, good communication skills and ability to resolve differences.

Defining the broad policy objectives is the primary step of the privatization of the sewerage system. Possible objectives include

a) Sale of assets to increase government income
b) Attracting private sector funds to reduce the burden on the public budget
c) Achieving good efficiency and level of services

The next step is the evaluation of local conditions in order to; a) assess private sector capacity for sewerage management; b) to assess corporate culture in the country which should be integrated within the private sector organization; c) to investigate existing regulating systems relevant to private sector participation and to investigate the legal frame work for public services management.

Existing utilities and their performance should also be evaluated in order to estimate a) Conditions of infrastructure assets, b) performance parameters, future development plans, c) future development plans on sewerage management and other utility projects.

Risk assessment, specific contributions from stakeholders and specific needs of stakeholders should also be assessed.

6.16 Recommendations for private sector involvement for the protection of coastal and marine system through investment in sewerage management

Pollution of marine system directly affect the socio-economic activities associate with the coastal eco-system such as coastal tourism, recreation, treasures and other marine activities. An analysis has demonstrated that the urban and domestic sewerage is one of the major causes of the pollution of marine eco-system. One of the reason for this is that the heavy orientation of sewerage investments from public sector. Most developing countries are not in a position to allocate their sufficient budget to sewerage management from their limited resources. Therefore, private sector investment opportunities in the field of sewerage management should be sought in addition to public investments.

Private investment can only however be promoted if the enterprise is economically viable. The benefits of coastal and marine eco-system protection are non-marketable. Therefore, the benefit of coastal and marine protection of the sewerage investment are not generally considered in private sector benefit cost analysis. Therefore, the sewerage management projects can not attract private investment. If the indirect benefit of sewerage management project such as benefit of coastal and marine eco-system protection are included in the benefit cost analysis the most sewerage management project particularly in coastal areas may be economically viable. The only problem is that the indirect and non-use benefit of coastal eco-system protection cannot be converted in to real money. Therefore, private sector investors do not consider such benefit as revenue for their enterprises. In order to address this problems governments should develop strategies to internalize the indirect benefits of marine and coastal protection.

Following public private partner ship can be effectively use in the sewerage management in the South Asian Region if governments recognize the non-market benefit of the coastal and marine protection;

a. Private public partnership in the coastal sewerage management projects

b. Privatizing the maintenance existing sewer network through service agreement.
c. Leasing out sewerage management facilities.
d. Build-operate-transfer (BOT) sewerage project.
e. Formulating full private company for providing sewerage facilities.

Any of these privatization options are possible for the management of sewerage if all indirect benefit of such investment particularly protection of coastal and marine system from land based source of pollution are included in to the project analysis.

Governments should be able to translate indirect use benefit of coastal and marine system into real money for above private sector enterprises to be economically viable.

Chapter 7

Summary conclusions and recommendations

7.1 Introduction

The pollution of marine ecosystem directly affects the socio-economic activities associated with the coastal ecosystem. Most South Asian country experts are of the view that domestic and urban sewage to be one of the major threats to the coastal and marine pollution. Yet, governments of developing countries have not been convinced on the importance of investing in sewage management. They have limited knowledge on the economic activities provided by the coastal and marine environment. Major economic activities that are affected include coastal tourism, recreation use, fisheries and associated activities. These potential economic benefits itself present some solution to protect marine system from land based activities, because the economic value justifies the investment in the marine pollution prevention technology. I t was therefore, suggested to review the possibility of using socio-economic 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.

The objective of this paper is therefore, to review potential socio-economic opportunities in the region of South Asian Seas affecting the marine and coastal environment with special reference to urban and domestic sewage. The paper addresses several major issues related to sewerage and marine environment: a) identifying economic sectors making use of coastal and marine environment; b) national and sub-national development plan affecting marine system; c) quantitatively the type of point and non-point sources of sewage domestic and urban centers; d) quantitative assessment of economic benefits of use of coastal and marine environment; d) the environment impact on the marine environment from sewage; e) potential investment from public – private partnership in sewage management.

This report focuses on the pollutants to the Indian Ocean from land based economic activities in the countries of the South Asian Region. Since recent studies show the major polluting factor to the Indian Ocean marine environment is sewage and it is common problem to the South Asian Regional Countries, this report highlights the problem of sewage.

7.2 Sewage as a pollutant to marine system

Due to increasing urbanization and industrialization throughout the region, the volume of sewage and industrial waste production is constantly on the increase. Many countries have several large rivers flowing through their landmass, but because of increased human activities around them many of these rivers have become badly polluted. These two human activities also contribute quite substantially to the degradation of the adjoining seas. Sewage and industrial wastes in these countries, either untreated or partially treated, are allowed to be discharged into the rivers and seas.

In Pakistan, only 25% sewage is treated. Most sewage is disposed into the city's watercourses without treatment. In the city of Karachi in Pakistan, it is estimated that about 262 million gallons per day (MGD) of swage is generated in Karachi and adjacent areas from domestic and industrial sources. Of these 111 MGD is generated form municipal and the remaining from industrial sources (6000 industrial units). The industrial wastewaters and sewage are discharged into the two seasonal rivers: Lyari river and Malir river of Karachi.

The townships and human settlements in the coastal areas of **Bangladesh** do not have any domestic waste treatment facilities and therefore effluents either directly or indirectly find the way untreated into the rivers and hence to the Bay of Bengal. A survey report of a waste water expert mission and DEPC data show that the two populous coastal cities of Chittagong and Khulna have poor sanitary conditions owing to a lack of sanitation facilities or the improper functioning of existing facilities. It is common practice to dump excreta in drains and canals, which go to nearby rivers. The flow of the river varies form 11,200 m (cube) /sec in the rainy season to 113 m (cube)/ sec in the dry season. During the dry season the river loses most of its capacity to purify itself of the biodegradable wastes. The total BOD load from the domestic waste in the Chittagong area is estimated as some 3.5 tons/day. The domestic waste load in the Khulna and Mongla port areas may be estimated to be approximately 2.2 tons BOD/Day.

Nearly 20% of the population of India live within 40km form the coastal sea. The constant increase of population and rapid industrialization in the recent years have led to the generation of enormous wastes in the coastal cities and towns. These wastes, both domestic and industrial in nature are directly disposed off into the sea through creeks or through the rivers situated in these coastal cities and towns.

In Sri Lanka, important sources of pollutants relevant to this assessment are: Sewage (the principal component for this presentation); Industrial effluents; Agricultural runoff , Storm water; Urban waste streams; Marine waste streams; Sea shore activities; Off shore activities. In assessing the impact value both the quantity (flow rates) and the quality (i.e. composition) are of importance. Kelani ganga – industrial waste and sewage (Kelani ganga is by far the most polluted river in Sri Lanka). This drains an area of 2,278 km^2 in the wet zone (includes the CMR) emptying into the Indian ocean at a flow rate of 213.8 m^3 sec^{-1}. The estimated BOD to the river from the industry is 8%. In San Sebestian canal, the estimated BOD load is daily 1800 kg (industry factor 10%) the rest is sewage related load.

For Sri Lankan total population of 18,112,000 (With population growth at 1.4%, an annual addition of 20 million is expected to this figure), based on the potential waste generation per person at 0.4 kg per day (*(literature varies on this figure up to 1 kg per person per day)*, the total sewage generation has been estimated to 7244800 kg (as average sewage gives about 250 mg/l BOD and assuming a density of 1000 kg/m3) and 1811200 kg BOD load per day. Of this, the total load on the coastal zone (from 1/3 of population) is estimated to 597696 kg BOD per day.

Currently, only 80% of the total population of the Colombo Municipal Council (CMC), approximately 300,000, are connected to the sewerage system. The area serviced by a sewerage network is about 3600 ha, which corresponds to 80% of the total CMC land area. The rest of the population within the large Greater Colombo Area (total population, approximately 1.2 million) make use of septic tanks, river and canal banks, the seashore and open land. It has also been estimated that about 15% of the total population of CMA, primarily in low-income areas, have no sanitation facilities at all. Furthermore, about 50% of the population in the CMA belong to the low-income category and live in semi-permanent dwellings, where high population densities strain existing waste disposal infrastructure and also result in the placement of septic tanks near drinking water sources. Inadequate, as well as lack of maintenance and cleaning of, sewage system /network cause a lot of problems.

Available data indicates that, in an area with approximately 500,000 households, there are approximately 300,000 sewerage connections. Consequently, a significant proportion of households rely on the use of septic tanks, which if not constructed or sited properly (particularly in areas where the water table is high), will only compound the problem of urban water pollution.

Sewerage pollution to 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 system. In the South Asian region, given high rate of population increase, the impact of sewage on the marine system can be great.

7.3. Economic Assessment

Marine and coastal ecosystems have been the foremost economic base for the coastal population in the world. The economic activities of the marine eco-system are largely based on the two economic functions of the marine environment viz., as a resource supplier (Coastal and marine environment as a supplier of natural resources ,both existing use and potential use) and as a waste assimilator (use of coastal and marine environment as a waste sink, both existing use and potential use).These activities range from direct uses such as fish production to recreation benefits and indirect benefits such as maintaining biodiversity, nutrient cycling and hydrological functions. This type of multiple use inevitably create conflicts between different uses and hence different sectors. It is therefore important to recognize at the outset the specific type of needs required by each sector from marine and coastal environment.

Marine ecosystems provide basic support to economic activities by yielding raw materials, supporting and protecting natural and human systems and maintaining options for future economic production and growth. - to households, to businesses, to governments and to the global community. Economic analysis helps to understand and quantify both the value of these benefits, and the costs associated with their loss, and thus provides a justification for conservation of the environment.

The report identifies economic activities that are almost inherent and which are common like agriculture, fisheries, tourism, industrialization and development activities to Bangladesh, India, Maldives, Pakistan and Sri Lanka. The report also, quantitatively analyses the economic benefits of the coastal and marine environment in Sri Lanka. Methods of destruction owing to the economic activities, pollutants and the future cost of total destruction of the marine environment are discussed in this report.

According to the recent estimates, lagoons have the total economic value of US$ 2000 ha^{-1} y^{-1}. Carbon sequestration benefits of coral reefs have been estimated to US$ 50,000 per square meter coral reef in terms of the global warming damage avoided. The value of marine and estuarine fisheries is about US$ 85 ha^{-1} y^{-1}. Protection from storm damage offered by mangrove has been valued at about US$ 38 ha^{-1} y^{-1}. Contribution to the agriculture from mangroves has been estimated to US$ 165 ha^{-1} y^{-1}. Potential economic value of shrimp farming is about US$ 2106 ha^{-1} y^{-1}. The aesthetic value of the coastal and marine environment has been estimated to be US$ 230 ha^{-1} y^{-1}.

The cost saving from coastal wetland for treatment of wastewater range from US$ 78 to 3470 per acre of wetland use for treatment. The value of lagoon as sink for untreated industrial waste is estimated as US$ 600 ha^{-1} y^{-1}. The value of lagoon as sink for domestic and municipal waste has been estimated as US$ 2.5 ha^{-1} y^{-1}.

The report deals with case studies of actions and plans taken for the cleaning up of the environment in Sri Lanka. The economic cost of cleaning up of the environment is highlighted to focus on the need for the initial necessity to plan for environment protection in the development plans of these countries. For example, Sri Lanka has a coastline of some 1700km. The contamination of Sri Lanka's coastal waters stems mainly from misuse of land-based sources. As in most other developing countries concern for environmental problems is relatively recent. Data relevant to the pollution of the marine environment had neither been collected in a coordinated manner nor had the little data available been subjected to rigorous analyses. The principal sources of land-based marine pollution in Sri Lanka are sewage, urban, industrial and agricultural effluents. The potential of environmental damage from urban and industrial waste disposal appear to be particularly high. The necessity to develop primary tools for the prevention of marine pollution, including the development and enforcement of standards and regulations, is emphasized (Costa, 1990)

Government regulations are not implementable in developing countries such as Sri Lanka where the non-affluent who exploit the reefs are unable to appreciate conservation and aesthetic perspectives due to the immense socioeconomic pressures they experience in meeting their daily needs. It is therefore proposed that management strategies be modified to (1) incorporate the development of non destructive low-cost alternatives for the presently exploited coral reef resources so that eventually the availability of cheaper alternatives would render coral reef exploitation economically unrewarding, and (2) rationalize the techniques for exploitation so that exploitation of the resource would not cause undue waste. Breeding and growing reef fish and reef invertebrates that are presently exploited heavily for the aquarium trade, identifying alternatives to the coral

species that are ruined intensively at present, and developing exploitation techniques that are amenable to rational utilization of resources, need to be encouraged (Ekaratne, 1990).

7.4. Development plans

Relocation and modernization of tanneries project at Bata Ata in Sri Lanka is a unique project which has significant impacts on coastal water. The tanners that are to be relocated are presently housed in and around Rajagiriya, Hendala and Wattala area significantly polluting the water bodies. A study done on the water quality of Kelani river indicated that although the impact from industries to the quality of water in the Kelani river is limited some amount of Chromium particulate have been found from the river waters. This amounts to the major sources of industrial pollution in the Kelani river. This could have a great impact on coastal seas also because Hendala, Wattala is right on the river mouth while Rajagiriya is also closer to the river mouth.

Relocation and modernization of tanneries at Bata Ata would prevent this occurrence and would contribute towards the purification's of the ocean. The memorandum of understanding signed between the Dept. of Wild Life, Ministry of Industrial Development and the Sri Lanka Association of Tanneries regarding the tapping of water up to 200,000 gallons per day from the river mouth could also have a bearing on the sea. The EIA approval for this project was finally granted by the CEA with the concurrence of CCD because the ultimate wastewater is discharged to the coastal waters. A monitoring committee to regulate these activities also includes representatives from Dept. of Coastal Conservation, National Water Supply and Drainage Board, CEA and all institutions connected to the protection of coastal waters. The frequent plan that could be erected is designed and constructed under the patronage of UNIDO regional office and would conform the latest technological standings. Thus, helping in prevention the pollution of coastal waters in Colombo region by eliminating the major pollution source in the industry sector and contributing towards a sustainable environment in the south.

Moratuwa, Ratmalana, Ja-Ela, Ekala area is congested with unplanned industrial activities. The solutions that has been suggested is the establishment of the common wastewater treatment plant at Ja-Ela, Ekala and improvements to the wastewater system in Moratuwa, Ratmalana area. At present wastewater discharged to the ocean from 2 sea outfalls at Wellawatte and Modara. At present the chances of getting this project through are quite remote. Therefore, as at the present position, one could conveniently come to the conclusion that the highest impact on coastal water from an industrial area is from Moratuwa, Ratmalana and Ja-Ela, Ekala areas. This is because the industries are situated in a congestion area very much closed to the sea. No where in the coastal zone of Sri Lanka even come closer to such a heavy concentration of industries as in these two areas.

7.5. Public Private Partnership (PPP) for sewage management

The United Nations General Assembly at its fifteenth session adopted resolution on "Water Supply and Sanitation"(A/RES/5/126) which recognized "that at the current rate of progress, the provision of drinking water will be insufficient to satisfy very large

number of people by the year 2000 and that the lack of progress in the provision of basic sanitation services is likely to have dramatic environmental and health consequences in the near future. Therefore the private public partnership (PPP) has been internationally recognized as a solution to increase investment for sewerage sector. However many governments in the South Asian region have failed to attract private sector investors into the sanitation and sewage management. At the same time, sanitation and sewage infrastructure development in the region provide unprecedented business opportunities for the private sector, since public capital becoming increasingly limited.

The number of people with access to adequate sanitation in the Asia and Pacific increased by 24 million from 892 million in 1990 to 916 million in 1994. During the same period the number of people without access to adequate sanitation increased by 171 million from 2,34 million in 1990 to 2,25 million in 1994. South Asia's share is greater than other part of the Asia. Providing Water Supply and Sanitation to urban areas of Asian Countries is difficult task without private sector contribution, because of high urban population growth. The number of urban dwellers in Asia without access to sanitation reached to 371 million in 1994. In 1994 only 15 percent of rural Asian population had access to sanitation which only 332 million.

In early 1990, annual global funding commitments for water and sanitation sector in developing countries remain stagnant around US$ 10 billion of these around 65 percent came from national sources while rest came form external support agencies (UN 1996). According to Asian Development Bank estimate, the Asia pacific region need about US$ 80-100 billion in investments in order to ease water supply and sanitation problem. These amounts of money cannot be expected to come from traditional government sources and official development assistance. Therefore a large share of investment has to be obtained from private sector, both domestic and foreign. Private sector investment should be encouraged not only to raise investment capital, but also to increase financial efficiency and improve the quality of services.

Expenditure level on wastewater management in the Asia and Pacific varies from less than US$ 0.01 to over US$ 200 per Capita per annum. The common trend for all countries is an annual expenditure per capita for both capital and operational costs.
In the Asia and pacific region Malaysia is leading in private sector involvement in this sector. Malaysia has adopted a plan to modernize its sewerage system through a long-term contract with a group of investors led by a British water company. This project involve investment of around US$ 2,220 million spread over next 25 years. This project is expected to generate revenues around US$ 9000 million. States of Labuan, Ipoh, Johor, Sabah and Selangor have initiated privately funded projects on sewer system and water supply on Build-Operate-Transfer (BOT) basis. Several other states have privatized existing facilities.

The major sanitation utilities in the world are provided by public sector organizations. The reasons for this situation include, a) sanitation is perceived as a basic need b) sewerage system are natural monopolies, c). Sewers are buried under road belonging to the government, d). several systems should have the clear ownership. The advantages of

private sector participation in the sewerage management activities includes a). Private sector can obtain or provide funds through equity or debt in addition to the funds available to a government under ceilings of expenditure. The private sector can collect money commercial terms so that the private sector investments are sustainable, b). Clear regulatory procedures can be introduced when dealing with the private sector, c). consumers are kept better informed by the private sector publications, d). private sector companies are more flexible in their approach to solve problems, e) employers are motivated due to remuneration packages, f).private sector can bring specialist skill to the sector.

The type of public private partnership available for sewerage management includes service agreement (contracting out, management contract), leasing, Built-Operate-Transfer (BOT), turnkey, franchise, concession, built-own-operate-transfer (BOOT), full private company.

Some components of sewerage management system can be transferred to the private sector through a service agreement. In the sewerage management sector, leasing can be used for running the entire facility by private sector. Private organizations operating under a lease makes larger financial input to cover the maintenance cost but not the capital cost. The government will have to make necessary capital investment. Built-operate-transfer agreement, built-owned-operate-transfer, built-transfer-operate, built-lease-transfer are some of the lease agreements that can be used for private sector involvement in sewerage management. Franchise is one of the best private public partnerships to increase private investment for possible sewerage management. Franchising involves private sector financing all or most of the investment cost of the sector. Therefore, when government budgets are severely limited for sewerage management franchised private sector involvement can be used as a good option.

Under concessions, the concessionaire provide finances for the investment costs, agreed expansion costs and working capital. Concessionaire collect revenue from customers a fee based on the agreed formula by the government.

Full Privatization approach involves transfer of existing assets from the public to the private sector, which is referred to as divestiture. Under the divestiture option, the private company purchases the right to operate the public services and compensates the government by purchasing the existing works and assets.

Public Private Partnership (PPP) is considered to be a joint approach by the government and the private sector. The public and the private sector working together within one organization barring responsibility for all aspects of the operation is the closest partnership. In this process major constrain is in deciding the degree of responsibility that can be given to the private sector. The ideal scenario should be combining the government and the private sector in an join operation.

7.6. Conclusions recommendations

1. Since sanitary facilities in the South Asian Region is poor, both domestic and urban sewage pause considerable pressure on the coastal and marine eco-system in the Indian ocean.
2. The total sewage generation in Sri Lanka has been estimated to 7244800 kg per day (as average sewage gives about 250 mg/l BOD and assuming a density of 1000 kg/m3) and 1811200 kg BOD load per day. Of this, the total load on the coastal zone (from 1/3 of population) has been estimated to 597696 kg BOD per day.
3. According to this approach, the BOD load from sewage on the coastal zone of South Asian Region has been estimated to 23.9 million kg BOD per day. This consists of 0.6 million kg BOD from Sri Lanka, 19.7 million kg BOD from India, 1.2 million kg BOD from Bangladesh, 2.3 million BOD from Pakistan, and 0,028 million kg BOD from Maldives.
4. National and sub-national development plans that address the domestic and urban sewerage will have significant in fact on the marine system i.e. Beira Lake restoration plan, Ja-Ela, Ekala sewerage system development plans in Sri Lanka.
5. The coastal and marine system provide great deal of socio-economic opportunities that include tourism, nature based tourism, provision of construction material, corals, agriculture, fisheries etc.
6. Domestic sewerage management itself is an economic activity i.e. re-use of treated water, bio-gas generation from sewerage etc. that will help to protect marine system.
7. It is inevitable that the growing demands for sewerage facilities for the population can not be met with the public investments. The Asia Pacific region requires about US$ 80 - 100 billion in investments in order to ease water supply and sanitation problem. The minimum investment required for meeting the basic sanitation in India would be Rs.10.4 - 43.4 Billion. The proposed investment programme of sanitation in Sri Lanka and Pakistan are Rs. 1.0 billion and Rs. 7.8 billion respectively. Therefore private sector involvement in the sewerage management sector is necessary in order to protect the marine environment from sewerage pollution.
8. The type of private sector involvement options in the sewerage management includes services agreement, leasing, Built-Operate-Transfer (BOT), Turnkey, Franchise, Concession, Built-Own-Operate-Transfer(BOOT) and full private company
9. Experience in the world has demonstrated the viability of private sector involvement in the sewerage management.
10. It is recommended that Public Private Partnership (PPP) in the sewerage management in South Asian Region can improve the quality of sanitation facilities available for the people while protecting the coastal and marine system in the Indian ocean from domestic and urban sewerage pollution.
11. However since sewerage management sector is not yet attractive to the private sector investment, governments in the South Asian Region should provide attractive incentive packages for private sector that involve in the investment in sewerage management activities. The cost of incentive package to the government can be well justified by the benefits of the protected coastal and marine system in the South Asian region alone with the improved health condition of the public.

References

Asian Development Bank Annual Report –1997.

Asian Development Outlook 1999 – Asian Development Bank.

Costa, H.H (1990) Land -Based Sources of Marine Pollution in Sri Lanka, Paper presented at the International and interdisciplinary symposium, Ecology and landscape management in Sri Lanka: conflict or compromise?, 12-26 march 1990, Taj Samudra Hotel - Colombo - Sri Lanka

CCD 1992, Coastal 2000, Vol 1 and 2, A resource management strategy for Sri Lanka's coastal region.

Coral reef degradation in the Indian Ocean – Status reports and project presentation 1999

Ekaratne, S.U.K Development of Altematives for the Effective Management of Coral Reef Resources of Sri Lanka Paper presented at the International and interdisciplinary symposium, Ecology and landscape management in Sri Lanka: conflict or compromise?, 12-26 march 1990, Taj Samudra Hotel - Colombo - Sri Lanka

Global Programme of Action for the Protection of the Marine Environment from land based activities – 1995.

Hodges C.N., Thompson T.L., Riley J.J. and Glenn E.P., Reversing the Flow: Water and Nutrients from the Sea to the Land, Ambio, Vol. 22, No. 7,1993

Human Development in South Asia 1999 – The Crisis of Governance

IMF, The World Economic Outlook – October 1997 –.

Jayasinghe JMPK (1999) Impact of the reclamation of coastal acidic sediments of coastal biodiversity, Paper presented at the Global biodiversity forum –South and Southeast Asia, Colombo, Sri Lanka.

Lundin C. G., Linden 0., Coastal Ecosystems: Attempts to Manage a Threatened Resource, Ambio, Vol. 22, No. 7,1993

Ngoile M.A.K. and. Horrill C.J, Coastal Ecosystems, Productivity and Ecosystem Protection: Coastal Ecosystem Management in Ambio, Vol. 22, No. 7,1993

National Programme of Action (Bangladesh) for the implementation of the Global Programme of Action (GPA) for the Protection of the Marine Environment from Land Based Activities. October 1999.

Ohman M. C., Rajasuriya A., Linden 0., Human Disturbances on Coral Reefs in Sri Lanka: A Case Study, Ambio, Vol. 22, No. 7,1993

Pakistan's National Programme of Action under the Global Programme of Action for the Protection of the marine environment from land based activities. December 1999.

Samarasekera VN (1999) Towards sustainable marine and coastal conservation: A strategy for action for WWF Malaysia

Samarakoon J. Coastal ecosystems and their biodiversity, Soba, November 1994, Environmental publication

Silva EIL, Water Quality of Sri Lanka: A review on twelve water bodies,

UNEP. (1986) Environmental Problems of the marine and coastal area of Bangladesh: National Report. UNEP Regional Seas reports and studies No 75.

UNEP (1986), Environmental Problems of the marine and coastal area of Maldives; National Report. UNEP Regional Seas Reports and Studies No 76.

UNEP (1985), Environmental Problems of the marine and coastal area of India: National Report. UNEP Regional Seas Reports and Studies No 59.

UNEP (1986)., Environmental Problems for the marine and coastal area of Pakistan; National Report, UNEP Regional Seas Reports and Studies No 77.

UNEP (1985), .Management and conservation of renewable marine resources in the Indian Ocean region: Overview. UNEP Regional Seas Reports and Studies No 60

UNEP (1987), Environmental Problems of the South Asian seas region; an overview. UNEP Regional Seas Reports and Studies No 82.

UNEP 1982, Pollution and the Marine Environment in the Indian Ocean. UNEP Regional Seas Reports and Studies No 13..

Vinobaba P. (1999) Exploitation of the fishery resources from the lagoons and the need for conservation measures to preserve the biodiversiy of the lagoon and the adjoining ecosystems in the Batticaloa district, Paper presented at the Global biodiversity forum – South and Southeast Asia, Colombo, Sri Lanka.

Winpenny J T. Values for the Environment – A guide to Economic Appraisal.