NATIONAL ACTION PLAN FOR PROTECTION OF MARINE AND COASTAL ENVIRONMENT FROM LAND BASED ACTIVITIES

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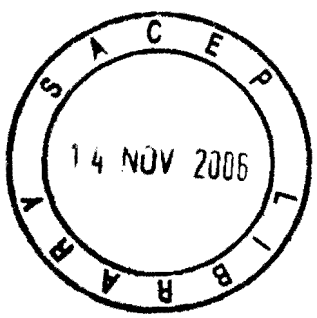

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CHAPTER 1

MARINE AND COASTAL ENVIRONMENT

1.0 Physical features of the marine and coastal environment of Sri Lanka

Sri Lanka is an island with a total land area of 65,525 km^2 which is located on a relatively narrow continental shelf. The total area of the continental shelf is 44,250 km^2 with a width ranging from 8km (along the southeastern and eastern coasts) to 45km (in the northeastern and northwestern coasts), 20 km. in most parts, and a depth ranging from 0 to 200 m. Some important maritime data of the country is given in Table 1.1. The island is surrounded by about 1770km long coastline which comprises of highly productive marine ecosystems such as fringing coral reefs and shallow beds of coastal and estuarine seagrasses . Mangrove forests (8687ha), salt marshes (23,819ha), beaches (11,800ha), sand dunes (7606ha) lagoons and estuaries (158,017ha), coastal marshy wetlands (9754ha) and other water bodies (18,839ha) are the other important ecosystems found along the coast line (Table 1.2). The country claimed a 200 nautical mile Exclusive Economic Zone (EEZ) in 1976, adding to its territorial waters a total of 233,000km^2. Its maritime boundaries are shown in Fig. 1.1

The climate of Sri Lanka is influenced by two monsoon and two inter-monsoon periods. The southwest monsoon, which occurs from May to September is associated with cyclonic wind circulations or depressions and is marked by heavy rainfall and squally weather, especially in the southwestern seaboard. The northeast monsoon period occurs between December to February, and is characterized by heavy rainfall more or less confined in the northeastern half of the country and with wind generally coming from an easterly direction. Wind becomes generally light during the two inter-monsoon periods, one from March to April and another from October to November. Hydrographic information collected from research surveys conducted from 1978-1980 shows that sea surface currents are directly influenced by the monsoon and are often strong at the beginning and end of the southwest monsoon and during the entire northeast monsoon. During the southwest monsoon, the general oceanic circulation is from west to east, with current velocities of two to three knots near the shelf. The circulation is reversed during the northeast monsoon and current velocities are only one to two knots in this period. In general, the currents are

stronger off the coast during the northeast monsoon and off the west coast during the southwest monsoon. The strongest currents are recorded off the southern coast. The depth of the thermocline is also dependent on the prevailing monsoon. It is about 100- 125 m deep on the west coast during the northeast monsoon and 40-60 m deep during the southwest monsoon. On the east coast, the thermocline reaches a depth of 50-70 m during the October-November inter-monsoon period and 20-40 m right after the March-April inter-monsoon period. The tidal pattern in Sri Lankan waters is predominantly semi-diurnal and microtidal, with the highest amplitudes around the Colombo area and lowest around the Jaffna and Trincomalee coastline (Dassanayake, 1994). Fig 1.2 illustrates the surface current patterns around Sri Lanka.

Table 1.1 Some Important Maritime Features of Sri Lanka

(Sources: Country study, Development of the resources of the sea for regional co-operation and national development-MARGA and Central Bank Reports; Wijeyananda,1997; Jinadasa, 1977)

Land area (Excluding Inland Water)	62,705 sq. km
Coast line of the country	1739.3 km
Continental shelf area	44,250 sq. km
Exclusive Economic Zone	233,000 sq. km*
Brackish water area	158,016 hectares
Fresh water area	201,832 hectares
Average width of continental shelf	25 km
Number of rivers	103
Number of islands	113
Coastal population	6.12 mill ion (34 % of total)
Total Fish production (1996)	228,550 mt
(1997)	242,000 mt
Share of fisheries in GNP (1996)	1.7 percent
(1997)	1.6 percent

*Territorial water is not included

— **The territorial sea,** extending to a distance of twelve nautical miles from the coast of the main island.

— **The contiguous zone,** which extends a further twelve nautical miles from the outer limits of the territorial sea.

— **The Exclusive Economic Zone** (EEZ), which extends 200 nautical miles from the coasts (and includes the territorial and the contiguous zones).

— **The Internal Waters,** for which a demarcation is necessary in the Gulf of Mannar and the Palk Strait, where the above zones overlap with India's nautical zones.

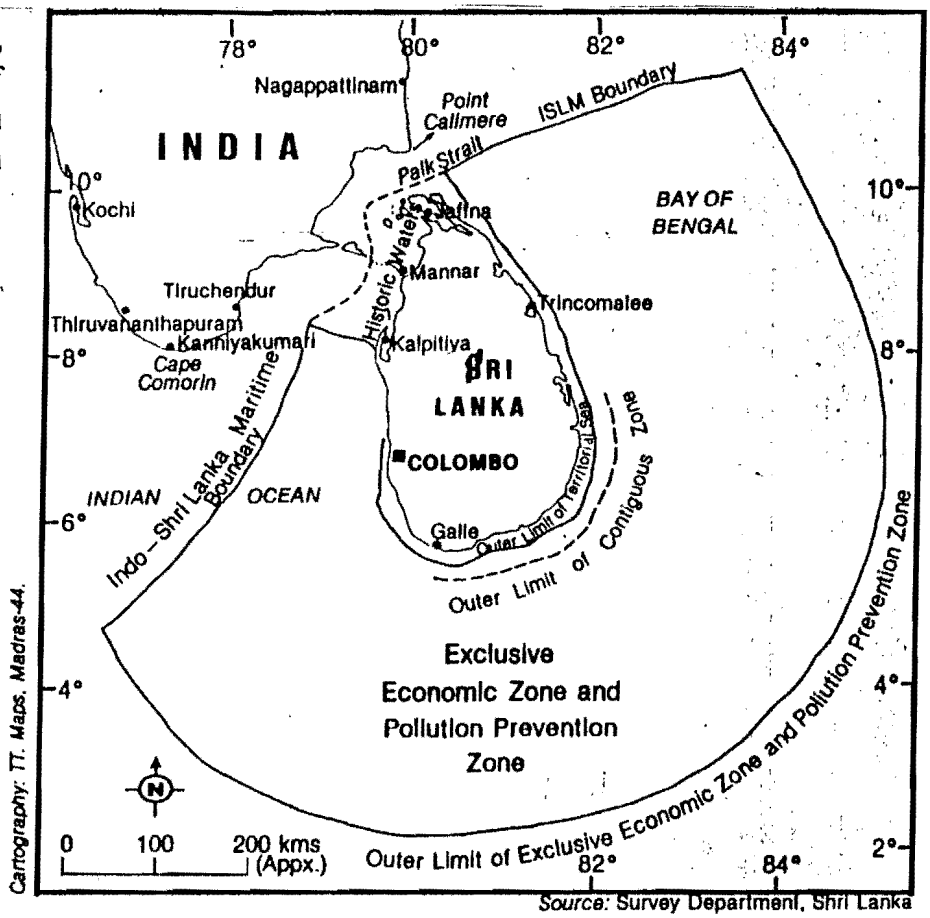


Fig.1.1 Territory of Sri Lanka (including maritime zone)

(Source: Survey Department of Sri Lanka)

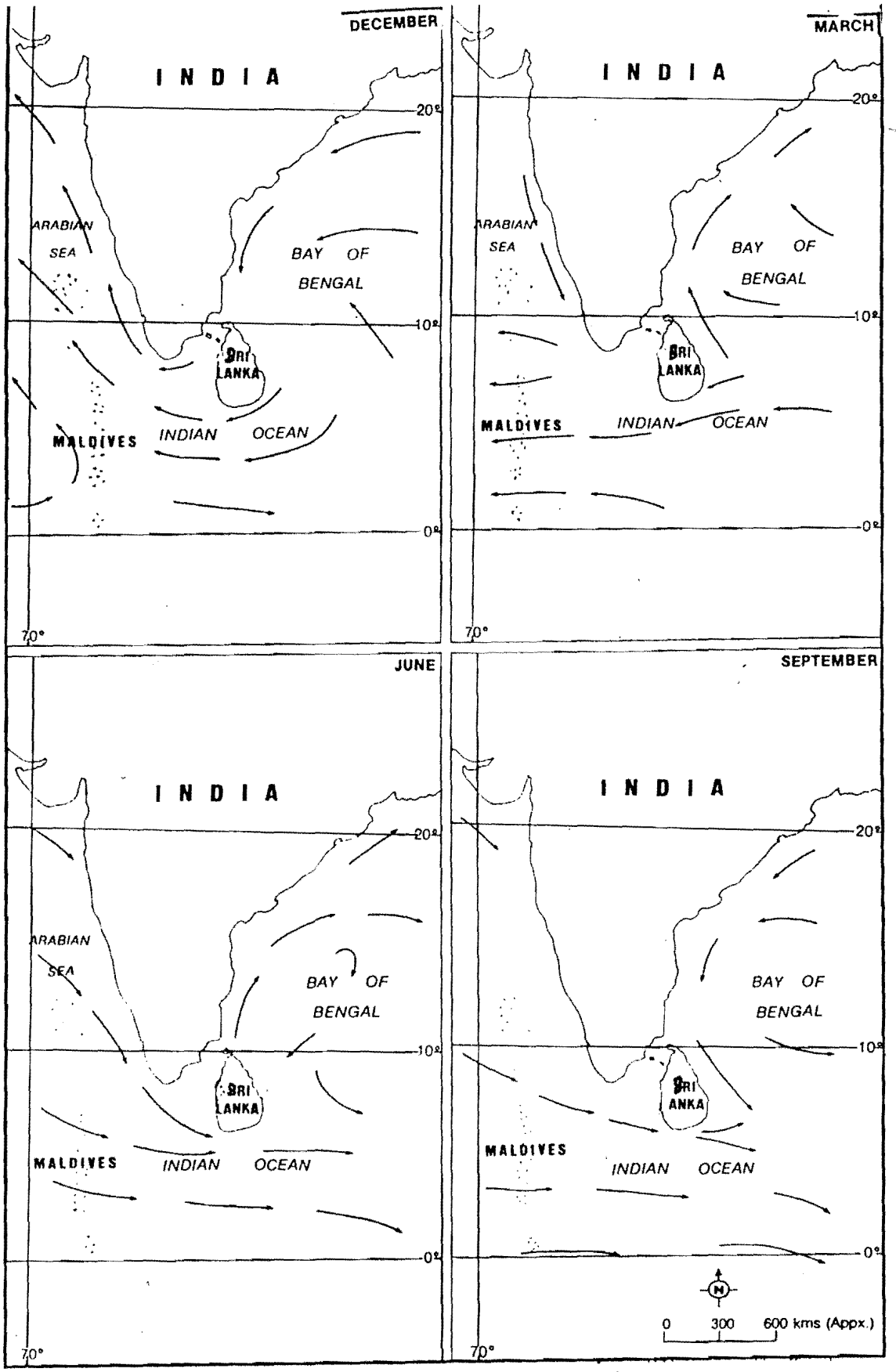


Fig. 1.2 Surface currents around Sri Lanka

(Source: H.M. Hydrographic Office, London)

Table 1. 2 Extent of Coastal Habitats, by District

(Source: Anon, 199 7)

District	Mangroves	Salt Marshes	Dunes	Beaches, Barrier Beaches, Spits	Lagoons, Basin Estuaries	Other Water Bodies	Marshes
Colombo	-	-	-	112	-	412	15
Gampaha	122	497	-	207	3442	205	1604
Puttalam	2264	3461	2689	2772	39119	3428	2515
Mannar	1261	5179	1458	912	3828	2371	308
Kilinochchi	312	4975	509	420	11917	1256	1046
Jaffna	260	4963	2145	1103	45525	1862	149
Mullativu	463	517	-	864	9233	570	194
Trincomalee	1491	1401	-	671	18317	2180	1129
Batticaloa	1421	2196	-	1489	13682	2365	968
Ampara	292	127	357	1398	7235	1171	894
Hambantota	539	318	444	1099	4488	1526	200
Matara	6	-	-	191	-	234	80
Galle	187	185	-	485	1144	783	561
Kalutara	70	-	4	77	87	476	91
Total Extent	8687	23819	7606	11800	158017	18839	9754

Note: Includes an area of approximately 2 km inland from the coastline; information was taken from existing maps of the Survey Department and air photographs for some areas; the maps were not ground checked.

1.1 The marine and coastal zone strength

Food security and poverty alleviation

Sri Lanka's coastal zone has served as a focal point for the social, cultural, environmental and economic development of the country for centuries. Sri Lanka's land area of the coastal zone which is approximately 24% of the total land area is occupied by 32% of the country's population due to the fact that it is the of closest proximity to many important resources including food. 65% of the country's urbanized areas are located in this zone. Therefore a highly developed road and rail road transport infrastructure can be found in this area together with the country's commercial ports and fishery harbours and anchorages. The coastal area thus provides access to transportation and shipping lanes which lead to distant markets and link together neighbouring communities through navigable lagoons, rivers, and canals. Some of the richest bio-diversity areas in the country occur in the coastal zone, including coral reefs, extensive seagrass beds, mangrove forests, highly

productive estuaries and lagoons, and sanctuaries which altogether cover an area of 160,000 ha.

Coastal zone also serves as a focal point for economic development. 40% of the Gross Domestic Production (GDP) of the country comes from the coastal zone with a 70% of its total industrial output.

80% of the annual fish production comes from the coastal zone (from its coastal waters and brackishwater farms) which is about 30% of the consumable animal protein production of the country. The National Fisheries Development Plan, 1995-2000 states that about 150,000 people are directly engaged in fisheries, including aquaculture; another 30,000 are employed in related service activities such as fish trading, processing, manufacture of fishing vessels, gear etc. and around 700,000 fisherfolk are dependent on fisheries for their livelihood. It is envisaged that about 100,000 more could be provided employment by the year 2000.

Country's economy is also enhanced by the commercial ports, fishery harbours, anchorages and salterns located in this area. Significant extent of agricultural land (mainly coconut) also emphasizes the importance of coastal zone in economic development of the country. There is a large extent of usable land available for various development projects in the future. There are substantial resources of minerals associated with this zone (ie. Pulmudai mineral sands).

Contribution to economic development by way of tourism related industries is highest from this, as more than 80% of tourism related infrastructure is located within this zone (majority in the western and southwestern coastal belt). There are 5000 hotel rooms in coastal resorts, excluding the Colombo area, out of a total of almost 10,000 rooms.

Sri Lanka's coastal fisheries resources consist of the exploitable pelagic and demersal marine species of the entire water column on the continental shelf. About 70 percent of the exploitable coastal resources consists of small pelagics such as sardines, herrings, anchovies, mackerels, and flying fish. Oceanic large pelagics such as tuna, marlins, sharks, sailfish, and swordfish are also caught in the coastal waters of the

country. The common oceanic pelagic species are the yellowfin tuna *(Thunnus albacares),* skipjack *(Katsowonus pelamis),* kawa-kawa *(Euthynnus affinis),* frigate tuna *(Auxis spp.),* and seer fish *(Scomberomorus commersoni).* Other species caught are demersals such as emperors, snappers, groupers, sweetlips, sciaenids, carangids, breams, goatfishes, and leiognathids as well as invertebrates like squids, prawns, crabs, and lobsters. Economically important foodfish caught in the coral reefs are the groupers, snappers, emperors, rabbitfish, sweetlips, surgeonfish, parrotfish, and barracudas. Important invertebrates caught are spiny lobsters *(mainly, Panulirus versicolor and P. ornatus),* sea- crabs, octopus, sea cucumbers, squids, chanks and cuttlefish. Many species are exploited for the ornamental fish industry, including butterflyfish, surgeonfish, blennies, dragonets, gobies, wrasses, filefish, angelfish and damsels, among others. The estimated production from coastal waters is around 153,000 t valued at Rs 15.7 billion. Of this quantity, about 3,250 t were exported in 1997 at a value of Rs 726 million.

In the estuaries and lagoons spread throughout the coastline and with a combined surface water area of 1,265km^2, only the major lagoons and estuaries, such as Puttalam Lagoon, Negombo Lagoon, Bolgoda-Panadura Estuary, Batticaloa Lagoon, and Jaffna Lagoon, contribute significantly to the fishery. Clupeids constitute the most important finfish group in the estuarine environment but other finfish such as mullets, milkfish, catfish, rabbitfish, and grunts are also found in the catch. The economically important invertebrates found in the estuaries are shrimps, mud-crabs, and edible bivalves. Over 26 species of shrimps have been recorded in Sri Lanka and fished in various lagoons, estuaries, and the sea using traditional methods. Lagoon crab or mud-crab is found in almost all lagoons and is a popular food item among Sri Lankans. Mud-crabs from Batticaloa Lagoon have been very large which fetched very high prices in the international market. The spiny lobsters abound in reefs and rocky areas, and NARA scientists estimate the annual lobster catch in the South to be around 800 t. In 1997, some 214 t of lobsters were exported with a value of Rs.271 million.

From about 710km^2 of brackishwater mangrove swamps, marshlands, and salt marshes along the coastline, about 35 km^2 have been converted into prawn ponds. Aquaculture, particularly of the jumbo tiger prawn, *Penaeus monodon,* is

concentrated in the Chilaw-Puttalam area and in the Dutch Bay and Negombo Lagoon. It is also seen on a limited scale around Hikkaduwa, Galle, Dondra Head, and Tangalle. Aquaculture has gained importance in the recent past because of the high export demand. In 1997, the export of prawns generated the highest contribution to foreign exchange revenues from fisheries at Rs. 2.194 billion, equivalent to 51% of total export earnings.

Cultural value

There are nearly 100 sites of special historical, archaeological, cultural and religious significance and 100 more of special scenic and recreational importance scattered within the coastal zone.

For administrative purposes, the "Coastal Zone" of Sri Lanka is defined in the Coast Conservation Act (1997) (Apendix 1) as:

"The area lying within a limit of three hundred meters landward of the Mean High Water Line and a limit of two Milometers seaward of the Mean Low Water Line and in the case of rivers, streams, lagoons, or any other body of water connected to the sea either permanently or periodically, the landward boundary shall extend to a limit of two Milometers measured perpendicular to the straight base line drawn between the natural entrance points [defined by the mean low water line] thereof and shall include waters of such rivers, streams and lagoons or any other body of water so connected to the sea"

It is also divided into 67 coastal divisions of the Divisional Secretaries.

1.2 Critical land based activities adversely affecting the marine and coastal zone

The coastal zone, while extremely valuable to the country's economy, is also very fragile and highly vulnerable to the many dynamic processes which occur on land and in sea, caused by both natural and man-induced forces. Beaches and coastal stretches are continuously subjected to wave action and increasingly threatened by natural

processes like storm surges which cause erosion or accretion . The dynamic balance which normally exists between erosion and accretion has been upset by human intervention, and severe imbalance in these complementary processes have occurred in the last several decades. Sand mining in the major rivers as well as on the beaches and dunes has reduced the amount of sand which would otherwise be available to replenish sand lost during storm events.

Other human activities such as breaking the reef for coral mining, dynamiting the reef for fisheries, and removal of coastal vegetation contribute to the problem. The end result is increased coastal erosion and the consequent loss of usable land and associated infrastructure, houses, and archaeological and religious sites, all accompanied by social and economic losses.

In addition to natural, physical processes which have a adverse impact on the coastal resources, human settlements on the coast are equally responsible for their degradation or loss through their many extractive and exploitative activities which adversely affect coastal habitats as well as fish and other aquatic resources. Due to destructive fishing practices and environmental impacts such as siltation and pollution, only two (Kandakullya and Talawila) out of some eight coral reef areas studied under the USAID-funded Coastal Resources Management Project showed live coral coverage greater than 50 percent. Two nearshore reefs, Weligama and Polhena, showed a significant proportion of dead corals, while at Hikkaduwa and Akurala, about 25 percent dead corals were reported. Even within the country's two declared marine protected areas, corals continue to be damaged as a result of the activities of divers collecting fish for the ornamental fish export trade and overuse of the coral reef area by tourists and boat operators.

Cumulative damage to mangroves has resulted from over-utilization of the resource and transformation of large areas to other uses such as shrimp pond aquaculture and lowland agriculture. Some 600 ha of coastal area between Chilaw and Puttalam, most of it mangrove forest, have been developed for aquaculture, and about 63 percent of the previously existing mangroves in Puttalam Lagoon have been reported lost in the ten-year period 1982-1992. In Negombo, 50 ha of mangroves were cleared and filled in the mid-1980s for a national housing project. Salt marsh areas have also been

destroyed by certain transformative uses, including conversion for salt farming (e.g., at Hambantota and Palavi), shrimp aquaculture (various lagoons), or reclamation (e.g., Muthurajawela Marsh). In Puttalam Lagoon, 50 percent of the existing marshland was lost within a ten-year period.

Lagoons and estuaries are threatened by pollution and siltation and exacerbated in some cases by water diversions that reduce natural flows. Pollution can result when lagoons are used as harbours (Negombo, Chilaw),.disposal sites for sewage (Kelani Estuary, Negombo and Lunawa lagoons), or receiving waters from industrial effluents (Lunawa and Negombo, Kelani and Valaichchenai estuaries). A number of lagoons are being severely impacted by encroachment and land reclamation which contribute to a direct loss of functional lagoon area (Chilaw, Negombo, Mawella lagoons). All such impacts hamper the preservation of areas of high ecological and aesthetic value, which is already evident in Bentota Estuary, Bolgoda Lake, and parts of Negombo Lagoon, in which the subsequent use of these sites for recreation, conservation, scientific research and educational purposes is hampered.

Unregulated fishing effort and the use of destructive fishing methods such as dynamite fishing, cyanide poisoning, and mechanized push nets, have seriously destroyed fish habitats and reduced fish stocks. The use of "moxy nets" for collection of ornamental fish for export has destroyed coral reefs and led to a reduction of fish and shellfish stocks utilizing the reefs for their habitat. Pollution from industrial, agricultural, and domestic sources have degraded coastal habitats and threatens the sustainability of the nearshore/coastal fisheries. The increasing number of mechnized fishing crafts contribute to the oil pollution of the nearshore/coastal areas which also threatens the sustainability of fisheries. Adverse effects of oil pollution by washing oil tanker holds and discharges in bilge water is felt in the offshore areas and pollution of nearshore/coastal areas by way of tar balls that wash ashore is evident in Sri Lanka which hampers the tourist industry and threatens the aquatic life.

The growth of the tourism industry has resulted in the incorrect siting of facilities, increase coastal pollution due to inadequate or poorly designed infrastructure, and increased shoreline protection works as well as limited access of fishermen and local residents seeking recreational opportunities and a deterioration in traditional social

structure and values. Encroachment or unplanned and unauthorized development has caused direct habitat loss and increased public health risks as a result of inadequate infrastructure for sanitary sewerage and potable water. Rampant logging and mining in upland areas, which may have brought economic benefits to companies undertaking these activities and, to a certain extent, increased government revenues, have proven detrimental to lowland activities such as fisheries, aquaculture, and coastal tourism dependent industries. Most importantly, the inability of the resource base to renew itself under such heavy exploitation and pollution pressure makes the situation even worse.

In summary, a number of problems are being increasingly experienced in many coastal areas of Sri Lanka at present, which calls for an effective development and implementation of a national programme of action for a sustainable, pragmatic and integrated environmental management approaches and processes, such as integrated coastal area management. Specific national programme should address the measures to promote sustainable use of coastal and marine resources and to prevent/reduce degradation of the marine environment, a process which requires

- identification and assessment of problems
- establishment of priorities
- setting management objectives for priority problems and
- identification, evaluation and selection of strategies and measures.

Following chapters deal with above objectives as a preliminary step in preparing a national programme of action for the implementation of the global programme of action for the protection of the marine environment with emphasis on land -based activities.

CHAPTER 2

CRITICAL MARINE AND COASTAL HABITATS

2. 0 Introduction

The natural habitats found within the marine and coastal zone are diverse, and include lagoons and estuaries, coral reefs, mangrove swamps, seagrass beds, other wetlands, and dune systems. Table 1. 2 summarises the aerial extent of various important marine and coastal habitats located within the 14 districts of the island.

Marine and coastal habitats play an important role in the daily lives of the people in terms of livelihood, economic output, and food production, among others. However, they are extremely susceptible to degradation, and measurable declines have occurred in the extent and quality of a number of biologically productive coastal ecosystems.

2.1 Marine and coastal habitats, their uses and impacts of land based activities on them

The following sections give brief descriptions of the unique biological habitats found within the marine and coastal zone of Sri Lanka and the specific problems affecting each type of habitat. These various habitats are utilized to fill diverse needs. Generally, the ways in which the resources are used can be classified under three categories under which uses of each resource is discussed. They are;

non-extractive use : a passive use of the environment that does not require harvesting of resources

extractive use : an active use of the environment in which resources are removed

transformative use:a use which, while not involving removal of resources for direct utilization, results in significant alteration (or destruction) in the physical or biological characteristics of the environment

2.1.1Coral Reefs

Coral reefs are one of the most complex and productive habitats known. The reefs support an entire food chain, from primary producers and plankton up the chain to larger predatory fishes and invertebrates, many of which are themselves favoured foods for human consumption.

Coral reefs in Sri Lanka can be found along 2 to 3 percent of the nation's total shoreline (Figure 2.1). They are mostly of the fringing type, meaning they occur adjacent to shore and grow from the sea floor, usually on a nucleus of rock. Barrier reefs, which are ridges of corals lying some distance from shore and running parallel with it, are rare in Sri Lanka (Rajasuriya and White, 1995). Examples of barrier reefs are the formations at Vankalai and Silavathurai. Both fringing and barrier reefs dissipate wave energy and are important for coastal stability and as a source of beach material. The total extent of coral reefs in Sri Lanka has still not been estimated. However, some available figures are given in Table 2.1.

They are scattered around the entire coast, with many clustered in the south (Akurala to Tangalle). Several offshore reefs are found on the continental shelf off the northwestern coast (Bar Reef, Vankalai Reefs, and Arippu Reef). Surveys have recorded 171 species of reef building corals in Sri Lanka waters(Rajasuriya and White, 1995). The staghorn coral (*Acropora* spp.) is the dominant genera. Table 2.2 summarises the uses of coral reefs.

Spatial heterogeneity is a key reef characteristic providing diverse living opportunities for a multitude of plants and animals. Loss of spatial heterogeneity inevitably results in a general decrease in the diversity of coral reef organisms. This spatial heterogeneity is lost when corals are broken, removed or damaged. Over harvesting of resources, damaging fisheries practices, or poorly planned coastal development, are among the activities that can quickly destroy any valuable coral habitat and all these are evident in the coral reef ecosystems of Sri Lanka.

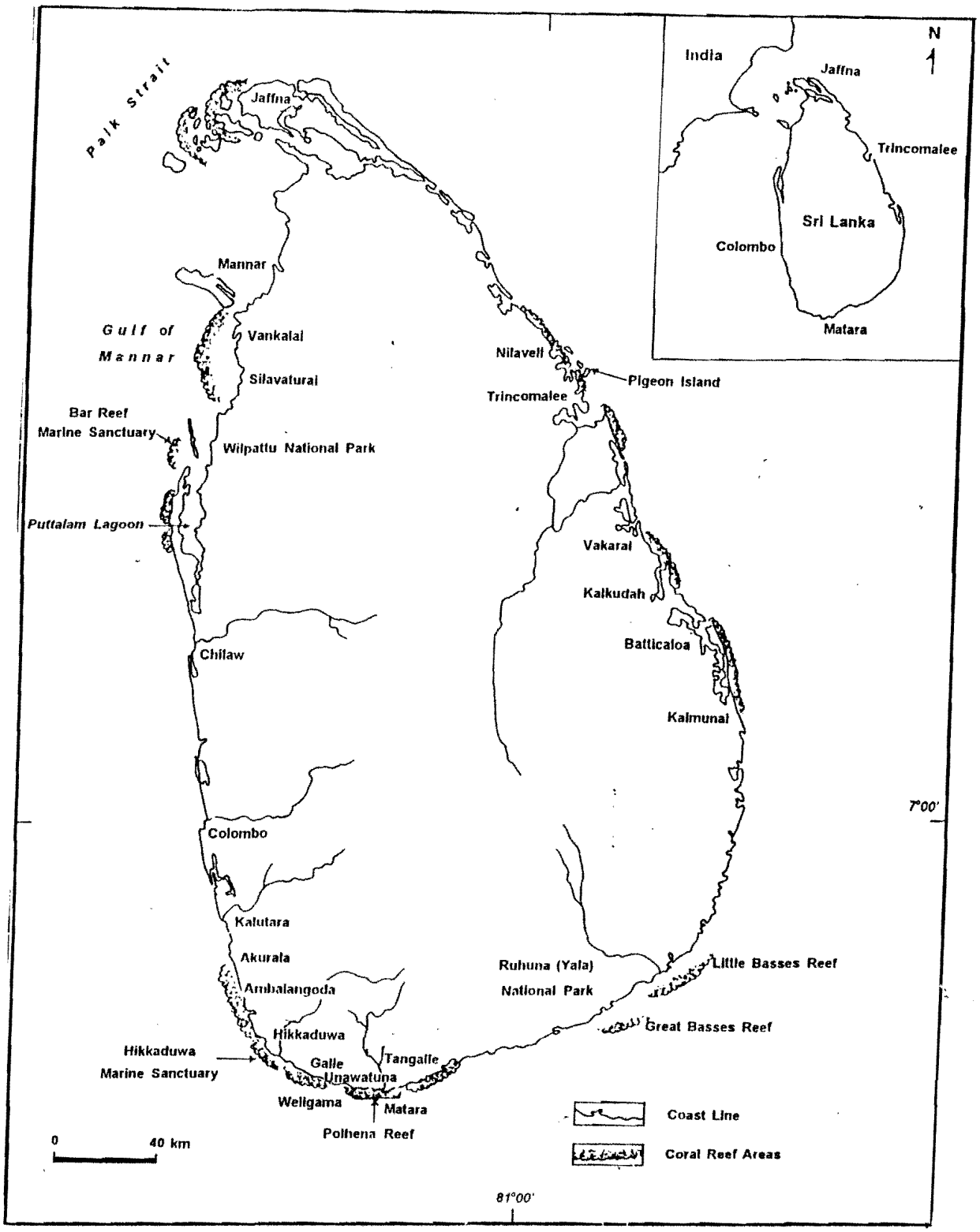


Fig.2.1 Distribution of coral reefs in marine and coastal waters of Sri Lanka

(Source: Anon, 1997)

Table 2 .1 Extents of some coral reefs of Sri Lanka

(Source: Dassanayake, 1994)

District	Reef	Linear extent (km)/ area ($km^{2)}$
Mannar	Vankalai Arippu Silavaturi	4km 7km 2km
Jaffna	Point Pedro	10km
Trincomalee	Foul Point Coral Point	6km 2km
Batticoloa	Thennadi bay Palavi Point Palavi Bay Elephant Point Vandeloo Bay Pasikuddah Kalkudah	8km 4km
Galle	Hikkaduwa Unawatuna	$1.6km^2$
Puttalam	Bar reef	
Mullativu	Nilaveli Pigeon Island	1-2 2-3

Coral reefs in Sri Lanka support a variety of uses, which are briefly summarised in Table 2. 2

Table 2.2 Typical uses of coral reefs

(Source: Anon,1997)

Type of Use	Specific Use/Benefit
Non-Extractive	a. Tourist viewing generates employment b. Scientific/educational research on coral reefs is being conducted by NARA, University of Colombo and University of Kelaniya c. Acting as natural breakwaters, reefs slow the force of destructive storm waves and control coastal erosion, one of the country's most serious coastal management problems. d. Perhaps more than half of the edible seafood species caught in Sri Lanka's waters depend upon the reef ecosystem for habitat to breed, feed, and shelter.
Extractive	a. Coral mining for coral based lime b. Ornamental fish and reef products primarily for exports; amounts unknown c. Fishing by hook and line, with spear guns, with gill nets and explosives

	d.	Reef organisms offer untapped potential for the development of a variety of compounds with beneficial pharmaceutical properties (e.g., antiviral and cancer-fighting compounds, as well as substances for use in bone repair). Development of such pharmaceuticals could potentially contribute significantly to national revenues and to human health worldwide.
Transformative	a.	Anchorages, fisherman sometimes blast channels through reefs to create anchorages

A recent study of coral reefs of Sri Lanka (Rajasuriya and White, 1995), showed that the coral reefs of the country are adversely affected due to destructive fishing practices and environmental impacts such as siltation and pollution and only two of some eight coral reef areas which have been studied (Kandakuliya and Talawila) had live coral coverage of greater than 50 percent. Two nearshore reefs, Weligama and Polhena, showed a significant proportion (> 50 percent and >80 percent, respectively) of dead coral, while at Hikkaduwa and Akurala, about 25 percent dead corals were reported (Fig. 2.2). Most of this damage is believed to have occurred over a 10- 15 year period. The percentage of dead corals at Hikkaduwa is now much higher (70 percent mortality has been estimated for branching *Acropora* corals) as a result of a bleaching event in April 1998 caused by high water temperatures associated with *El Nino*. Even within the country's two declared marine protected areas, corals continue to be damaged. At Bar Reef Sanctuary, impacts have been increasing as a result of the activities of divers collecting fish for the ornamental fish export trade. Use of destructive moxy nets has been reported and some dynamiting of the reef has occurred (Rajasuriya and White, 1995). At Hikkaduwa, a popular tourist spot, the corals in the core protected area have suffered due to overuse by tourists and boat operators. Much of the damage is caused by anchors and boat keels and by large numbers of people walking on the reefs.

Destruction of coral reef habitat has obvious consequences for small-scale fisheries: since many economically important fish and shellfish species utilise reefs for habitat, spawning, and feeding grounds, the destruction of the habitat can lead to reduced stocks of fisheries resources. 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.

The main threats to coral reefs in Sri Lanka are summarized in Table 2.3.

Table 2.3 Reef Location, Status, and Cause of Damage or Threats

(Source:Rajasuriya and White, 1995)

Location	Status	Causes of Damage or Threats
Bar Reef	Not degraded	Destructive fishing, crown of thorn star fish, ornamental fish collection, boat anchors
Kandakuliya	Heavily degraded	Destructive fishing, boat anchors, ornamental fish collection
Talawila	Degraded	Destructive fishing, boat anchors, ornamental fish collection
Chilaw	Partially degraded	Destructive fishing
Negombo	Degraded	Destructive fishing, sedimentation
Colombo	Degraded	Destructive fishing, pollution, silt ornamental fish collection
Ambalangoda	Degraded	Destructive fishing, sedimentation
Akurala	Degraded	Coral mining, destructive fishing
Hikkaduwa	Degraded	Boat anchors, glass bottom boats, pollution, siltation, ornamental fish collection, reef walking, oil
Galle	Degraded	Destructive fishing, ornamental fish collection, blast fishing, pollution, oil, sedimentation
Unawatuna	Partially degraded	Ornamental fish collection, boat anchors, pollution, reef walking, sedimentation
Weligama	Degraded	Ornamental fish collection, boat anchors, oil from boats, sedimentation
Polhena	Degraded	Pollution due to coconut fiber retting, ornamental fish collection, sedimentation
Tangalle	Partially degraded	Ornamental fish collection, reef walking, destructive fishing, sedimentation
Great and Little Basses Reefs	Not degraded	Unregulated fishing and diving for spiny lobsters, destructive fishing
Batticoloa and Trincomalee	Partially degraded	Destructive fishing, ornamental fish collection, coral mining, crown of thorns, boat anchors

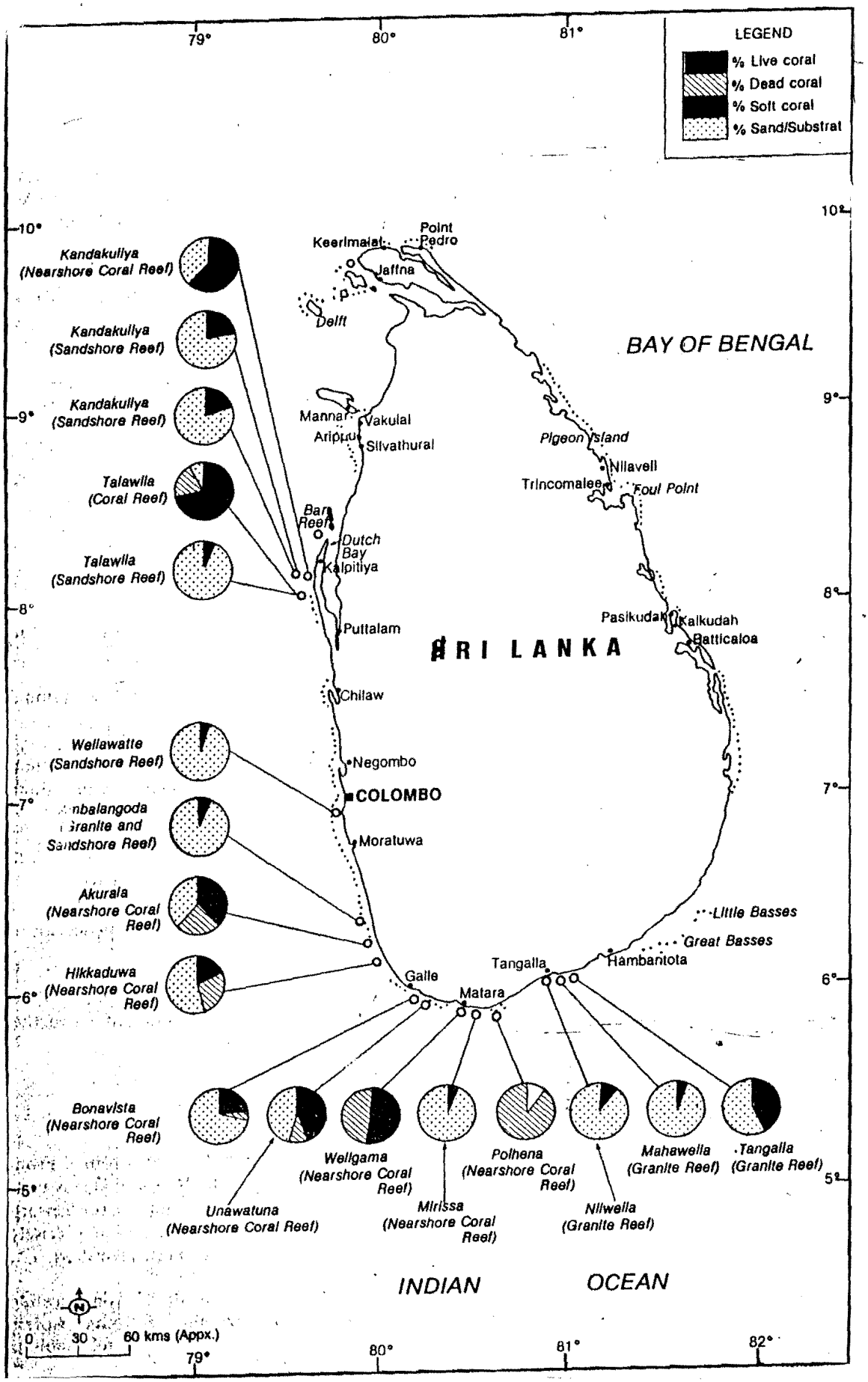


Fig. 2.2 Condition of the coral reefs of Sri Lanka

(Source: Rajasuriya and White, 1995)

2.1. 2.Mangroves

Since tidal amplitude in Sri Lanka rarely exceeds 75 cm, mangroves occur as a narrow intertidal belt and extend less than one km landward from the mean low water tidal level in association with estuaries and lagoons. Mangrove cover in the country was 8687 hectares in 1993 (Anon,1993). This area represents a small percent of Sri Lanka's total low energy coastal habitat (salt marshes, tidal flats, estuaries, lagoons).The most extensive occurrence is in Puttalam district, with over 2,000 ha. Other areas having extensive mangroves are the Trincomalee and Batticaloa districts, each with over 1,000 ha (see Table1. 2) and Jaffna and Gampaha districts.They are absent along exposed shorelines affected by seasonally high wave energy in the southwestern, southern and northeastern coastal sectors. Some dense localized stands occur in association with lagoons at Koggala and Kalametiya which are more or less separated from tidal influence. The important locations of mangroves in the country are shown in Figure 3.There are 14 species of true mangroves and 12 species of mangrove associates in Sri Lanka. Fig. 2.3 shows the distribution of mangroves in Sri Lanka and Table 2.4 summarizes the uses of mangroves.

Cumulative damage to mangroves in Sri Lanka has resulted from over utilization of the resource and the transformation of large areas for other uses. While small-scale utilization of mangrove products by itself could be sustainable, conversion of mangrove lands usually occurs on a larger scale which can damage or destroy extensive areas of healthy mangrove habitat. Mangrove areas are converted for use in shrimp pond aquaculture and for lowland agriculture. Over 600 ha of coastal area between Chilaw and Puttalam, much of it mangrove forest, have been developed for aquaculture. The conversion process not only results in direct loss of mangroves by clear-cutting but also alters water flow patterns which may cause the surrounding mangroves to die. The loss of 63 percent of the previously existing mangroves in Puttalam Lagoon has been reported as having occurred in the ten-year period from 1981-1992 (Dayaratne et al. 1997) (see Table 2. 5). Conversion for coconut and paddy production also causes irreversible change. In addition, mangrove areas may be reclaimed for housing and urban expansion. In Negombo, for example, 50 ha of mangroves were cleared and filled in the mid-80s for a national housing project. All

such conversion activities result in habitat destruction and accompanying reduction of productivity in the coastal fishery.

Table 2.4 Typical uses of mangroves

(Source: Anon,1997)

Type of Use	Specific Use/Benefit
Non-extractive	*Source of food and nutrients to estuarine, lagoon and nearshore coastal waters *Nursery for the early stages of commercially important crustaceans and fish *Stabilize shorelines against erosion, both in estuaries as well as along some segments of the eastern coast where their presence inhibits wave damage *Control runoff thereby reducing siltation in lagoons and estuaries, coral reefs and seagrass bed *Science and education for research and tourism (Universities of Colombo, Kelaniya and Peradeniya, as well as NARA and the Forest Department are engaged in mangrove related research)
Extractive	Mangrove harvest for subsistence and commercial uses such as * fuel, either as firewood or charcoal, domestically and for the firing of bakeries, lime kilns, and illicit distilleries * house construction and canoe outriggers * in making brush-piles (mas~athu) for fishing * tanning of fishnets using an extract of the mangrove bark. * traditional mask making using the woody species *Cerebra manghas*, locally called kaduru. * fodder or manure * food (The young fronds of a mangrove-associated fern (*Acrostichum*) and fruits of important mangrove species (*Sonneratia caesiolaris*) are used for food.
Transformative	Mangrove conversion for aquaculture, coconut, paddy, housing and urban expansion

Table 2. 5 Changes in Area of Wetland Habitats, Puttalam Lagoon, 1981-1992
(Source: Dayaratne *et al*, 1997)

Habitat	Area (ha), 1981	Area (ha), 1992	Percent Loss
Mangroves	1,181.50	431.57	63
Salt Marsh	1,303.27	640.9	50

2.1. 3. Estuaries and Lagoons

Sri Lanka's estuaries and lagoons are shown in Figure 2.4. They are one of the country's most prominent natural features and cover some 160,000 ha of area. The lagoons themselves are complexes of other wetland systems and often contain marshes, mangrove areas, seagrass beds, and mud flats. Uses of lagoons and estuaries are summarized in Table 2.6.

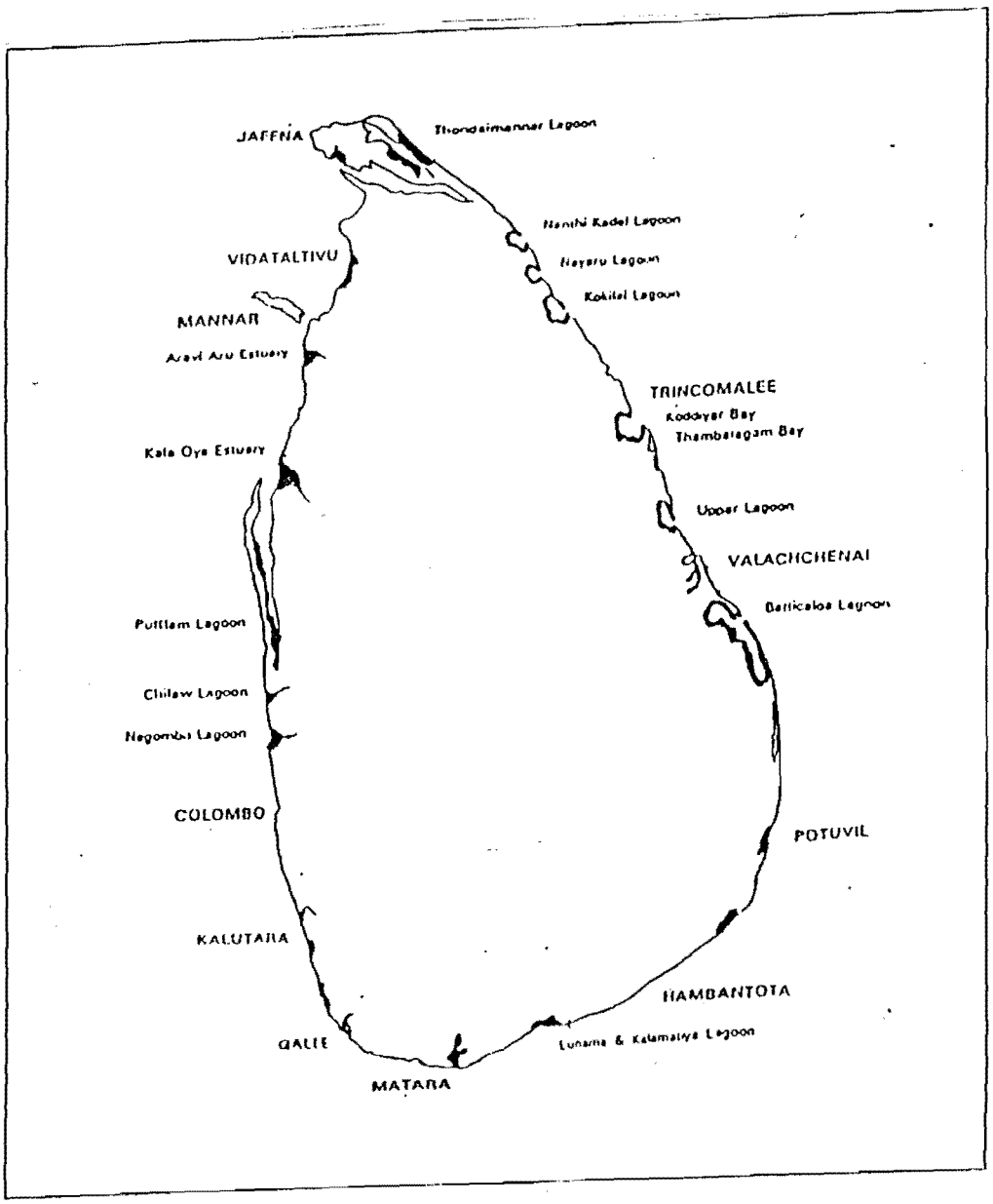


Fig. 2.3 Distribution of Mangrove vegetation in Sri Lanka

(Source: Amarasinghe, 1996)

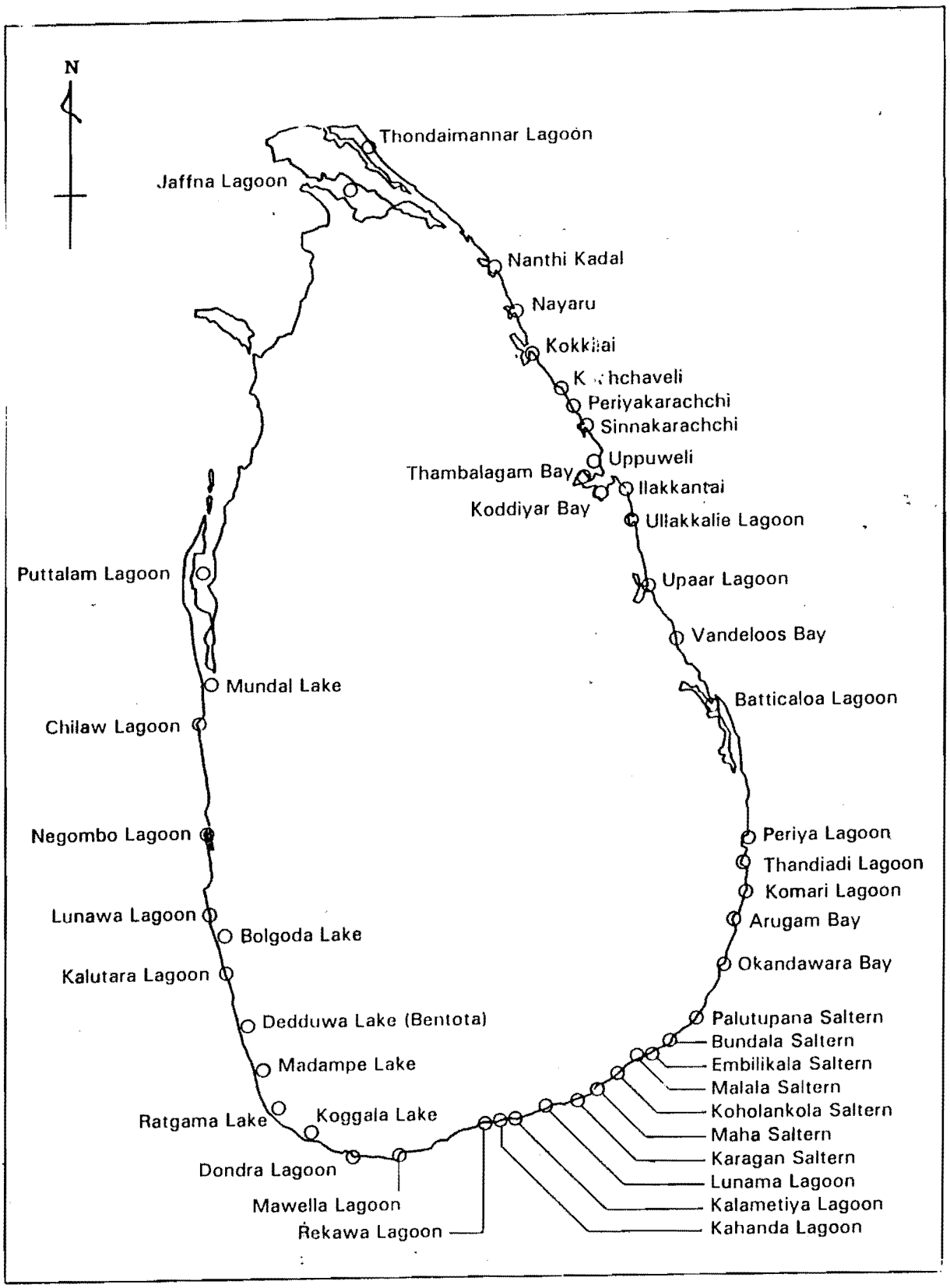


Fig. 2.4 Location of well known basin estuaries and lagoons in Sri Lanka

(Source: Anon, 1997)

Table 2.6 Typical uses of estuaries and lagoons

(Source:Anon,1997)

Type of use	Specific use/benefit
Non-extractive	*Serve as nutrient traps which support a highly diverse natural community of plants, fishes, invertebrates, birds, and other wildlife * Sand transported by rivers into the sea by way of riverine estuaries is important to beach maintenance * Anchorages for trading and fishing vessels * Tourist recreation (Negombo, Bentota) * Research and education * Raft culture of mussels and oysters (Trincomalee Bay, Puttalam Lagoon, Ratgama Lake and Mirissa Harbour)
Extractive	*Fishing, full or part-time, employment of 30,000 in 1993 * Sandmining, direct employment for about 2,900 in 1991 * Seedfish/shrimp collection, demand is increasing with more aquaculture * Ornamental fish collection (Negombo Lagoon, Bolgoda Lake, Trincomalee Bay)
Transformative	* Desalination experiments (Thondaimannar Lagoon) * Landfill (Negombo Estuary *.Pond aquaculture (Puttalam and Negombo Lagoons, Bolgoda Lake) * Sewage disposal

The eventual fate of basin estuaries and lagoons is extinction by sedimentation and pollution. Sedimentation is exacerbated by water diversions (ie. stabilization of shores by vegetation, barrier formation by longshore drift or opening up of an estuary mouth by erosion to form a bay), that reduce natural flows. Such flow reduction causes accelerated accumulation of sediments within the basin and further blockage of the channels that connect the lagoons to the sea and allow for natural water exchange. The pace of extinction depends primarily upon geomorphology and can be increased by human activities. At Negombo estuary, the effective water area was reduced by 791 ha between 1956 and 198I. The delta area at Attanagalu Oya nearly doubled during this period, indicating that high siltation rates were the likely cause of the reduction in water area (NARESA/IJSAID, 1991). Pollution can result when lagoons are used as harbors (Negombo Lagoon, Chilaw Lagoon), disposal sites for

sewage (Kelani Estuary, Negombo Lagoon, Lunawa Lagoon), or receiving waters for industrial effluent (Lunawa Lagoon, Negombo Lagoon, Kelani Estuary, Valaichchenal Estuary). A number of lagoons are being severely impacted by encroachment and land reclamation which contribute to a direct loss of functional lagoon water area (Chilaw Lagoon, Negombo Lagoon, Mawella Lagoon). Alterations in the salinity regimes within lagoons can cause added ecological imbalances. Excess agricultural irrigation water diverted from the Udawalawe reservoir and discharged into the Kalametiya-Lunama Lagoon system since 1950 has virtually eliminated the prawn fishery there. The Lunugamwehera irrigation scheme has reduced salinities in Malala, Rekawa, and Mawella Lagoons from 10-41 parts per thousand (ppt) to 5- 1 0 ppt, causing similar reductions in the penaeld shrimp fisheries in these three lagoons (Jayakody, 1993).

All such impacts hamper the preservation of areas of high ecological and aesthetic value, such as can be found in Bentota Estuary, Bolgoda Lake, and parts of Negombo Lagoon, and the subsequent use of these areas for recreation, conservation, scientific research, and educational purposes. Management measures being implemented at Muthurajawela Marsh (part of the Negombo Lagoon system) and the bird sanctuary at Kalimetiya Lagoon are allowing sustainable uses to continue at these sites.

2.1.4 Seagrass Beds

Seagrass beds are abundant along Sri Lanka's coast although their locations and extent have not been precisely mapped and estimated. Seagrass beds constitute the most extensive coastal ecosystem in Sri Lanka. They occur along the open coast as well as within estuaries and lagoons. A very large bed covers much of the area from Dutch Bay to Jaffna Lagoon. At Mannar, this same bed extends to the northwest toward.Rameswaram Island, India. Other smaller seagrass beds are found on the leeward side of coral reefs along the southwestern coast. They form dense underwater meadows, the edges of which may be glimpsed during low tide. They often occur in association with coral reef ecosystems. The linkage between seagrass beds, coral reefs and fisheries are production is direct and critical, but not usually quantified nor always recognized. Sri Lanka's seagrass beds are subject to various uses as shown in Table 2.7.

Table 2.7 Typical uses of seagrasses

(Source:Anon,1997)

Type of Use	Specific Use/Benefit
Non-extractivea.	a. Sediment stabilization, seagrass foliage decreases water current speed and prevents sediment displacement b. Research on seagrass ecology and chemical uses c. Seagrasses allow epiphytic organisms to obtain sites for attachment and provide nesting habitat and food for a number of species of fish and shrimps d. important nurseries for penaeid shrimp juveniles e. habitats and food for the endangered Dugong and Sea turtles f. herbivorous fish consume the leaves, some juvenile fish feed upon epiphyses and several shrimp species feed upon grass detritus
Extractive uses	a. Polychaete harvests are used as brood stock feed in commercial shrimp hatcheries harvested from selected seagrass beds b. Fishing along northwestern and northeastern coasts c. Fodder at some locations

Though not well-studied, several activities are known to be destructive of seagrass beds, including digging for polychaetes, sewage disposal, and use of destructive fishing gear (such as bottom trawls and drag nets). Less extensive damage is caused by beach seining and dragging of propellers. Excessive siltation can also cause damage to this critical habitat.

2.1.5 Salt Marshes

Over 23,800 ha of salt marsh lands are estimated to occur in Sri Lanka. In Sri Lanka salt marshes occur mainly in regions where the dry season is prolonged as in the north, northwest, northeast and southeast. Whereas the salt marshes in the northern regions occur mainly on exposed tidal flats, in the south they occur largely in the shelter of sand dunes.

Salt marsh vegetation in Sri Lanka typically occurs as sparse, short growth interspersed with scrub mangroves. In the Mannar district where tidal flats are more extensive, marsh vegetation contains up to 56 species. In the vicinity of Mundel Lake, there are salt marsh and mangrove associations. Various uses of salt marshes of the country are summarized in Table 2.8.

S small-scale grazing, hunting of waterfowl, and collection of milkfish fry for aquaculture from tidal pools. There has recently been increasing interest in tourism to marsh areas for nature appreciation and bird-watching. Destruction of salt marshes is brought about by certain transformative uses, including conversion for salt farming (e.g., at Hambantota and Palavi), shrimp aquaculture (various lagoons), or reclamation (e.g., Muthurajawela Marsh).

Table 2.8 Typical uses of salt marshes

(Source:Anon,1997)

Type of Use	Specific Use/Benefit
Non-Extractive	a. Sources of nutrients for nearshore waters b. Serve as a discharge area that can absorb stormwater runoff c. Feeding habitat for birds and nursery grounds for juvenile fishes d. 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 aquaculture in some area

As shown in Table 2.5, the decline in salt marsh land due to these activities may be dramatic. In Puttalam Lagoon, for example, 50 percent of the existing marshland was lost in a ten-year period (Dayaratne *et al.* 1997).

2. 1. 6 Barrier Beaches, Spits and Dunes

Barrier beaches, spits and dunes are prominent natural features found within Sri Lanka's coastal zone.

Barrier beaches are accumulations of unconsolidated sediment transported ashore by waves and moulded into a form that lies across a body of water (eg. rivers and estuaries/lagoons) and isolates it from the sea (Rekawa and Koggala Lagoon). Other barrier beaches are free at both ends and form islands (Karaitivu). Barrier beaches predominate along the southern and southwestern coasts

Spits are essentially incipient barrier beaches that project from the shore in the direction of dominant drift and are free at one end (the end farthest from the prevailing current) (e.g. the shoal that builds seasonally at the mouth of Negombo estuary). Spits are more common along the western and eastern coasts forming in the direction of longshore drift.. Sand spits are usually unstable structures that shift with current changes. For instance, the inlet of Batticaloa has moved to its present position from a previous location 5 km south. Spits protruding into estuary (such as at Kalu Ganga) are especially unstable, and shifting sands may result in changes in the physical location of estuarine outlets. Barrier beaches tend to be more stable structures than spits, but may be breached by the highest tides or floodwaters, depending on site-specific conditions.

Dunes are wind blown accumulations of sand which are distinctive from adjacent land forms such as beaches and tidal flats. The formation and persistence of dunes depends on the delivery of sand to the dune by wind and retention of sand by moisture and vegetation cover. Although they resemble beaches they differ mainly with respect to absence of tidal effect. Dunes are unstable unless covered by vegetation and may continue to shift in the wind. For instance, removal of vegetation resulted in dune migration as experienced in Manalkadu, Point Pedro in 1950. Unique communities of plants may colonize some dunes and once vegetated, these become stable features.

Dunes lie beyond the tide line and are thus not eroded by normal wave action. Extensive dune systems occur between Ambakandavila and Kalpitiya, between Kirinda and Sangamukanda Point, in the Hambantota area, and across Mannar Island.

.Barrier beaches and dunes are subject to a number of uses as shown in Table 2.9.

Table 2.9 Typical uses of barrier beaches and dunes

(Source:Anon,1997)

Type of Use	Specific Use/Benefit
Non-Extractive	a. Beach landing of fishing boats, drying of gear on barrier beaches b .Coast protection and sand supply c. protective barriers particularly during storm conditions d. Some segments of beaches serve as nesting areas for sea-turtles (Kosgoda, Kandakuliya, Kossgoda, Bundala,Kirinda)
Extractive	a. Mining of beach sand on barrier beaches and some dunes (Point pedro and Hambantota)
Transformative	a. Construction of housing on dunes (Hambantota, Ambakandawila); houses and temples at Point Pedro

The dynamic spits that form seasonally at estuarine inlets obstruct natural water flow patterns, often resulting in the flooding of low-lying lands (Kalu Ganga and Maha Oya estuaries), and in decreased fishery productivity. For example, fishery yields

2.1.7 Nature of threats to marine and coastal habitats

The habitats discussed above support many of the nation's coastal fisheries and, in their natural state, provide the nation with a buffer against the sea's erosive force. Sri Lanka's important coastal habitats are small and highly vulnerable to degradation. The areal extent of biologically productive mangrove systems, estuaries, coral reefs and seagrasses is decreasing. Mangroves estimated to cover about 12,000 ha in 1986 were reduced to 8,687 ha by 1993 and are predicted to cover only 6000 ha by the year 2000 (Anon.1990a, b; Anon, 1996).

The number of people attempting to make a livelihood in the coastal region will increase by at least 37 percent over the 1981 census numbers by the year 2000, and by fifty percent towards the middle of the twenty first century (Korale, 1991). Population density in the coastal region is projected to be 446 person per km^2 by the year 2000 and more than 1 000 per km^2 in 27 of 67 coastal AGA divisions. The resource management problems associated with increasing population pressures, the need for expanding settlements, the need for industrial development and increasing exploitation of resources will intensify. The challenge is to manage the development and use of natural habitats in a manner that will provide sustainable yields (Deheragoda and Dhanapala, 1994).

Activities that occur outside the legally defined Coastal Zone often create impacts on coastal habitats (Table 2.11). In addition, a number of governmental agencies share responsibility for aspects of coastal habitat management. Hence, wise management of coastal habitats requires inter-agency co-operation, participation of resource uses and careful analysis of long-term impacts of patterns of resource use.

Table 2.10 Summary of potential impacts on marine and coastal habitats
(Source:Anon,1997)

Habitat	Potential Impacts
Coral Reefs	Physical damage to coral reefs and over collection of reef organisms Increase in fresh water runoff and sediments Introduction of waterborne pollutants
Estuaries/Lagoon	Encroachment 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 fresh water runoff, salinity regime and tidal flow patterns Excessive siltation Introduction of pollutants Conversion of mangrove habitat and over harvesting of resources
Seagrass Beds	Physical alterations Excessive sedimentation or siltation Introduction of excessive nutrients or pesticides
Salt Marshes (Tidal Flats)	Degradation of bird habitat or seed fish collection sites Obstruction of storm water runoff
Barrier beaches, Dunes and Spits	Sand mining Erosion Dune migration

2.2 Present Management Strategies for marine and coastal habitats

Management of natural habitats is being carried out by the CCD under the implementation of Coast Conservation Act of 1981 and the revised Coastal Zone Management Plan of 1997. In the implementation of the CZM Plan (1997) the following management strategies were adopted:

- **Regulations** (banning of extraction, possession, processing, and transportation of corals and operation of lime kilns within the coastal zone by the Coast Conservation Act of 1981 as amended in 1988 and permit requirements for all development activities in the coastal zone);

- **Education and awareness** (published and distributed materials on habitats, inclusion of issues affecting coastal habitats into the secondary school curriculum, conducting seminars for officials of national level and regional level, holding exhibitions);

- **Planning and policy development** (conservation of coastal habitats through Special Area Management Plans at Hikkaduwa and Rekawa);

- **Monitoring** (implemented monitoring program on coral mining);

- **Research** (supported research on coastal ecosystems); and,

- **Coordination** (established habitat management and research priorities with other agencies).

Experience has revealed that more participatory approaches are necessary for the management of Sri Lanka's coastal habitats. The success of participatory approaches will largely depend on the continued co-operation and involvement of governmental and non-governmental agencies who are concerned with the protection of coastal habitats and their uses, as well as the people who exploit these habitats for their livelihood.

2.3 Participatory approaches required for a better management of the marine and coastal habitats

Objective 2.3.1 Preserve and enrich the coastal habitats and natural features of exceptional value including protected areas.

Policy 1 Prohibit or require modification of development activities where there is a reasonable probability that significant degradation will occur in designated protected areas (National Reserves, Sanctuaries and Fisheries Conservation Areas) in the coastal zone.

Actions 1 . Periodically update the list of designated sites as areas of

exceptional value with a view to protect them by having them declared as conservation areas under the Fauna and Flora Protection Ordinance and the Fisheries and Aquatic Resources Act.

2. Regulate all development activities through coastal development permit and EIA procedures.

Policy 2 Ensure sustainability of the coastal habitats including protected and designated natural areas of exceptional value.

Actions

1. Co-operate with other relevant governmental and non-governmental agencies to Jevelop protection and management plans for protected areas and natural areas of exceptional value.

2. Participate directly and indirectly in the identification, prioritisation and implementation of management plans for Special Area Management sites and identified Areas of Particular Concern.

Objective 2.3.2 Promote sustainable development of resources found within coastal habitats.

Policy 1 Promote inter-agency cooperation in development planning to minimize adverse impacts on coastal habitats.

Policy 2 Prohibit or require modification of development activities where there is a reasonable probability that significant degradation or destruction of the coastal habitat is likely to occur.

Policy 3 Encourage and directly sponsor scientific research on coastal habit

Policy 4 Promote awareness of the nature and significance of coastal habitats.

Objective 2. 3.3 (Coral Reefs) **Seek to prevent the degradation or depletion of coral reefs and maintain reefs as a scientific, educational and tourist resource.**

Policy 1 Breaking of reefs, collecting of offshore coral debris and mining of corals prohibited in the Coastal Zone.

Actions

1 . Strictly enforce the Coast Conservation Act jointly with concerned authorities.

2. Conduct annual surveys to determine the level of illegal mining activities in the coastal zone.

3. Amend the existing legislation pertaining to coral mining activities.

4. Conduct awareness programmes for identified target groups and initiate community actions.

Policy 2 Promote introduction of alternative sources of lime to meet the requirements of the construction industry and agriculture.

Actions 1. Co-ordinate with concerned agencies which promote the use of alternative sources of lime.

Policy 3 Identify areas where reef restoration will impede erosion and provide additional habitat.

Actions 1.Initiate and/or assist community based reef restoration and preservation at identified locations.

2.Assist other agencies undertaking action programmes on restoration and preservation of reefs.

Policy 4 In considering proposed development in the vicinity of coral reefs, ensure the adverse impacts of increases in fresh water runoff and sediments and the introduction of waterborne pollutants will be minimized.

Action 1.Initiate research and awareness programmes with NARA and CEA to mitigate the adverse impacts of runoff and sedimentation on coral reefs at identified location

Policy 5 Collection of small and limited coral specimens may be permitted by the CCD if it is for valid scientific research purposes.

Action 1. Issue permits for collection of corals only for the purpose of scientific research provided that the proposed research is in compliance with specified guidelines.

Policy 6 Protect and preserve coral reefs as an important coastal habitat to ensure a sustainable marine environment

Action 1.Cooperate with other government and non-government agencies to develop appropriate coral reef management plans (ie. Marine protected areas) for identified vulnerable areas.

Policy 7 Ensure that removal of reef organisms, such as aquarium fish, does not exceed sustainable levels.

Policy 8 Promote breeding of marine aquarium fish

Objective 2.3.4 (Estuaries and Lagoons) **Maintain fishery habitat and water quality, protect recreational values, and regulate sand mining at levels that do not have an adverse impact on beach replenishment.**

Policy 1 Ensure that impacts due to encroachment, sedimentation, desalination and pollution are minimized in considering proposed development within and adjacent to estuaries or lagoons.

Policy 2	Cooperate with other governmental and non-governmental agencies to develop special area management plans for selected estuaries and lagoons.
Objective 2.3.5 (Mangroves)	**Preserve the mangroves as an important habitat for wildlife, a nursery for fish, a nutrient trap, and to enable extraction at a sustainable level.**
Policy 1	Prevent further depletion of mangroves or degradation due to excessive fresh water or pollutants.
Action	1.Ensure that impacts of fresh water runoff, excessive siltation, oil pollution, and conversion of mangrove habitats are minimized when reviewing proposed developments in the coastal zone.
	2 . Revitalize in the Sri Lanka National Mangrove Committee.
	3. As part of management responsibilities for development activities within or adjacent to mangrove habitats in the Coastal Zone, the CCD will consider the guidelines developed by relevant national agencies
Objective 2.3.6 (Seagrass Beds)	**Preserve seagrass beds as fisheries habitat and a habitat for Dugong and sea turtles.**
Policy 1	In considering proposed development in the vicinity of seagrass beds, ill ensure that physical alterations are prohibited, and excessive sedimentation or siltation, and introduction of nutrients or pesticides are minimized.
Actions	1.Identify a zoning scheme for utilization of seagrass beds that will enable fishing to co-exist with movements of the Dugong and the Sea turtles.
Objective 2.3.7 (Salt Marshes)	**Ensure the sustainable use of salt marshes as an important waterfowl habitat, as a buffer which protects coastal settlements from flooding (by storm water runoff and tidal surges) and to protect an estuary or lagoon from chemical pollution in runoff from land.**
Policy 1	Ensure that coastal development will not significantly degrade important bird habitats, seed fish collection sites, or significantly obstruct storm water runoff.
Policy 2	Support activities to map distribution and extent of salt marshes, clarify ownership, and identify types and scales of development that can be accommodated on particular salt marsh areas in a manner harmonious with ecological and social needs.

Policy 3	Support research that will assist in identification and rehabilitation of particular sites by mangrove reforestation.
Objective 2.3.8 (Barrier Beaches, Spits and Dunes)	**Conserve barrier beaches, spits and dunes.**
Policy 1	Ensure that alteration of particular barrier beaches, spits and dunes ,will not be permitted without due regard for their particular ecological function.

CHAPTER 3

CONTAMINANTS FROM POINT SOURCES AND NON POINT SOURCES CAUSING MARINE AND COASTAL POLLUTION

3.0 Introduction

Sri Lanka's efforts to achieve economic development are accelerating urbanization and industrialization in coastal areas. This is leading to substantial increases in the amount of wastes produced. The larger waste stream has increased strains on the capacity of natural systems to absorb these wastes and on institutions to manage wastes effectively. The trend of increasing concentrations of urban wastes and inadequate waste management will extend into the 21st century (Deheragoda *et al* 1992).

Waste management and coastal water pollution control are of increasing concern. Urban pollutants of heavy metals, petrochemicals, sediments and fecal matter degrade marshes, estuaries, lagoons, coral reefs and other coastal habitats and directly threaten the sustainability of nearshore fisheries. A lack of access to uncontaminated water for drinking, cooking and bathing increases exposure to water-borne pathogens and to gastroenteritis, hepatitis, dysentery and other illnesses. The adverse health effects of indiscriminate disposal of heavy metals are well illustrated in the two incidents of cumulative poisoning; one known as Minamata Bay disaster occurred in the1950s in Japan due to methyl mercury released to water and the other in 1960s in Jintsu river basin in Japan where Cadmium was released from a industry which caused severe bone pain due to Osteomalacea (Seneviratne, 1997)

Since pollution mitigation activities are generally cheaper than pollution clean-up strategies, waste management is essential. Urban sewage treatment plants, community-based sewage disposal systems, pollution mitigation plans for industrial estates and even small scale campaigns to prevent people from dumping oil and other wastes into streams and canals are generally far more cost-effective than after-the-fact clean up strategies. Also since increased levels of pollution degrade coastal environments and threaten coastal tourism. Sri Lanka's second largest foreign exchange earner is vulnerable (Olsen *et al*, 1992).

The health, environmental and economic benefits associated with pollution management are substantial. When the full costs and benefits of pollution control are analyzed as has been done for Hikkaduwa, a more aggressive approach to coastal pollution control is seen to support rather than detract from economic development objectives. The challenge is to understand the singular and cumulative impacts of pollutants, identify activities causing adverse pollution loads, and to design and support pollution control strategies that are both fairly distributed and cost-effective.

3.1 Marine and coastal water regimes affected by pollution

The water regimes which are relevant to coastal pollution include rivers, streams, estuaries, lagoons, ground water sources and the ocean. The main water pollutants are urban, domestic and industrial waste plus solid and toxic agricultural waste including agro-chemicals, sediments and runoff. Oil spills, direct discharge of oil, solid and other wastes from the fishing vessels and ships pollute the ocean waters and the beaches.

Rivers and Streams

Over 100 rivers radiate to the sea through the Coastal Zone in Sri Lanka. Rivers and streams in the urban areas are highly polluted as a result of direct discharge of effluent, garbage, sewage and oil.

The Kelani River, the second largest and most polluted river in the country, drains an area of 2,278 km^2 in the wet zone. This drainage area includes the Colombo Metropolitan Region. A greater part of the 487 km^2 Colombo catchment area drains into the Kelani river. The sea outfalls at Wellawatta and Galle Face and the different canals opening into the Kelani river constitute the main outlets of the city's storm water and canal systems.

Significant sources of the Kelani River pollution are sewage, industrial effluent and agricultural runoff. According to 1991 data between 67,500m^2 and 90,000m^2 of Colombo's untreated sewage is dumped daily into the Kelani River (Baldwin,1991). However, with the establishment of two ocean outfalls, this level has now reduced to

a considerable level. Heavy metals and pesticide levels in the Kelani river have not been studied in detail, but cadmium and copper have been found at levels in excess of tolerance limits (Anon,1997). Most of the organic pollutants enter the river in the 50 km before the river mouth.

Pollution levels in the Mahaweli River are less than those of the Kelani. Heavy use of pesticides and fertilizers in upland agriculture pollute this river. The Walawe River has been polluted by black liquor effluent from the Embilipitiya paper mill and from sugar processing effluent from the Sevanagala Sugar Mill.

Estuaries and Lagoons

Brackish water bodies include about 158,000 ha of estuaries and lagoons many of which are highly vulnerable to pollution, particularly those located near urban areas such as the Kelani and Mahaweli river estuaries. A number of lagoons and basin estuaries are exposed to considerable discharges of sewage and waste water (Negombo lagoon, Bentota estuary, Valachchanai estuary and Bolgoda-Panadura estuary)(Baldwin, 1991). Analysis of water from a number of lagoons and estuaries shows evidence of pesticides at various locations, including the Chilaw and Mundel lagoon, Kala Oya, Deduru Oya and Dandugam Oya (Anon, 1993). Studies conducted on the Negombo Lagoon indicate that conform (total and fecal) bacteria counts were unacceptably high at some locations (Anon, 1993). Disposal of industrial waste at a few spots causes a high concentration of heavy metals. Lunawa lagoon in the southern periphery of the city of Colombo receives an average of 81 tons chemical oxygen demand and 43 tons suspended solids annually from surrounding residential housing and industry. This water body has thus lost its value for recreation and aquaculture.

Ground Water

Ground water is increasingly used for drinking, especially in small urban centers and rural areas. The estimated ground water potential for the country is 780,000 ha/meters per annum (Baldwin, 1991). For this water to remain safe, the rate of water extraction must not exceed the aquifer's replenishment capacity. High rates of

extraction will cause the wells to run dry or result in brackish water intrusion. This has occurred in northern and northwestern coastal areas where ground water is used to irrigate rice and cash crops.

The most serious threats to ground water come from nitrate and bacterial (fecal) contamination. Nitrate pollution is due to excessive use of nitrogenous agrochemicals. Sewage effluent from pit latrine soakways and septic tanks causes bacterial contamination of ground water. River and canal pollution also affect ground water. Leaching of pesticides into ground water may occur in agricultural areas. In peripheral areas of the Colombo Municipal Region, fecal contamination of ground water is very high. The nitrogen levels of the ground water in some places has reached intolerable levels. The ground water has also been contaminated with fecal material at tourist resort centers such as Beruwala, Ahungalla and Hikkaduwa. The cost of ground water treatment will increase significantly unless proper treatment and disposal facilities are provided in these areas (Anon,1985; Baldwin, 1991; Riznychack and Schmidt,1992)

Ocean

The ocean, sometimes viewed as having an unlimited capacity to receive wastes. is limited in its assimilative capacity. In Sri Lanka the direct ocean disposal of waste materials is limited to sewage waste, dredged materials, and industrial and domestic wastes. These effluents can still contain substantial quantities of suspended solids, toxic metals, synthetic organic compounds, fecal coliform, and other potentially pathogenic micro-organisms. The main sources of ocean pollution are industry (textile, tanning, paint, pulp and paper, metal finishing,, dyeing, printing, chemicals, food and beverages and petrochemicals), agriculture (pesticides, fertilizers), housing and tourism (sewage, waste water and solid wastes).

3.2 Contaminents

The major sources of coastal water pollution along the west and southwest coasts are domestic sewage, industrial wastes., solid wastes and agricultural chemicals (Table 3.1).

Table 3.1 Major sources of coastal pollution in Sri Lanka

(Source: Silva,1993)

Source	Pollutants
Domestic Sewage	Organic Compounds Metals (Na, Ca, Cu) Nutrients (N, P) Gases (CO_2, CH_4)
Industry	Organic Compounds Heavy Metals (Cr, Zn, Cd) Gases (CO_2, SO_2, NO_2)
Agriculture (Pesticides & Fertilizer)	Organic Compounds Metals (Cu, Hg, Cd) Nutrients (N, P)
Vehicles and ships	Heavy Metals (Zn, Pb, Fe) Gases (CO, CO_2, SO_2) Particulate (Pb) Oil

Na	Sodium
Ca	Calcium
Cu	Copper
N	Nitrogen
P	Potassium
CO_2	Carbon Dioxide
CH_4	Methane
Cr	Chromium
Zn	Zinc
Cd	Cadmium
SO_2	Sulfur Dioxide
NO_2	Nitrogen Dioxide
Hg	Mercury
Pb	Lead
Fe	Iron
CO	Carbon Monoxide

3.2.1 Domestic Sewage

Growing urban population densities coupled with inadequate housing and lack of urban infrastructure, such as water and sewage disposal facilities, has led to fecal contamination of surface and ground water. More than 40 percent of the Sri Lanka population is affected by typhoid, amoebic and bacillary dysentery, infecticus hepatitis, gastroenteritis, colitis and worm infections (Baldwin,1991).

Properly planned sewage systems have not yet been devised in Sri Lanka except in the Colombo Municipal area. The Colombo Municipal Area has a population of 625,000 million, but only 60 percent live in households served by the city's sewage collection system. In this system, sewage is screened for large particles and floating matter, then pumped directly into the ocean without treatment . The Colombo sewage system

consists of two ocean outfalls located in Wellawatta (Southern outfall), and Modara (northern outfall) (Fig.3.1). Reports show that these outfalls have discharged 43,908 m^2/day and 57,943 m^2/day respectively in 1990 (Dassanayake, 1994) which could be much more at present. The Dehiwala- Mount Lavinia and Kolonnawa sewerage systems are planned to be connected to the Colombo ocean outfall system. Sri Lanka Sewerage Project Report of 1981 also proposes the construction of ocean outfalls for the disposal of waste from the Galle and Negombo Municipal Councils (Dassanayake, 1994). Between 67,500m^2 and 90,000m^2 of Colombo's untreated sewage is also dumped daily into the Kelani River (Baldwin,1991).

The different disposal methods in Colombo are shown in Figure 3. 2. The problem of sewage disposal in Colombo is compounded by the inadequacy of urban infrastructure for the city's poor residents. About half of the population lives in slums and squatter settlements of which 75 percent of the residents live along streams and canals. The waste, along with storm water and some industrial effluent, is discharged directly into canals. Organic pollution from sewage accounts for 50-60 percent of the total waste load (10,000 kg BOD 5/day) discharged into the canal network in Colombo (Baldwin,1991). This pattern of turning canals and water ways into sewers is replicated in urban areas throughout the country.

Water quality problems along the southwest coast are compounded by the proliferation of squatter settlements. Such settlements near Chilaw, Negombo (Porutota, Duwa, Kamachchode), Dehiwela, Panadura, Ambalangoda, and Galle (between Fort and Dewata) have resulted in fecal pollution and solid waste on the beaches and in nearshore waters.

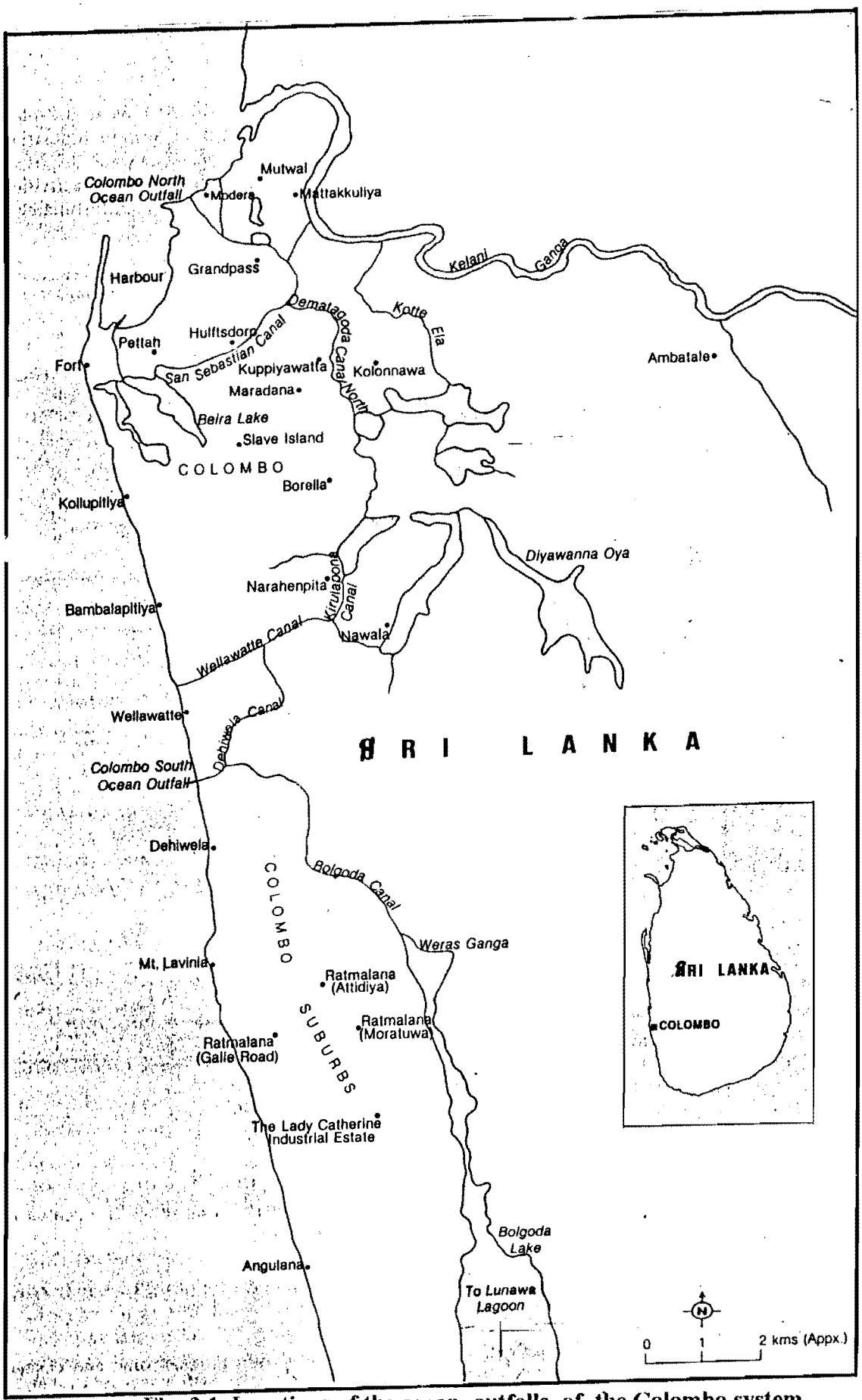


Fig. 3.1 Locations of the ocean outfalls of the Colombo system

(Source: Dassanayake, 1994)

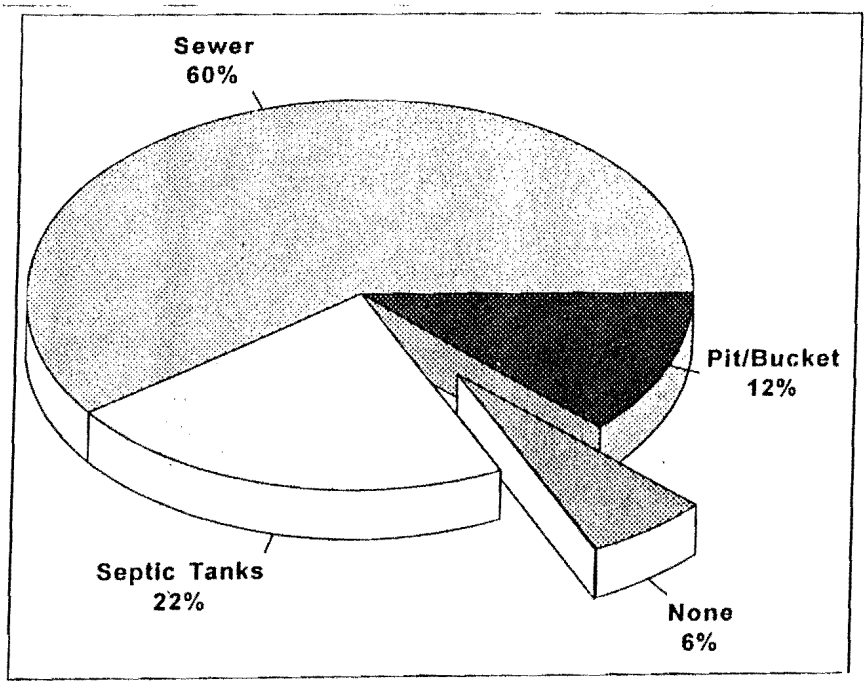


Figure 3.2 Percent of Colombo Population served by different sewage disposal methods (Source:Tillakaratne, 1984)

3.2.2 Industrial Pollution

There are approximately 60,000 industrial establishments in Sri Lanka, ranging from large-scale to repair shops and small mining and quarrying operations. About two-thirds of Sri Lanka's industrial plants are located within the coastal region, primarily in the Greater Colombo Metropolitan Region. Two of the three Investment Promotion Zones (IPZ) and two primary industrial estates are located in coastal areas near Colombo. The third IPZ is at Kogalla near Galle.

In 1969, a strategy for the industrialization of Sri Lanka was published by the Government. The document envisioned making Sri Lanka a newly industrialized country (NIC) in six years.

All new industries, it recommended, should be situated in specially designated industrial zones that would be provided with the basic infrastructure facilities needed to sustain industrial development. The facilities suggested were adequate supply of potable water, waste water disposal , energy, transport, solid waste management etc.

Most industries and industrial states started prior to the establishment of the Greater Colombo Economic Commission (GCEC) such as Ratmalana, Moratuwa-Lunawa, and Ekala were not in fact provided with these basic infrastructure facilities (Dassanayake,1994).

Three export processing zones have been established under the GCEC. The zones are located in Katunayaka, Biyagama and Koggala (Fig. 3.3). In Katunayaka, textile factories account for nearly 50% of the total industries. In Biyagama, only 25% are textile factories. Other types of industris in the Export Processing Zones are metal-based, rubber products, electronic and electric appliances, ceramic products and tobacco processing.

Both the Katunayaka and Biyagama Export Processing Zones (KEPZ and BEPZ) are provided with central waste water treatment facilities. All effluents discharged from the enterprises in each zone are collected through a network of sewer connections into a central treatment facility. The process adopted is very similar in both zones (Dassanayake,1994).

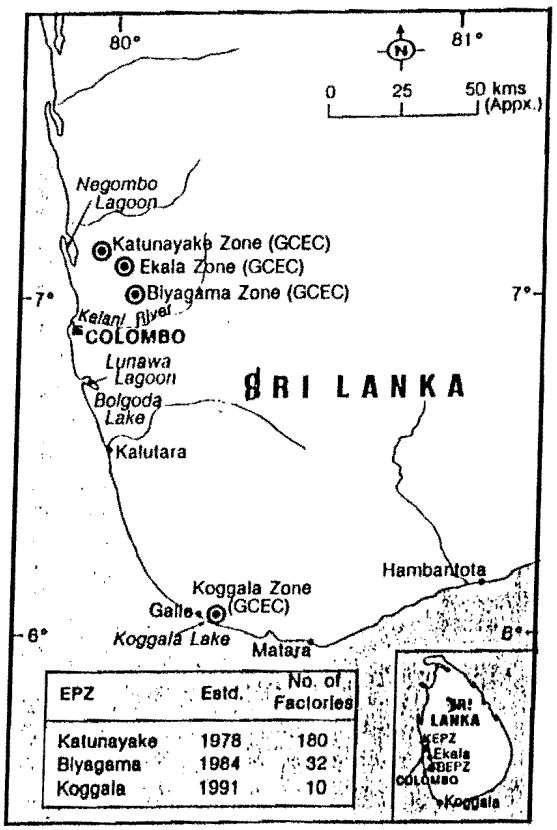


Fig. 3.3 Location of Export Processing Zones

(Source: Dassanayake,1994)

The central treatment plan at the KEPZ has been designed for a loading rate of 3000m^3/day and has a peak loading rate of 9000m^3/day. The central treatment plant at the BEPZ has been designed for dry weather; 3400m^3/day with a peak flow rate of 10,200m^3/day. Treatment process include the following:

Pre-treatment

Screening
- Bar screen
- Coarse screen
- Fine screen

Grit removal - Two parallel grit removal chambers for alternate use.

Biological treatment

Aerated lagoons
- Four rectangular lagoons at KEPZ, each of 7000 m^3 capacity
- Two rectangular lagoons BEPZ, each of 10,500 m^3 capacity.

Sludge settling

Settling tanks
- Four at KEPZ, one adjacent to each of the aerated lagoons. Scum is removed manually.
- Two at BEPZ, hopper bottom type circular tanks. Settled sludge is pushed in to a hopper in the middle of the tank by a rotation scraper. Scum is also removed from the surface by a mechanical devise.

Sludge removal

Sludge sediments in the settling tanks are, from time to time removed by gravity flow and let into drying bed setup for this purpose. Water content in the sludge is removed partly by evaporation and partly by drainage. The drained water is then pumped back into the treatment plant.

Effluent polishing

At the BEPZ, a reservoir has been constructed to collect and treat the final effluents. This reservoir provides for an additional retention time of ninety days, during which time the remaining organic and inorganic material is further decomposed by microorganisms. During the rainy season, effluents stored in the reservoir get diluted by rain water and spill over the spill structure provided in the dam. This water flows into the Kelani river along a natural water course. An additional pump house

however, has been provided to pump the effluent stored in the reservoir during dry weather. These effluents are channeled into the Kelani river through a pipe line constructed to dilute them for an emergency. At KEPZ, there is no provision for effluent polishing. The treated water is discharged into the Dandugam Oya.

Ekala Industrial Zone

The Ekala Industrial Zone consists of textile, battery- manufacturing, asbestos and food-canning factories. Adequate waste treatment facilities are not available in most of the factories. The waste water is discharged in to open lands, roadside drains and finally into Ja-ela Oya which flow into the Negombo estuary. Disposal of solid waste is carried out by the private contractors. There is no supervision of their work and serious environmental damage from the disposal of solid waste containing batteries waste as well as waste from tanneries may occur.

Smaller industries

Smaller polluting industries are the desiccated coconut and copra industries, coconut fiber and batik units as well as licensed and illicit distilleries. Waste water from desiccated coconut milk for example shows high values of BOD. Coconut husk retting is a microbial fermentation process carried out in the south. Effluents from batik industries include textile dyes, oil and organic components. The distilleries are located in Seeduwa, Wadduwa, Paiyagala, Maggona, Beruwala, and Aluthgama. These effluents contain sulfur, organic compounds, copper and tin. Surface waters, ground water and coastal waters are polluted by direct discharge of wastes from these industrial facilities as well as by leakage and seepage (Dassanayake,1994).

Table3.2 summarises the estimated waste loads from the industrial areas in Colombo city and Table 3.3 gives the required standards for industrial waste water discharged into coastal areas of Sri Lanka.

Table 3.2 Estimated water loads from the industrial areas in Colombo city

(Source: Anon, 1985)

Zone	*Waste water load (m^3/day)*	*Waste water disposal site*
Katunayake	6300	Dandugam Oya which flows into Negombo Estuary
Biyagama	4437	Kelani River
Koggala	—	Proposed to be discharged into sea by ocean outfall

Table 3.3 Tolerance limits for industrial and domestic effluents discharged into marine coastal areas

(Source: Anon. 1998)

Determinant	Tolerance Limit
Total Suspended Solids, mg/l, max	
(a) For process waste waters	150
(b) For cooling water effluents	total suspended matter content of influent cooling water plus 10%
Particle size of	
(a) Floatable solids, max	3 mm
(b) Settlable solids, max	850 micro m.
pH range at ambient temperature	6.0-8.5
Biochemical Oxygen Demand (BOD_5) in 5 days at 20°C, mg/1, max	100
Temperature, max	45°C at the point of discharge
Oils and grease, mg/l, max	20
Residual Chlorine, mg/l, max	1.0.
Ammoniacal Nitrogen mg/l, max	50.0
Chemical Oxygen Demand (COD) mg/l, max	250
Phenolic compounds (as phenolic OH) mg/l, max	5.0
Cyanides mg/l, max	0.2
Sulfides mg/l, max	5.0
Fluorides mg/l, max	15
Arsenic mg/l, max	0.2
Cadmium total, mg/l, max	2.0
Chromium total, mg/l, max	1.0
Copper total, mg/l, max	3.0
Lead total, mg/l, max	1.0
Mercury total, mg/l, max	0.01
Nickel total, mg/1, max	5.0
Selenium total, mg/l, max	0.05
Zinc total, mg/l, max	5.0
Radio active material	
(a) Alpha emitters, micro curie/ml, max	10^{-8}
(b) Beta emitters, micro curie/ml, max	10^{-7}
Organo-Phosphorus compounds, mg/l	1.0
Chlorinated hydrocarbons, mg/l max.	0.02

The industries contributing most to water pollution are textiles, paper, tanning, metal preparation, finishing and engineering, paints, chemicals, cement, food and beverages and distilleries. The main pollutants of those industries are untreated wastewater, solid waste, heavy metals, and gases. In 1994, 366 industrial facilities were identified in coastal areas with "high" or "medium" pollution potential (Anon, 1994). The types of facilities and their estimated daily pollution loads are shown in Table 3.4.

Table 3.4 Number of industrial facilities in coastal areas with high or medium pollution potential and their waste loads

(Source: Anon, 1994)

Type of industry and process	No. of units	Total waste water load m^3 per day	Estimated pollution and kg/day	
			BOD	COD
Textile	41	7100	4970	11360
Food & Beverage	47	4111	6166	12333
Rubber Processing	154	4840	9670	29040
Tanning of hides	151	614	3229	8070
Metal Preparation Finishing and Engineering	76	6692	669*	
Paints and Chemicals	33	928	92.2*	

* Measured in Toxic kg/day

Of the industrial pollutants discharged into canals and streams, toxic wastes are of particular concern. Inorganic compounds, including metals such as arsenic, cadmium, chromium, nickel, copper, mercury, tin, lead and zinc are discharged into coastal areas by both natural processes and human activities. Fig. 3.4 shows the major trade discharges in the Kelani river catchment area. Toxic waste production by the metal preparation finishing, engineering and chemical industries are shown in Table 3.4.
A recent study has shown that the chromium levels of the Kelani estuarine waters were 40 fold enriched by tannery waste released to the water body (Table 3.5)

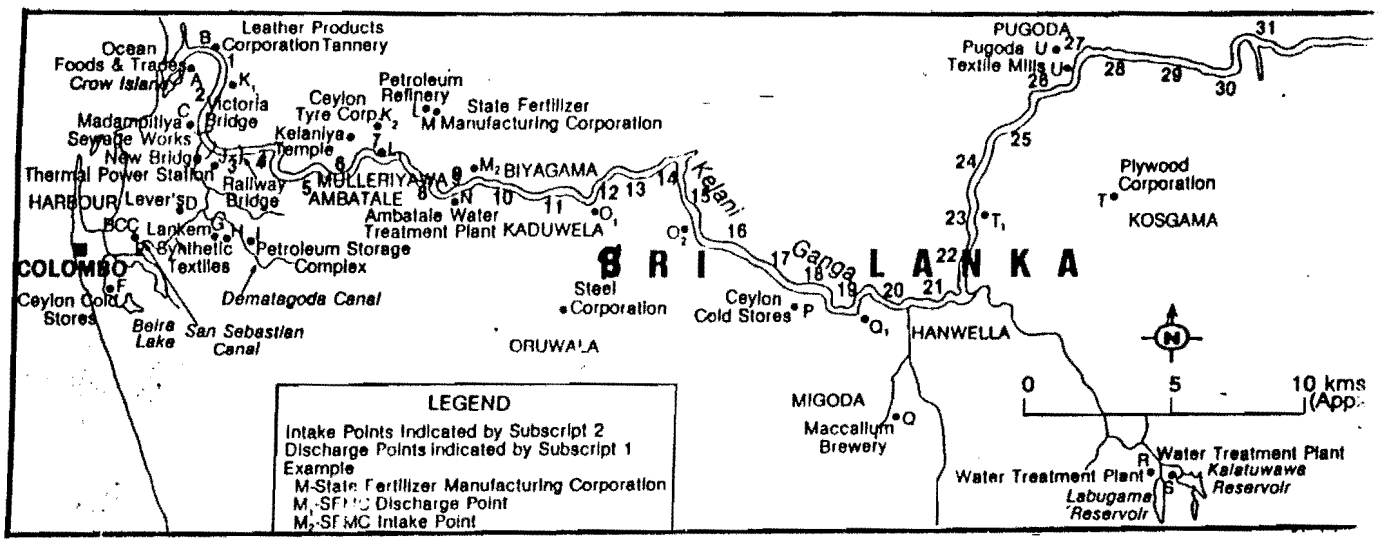


Fig. 3.4 Major trade discharges in the Kelani river catchment area

(Source: Dassanayake,1994)

Table 3.5 Longitudinal and cross sectional distribution of chromium (Mean±SD in mg l^{-1}) in the kelani Estuary water in January 1992

[In a column, means denoted by the same letter are not sinificantly different ($p>0.05$). In a row, means denoted by the same number are nor significantly different ($p>0.05$)].

(Source: Wijegunawardene et al, 1997)

Location	Right bank	Middle	Left bank	Mean
1	$25.4\pm0.2^{a,1}$	$20.0\pm0.1^{d,2}$	$19.8\pm0.5^{f,3}$	21.7±3.1
2	$28.6\pm0.05^{a,1}$	$22.0\pm0.5^{b,3}$	$26.0\pm1^{b,2}$	25.5±3.3
3	$27.4\pm0.3^{a,1}$	$29.6\pm0.1^{c,1}$	$28.5\pm0.3^{a,1}$	28.5±1.1
4	$22.4\pm0.3^{a,2}$	$20.4\pm0.2^{e,3}$	$27.7\pm0.5^{d,1}$	23.5±3.7
5	$26.0\pm0.5^{a,2}$	$22.2\pm0.3^{a,3}$	$35.6\pm0.2^{c,1}$	27.9±6.9
6	$29.1\pm0.1^{a,2}$	$24.6\pm0.2^{c,3}$	$30.2\pm0.2^{e,1}$	27.9±3.0
7	$27.9\pm0.1^{a,1}$	$21.0\pm0.5^{e,3}$	$24.6\pm0.2^{g,2}$	24.6±2.0
Mean	26.7±2.3	22.8±3.3	27.5±4.9	

Production processes for food and beverages, footwear and leather, wood and wood products, paper and painting and petroleum and service utilities are the primary sources of organic compounds. These wastes include: pesticides, phthalate esters, polynuclear aromatic hydrocarbons, metal organic compounds, alkyl-benzene, plasticisers, polychlorinated biphenyls (PCBS) and halogenated hydrocarbon compounds which can get accumulated in water bodies and in turn get accumulated in the bodies of fauna and flora through bio- accumulation. This is well exemplified by the heavy metal levels and their concentration in fish/ shellfish bodies in the Negombo lagoon (Table 3.6 and 3.7).

Table 3.6 Mean trace metal concentration (10^3 μg g^{-1}) in the surface water and sediment from Negombo Estuary

(Source: Anon, 1998)

Medium	Metal	Stations					
		1	2	3	4	5	6
Water	Mn	1.40	2.10	1.30	1.56	1.48	1.50
Sediment	Mn	1.78	5.02	12.80	6.68	6.9	10.12
Water	Zn	2.80	2.90	3.40	3.35	2.92	1.52
Sediment	Zn	72.00	48.80	66.10	65.56	86.63	53.60
Water	Fe	49.20	41.60	40.80	52.00	59.81	15.00
Sediment*	Fe	31.70	30.63	32.75	28.80	29.28	28.66
Water	Pb	1.84	1.82	1.20	1.34	1.44	1.48
Sediment	Pb	46.90	30.20	29.32	20.70	33.8	16.35
Water	Cu	1.78	2.16	1.30	1.92	1.66	1.72
Sediment	Cu	45.05	39.65	60.10	54.25	35.25	39.77

* Fe Sediments concentrations are in mgg^{-1}

Table 3.7 Mean trace metal concentration ($\mu g\ g^{-1}$) in the fish/ shrimp/crab samples from Negombo estuary

(Source: Anon, 1998)

Species	Mn	Fe	Zn	Cu
Arius maulnculantus (Fish)				
Mean	3.533	70.583	35.907	1.84
Range	2.1-4.9	56.5-83.4	27.1-46.12	0.45-2.7
Std	1.13	12.2	7.0	0.85
Etroplussunatensis				
Mean	3.16	58.23	26.379	2.570
Range	1.4-4.05	37.8-78.9	14.95-41.9	0.95-1.3
Std	1.5114	18.409	9.954	1.3391
Liza veigenis (Fish)				
Mean	3.11	56.490	16.191	2.940
Range	1.2-5.45	43.5-83.0	11.87-20.8	0.3-7.15
Std	1.6727	16.06	4.104	2.6836
Terepon sp. (Fish)				
Mean	4.27	58.41	31.480	2.410
Range	3.2-5.9	55.6-77.25	27.13-35.9	0.55-4.9
Std	1.0986	31.8719	3.199	2.0723
Lutjanus fulviflaminus (Fish)				
Mean	6.620	58.090	35.883	3.220
Range	1.25-20.1	28.5-81.8	13.72-70.1	0.8-8.8
Std	7.7517	21.8633	22.59	3.275
Siganus canaliculatus (Fish)				
Mean	3.866	61.316	17.680	3.900
Range	1.8-7.0	43.85-83.5	12.05-22.9	2.05-7.1
Std	2.7592	20.2082	5.4652	2.7825
Hyporhampus dussumeiri (Fish)				
Mean	3.575	56.125	27.225	3.450
Range	1.6-5.55	48.8-63.45	36.545-33.8	1.3-5.6
Std	2.7931	10.3591	9.4328	3.0406
Penaeous monodon (Fish)				
Mean	3.23	65.550	34.88	2.5166
Range	1.6-5.1	51.7-78.9	31.02-41.9	0.65-3.85
Std	1.742	13.0609	6.0966	1.6653
Panaeous indicus (Shrimp)				
Mean	3.5875	62.450	36.578	7.775
Range	1.6-7.45	41.35-83.3	23.8-45.8	2.75-16.5
Std	2.6336	17.8988	9.2179	1.7149
Scilla serrata (Crab)				
Mean	4.9625	77.735	48.56687	6.9125
Range	3.4-7.2	59.8-143.1	37.2-70.1	1.0-11.3
Std	1.702	56.7431	31.29	4.7652

3.2.3 Waste Oil

Waste oil is of increasing importance as a source of coastal water pollution. It sometimes forms tar balls that wash ashore on beaches used by tourists and wildlife. Oil pollution comes from washing oil tanker holds, the discharge of oil in bilge water (this aspect is discussed under maritime activities) and discharges from mechanized boats. Oil waste also results from careless handling of oil products by more than 100 service stations and automobile service facilities. Waste oil is often dumped directly into canals.

The magnitude of oil wastes in coastal waters is not known but oil slicks are visible in ditches, marshes, lagoons and the sea. A slick with a silvery surface is equivalent to 0.25 ppm oil in the top 30 cm layer of water. The accepted maximum of oil in water for fish culture is 0.1 ppm, but even 0.01-0.02 ppm of crude oil, petrol and diesel oil can taint the flavor of fish and shellfish, damage fish larvae, and clog gills of fish (Anon, 1985).

3.2.4 Solid Wastes

Solid wastes include garbage, refuse and other discarded materials resulting from industrial, commercial and household activities (Table 3.8) illustrates the composition of solid waste collected in the Greater Colombo area (1993 data).

Table 3.8 Composition of solid waste collected in the Greater Colombo area

(Source: Anon,1998)

Composition	Household waste (% by weight)	Commercial waste (% by weight)
Paper	7	6.7
Plastic	5.6	5.2
Metals	2	0.6
Glass	0.7	0
Organic Waste	83.6	86.4
Other	1.1	1
Total	100	100

More than 700 tons of solid waste is generated daily within the Colombo Municipal Region (Baldwin, 1991). This amount is yet to rise with increasing population. At the national level, more than 45,000 tons of hazardous materials are produced (Anon, 1998). Waste collection and disposal systems have been established in Colombo and other urban centers, but many households are outside this collection system.. In some areas solid waste is dumped indiscriminately in low-lying wetlands or thrown in canals or streams. Some industrial processing facilities lie outside the collection network. Textile, wood processing, paper manufacturing and plastic and metal plants are the industrial plants generating most of the solid waste. Solid waste collection and disposal problems are particularly acute in and around Negombo, Colombo, Ratmalana, Moratuwa, Panadura, Galle, Koggala, Trincomalee, and within tourism beach areas.

3.2.5 Agriculture Wastes

The heavy use of chemical fertilizers and pesticides degrades the soil and contributes to the pollution of water in marshes, lagoons and nearshore coastal water. As soil humus is leached out reducing the soil's ability to retain essential nutrients, more fertilizers have to be applied per unit area to maintain production levels. With the depletion of soil humus, the fertile topsoil is also more susceptible to erosion.

The increasing use of agrochemicals, some of which are persistent and accumulate in dangerous concentrations, is a growing problem. However, the use of the more persistent type of organochlorine pesticides is banned, or restricted in Sri Lanka. The annual level of chemical fertilizer use in Sri Lanka is estimated to be 77 kg/ha which is two to eight times more than in other Asian countries (Baldwin, 1991). The annual average use of pesticides in Sri Lanka is between 1,200 and 1,600 grams per hectare. Over half of the farmers use at least twice the recommended dosage. Information on the levels of pesticide residues in water and organisms is not available, but data on agrochemical use for Sri Lanka from 1992-1995 is available (Table 3.9) . The following pesticides are prohibited for import and use in Sri Lanka; Arsenate, Arsenites, chlorodimeform, DBCP, DDT, EDB, Endrin, Heptachlor, Leptophos, Parathion and Methyl Parathion, Thallium sulphate, 2-4-5 T.

Table 3.9 Pesticides and other agrochemical use in Sri Lanka (metric tons) during 1992- 1995

(Source: Anon,1998)

Category	Type	Year			
		1992	1993	1994	1995
Insecticides	Clorinated Hydrocarbons	0.82	1.14	085	0.6
	Organao phosphates	293.46	330.54	281.53	202.00
	Carbomates	193.30	79.20	84.07	77.31
	Pyrethroids	0.25	0.24	NA*	0.46
	Insect growth reglators	0.27	0.39	0.36	0.27
	Others	65.59	59.74	85.47	114.38
Total		523.28	448.34	NA*	404.27
Herbicides	Phenoxy hormone products	308.74	88.83	318.48	189.45
	Triazines	0.44	1.19	0.47	0.82
	Amides	357.11	356.14	439.03	443.72
	Carbomates	0.80	NA*	NA*	NA*
	Salphonyl ureas	30.25	26.61	21.50	31.62
	Bytiridils	277.13	35.71	65.74	54.49
	Others	15.96	31.66	67.37	95.13
Total		990.43	541.14	912.59	815.23
Fungicides Bactericide and see treatment	Inorganics	297.04	379.53	218.13	182.22
	Diphiocarbomates	206.77	255.62	237.12	265.17
	Benzimidezoles	3.29	3.58	4.45	4.92
	Diazenes, morphopines	1.63	4.80	6.53	2.65
	Others	88.64	94.33	28.22	40.52
Total		597.36	737.86	494.45	495.48
Rodenticides	Anticoagulants	0.51	0.63	0.71	0.0006

* NA- Not Available

3.2.6 Aquaculture

The development of pond aquaculture has been encouraged by the Ministry of Fisheries during the last decade by initiating various incentive schemes. The construction of ponds has been subsidized and shrimp farmers have been given long-term land leases at nominal fees. Successful pond aquaculture is above all a matter of appropriate site selection. Unfortunately this has not always been taken into consideration in Sri Lanka for fish culture ponds . For instance in 1987, it was found that 82% of the small pond constructed under the subsidy scheme in the Negombo area were non-functional. However, in contrast to this, shrimp industry has thrived in

the last decade earning foreign exchange to the country. Most of the shrimp culture sites are located in the northwestern coastal belt of the island (Fig. 3.5). Unplanned development of shrimp farms in this area has caused many environmental hazards as well as down-fall of industry itself. For instance, most farms in the area use Dutch canal as their water resource . At the same time the effluents from farms are discharged to this same water body causing disease contamination, eutrification etc. Recent outbreaks of viral diseases which collapsed the industry is a result of this which demonstrates adverse effects of unplanned development of aquaculture industry. Table 3.10 shows the proposed quality standards for different use classes of coastal water in Sri Lanka and Table 3.11 compares some optimal water quality parameters required for shrimp culture with that of post-disease outbreak studied in the Dutch Bay, which also emphasizes this point.

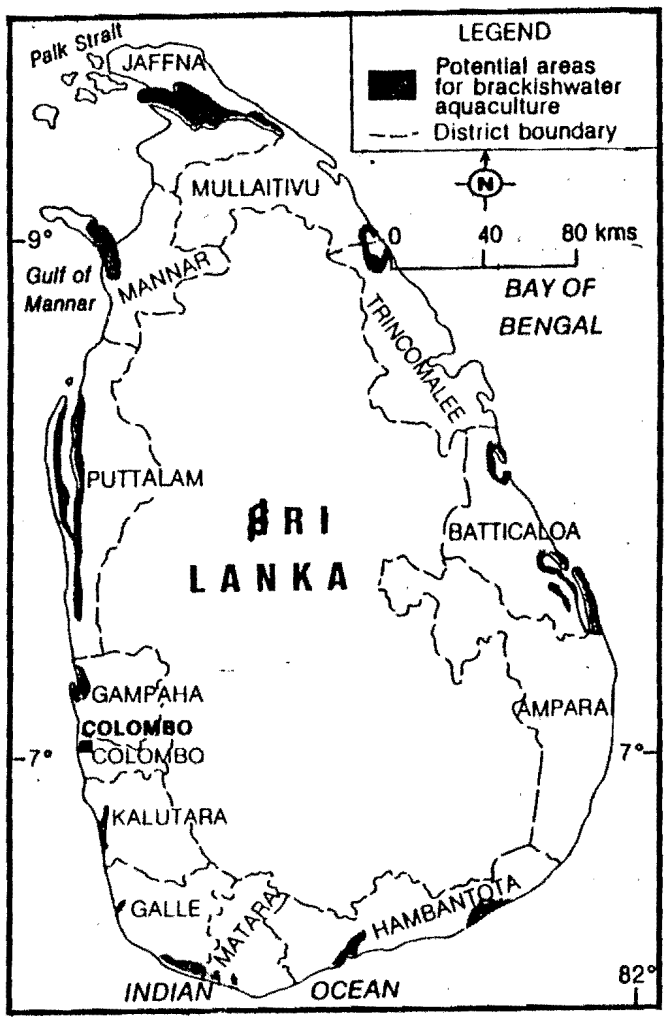


Fig. 3.5 Potential areas for aquaculture development

(Source: Dassanayake,1994)

Table 3.10 Proposed quality standards for different use classes of coastal water in Sri Lanka

(Source: Anon,1998)

Parameter	Unit	Value for different use classes			
		1 Nature conser-vation	2 Fishery of shell fish	3 Fishery of fin fish	4 Non consump-tion use
Floatable solids		N	N	N	NO
Floatable oil/grease		N	N	N	NO
Suspended solids		N	N	N	NO
Transparency[1]		N	<10%	<10%	<50%
Color		N	NV	NV	NO
Odor		N	N	N	NO
Temperature	°C	<32	<32	<32	<32
Coliform (total)	MPN/ml	N	N	<10	<20
Coliform (fecal)	MPN/ml	N	N	<3	<6
pH		N	7.0-8.5	7.0-8.5	6.5-9.0
Salinity[1]	g/l	N	29-35	<10%	<20%
Dissolved oxygen	satur.	N	>80%	>70%	>60%
BOD	mg O_2/ml	N	<5	<5	<10
Phosphate (total)	mg P/ml	N	NA	NA	NA
Nitrogen (total)	mg N/ml	N	NA	NA	NA
Ammonia (free)	mg N/ml	N	<0.4	<0.4	<1.2
Cyanide	mg/l	N	<10	<10	<20
Sulfide	mg/l	N	<5	<5	<10
Mercury	mg/l	N	<0.1	<0.1	<0.2
Cadmium	mg/l	N	<5	<5	<10
Chrome (hex.)	mg/l	N	<25	<25	<50
Lead	mg/l	N	<25	<25	<50
Copper	mg/l	N	<25	<25	<50
Manganese	mg/l	N	<100	<100	<200
Zinc	mg/l	N	<50	<50	<100
Iron	mg/l	N	<300	<300	<600
Arsenic	mg/l	N	<50	<50	<100
Fluoride	mg/l	N	<1.5	<1.5	<3
Phenols	mg/l	N	<30	<30	<60
PCB (total)	mg/l	N	<0.03	<0.03	<0.06
Chlor. pestic. (total)	mg/l	N	<0.05	<0.05	<0.1

[1] % = change from natural condition

N Natural condition

NO Not objectionable

NV Not visible

NA Below level causing algae bloom (to be established) < smaller than > higher than

Table 3.11 Accepted ranges of optimal water quality for shrimp culture, and levels in Dutch canal during disease out breaks
(Source: Jayasingha & Mackintosh 1993)

Parameter	Acceptable Range	Optimal Level	Value recorded In Dutch Canal
Temperature ^{0}C	26 – 33	29 – 30	29 – 32
Turbidity (FTU)	0 – 150	2 – 30	16 – 320
Total suspended solids (mg/1)	2 – 14	< 5	80 – 160
Dissolved oxygen level (mg/1)	3 – 12	4 – 7	4.0 – 7.2
Salinity (ppt)	10 – 35	15 – 20	02 – 31
PH	7.5 – 8.7	8.0 – 8.5	7.6 – 8.5
Nitrate (mg/1)	0 – 200	na	.001 - .065
Nitrite (mg/1)	< 0.25	<0.02	.091 – 065
Ammonia (unionized mg /1)	< 0.25	< 0.11	.23 – 0.37
Hydrogen sulphide (mg/1)	< 0.25	< 0.002	.24 – 0.67
BOD (mg /1)	< 10	na	8 – 54

na - not available

Among the impacts of this development activity, the excessive use of various chemicals which are discharged to the coastal environment pose a great problem. These chemicals can be detrimental to fauna and flora of natural environment (eg. estuaries and lagoons to which the effluents containing various chemicals and nutrients are discharged). In most cases drugs are overused (Table 3.12). Especially, high concentrations of antibiotics in effluents may increase populations of resistant strains of pathogenic bacteria in the environment which can harm the fauna and flora.

Table 3.13 shows quantities of other material used in a typical shrimp farm in Sri Lanka. Increased concentration of nutrients can cause excessive growth of algae which will reduce the availability of oxygen in a waterbody, harming other living organisms.

Table 3.12 Main chemicals and antibiotics reported as in use in shrimp culture operations in Sri Lanka

(Source: Jinadasa,1998)

Chemical	Purpose of application
Lime (dolomite and quick lime)	To increase pH
EDTA	As a chelating agent
Urea	Fertilizer
TSP	Fertilizer
NPK	Fertilizer
Chlorine	Disinfect bacteria
Benzakonium chloride	Disinfect bacteria
Copper sulfate (copper control)	Reduce plankton density
Malachite green	Disinfect fungi /external parasites
Methylene blue	Disinfect fungi
Oxytetracycline	Disinfect bacteria
Erythromycin	Disinfect bacteria
Furazolidone	Disinfect bacteria
Treflan	Disinfect fungi
Chloramphenicol	Disinfect bacteria
Formalin	Eliminate external parasites
Saponin	Eradicate pests

Table 3.13 Quantity of chemicals and other material used in the existing system.

(Source: Jinadasa,1998)

	MATERIAL	Qty / ha / cycle	Use
1.	Bleaching powder	450 Kg	Sterilization
2.	Water	300 000 m3	Medium for organisms
3.	Prawn feed	8000kg	feed
4.	Tea seed cake	150Kg	Eradicate unwanted organisms
5.	Gypsum	160Kg	to eliminate clay turbidity

Non product outputs of culture systems such as fecal matter, microbial population and suspended organic solids can be detrimental to fauna and flora (Table 3.14). Among other adverse effects of aquaculture are land salinization, soil and water acidification, natural wetland siltation and changes in coastal land use.

Table 3.14 Non – product output of the culturing system
(Source: Jinadasa, 1998)

Material	Source	Contents	Qty/Ha / Cycle	Total water Discharged Cycle/Ha	Qty/ Cycle
Organic Solids					
Fecal matter	Live Prawns	Organic Matter	300,000 m	1,800,000m	
Excess feed		Organic Matter			
Microbial P opulations		Organic Matter	600 Kg		3,600 Kg
Dead shrimps	Shrimps				
Dead Plankton	Plankton				
Dissolved Nutrients Total Phosphorous		Phosphates	20 – 30Kg		120-150 Kg
Total Nitrogen		NO_3, NO_2	25-30 Kg		100-120 Kg
Hydrogen Sulphide		H_2S	25-30 Kg		30-72 Kg
Ammonia		NH_3	1 – 2 Kg		6 – 12 Kg
Methane		CH_4	02-05 Kg		12 – 30Kg

3.2.7 Tourism

Most of the tourist resort areas are distributed along the coastal zone of the island. Among the six tourist development regions, four are situated in the coastal belt *i.e.* Colombo and Greater Colombo economic area, southern coastline, eastern coastline, and northern area. The construction of hotels and resorts without paying due regard to coastal dynamics and behaviour of the ecosystem has caused occasional erosion of

beaches. These hotels have also cleared natural vegetation in some areas. Pollution from untreated sewage, kitchen wastes, swimming pool and laundry wastewater is causing water quality problems in all the major tourist centers along the south and southwest coast. Hikkaduwa and Beruwala are of particular concern. Only several of the tourist resorts along the southwest coast have effective sewage disposal systems or treatment plants.

3.2.8 Maritime activities

Sea-bed exploration can be a potential activity that can adversely affect the coastal and marine environment of the country.

Attempts were made to explore for oil in Pesale in the Mannar district without much success. Investigations to study the feasibility of extracting Monozite bearing heavy mineral placers at Beruwala were carried out in 1997 (Fernando and Wijayananda, 1998). Though these are not commercially done in Sri Lanka as at present, future excavations may bring disastrous effects to the coastal zone by disturbing its fauna and flora by physical contamination with toxic by-products, smothering with silt, and reducing primary production etc.

Maritime traffic is a current threat to the marine and coastal environment of the country. Marine traffic is very heavy around Sri Lanka due to the fact that the international shipping routes are located south of Sri Lanka , majority of vessels transporting oil from the Gulf to the far East and Australia. In addition large number of vessels enter our harbors for trading. Major contaminants from these ships are oil and and waste discharges. The southern coast is polluted with tar balls formed the coagulation of petroleum hydrocarbons (Wickremaratne and Pereira,1986) . Fig. 3.6 illustrates the tar concentrations recorded in the beaches along southwestern coast of the country in 1986.

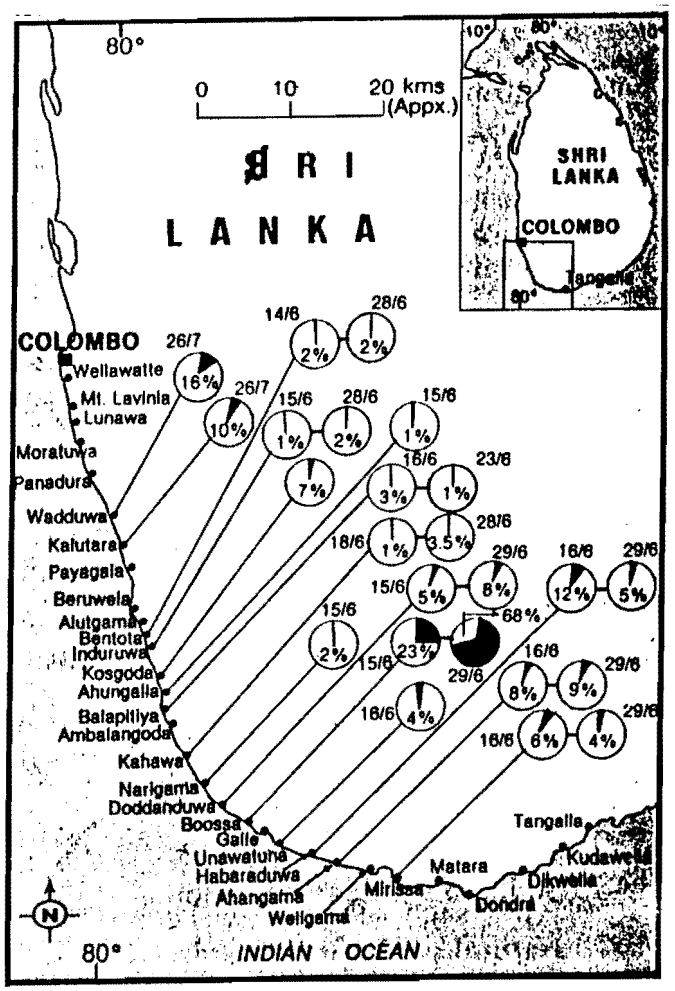


Fig. 3.6 Tar concentrations on the beaches of the southwestern coast of Sri Lanka [expressed as percentage of highest reported world value (Oman) 100%+ 2325 g/meter of shoreline]

(Source: Wickremaratne and Pereira,1986)

3.3 Present strategies of Coastal Pollution Management

Coastal pollution mitigation and control is a shared responsibility of several government agencies and the private sector. Although this plan focuses on the role of the Coast Conservation Department in pollution prevention, Table 3.15 lists all the agencies with prime responsibility for coastal pollution control. Table 3.3 shows the tolerance limits for industrial and domestic effluents discharged into marine coastal areas set by National Environmental act No. 47 of 1980.

Every effort should be made to remove colour and odour from effluents. These values are based on dilution of effluents by at least 8 volumes of clean receiving water. If the dilution is below 8 times, the permissible limits are multiplied by 1/8 of the actual dilution. The limits have been prescribed by regulations published in Gazette Extraordinary No. 595/1 6 of 02.02.1 992 under the National Environmental Act No. 47 of 1 990 as amended by Act No. 56 of 1988.

Table 3.15 Agencies responsible for coastal pollution control in Sri Lanka

(Source:Anon,1997)

Agency	Function	Management Mechanism
Central Environmental Authority National Environmental Act No. 47 of 1980 amended by Act No. 56 of 1988	• Investigate the cause, nature, extent and prevention of pollution • Promote research • Set standards, norms and criteria to maintain the quality of the environment • Coordinate all regulatory activities for the discharge of waste and pollutants • Recommendations, directives to Local authorities	• Implement environmental standards • Environmental Impact Assessments (EIA) and Initial Environmental Examination (IEE) • Prohibitions • Issue of Environmental Protection Licenses (EPL) • Research • Coordination • Appointment of committees
Coast Conservation Department Coast Conservation Act No. 57 of 1981 amended by Act No. 64 of 1988	• Control development activities which may create pollution in the Coastal Zone	• Permits for development activities • Guidelines • IEE and EIA • Public education • Coordination
Local Government Institutions (Local Government by-laws)	• Control pollution	• Removing solid waste • Cleaning • Providing facilities
Sri Lanka Land Reclamation and Development Corporation	• Management of inland waterways	• Rehabilitating existing canals and outlets
Water Supply and Drainage Board	• Management of sewage outfalls	• Providing new facilities • Managing existing sewage outfalls
Marine Pollution Prevention Authority Marine Pollution Prevention Act No. 59 of 1981	• Prevention, reduction and control of pollution in Sri Lanka waters • Effect international conventions for the prevention of pollution of the sea	• Prevention of marine pollution from land-base sources • Oil spill contingency plan and prevention • Port operation and shipping control

3.4 Participatory approaches required for a better management of the marine and coastal pollution control

Objective 3. 4.1 **Minimize effluent discharges and impacts in the coastal zone to prevent further degradation of coastal water quality and coastal habitats.**

Policy 1 Require that all development activities in the coastal zone comply with the Central Environmental Authority's standards for stipulated coastal and marine waters.

Actions

1. Impose CEA standards for discharges on all new development activities in the coastal zone subject to permits under provisions of the Coast Conservation Act.
2. Impose a compliance programme in collaboration with CEA against existing developers violating the stipulated standards.
3. Implement the guidelines stipulated by the Inter-ministerial Committee on Aquaculture Development for all aquaculture proj ects.
4. Initiate an awareness programme in collaboration with the Department of Fisheries and Aquatic Resources Development for fishing communities to encourage proper disposal of oil waste.
5. Initiate studies on water quality in collaboration with other concerned agencies on water quality and publicize the results.

Policy 2 Cooperate with other agencies in developing strategies for providing economic incentives to developers to minimize untreated discharges into the coastal waterways.

Action

1. Collaborate with other agencies to develop a programme of tax incentives, expedited permit approval processes or other incentives to encourage the private development of waste water treatment systems.

Policy 3 Encourage the relocation of high and medium polluting industries in industrial zones and encourage more efficient provision of pollution abatement technology.

Policy 4 Assist relevant agencies in establishing a single pollution abatement fund.

Policy 5 Actively participate in efforts to obtain technical and financial assistance to establish central sewage treatment systems at appropriate locations within the coastal zone.

Objective 3.4.2 **Improve the coastal environment by reducing the types and volume of solid waste disposed in the coastal zone.**

Policy 1 Assist in preparing solid waste management plans for identified coastal urban centers, coastal tourist centers and fishing harbours.

Action

1. Identify those urban centers, coastal tourist centers and fishing harbors for which solid waste plans are most urgently needed.

Policy 2 Discourage local authorities to disposal solid waste in the coastal zone.

Actions

1. Assist local authorities in identifying dump sites in environmentally less vulnerable locations outside the coastal zone.

2. Assist the local authorities to relocate dumping sites out of the coastal zone.

Policy 3 Collaborate in public education and awareness programs and join with other agencies in promoting public participation in solid waste management.

Actions

1. Facilitate the active public participation in preparation, implementation and monitoring solid waste management programmes.
2. Update the ongoing public education programme addressing the issues of discharges and solid wastes in regard to coastal pollution management.
3. Initiate a programme to involve the communities in designing local community pollution abatement programs adopting the Special Area Management and Areas of Particular Concern management approaches.

Objective 3.4.3 **Share and disseminate information on coastal pollution management.**

Policy 1 Collaborate with CEA, NARA and other agencies in formulating a research agenda for coastal pollution management.

Actions

1. Develop a research agenda for coastal pollution management for the next four years.

Policy 2 Support similar research programs conducted by other agencies or organizations on oil waste discharge and solid waste management

CHAPTER 4

PHYSICAL ALTERATION, INCLUDING HABITAT MODIFICATION AND COASTAL EROSION

4.0 Introduction

Coastal erosion is a severe problem in Sri Lanka that results in damage to or loss of houses, hotels and other coastal structures, undermines roads, contributes to the loss or degradation of valuable land and disrupts fishing, navigation, recreation and other activities. In economic terms, the public and private costs of coastal erosion are enormous. Millions of rupees are being spent annually to cope with the loss imposed by coastal erosion, while millions more are being spent on measures to reduce coastal erosion. These costs, however, do not reflect the personal losses, disruption and inconveniences imposed by coastal erosion (Anon, 1990a).

The impact of coastal erosion is most severe along Sri Lanka's western and southwestern coasts. It has been estimated that along the coastal segment extending about 685 km from the Kalpitiya to the Yala National Park Bay, about 175,000-285,000$m^2$of coastal land are lost each year. Of this amount, about 95,000-160,000 m^2 are lost annually from the 137 km segment that extends from the mouth of the Kelani River Oust north of Colombo) to Thalawila (Kalpitiya Peninsula) (Anon,1990a).

Coastal erosion in Sri Lanka is not new. Legends and narratives of coastal related erosion go back over 2,000 years, including references in the historical chronicle Mahavamsa. However, the retreating coastline was first viewed as a problem when large numbers of people began to settle and build in the coastal areas during the early part of this century. In the 1920's, there was concern about protecting Sri Lanka's coastline from erosion and construction of coast protection works began. Since then, the primary means of combating coastal erosion has been to construct revetments and groins. However, by the 1970's erosion control came to be regarded as constituting part of a broader programme of coastal resources management. Coastal erosion is the result of powerful natural forces that

humans can only partially control. Most shoreline protection structures only buy time, and sometimes make the problem worse. Approaches to managing coastal erosion that are based upon understanding the physical processes that cause erosion and working with, rather than against nature, are emerging around the world. Such approvals and understanding are even more important now if sea level rise becomes a reality.

The susceptibility of any length of shoreline to erosion is determined by its lithology and geomorphology, its exposure to the natural processes of waves and wind, and the availability of sediment to replenish it. Shoreline erosion is severe along most of Sri Lanka's shoreline but the country is fortunate in having important natural defenses against erosion. Although annual monsoons regularly cause severe erosion in some locations, small waves and weak variable winds prevail most of the time. The more devastating cyclones are infrequent events that occur once in ten to fifteen years.(Dayananda, 1992; Swan,1983).

Most of the coast consists of gently sloping shores composed of beaches that, when left undisturbed, form an effective first line of defense against the sea, dissipating the energy of breaking waves. Coral and sandstone reefs that parallel most of Sri Lanka's more developed reaches of shoreline act as natural breakwaters, sheltering the adjacent shore from large waves.

Despite these favorable circumstances, most of Sri Lanka's shoreline is retreating. In several locations, the rate of retreat has increased due to human activities. The proportion of each coastal sector that is retreating and in some cases accreting is presented in Table 4.1 and Figure 4. 1.

It is important to recognize that erosion is highly localized and within each coastal sector there is wide variation in erosion and accretion rates. Whether erosion of the shoreline is a problem depends primarily on the adjacent land uses. However, the rate of coastal erosion in Sri Lanka is not unusual when compared to world trends.

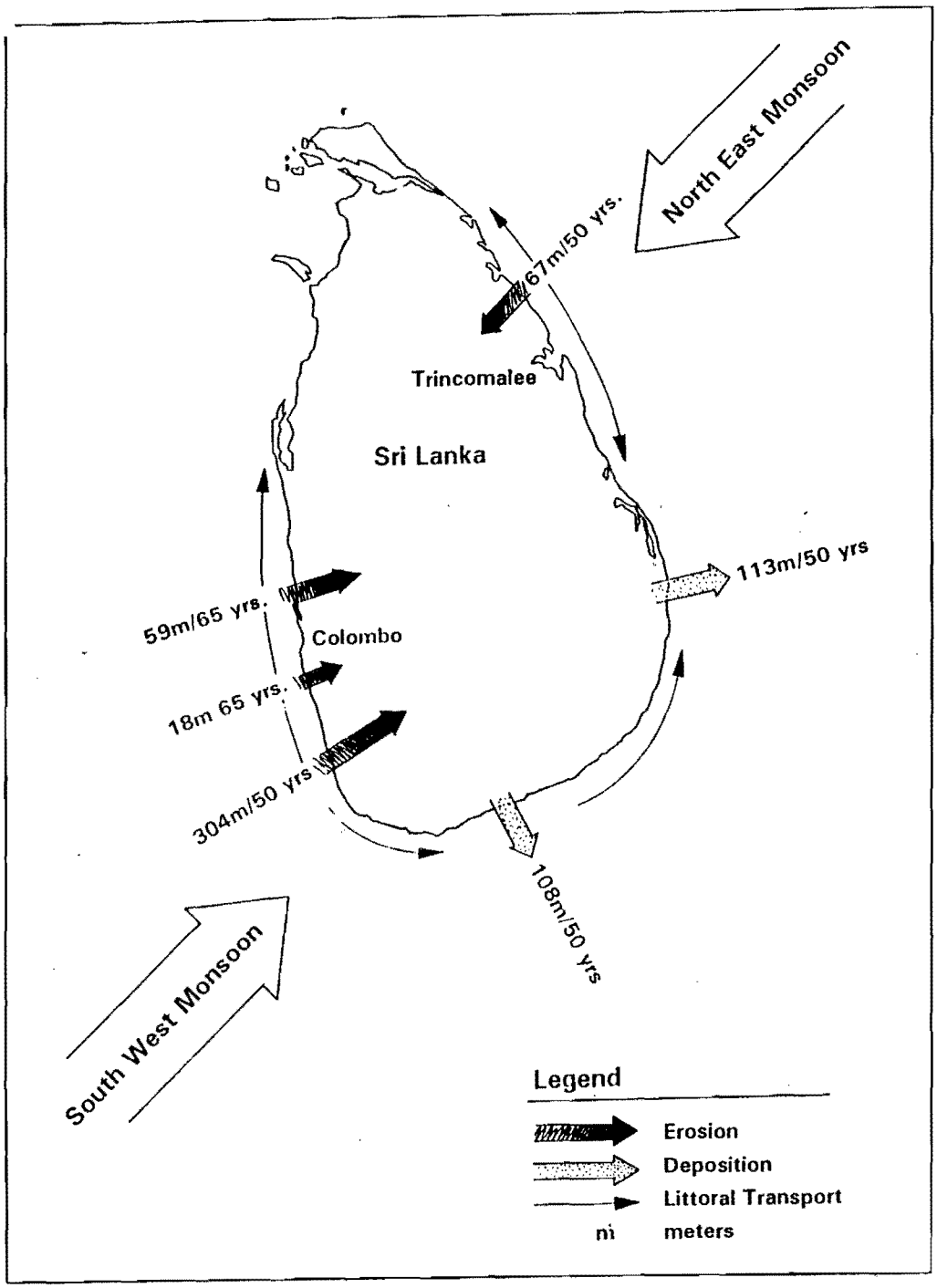


Figure 4.1. Erosion rates on southwest coast in 1995
(Source: Anon, 1997)

Table 4.1 Coastal erosion and accretion rates in Sri Lanka

(Source: Anon,1986a)

Sector	District	Coastline in km	Erosion, percent of coast	Erosion rate m/year	Accretion, percent of coast	Accretion rate m/year	Net erosion m/year	Net loss 100 m^3/year
West	Puttalam	300	30 - 40	0.3 - 0.4	30 - 60	0 - 0.1	0.2 - 0.4	60 - 120
	Gampaha	40	45 - 50	N.A - 1.0	10 - 20	0 - 0.1	0.9 - 1.0	35 - 40
South West	Colombo	40	20 - 25	0 - 0.1	N.A	N.A	0 - 0.1	0 - 5
	Kalutara	40	70 - 80	0.1 - 0.5	20 - 30	0 - 0.1	0 - 0.4	10 - 20
	Galle	75	60 - 65	N.A - 0.3	0 - 10	0 -0.1	0.2 - 0.3	10 - 20
South	Matara	55	N.A- 88	0.9 - 1.0	N.A	N.A	0.9 - 1.0	40 - 50
	Hambantota	135	40 - 50	N.A - 0.2	10 - 20	0-0.1	0.1 - 0.2	20 - 30
East	Amparai	110	40 - 50	N.A - 0.2	10 - 20	0-0.1	0.1 0.2	20 - 25
	Batticaloa	100	N.A- 60	0.1 - 0.2	N.A- 20	0-0.1	0 - 0.2	10 - 20
North East	Trincomalee	210	N.A- 40	N.A - 0.2	10 - 20	0.2 - 0.3	N.A - 0	10 - 0
	Mullaitivu	50	20 - 30	N.A - 0.2	0 - 20	0.2 - 0.3	0 - 0.1	0 - 10
North	Jaffna	275	60 - 70	N.A - 0.3	0 - 20	0.1	0.2 - 0.3	30 - 90
	Mannar	155	60 - 70	N.A - 0.5	0 - 20	0.2	0.3 - 0.5	70 - 80
All Country		1,585	45 - 55	0.30 - 0.35	10 - 25	0 - .15	0.2 - 0.35	300-500

N.A. Information not available

Note: Figures should be treated as indicative because of site specific variations which cannot be accounted for in broad coastal segments; figures for southwest coast were updated by CCD in 1995

4.1 Causes for erosion

4.1.1 Natural Processes and Sea Level Rise

All shoreline systems are dynamic. Moving water and air carry material from place to place, eroding and depositing, constantly changing the shoreline. In the short-term, these changes are in response to storms, waves, currents and human activities. If in any location erosion is not balanced by accretion, the shoreline retreats. In the long-term, shoreline retreat is a response to changes in sea level (Swan,1983). Storms can result in sudden and dramatic changes to a beach. However, in many instances, such changes are only seasonal and the beach will recover after a period of calm weather. Waves, wave induced currents and other sea currents (e.g. tidal) are dominant natural processes which cause sand

transport in the foreshore and under certain conditions, coastal erosion. Therefore, these processes have to be known and understood in order to predict shoreline development trends a to design coast erosion management schemes. The structural design of coast defence structures is based on the wave loads as well as on tidal and current conditions. Therefore a substantial knowledge of the wave climate including that of statistical distribution of characteristic wave parameters is of great importance in coastal engineering.

A comprehensive directional wave measuring programme was carried out at the South coast of Sri Lanka during the period February 1989 to September 1996. The data demonstrates the importance of directional wave climate studies as the waves at the south and west Coast are characterised by two different wave systems. These are the long period swell from almost due south in deepwater throughout the year, with small differences of the wave heights, and the other is the shorter period sea waves which are generated as result of the local monsoon winds. It was realized that particularly at the south west coast a small variation of the mean wave direction can result in different nearshore conditions and even an opposite net longshore drift.

Growing beaches and shorelines are fed or nourished by material that has been transported from some where else. Sources of beach sand in Sri Lanka include river-borne sediment from inland areas, sediment from eroding coastal features, offshore sand brought onshore by waves and currents, and broken seashells and corals. Attempts to reduce erosion in one area often result in reduced deposition and possibly increased erosion in adjacent areas.

Over the long-term, shoreline retreat occurs in response to rising sea level. During the last major ice-age about 18,000 years ago, the sea level fell an average of about 100 m worldwide. As the glaciers melted, the sea level rose, and despite short-term and local reverses, it is continuing to rise today. While scientists are not in complete agreement as to the current rate of the sea level rise, it is known that the sea level is now rising faster than in the past. Recent estimates of global mean sea level rise vary from 0.3 to about 1 meter or 1.0 mm - 1.5 mm per year during the next century. This will have significant effects on

low lying coastal areas resulting in shoreline retreat, erosion, flooding and salt water intrusion.

Barrier spits are located at most river outlets along the coastal reaches of the country, especially from Hambantota to Chilaw. These barrier spits average 1.0 m - 2.0 m above MSL, and are natural barriers against salt water intrusion in time of dry weather and low runoff. A rise in the sea level will erode these spits and allow additional salt water intrusion both upstream of rivers and via the ground water table (Perera and Ellepola, 1992).

4.1.2 Human Activities

While coastal erosion is caused by natural processes, a variety of human activities may add to the problem. Human activities that are contributing significantly to erosion of some segments of Sri Lanka's coast are summarized in Table 2.2.

4. 1. 3 Sand Mining

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 river bed 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 can contribute to shoreline erosion and beach retreat by cutting the sand supply to downdrift beaches. Determining the sand budget for any particular reach of shoreline and the role of different sand sources in maintaining beach stability requires site specific hydrographic and geophysical measurements. Such information is critical for determining the amount of

sand that can be taken from an area without causing erosion problems either at the site or at downdrift locations.

Table 4.2 Activities contributing to coastal erosion in Sri Lanka (Source: Anon, 1997)

Causal Agent	Process	Effect	Examples
Beach sand mining	Reduction of sand in beach maintenance system threatening renewal	Increased erosion	Panadura, Lunawa, Angulana and Palliyawatta
River sand mining	Reduction of sand in beach maintenance system threatening renewal	Increased erosion of adjacent beaches and of river banks	Kalu Ganga, Kelani Ganga and Maha Oya
Inland coral mining	Conversion of productive land into waterlogged area	Development of inland waste dumps and abandoned pits, reduction of coastal stability by creation of low-lying areas	Akurala, Kahawa, Ahangama and Midigama
Collection of coral from beaches	Reduction of beach nourishment material	Increased erosion	Ambalangoda to Hikkaduwa, Midigama, Ahangama and Polhena
Reef breaking or dynamiting for mining or fishing	Reduction of reef size, creation of gaps in reef	Increased wave energy on beaches resulting in erosion	Ambalangoda to Hikkaduwa, Koggala, Midigama, Polhena, Rekawa, Pasikudah, Kuchchaveli and Nilaveli
Improperly sited groins, harbours, revetments, jetties	Interference with natural sand transport processes	Erosion in some places, accretion in others	Beruwala and Kirinda Fishery Harbours
Improperly sited coastal buildings	Interference with dynamics of coastal processes	Loss of structures, other impacts due to retreat	Hikkaduwa, Bentota, Beruwala, Negombo
Removal of coastal vegetation	Exposed area subject to more rapid rates of wind erosion	Erosion, retreat	Palliyawatta, Koggala, Polhena, Negombo

The erosion of the river banks 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 to30 million per annum or Rs. 9.00 per m^3 of sand mined (Anon,1992).

The ongoing recession and depletion of sand in the river beds 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 socio-economic issues related to coastal sand mining from Puttalam to Dondra Head conducted by the CCD in 1984 was updated in 1991 (De Alwis, 1991; Anon 1984). 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. The sand extracted by site in 1984 and 1991 from the rivers and the coastal zone is quantified in Table 4. 3 (De Alwis, 1991).

River sand is preferred for construction activities and approximately 92 percent of the sand mined (1991) comes from the rivers. The Kelani Ganga and Maha Oya are the largest sources of river sand and together account for 77 percent of the river sand harvested in the study area. The above study further revealed that shoreline mining provided 48,724 cubes of sand in 1991, with most mining concentrated between Talpitiya and Panadura.

Table 4 .3 Location and estimated volume of sand mining (Puttalam to Dondra Head
(Source: Anon,1984; Anon,1990a; De ALwis, 1991)

Location	Number of landing sites 1984	Number of cubes* removed 1984	Percent of total	Number of land-ing sites 1991	Number of cubes* removed 1991	Percent of total	Change
River Sand							
Deduru Oya	2	22,896	4.00	9	2,841	0.5	-20,055
Maha Oya	61	111,720	21.00	122	221,242	35.4	+109,522
Gin Oya	2	79,445	15.00	5	4,652	0.7	-74,793
Kelani Ganga	181	222,771	43.00	427	226,240	36.1	+3,469
Kalu Ganga	67	46,667	9.00	1[illegible]	46,010	7.3	-657
Madu Ganga	2	799	0.30	[illegible]	4,384	0.7	+3,585
Gin Ganga	41	21,563	4.00	101	70,557	11.3	+48,994
Nilwala Ganga	7	2,005	0.70	3	1,012	0.2	-993
Sub Total	363	507,866	97.00	844	576,938	92.2	+69,072
Sea Sand							
Ratmalana-Walauwatta	5	768	0.10	5	2,184	0.3	+1,416
Ratmalana-Weliwatta	3	2,592	0.50	3	1,820	0.3	-772
Lunawa	3	576	0.10	3	8,424	1.3	+7,848
Egoda Uyana	3	672	0.10	--	--	--	--
Lunawa Beach Road	1	240	0.05	1	5,616	0.9	+5,376
Angulana	8	1,716	0.30	8	2,496	0.4	+780
Panadura	2	1,080	0.20	2	11,648	1.9	+10,568
Nalluruwa	15	3,756	0.70	15	1,820	0.3	+1,936
Talpitiya	6	2,988	0.60	6	7,800	1.2	+4,812
Malanwatuna	3	1,422	0.30	3	2,912	0.5	+1,490
Madampagama	1	104	0.03	--	--	--	--
Wellawatte-Hikkaduwa	2	392	--	--	--	--	--
Hediwela	--	--	--	1	1,092	0.2	--
Mirissa South	--	--	--	2	1,092	0.2	--
Wellamadama	--	--	--	3	1,820	0.3	--
Sub Total	50	15,914	3.0	52	48,724	7.8	+33,454
Grand Total	413	523,780	100		625,662	100.0	+102,526

* Cube equals 100 cubic feet or approximately 3 cubic meters

Between 1984 and 1991 the consumption of river sand increased by 13 percent and consumption of sea sand increased 200 percent. However from the total sand extracted from river sources only 6 percent is from areas under CCD jurisdiction while the other 94 percent is extracted from outside the coastal zone. Due to the enforcement of CCD regulatory measures on sand removal in lower reaches of river basins, the operators have shifted their illegal sand mining to the beach.

4.1.4 Coral Mining

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 (Anon,1990a; Hale and Kumin, 1992).

In 1984, an excess of 18,000 tons of coral 1985 was extracted in the coastal reach between Ambalangoda and Dickwella (Premaratne,1985). 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 4.4). 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 (De Silva *et al.*, 1991; Ranaweera Banda , 1994).

Table 4. 4 Coral collected from Sri Lanka's southwestern coastal sector, 1984 and 1994 (Source: Premaratne,1985; Ranaweera Banda,1994)

Location	Amount (tons) 1 984	Percent of total	Amount (tons) 1 994	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

4.1.5 Improper Location or Construction of Maritime Structures

Throughout the world, the effect of shoreline protection works as a means of slowing shoreline retreat has not been satisfactory. The complexity of the coastal forces, and an imperfect understanding of erosion processes in a specific area, often cause shoreline protection efforts to produce only short-term improvements. They can make the long-term situation worse. Poor results often occur when coastal works are constructed in response to an emergency and when there is an insufficient understanding of natural process prevailing at a specific site.

Other maritime structures such as fishery harbours and river outfall training schemes, unless carefully planned, can also aggravate or cause coastal erosion in adjacent areas. Unless the design of these structures is based on a sound understanding of natural processes prevailing at a site, they can, apart from causing downdrift erosion, fail to meet the objectives for which they are originally planned. Examples of such failures in Sri Lanka include fishery harbours that have silted up in a short period of time and river training works that have caused accelerated erosion of adjacent coastal areas.

In Hikkaduwa and Negombo, the construction of vertical or steeply- faced sea walls too close to the waterline has resulted in erosion. Although constructed to provide upland protection they have had the opposite effect. This is because vertical walls in areas where there is significant wave action, accelerate beach erosion. Much of the energy of waves breaking on the structure is redirected downward to where the wall meets sand or earth or reflected, and erosion is increased. The reflected energy creates a scouring action near the toe of the structure and may cause the undermining and eventual collapse of the structures.

4.1.6 Removal of Coastal Vegetation

Vegetation, particularly in undisturbed environments, provides important protection to coastal land. Roots and stems trap fine sand and soil particles, forming an erosion-resistant layer once the plants are well established. Vegetation also inhibits runoff and reduces siltation that can destroy coral reefs (Sullivan *et al*, 1995). In marshes and mangrove swamps, vegetation absorbs some of the water's energy, slowing down potentially erosive currents. Clearing coastal vegetation removes this natural protection and, therefore, frequently contributes to coastal erosion. The planting of appropriate vegetation in eroding areas provides protection against erosion but does not, assure protection against major storms.

4. 2 Present strategies for erosion control

Management of human activities and development along an eroding shoreline is difficult. Often,, it is not possible, to protect life and property from erosion-caused destruction. Coastal dwellers, however, demand that their property be safeguarded from the ravages of coast erosion. To meet these demands, the best option is to adopt a multifaceted management strategy that goes beyond the traditional approach of building shoreline protection structures to inhibit erosion. Elements of such a strategy include (Anon, 1990a).

*Use erosion control techniques that are cost effective and socially and environmentally acceptable;

*Direct new development away from eroding shoreline;

*Require new construction in erosion prone areas to be setback from the shore a sufficient distance
so that it will not be threatened by erosion for some time;

*Regulate of human activities which contribute to accelerated erosion, such as coral and sand
mining (regulations must recognize the socio-economic dimensions of the activities, as well as their
impacts on the shoreline);

*Protect, and where possible, restore of natural features that inhibit erosion.

Erosion management activities of CCD consist primarily of installation of shoreline protection structures, use of setback lines and directing development away from eroding areas through the implementation of a regulatory system. A discussion of shoreline protection structures follows.

Sri Lanka has made significant financial investment in protecting its shoreline. More than 3 73 million rupees since 1970 have been invested in the most commonly used shoreline protection structures of revetments and groins. In addition, sand nourishment has been utilized in restricted areas. Existing lengths of shoreline protection works are summarized by coastal sector in Table 4.5.

Table 4. 5 Length of existing effective shoreline protection works

(Source: Anon, 1997)

Coastal Sector	Total length (meters) 1 996
Revetments	
West coast	**5,633**
Southwest coast	**25,698**
South coast	**3,920**
Total	**35,271**
Groins	
West coast	**2,135**
Southwest coast	**2,912**
South coast	**663**
Total	**5,710**

A revetment provides protection only to the length of the coastline it covers, and a groin, if effective, to about three times its length. Hence, all the protective structures so far built in these sectors provide effective protection only to approximately 52 km of coastline; whereas approximately 270 to 380 km of coastline in these sectors are considered erosion prone areas. Thus investment in structures protects only between 18 and 25 percent of the shoreline that requires protection.

4.2.1 Solutions for Managing an Eroding Shoreline

4.2.1.1 Short-term Solutions

Coastal erosion-may occur irrespective of geographical location, time and season. In such instances a short term solution may be adopted to curtail the emergency situation in the absence of long term beach stabilization schemes. Because of the need to protect life and property from emergency situations, the CCD may implement short term solutions depending on the site specific problem. The potential impact of such solutions on the adjacent areas have be taken into account from the coast conservation perspective, before such protection works are undertaken. In providing short term solutions for emergency situations, CCD will

give priority to protection of public property. However, CCD may allow any private or other public agency to implement short term coast protection measures in compliance with CCD criteria and guidelines. Examples of such short term measures are sand bag protection, gabion revetments, boulder revetments and upland protection by dumping graded material.

4.2.1.2 Long-term Solutions

Long term solutions are planned coastal stabilization schemes formulated on the basis of coastal engineering information. This process involves comprehensive research, time, expertise, planning, funding and political acceptance. As a long term solution for coastal erosion, CCD developed a Master Plan for Coast Erosion Management in 1986.

a) Master Plan for Coast Erosion Management

The Master Plan for Coast Erosion Management (MP-CEM) was prepared with the assistance of the Danish Government (DANIDA). The MPCEM identifies erosion prone sites along the coast where structural solutions to the erosion problem are appropriate. Two coast protection schemes Negombo and Moratuwa, have been completed under "DANIDA Stage One" (1987-1989) stabilizing 16 km of coast at a cost of Rs. 322 million. The Negombo scheme (7 km of coastline) consists of 400,000 cubic meters of beach nourishment, 4 offshore breakwaters, and 2 groins, while the Moratuwa scheme (9 km of coastline) consists mainly of the construction of some 5000 meters of revetments including rehabilitation of existing revetments. Under the "DANIDA Stage Two" (1 990-1992), a further Rs. 520 million was spent to undertake schemes to protect the main coastal road between Beruwala and Weligama at points where it is threatened by erosion.

The German Technical Assistance Agency (GTZ) has also provided assistance for strengthening the CCD database on the coastal situation and CCD's capacity for wave measurement; pilot projects for coast protection; equipment; maintenance and structures and environmental education and training. The GTZ provided Rs. 120 million in the stage 1

(1990-1991); Rs. 90 million in stage 11 (1991-1993) and Rs. 90 million in stage 111 (1994-1995) (White and Wijeratne, 1993).

Commencing in 1986, the Government of Sri Lanka planned to invest, with bilateral assistance, more than Rs 1,200 million to implement the recommendations of the Master Plan for Coast Erosion Management (Anon,1986a). This expenditure provided protection to a total of 155 km of Sri Lanka's coastline. This still leaves 160 to 225 km of erosion prone coastline in western, southwestern and southern areas where coast erosion will have to be accepted as a given. Here development activities and human settlements need to be planned accordingly.

b) Non-structural solutions

The Coastal Zone Management Plan has clearly identified the necessity of adoption of structural and non-structural solutions to curb the erosion problem. However, in the implementation of the Master Plan for Coast Erosion Management more emphasis has been given to structural solutions. The implementation experience of the CCD revealed that structural solutions alone will not curtail the coastal erosion problem in full. Therefore it is important to place more emphasis on adoption of non-structural solutions to achieve the desired objectives. In the long term, the non-structural solutions will be more cost-effective and more economically, socially and environmentally viable. In this phase of the coastal zone management more attention is given to the non-structural solutions. These include land acquisition, transfer of development rights, implementation of setback standards, regulating sand and coral mining activities and enhancement of community awareness through education.

4. 3 Participatory approaches required for better management of the coastal erosion control

Objective 4. 3.1 **Ensure that the location of development activities in the coastal zone does not contribute to or aggravate erosion and that development does not occur in hazardous areas .**

Policy 1 New construction may be permitted only in accordance with the setback standards set forth

Actions

1 . Enforce coastal setback standards.
2. Conduct annual permit compliance monitoring surveys.
3. Institute legal action against non compliance of stipulated setback conditions.
4. Build awareness of setback regulations.

Policy 2 Minimize adverse impacts due to construction of maritime structures such as piers, Jetties, breakwaters and recreational facilities within the coastal zone.

Actions

1. Formulate and implement guidelines governing the location and construction standards of maritime structures within the coastal zone.

Objective4. 3. 2 **Ensure that sand mining within the coastal zone does not contribute to unacceptable levels of coastal erosion .**

Policy 1 Sand mining shall be regulated by means of guidelines specifying quotas, time limits, setbacks, site rotation and the imposition of monitoring schemes.

Actions

1. Enforce guidelines specified in the CZM Plan.
2. Undertake periodic monitoring surveys of sand mining.

Policy 2 Research shall be conducted to define sustainable limits and site specific sand budgets, and to identify alternative sources of sand to meet the requirements of the construction industry.

Actions

1. Implement recommendations made by the National Sand Study.

Objective 4. 3. 3 Identify the coastal erosion trends and formulate appropriate mitigation measures that are cost effective and socially and environmentally acceptable.

Policy 1 Carry-out the coast protection programmes consistent with the updated Master Plan for Coast Erosion Management (Anon, 1997).

Action

1. Update the Master Plan for Coast Erosion Management for identification of erosion-prone areas and design strategies to manage them
2. Conduct and support research on coastal processes relating to erosion and its control, including investigating the feasibility of using soft solutions to control erosion.

Policy 2 Shoreline protection schemes implemented by public or private entities other than the CCD may be permitted if consistent with CCD guidelines.

Actions

1. Formulate guidelines and criteria to allow for the construction of private coast protection works in compliance with Master Plan for Coast Erosion Management.
2. Prepare monitoring plans with the project proponent to determine impacts of such measures.

Policy 3	Support action to minimize the social and economic impacts caused by the prohibition of coral mining.
Actions	1. Co-ordinate inter-agency efforts to provide alternative employment to displaced coral miners.
Policy 4	Carry out a land acquisition and development rights purchase programme as a soft solution for managing vulnerable coastal stretches where necessary.
Actions	1. Conduct a survey to identify potential sites for acquisition or purchase of development rights; 2. Develop financial mechanisms for a land acquisition and development rights purchase programme.
Policy 5	Promote the collection of scientific information on coastal erosion rates and trends.
Actions	1. Collaborate with universities and other concerned agencies to assess erosion trends and patterns. 2. Establish fixed locations to monitor erosion trends.
Policy 6	Encourage the collection and use of scientific and socio-economic information required to update the CZM plan.
Actions	1. Establish and develop a comprehensive database on coastal processes and socio-economic characteristics. 2. Collect, store, disseminate and exchange data with public and private agencies for research and planning purposes.

Objective 4. 3. 4 **Minimize the negative impacts of coastal erosion and possible sea level rise by reclaiming suitable coastal frontages to ensure additional buffers** (Anon, 1997).

Policy 1 Promote measures to expand the existing coastal front, thereby providing additional buffers against sea erosion and possible sea level rise.

Actions

1. Prepare guidelines on coastal reclamation.
2. Identify potential reclamation sites, prioritize the most vulnerable places, and prepare reclamation plans.

Objective 4. 3. 5 **Enhance, economic potential of coastal frontages and their capacity to withstand erosion, by implementing development schemes based on coastal reclamation, at sites where such reclamation will not have adverse environmental consequences** (Anon, 1997).

Policy 1 Enhance the economic potential and ability to withstand erosion of selected coastal reaches by implementing environmentally acceptable reclamation schemes.

Actions

I. Encourage development consistent with this objective.

2.Implement reclamation schemes at sites where protection costs can be recovered through developments consistent with this objective

CHAPTER 5

BIODIVERSITY OF THE MARINE AND COASTAL ECO-SYSTEMS

5.0 Introduction

The marine and coastal zone of Sri Lanka supports highly productive ecosystems such as fringing coral reefs and shallow bed of coastal and estuarine sea grasses. Other marine and coastal habitats comprise an extensive system of estuaries and lagoons, mangroves, salt marshes, sand dunes, beaches, coastal marshy wetlands and other water bodies. All these habitats are rich in biodiversity with endemic, indigenous and common species of flora and fauna .

In the coral reefs of the country , a total of 68 indigenous coral genera and 183 species have been recorded to date. The common coral genera are *Acropora, Echinopora, Montipora, Porites, Favia, Favites, Pocillopora, Goniastrea, Platygyra* and *Leptoria.* Invertebrates that occur among reefs consist mainly of molluscs, sea anemones and sea cucumbers. Marine algae, including *Halimeda* spp., are found on sandy patches and coral rubble between live coral. Coral reefs may also support around 350 species of reef fishes, such as groupers, snappers, sweetlips, emperor fish, parrot fish, rabbit fish, surgeon fish, butterfly fish, and damsel fish. Several species are harvested in the ornamental fishery, and some, such as *Chaetodon bennetti, Chaetodon unimaculatus* and *Balistoides conspicellum, have* small populations though widely distributed.

Off.shore fish species include large predatory fish such as the black-tip reef shark and the white-tip reef shark, and food fish such as tuna, seer and skipjack. These waters also contain about 37 species of cetaceans, including 20 species of dolphins and the sperm and blue-whales. The dugong is also present in Sri Lankan waters, but is considered rare, and sightings have been made mainly off the Kalpitiya coast.

The shoreline and near-shore areas contain a variety of marine habitats, including seagrass beds. Among the invertebrate fauna are 201 species of crabs. There are five species of turtles that come ashore for nesting on Sri Lankan beaches. The fauna of the lagoons and estuaries are economically important. They include about five

annelids, 28 molluscs and 25 arthropods, none of which is endemic. Sri Lanka has also been known over the years for its pearls from the pearl oyster beds located in the northwestern coast of the island, but these are now much reduced due to over-harvesting and siltation. The mangrove areas are discontinuous, but are important breeding grounds for marine organisms. The flora found here comprise both true mangroves and mangrove associates, and some are limited in distribution to specific parts of the coastline. Sri Lankan beaches vary in size and type. Many are wide and sandy and have high potential for tourism. They also support a distinct littoral sandy shore fauna and flora.

5.1 Marine and coastal bio-regions and biodiversity

The climatic and geomorphological variations in the country have resulted in a clear demarcation into broad climatic, floristic and faunal zones which help in the classification of bio-regions (Anon, 1998). Coastal bio-regions are included from 8 - 15 (Fig. 5.1). Their basic information is given in Table 5.1 and the following is a description of some regions where information is available.

Bio-region 11 (-near-shore coral beds)

This bio-region covers a 22.2 kin (12 nautical miles) wide marine area and a 300 in coastal belt from Hikkaduwa to Tangalle in the districts of Galle and Matara. This region covers a belt of coral reefs which, though relatively narrow, is important due to its proximity to the coast and the richness of its fauna and flora. These reefs are of importance in the tourist industry, and because of easy access they have been well studied. The dominant species of coral found in this area belong to the families Acroporidae, Faviidae, Poritidae, Mussidae, and Pocilloporidae. Most shallow water, near shore reefs are dominated by *Acropora sp., Montipora sp., Porites sp., Favia sp., Favites sp., Echinopora lamellosa* and species of *Pocillopora, Platygyra* and *Goniastrea.* A typical near-shore reef in this area supports 40 to 50 species of coral. The marine plants in the coastal waters of this region include many species of algae found on sandstone coral reef or rock formations. There is large scale destruction of the coral reefs for the lime industry, and several tons of live coral are collected annually from this area. This region is also famous for the beach seine fishery and the

characteristic wide sandy beaches which are a popular tourist wide sandy beaches which are a popular tourist attraction. The Hikkaduwa marine sanctuary is situated in this region.

Bio-region 13 (western ***marshes)***

This bio-region covers a 300 m wide inland strip and extends 22.2 km offshore, stretching from Kandakuliya to Chilaw, in the district of Puttalam. It includes mangroves, mud flats, sand dunes and a system of lagoons. This area is important in terms of the estuary ecosystems, in which the faunal biodiversity is not high, but is of considerable economic importance.

This region is critical because of its economic significance in aquaculture development, which has led to the extensive exploitation of coastal wetland habitats for the establishment of prawn farms.

Bio-region 14 ***(large*** off-shore ***coral*** reefs)

This covers a 22.2 km wide marine area and a 300 m coastal belt from Mannar to Kandekuliya in the districts of Mannar and Puttalam. It has some of the largest and well developed offshore coral reefs of this country, including the Bar Reef marine sanctuary which contains intact coral reefs and sandstone habitats, and harbours dolphins and turtles. Off-shore coral patches in this region may extend 100 m or more across and are usually found beyond a distance of two kilometres from the shoreline. Although much of the larger coral reefs in this region are spared of excessive destruction, some are severely degraded due to adverse fishing methods and feeding by the Crown- of- Thorn starfish. This region is also important due to its fringing mangrove vegetation and an extensive shallow lagoon system including Portugal Bay, Dutch Bay and the coastal areas of the Wilpattu National Park. Sea turtles are caught regularly in this area. It is also important due to its abundant fish stock and habitats for diverse fauna. The fauna include juvenile and adult fish and many species of commercially important invertebrates including the spiny lobster and crabs. This region also contains extensive sea grass beds that are the habitat of the endangered dugong.

There is an urgent need for management of activities connected with fishing practices by both national and foreign trawling vessels, and for stringent measures to conserve the valuable coral reefs of this region.

Table 5.1

Basic information of the marine and coastal bio-regions (Source: Anon, 1998)

8	Kathiraveli to Mullaitivu (mineral sands)	Coral reefs and rocky habitats (comparable to bio-region 9), mangrove habitats, lagoons and estuarine systems (Trincomalee), and mineral sands (Mullaitivu area). Large marine mammals (whales) present. Important for fisheries.
9	Panama to Kathiraveli (eastern lagoon systems)	Near-shore coral reefs (relatively extensive but less than in bio-region 14). The Great and Little Basses reefs, mangrove habitats associated with lagoon systems, multiple lagoons and estuarine systems (Batticaloa). Important for fisheries and has minimal human interference (Panama to Kalmunai).
10	Tangalle to Panama (wildlife habitats)	Rocky and sandstone habitats, shield lagoons and estuarine deltas (Tangalle to Ambalantota), extensive sand dunes (Ambalantota to Dorawa Point), and large lakes and lagoons (*lewayas*). Conservation areas including national parks and turtle nesting sites. Coastal wetlands include a RAMSAR site, and salt production in *lewayas*.
11	Hikkaduwa to Tangalle (near-shore coral beds)	Rocky and near shore coral reefs and pockets of mangrove habitats (Koggala, Polwattu modhara in Weligama). Important for fisheries and tourism. Coral beds over-exploited for the lime industry, coastal erosion.
12	Chilaw to Hikkaduwa	Coastal marshes and lagoon systems. (Chilaw to Peliyagoda), pocketed mangrove habitats (Chilaw, Bolgoda, Panadura, Kalutara, Bentota), and sandstone rocky habitats and sandstone reefs (Galle Face to Mt Lavinia). Beach seine fishery, tourism associated with sandy beaches, and high human population density.
13	Kandakuliya to Chilaw (western marshes)	Coral reefs, sandstone reef habitats, swamp marshes, lagoons and associated mangrove ecosystems (Puttalam), important for fisheries and prawn farming.
14	Mannar to Kandakuliya (large off-shore coral beds)	Extensive coral reefs, sandstone reef habitats, sand dunes, mud flats, salt marshes (Kalpitiya), and limestone rich soil. Dugong sightings.
15	Mullativu to Mannar (limestone beds)	Coral reefs lie off-shore (north of Jaffna Peninsula). Sandstone reef habitats, limestone rich soil, shallow-wide continental shelf, salt marshes, lagoon systems, associated mangrove habitats (Jaffna), and sand dunes. Fish resources unexploited for the past decade.

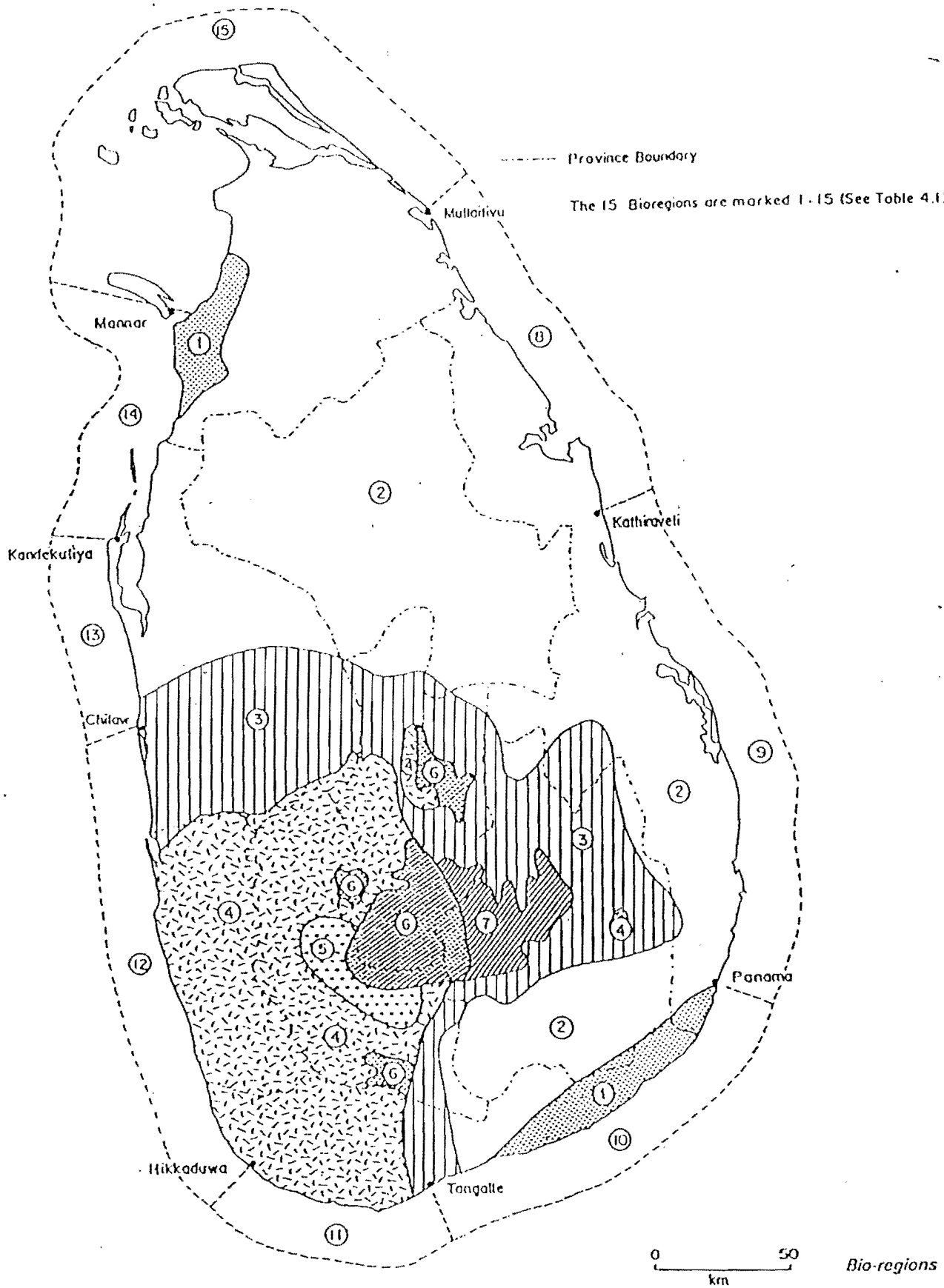


Fig. 5.1 Bio-regions of Sri Lanka

(Source: Anon, 1998)

5. 2 Threats to marine and coastal biodiversity

Fisheries is a major activity affecting marine biodiversity in the coastal waters of Sri Lanka. Fish supply is important in terms of food and income, and it has continued to increase in recent years. As a result, many nearshore waters are now over-fished or at their maximum levels of exploitation. Another development is the increased mechanization and modernization of the fishing industry. The capture techniques adopted include the use of trammel nets and purse seines. There is also the use of explosives to catch fish, and this destroys biodiversity. Bottom set nets used to catch reef fish destroy the habitat, and nylon gill nets used to catch food fish are death traps to turtles and small marine mammals. Blast fishing in particular affects coral reefs. With the use of large multi-day motorized crafts with insulated fish hold facilities, the catches are much larger than in the past, and there is a much increased catch of marine mammals encountered in the deeper waters. As a result, some species of dolphins are now considered threatened in Sri Lankan waters. Fishing by local and foreign trawlers that use bottom-set nets and long drift nets may also affect biodiversity.

Resources within lagoons and estuaries have been over-used for fishery and shrimp culture. There is also uncontrolled use of these sites for anchorages of boats. Sand mining, siltation, as well as dumping urban wastes and chemical pollutants from agricultural farms and industries in estuaries are the other major problems. Seagrass beds, which support a rich flora and fauna and are breeding grounds for marine fish have been damaged due to destructive fish harvesting techniques.

Brackishwater shrimp culture is an industry that earns over a billion rupees in foreign exchange annually. It has, however, caused considerable loss of coastal wetlands since 1980 due to encroachment and pollution by the establishment of mariculture ponds covering an area of over 2000 ha. Other adverse effects are disruption of nutrient chains and increased salinity of waterways resulting in biodiversity loss. Abandoned shrimp farms in the form of barren land with no topsoil are an eyesore and may become breeding grounds for many vectors of diseases. Mangroves are destroyed for expansion of human settlements (much of its as encroachments) and for expansion of aquaculture. Poles and fuelwood for domestic use and twigs for brush-pile fishery are also extracted from the mangroves. The mangrove swamps are,

therefore, fragmented, heavily exploited by local people, and degraded by water pollution and siltation. It is estimated that the current mangrove habitat will be reduced to half by the year 2001. Despite the efforts taken by NG0s to re-establish mangrove habitats and to create awareness about this resource, little progress was made in the past to conserve mangroves on the southwestern coast.

The increased allocation of coastal zone lands especially in the south and southwest coast, for hotels is also a serious problem. There is also a proliferation of slums and shanties in certain sections of the coast. With the projected increase of urban populations by the 21st century, it is evident that most shorelands of the country will be converted to other uses. Much of the biologically diverse shorelands are state owned, but inadequacies in the law and poor enforcement contribute to habitat loss. Effluents discharged from urban industries near natural water bodies also destroy biodiversity.

The Lobster. resource in the southern coast has been depleted due to indiscriminate harvesting of gravid females and juveniles. While laws are present to prevent such activities, their enforcement has to be strengthened. A study is currently in progress to assess the gravity of this problem so that remedial measures may be taken. At present the export trade in ornamental fish ranks next to that of prawns and lobsters in terms of value, and the current levels of ornamental fish collection for sale and export is widely considered to be unsustainable. Clearly, there is need for more data. The selective harvesting of rare species has caused their depletion, and the high intensity of collection disturbs the equilibrium of the reef ecosystem. The corals themselves are damaged due to the use of moxy-nets for collection of reef fish for the aquarium trade.

Naturally occurring shrimp resources in the lagoons of the northwest coast are depleted due to siltation from soil disturbed by agricultural and construction practices and deforestation inland. Silt smothers coral reefs, causes a reduction in the depth of water bodies and has a destructive effect on bottom dwelling species, For example, the pearl oyster beds that supported a lucrative trade up to the 1920s have probably been adversely affected by the silt carried down from rivers. Siltation can also be detrimental to fishery that is dependent, on clear water. Pollution from unregulated

discharge of sewage, untreated water from industries, wastes from ships, and coconut husk retting at some sites along the coast also cause destruction of coastal biodiversity.

Sri Lankan waters have seven species of edible *Holothuria* (sea-cucumber) out of 20 edible species found in the Indian Ocean. While the traditional harvesting of sea cucumber was limited to estuarine environments, the demand for this commodity for export has resulted in large numbers being collected, especially in the Kalpitiya and Batticaloa areas. It is possible that collection may prove to be disastrous to some species, especially when collection is selective. This is an area where studies are needed.

5.3 Present strategies for the management of biodiversity

The fisheries sector has traditionally sought to increase productivity without paying adequate attention to conservation and sustainable use of aquatic resources. However, due to the recent heavy decline of nearshore fish yields, there is now greater awareness of the need to conserve these resources. This has resulted in the new Fisheries and Aquatic Resources Act of 1996 addressing measures for "protection of fish and other aquatic resources" and for increased concern about the sustainable use of aquatic biodiversity in the fishery sector. A sign of the current interest in active management for conservation and sustainable use is the identification of fisheries management areas (e.g. the Negombo lagoon), and the selection of lobster management areas in the southwest followed by the preparation of management plans.

First efforts at systematic coastal resource management in Sri Lanka commenced in the early 1980s with the setting up of the Coast Conservation Department (CCD), The Coast Conservation Act of 1981 identified the CCD as the prime agency for coastal issues and gave it the mandate to survey and inventorise the coastal resources, issue permits for developmental activities in the coastal zone, and prepare management plans. The department is responsible for the conservation of natural coastal habitats and areas of cultural and recreational value and has been successful in attracting funding for its work. Programmes carried out so far include mitigating

coastal erosion, policy development and coastal resources management. The CCD is expected to co-ordinate all sectoral activities in the coastal zone, including the activities of other state departments in the fisheries, shipping and tourism sectors, the Department of Wildlife Conservation, the Forest Department, the Urban Development Authority, the Irrigation Department and the Central Environmental Authority.

A landmark event in coast conservation planning was the preparation of the first National Coastal Zone Management Plan (CZMP) in 1990. It dealt mainly with the problem of coastal erosion and the degradation and loss of critical habitats and sites of historic, cultural, scenic or recreational value within the coastal zone. Subsequently, "Coastal 2000: Recommendations for a Resource Management Strategy for Sri Lanka's Coastal Region', was produced in 1992 and endorsed by the Cabinet of Ministers in 1994. This document addresses coastal zone management more logistically than in the 1990 plan, and takes into account, the social and economic factors in identifying measures to conserve unique natural coastal resources with the long term goal of sustainable use. A deficiency in the plan of 1990 was its failure to recognize the importance of giving a participatory role to local stakeholders in the management of coastal resources. The shortcoming is rectified in the strategy of 1996 which promotes the formulation and implementation of Special Area Management (SAM) Plans for selected coastal sites. At present SAM Plans have been prepared for Hikkaduwa and Rekawa, and implementation of some of the proposed activities has commenced.

There are several statutes, in addition to the Coast Conservation Act, that can influence the conservation of biodiversity in coastal and marine areas. These are;

- The Marine Pollution Prevention Act (1981) that provides for prevention, reduction and control of pollution in Sri Lankan waters and has provision for penal action for any form of marine pollution or damage to live marine resources and wildlife;
- The Fisheries and Aquatic Resources Act (revised in 1996) that provides for the integrated management, regulation, conservation and development of fisheries and aquatic resources of Sri Lanka and the declaration of fisheries reserves;

- The Fauna and Flora Protection Ordinance (revised in 1993) that provide fisheries and aquatic resources in Sri Lanka, and the declaration of fisheries reserves;
- The Fauna and Flora Protection Ordinance (revised in 1993) that provides protection to specified threatened species of corals, fish and turtles and all marine mammals in Sri Lankan waters;
- The National Environmental Act (amended in 1988) that forbids pollution of marine waters;
- The Crown Lands Ordinance of 1929 that bans the removal of corals;
- The Forest Ordinance which can be used for taking action against those responsible for the illicit cutting of mangroves or encroaching on such land.

Notwithstanding the multiplicity of statutes that are expected to act as deterrents, degradation of coastal and marine habitats continues to take place due to deficiencies in the laws and law enforcement and the failure to recognize the social dimensions of the problem when attempting to take remedial action.

Several marine areas have been identified as deserving protection, but currently there are only two areas that have been declared as marine sanctuaries. The Bar Reef, located west of the Kalpitiya peninsula in the vicinity of Pluttalam lagoon, was declared a marine sanctuary in 1992. The total area of the sanctuary is 306.7 km^2. The core zone, with an area of 70 km^2 supports true coral reefs. Around 300 species of reef associated fish have been recorded in the Bar Reef, and some (e.g. *Chaetodon semeion)* are restricted to this site. The Hikkaduwa marine sanctuary is located in the southern province of Sri Lanka. It is 45 ha in extent, with about 25 ha of corals within and abutting the sanctuary. This area is endowed with a near-shore coral reef with about 60 coral species and 168 reef fish species. The sanctuary is also the centre of lucrative tourist based activities.

The prime national institution for research in the coastal and marine sector is the National Aquatic Resources Research and Development Agency (NARA). Reef research in Sri Lanka is being carried out mainly by NARA. This institution has also initiated research on the *ex situ* conservation of a few species of the fauna and flora which are becoming rare in their natural habitats. These include the sea cucumber

Holothuria spinifera, two species of brackish water ornamental fish *Scaiophagus argus and Monodactylus argentius, and* two species of mangrove plants *Heritiera littoralis* and *Xylocarpus granatum.*

To remedy the paucity of data on offshore fisheries resources, NARA is currently conducting a Fisheries Resources Survey. NARA has also taken action to promote the survival of lobsters by providing new habitats. A survey of some species of coastal fish is also currently being undertaken by NARA to determine. the status of species harvested for the aquarium trade. For centuries, the coastal reefs have been a valuable resource for the people of Sri Lanka, in particular for the coastal communities. More recently, the export of coral reef organisms has contributed substantially to the economy. These reefs are now severely degraded, especially in the southern region, due mainly to coral mining for production of lime. Annually,. over 7000 tons of coral and coral debris are removed from a 60 km stretch along the southwest coast, and both corals and shells are collected for the tourist industry. Although the removal, possession and processing of coral is illegal, the destruction of reefs has continued due to poor law enforcement and the profitability of the lime industry. Attempts have been made to provide alternative employment to those involved, but without much success.. Conservation and management of coral reef's is also impeded because some of the largest and species-rich reefs occur off-shore, beyond the coastal zone, and are outside the jurisdiction of the Coast Conservation Department. Coral reefs are also damaged by natural factors such as the proliferation of the coral predator the Crown- of- Thorn Starfish *(Acanthaster planci)* and the effect of high wave action. Unless stringent conservation action is taken, it is believed that by the 21st century most near-shore reefs would be adversely affected, and only the reefs in protected areas may survive to provide habitats for important and threatened species of fauna and to cheek coastal erosion.

Reef destruction is very severe at the marine sanctuary at Hikkaduwa where many coral reefs are dead or dying. Even after receiving Protected Area status, reef degradation continues to damage caused by heavily loaded glass bottom boats, pollution from hotels, oil pollution, sedimentation, trampling by divers and collection of reef organisms and anchoring of boats.

The action taken hitherto to manage marine biodiversity by establishing Marine Protected Areas and preparing management plans for important near-shore and off-shore coral reefs is far from adequate. Some proposals for environmental management and planning of coastal and marine zones in Sri Lanka have been made by UNEP, CCD, the Department Fisheries and Aquatic Resources (DFAR), and CEA but there has been no implementation. The Inter-Ministerial Committee on Marine Parks an Sanctuaries set up by NARA in 1982 had identified more than 20 coastal sites to be declared as marine parks and sanctuaries, but only two have so far been declared as Protected Areas by statute and management plans have been prepared only for one of them.

There are a number of government organizations that should play a role in the conservation and management of coral reefs and the implementation of laws that govern the use of marine resources. These include NARA, CCD, CEA DWLC, and DFAR. While conservation and management of coral reefs is considered an urgent issue, implementation efforts are impaired due to inadequacies as regards institutional co-operation political commitment and awareness among the public of the importance of this resource.

Recently, Forest Department has assumed control of several mangrove areas identified for protection, and management plans are being prepared for them. The management proposals take into consideration, the socio-economic factors and in keeping with other policy initiatives for coastal resources, promote a participatory approach.

Some of the picturesque sandy beaches of Sri Lanka, with their littoral and sandy shore biodiversity, are being degraded or lost due to extensive coastal erosion which is aggravated by coral mining; non-scientifically erected embankments, rivets and groins; and sand mining along the seashore and in rivers. Although direct removal of sand from the beaches has been curbed by the CCD, sand mining in rivers continues.

Eco-tourism has much potential in the coastal areas. Beaches and areas with fringing reefs are favoured sites for tourism. Snorkelling, scuba diving and viewing corals are

popular among tourists. The Ceylon Tourist Board has prepared a Master Plan for development of tourism and there are guidelines for hotel developers regarding pollution control. Nevertheless, some of the most uniquely diverse biological habitats in the southern and western coasts have been damaged due to construction of "Beach Hotels" that do not conform to regulations regarding waste disposal, environmental safeguards and land use planning to protect vulnerable ecosystems. Tourism is an important activity in the country and it is in the interest of the tourist trade to preserve the coastal environment and its biodiversity.

There is also a proliferation of private turtle hatcheries along the southwest coast, some in collaboration with foreign groups. Although the claim is that these hatcheries are set up for conservation purposes, investigations by NARA show that most are profit-motivated and tourist-oriented, and the practices adopted by the hatcheries can be detrimental to the survival of the young.

Several incentives available for economic activities in the coastal and marine region tend to adversely affect due to inadequate attention being paid to environmental conservation. These activities include; expansion of shrimp farming, export of marine fauna and flora, environmentally detrimental fishing practices, *ad hoc* land reclamation, unauthorized constructions and other infrastructures and the proliferation of industries that release effluents.

The ineffectiveness of law enforcement alone as the measures of curbing adverse activities in coastal areas has amply demonstrates the need for adopting a participatory approach involving the local communities. The need is also felt for coastal management to proceed simultaneously at the national, provincial, district and local levels, with the collaboration of state agencies, local entrepreneurs, NGOs and communities. At present, activities at the national level are guided by the CCD with the support of other relevant state agencies. In the future, resource management efforts for coast conservation need to focus on issues within the jurisdiction of the provinces. This will breed considerable strengthening of the capacities of provincial and local institutions and the preparation of provincial CZM plans in consultation with relevant state agencies. The national CZM plan has not yet been translated into

provincial actions, although activities at local level will be the ultimate determinants of the sustainability of coastal resources.

Current policies also require that work by national and provincial agencies at the local level in the coastal zone be planned and managed within geographically distinct sites, through the formulation and implementation of Special Area Management (SAM) Plans. These will make it possible for problems and opportunities to be examined and assessed in a site-specific context. SAM plans focus on effective devolution of resource management to local stakeholders through a participatory process by creating community-based management groups. SAM Plans have already been prepared for Rekawa and Hikkaduwa and implementation has commenced. Twenty other coastal sites have been identified for similar planning and management..

With the multiplicity of organisations involved in different activities within the coastal zone, a strong co-ordinating mechanism becomes necessary. Co-ordination is not effective at present, mid there is a clear need for a review of function which at presents rests with the CCD.

5.4 Participatory approaches required for a better management of the marine and coastal biodiversity

5.4.1 Objective

1 **To promote the conservation of marine and coastal habitats of the country such as coral reefs, sea grass beds, mangroves, lagoons, estuaries, salt marshes.**

Actions

1. Strengthen and expedite the implementation of actions proposed to protect the coastal and marine habitats in the revised Coastal Zone Management Plan of 1997.

2. Enlist support of NGOs and rural communities to establish woodlots in sand dunes adjoining mangroves, with fast growing fuelwood trees such as *Casuarina* to ameliorate pressure on mangrove vegetation.

3. Control the expansion of shrimp farms into mangrove areas and salt to prevent excessive biodiversity loss and preserve all biodiversity rich areas as habitats for aquatic fauna and flora.

4. Develop capacity among entrepreneurs and guidelines for aquaculture that take into account preservation of the natural environment.

5. Initiate action in collaboration with agriculture and irrigation authorities and provincial/regional bodies against siltation of lagoons, estuaries and marine ecosystems due to soil erosion inland.

5.4.2 Objective

To promote the conservation of threatened species (eg. marine mammals) as well as other species which are subject to exploitation for food, for the aquarium trade etc.

Policy 1 Promote conservation by *ex situ* cultivation of commercially important marine and coastal and marine species and identify alternatives to selectively exploited species

Actions

1. Initiate and strengthen research for *ex situ* cultivation of commercially important coastal and marine species and identify alternatives to selectively exploited species possible; disseminate results to the industrial sector seminars, workshops and training programmes.

2. Initiate a comprehensive programme to study wild stocks of marine mammals in Sri Lankan waters, the catch estimates and the feasibility of alternative income generation through eco-tourism and carry out an islandwide awareness campaign to stop the killing of these species.

3. Preserve sesgrass beds and encourage sustainable use of resources via proper *in situ* culture and harvest practices among local communities and entrepreneurs.

4. Strengthen and enhance current efforts to map the biological resources, including corals, seagrass beds etc. in the coastal waters of Sri Lanka based on Geographical Information Systems.

5. Carry out scientific biodiversity assessment of coral reefs and other important marine systems to identify a minimum network of marine reserves to conserve the totality of marine biodiversity based on principles similar to the National Conservation Review of Forests.

6. In collaboration with relevant state agencies, user groups and communities, prepare management plans for identified marine protected areas to conserve biodiversity and strengthen capabilities for management.

7. By prohibition or strict regulation of collection from the wild and other active measures, promote the conservation of coastal and marine species of fauna and flora under threat.

5.4. 3 Objective To promote sustainability in the use of coastal and marine bio-sources in the fisheries and tourist industries

Actions

1. Strengthen and enhance current efforts to conduct a comprehensive fish resource assessment in Sri Lankan marine waters and an assessment of sustainable levels of l arvesting for the food fishery.

2. Promote the preparation of management plans for the sustainable use of the fisheries resource, taking into consideration the establishment of fisheries reserves where necessary and regeneration of the nearshore fishery resource.

3. Promote research programmes to determine the sustainable levels of fish catches.

4. Monitor the extents and sustainability of harvesting coastal resources such as ornamental fish, sea cucumber, molluscs, sponges, beche-de-mer and other species with market demand.

5. Examine and monitor effects of fishing methods that may have adverse effects on biodiversity and take appropriate action.

6. Enforce, strictly, the current laws against the use of explosives, illegal types of fishing gear and harvesting of juvenile and gravid lobsters in the sea.

7. Strengthen capabilities to enforce existing regulations against the slaughter of small cetaceans and turtles (including harvesting of their eggs), and provide better protection for feeding, breeding and nesting grounds of marine species, including licensing and state monitoring of turtle hatcheries.

5. 4. 4 To increase collaborative participation among stakeholders with regard to policies and programmes that affect coastal and marine biodiversity and initiatives that support conservation such as research .

Policy To promote participatory approaches to natural resources management

Actions

1. Prepare and implement plans and strengthen capability among stakeholders for conservation and rational management of coastal areas and their resources using a community participatory approach.

2. Develop capacity for eco- tourism in selected coastal areas with the participation of communities and local entrepreneurs, for viewing coral life, watching marine mammals etc

CHAPTER 6

MARINE AND COASTAL AREAS OF SPECIAL SIGNIFICANCE

6.0 Introduction

Sri Lanka's marine and coastal zone contains many diverse sites of archaeological, historical, religious and cultural significance and sites of natural value. These sites provide evidence of the pattern and progress of Sri Lankan culture and represent part of Sri Lanka's heritage. Sri Lanka's marine and coastal zone is also a place of great scenic beauty. Picturesque bays, lagoons and coral reefs, wide sandy beaches, rocky terrain tumbling down to the beach, water-trapped rock fissures functioning as seasonal blowholes, and wide salterns and lagoons rich in bird-life can be found along the shoreline (Anon, 1993).

The cultural and scenic resources of Sri Lanka's marine and coastal zone make it a focus of people's cultural and recreational activities. These same resources support the nation's economically important tourism industry which generated over Rs. 11,000 million and directly employed over 35,000 individuals in 1994 (Dayananda, 1992).

Today, many of Sri Lanka's important cultural and natural sites are threatened with inappropriate development. When archaeological or historical sites are destroyed, they are lost forever. Problems of loss and degradation result from both natural and human causes. Over time, structures exposed to weather deteriorate unless they are carefully protected. Unplanned and poorly planned development have degraded scenic areas, limited access to public places, and interfered with local fishing activities.

6.1 Identification of Sites

In 1985, the CCD commissioned two inventories of places of religious and cultural significance and areas of scenic and recreational value. The first survey (Premetilleke, 1989) was from Kalpitiya to Kirinda and the second for the north and east coasts. The following types of sites were inventoried within the coastal zone:

*Places of archaeological, historical, religious and cultural significance; and,

*Areas of scenic and recreational value.

Archaeological, historical and cultural sites were categorized as follows:

A. Monuments and sites of notable antiquity, historical associations, aesthetic value and/or those which are the focal point of religious activities (high priority);

B. Monuments and sites older than 50 years which are also of some added historical, aesthetic and/or popularity value;

C. Religious monuments of recent origin, without any special aesthetic or popularity value.

6.1.1 Sites of Archaeological Significance

a) Definition

Sites of archaeological significance are all ancient sites, buildings and other structures, artefacts, religious and other cultural sites datable to the year 1850 or earlier, which are already declared as archaeological sites and monuments, or are eligible for inclusion in the above.

b) Nature and Significance

The inventory identifies a large number of sites with archaeological, historical, religious and/or cultural significance. Of these sites, those considered more important from the point of view of age or current public focus and popularity value and their locations are listed in Table 6. 1. Of these 93 sites, only 11 have been declared by the Department of Archaeology. However, the department has agreed in principle to adopt the list published in this plan.

The sites and monuments of pure archaeological value include prehistoric sites (Ussangoda, Bundala), and protohistoric sites (Pomparippu). In the second category, broadly classified as historic sites, such as forts (Kalpitlya, Negoinbo and Mannar),

ports (Kalpitiya, Negombo and Mannar), most of the Buddhist monastic sites (Kirinda and Muhudu Maha Viharaya) and some churches (Galle Fort Dutch Church).

Prehistoric sites such as that of Ussangoda are undisturbed sites with much archaeological potential. Test excavations at the Bundala site have revealed valuable data on prehistoric man in Sri Lanka, dating back about 27,000 years. The protohistoric (Megalithic) sites which have yielded black and redware pottery and burials can be dated between the 3rd century B.C. and 3rd century A.D. Of these sites, several excavations have been conducted at Pomparippu, while some others have been subjected to surface examination only. The data yielded so far and future findings will be significant for the study of this formative phase in Sri Lankan history.

6.1.2 Historical Sites and Monuments

a) Definition

Historical sites and monuments are those ancient sites, buildings and other structures, artefacts and other cultural property which are more than 50 years old. These include all archaeological reserves and sites which are eligible to be declared as reserves but are still functional.

b) Nature and Significance

The inventory identifies historical sites and monuments in the Coastal zone (Prematilleke,1989). These include such edifices as Buddhist Temples (Vehera-Navaya, Samudratheera viharaya), Hindu Kovils, (Sri Mariamman Kovil; Vishnu Kovil, Udappuwa), Devales (Sinigama), Christian and Catholic Churches (Dutch Church, Kalpitiya; St. Anne's Church, Talawila), forts (Kalpitiya, Galle), harbours (Colombo, Galle, Godaways), shipwrecks (Akurala, Galle, Trincomalee), esplanades and parks (Gordon Gardens, Galle Face), Lakes (Beira Lake), air bases (Koggala) and resthouses (Tangalle). The more important sites are indicated in Table 6. 1.

Table 6.1 High priority archaeological, historical, religious and cultural sites within the coastal zone

(Source:Prematilleke,1989)

The GN division names & numbers are as designated in 1986

No.	Place	Type	GN Division	GN Division Number
Puttalam District				
1	Kudiramalai	A/H/C	Pukulam	634
2	Kollan Kanatta	A/H/C	Pukulam	634
3	Dutch Church*	H/C	Sinnakudirippu	631
4	Dutch Fort*	H/C	Sinnakudirippu	631
5	St. Anne's Church	H/C/R	Mudalaipali	625/626
6	Mohideen Jumma Mosque	H/C/R	Udappuwa	594
7	St. Xavier's Church	H/C/R	Udappuwa	594
8	Vishnu Devale	H/C/R	Udappuwa	594
9	Ayanar Kovil	H/C/R	Karukkapona	582
Gampaha District				
10	Negombo Fort	A/H	Munnakkare	156
11	Our Lady of Sindrathri	H/C/R	Duwa	162A
12	St. Mary Maddalena Church	H/C/R	Talahena	163
Colombo District				
13	Siva Devalaya	H/C/R	Modera	02
14	St. Anthony's Church	H/C/R	Kochchikade (N)	09
15	Gordon Gardens	H/C	Fort	20
16	Galle Face Hotel/Green	H/C	Slave Island	21
Kalutara District				
17	Rankoth Viharaya	H/C/R	Pattiya North	685
18	Kechchimale Mosque	H/C/R	Paranakade	753/757
19	Duwa Viharaya	H/C/R	Moragalla	760/761
20	Pulinathalaramaya		Kalutara (N)	717
Galle District				
21	Dutch Church School	A/H	Maha Ambalangoda	82
22	Modera Devalaya	H/C/R	Maha Ambalangoda	82
23	Sinigama Devalaya	H/C/R	Sinigama	64
24	Galle Fort*	A/H	Galle Fort	96D
25	Wella Devalaya	H/C/R	Unawatuna South	137
Matara District				
26	Samudragiri Viharaya	H/C/R	Mirissa South	406
27	Samudratheera Viharaya	A/H/C/R	Kamburugamuwa	408
28	Fortress of Matara	A/H	Ginigasmulla	416
29	Sinhasana Kovil	H/R	Devinuwara South	433
30	Talgashena	A/H/C/R	Gandara East/Gandara West	473/473A
31	Gurukanda Viharaya	H/C/R	Bathigama	451
Hambantota District				
32	Fort of Tangalle	A/H	Kotuwegoda	458
33	Vehera-Navaya	H/C/R	Bata-Ata	562
34	Ussangoda	A	Lunama	555
35	Godawaya	A	Walawa	586
36	Bundala	A	Bundala	604
37	Telulla*	A/H	Bundala	604
38	Kirinda Vihare*	A/H/C/R	Kirinda	601
39	Patanangala	A/H/C	Magama	601
40	Palatupana Fort*	A/H/C	Kirinda	601
Ampara District				
41	Megalithic site	A/C	Kumana	1
42	Samuddha Vihara (Kumana)	A/C/R	Kumana	1

No.	Place	Type	GN Division	GN Division Number
43	Megalithic site(Panama)	A/C	Panama	2
44	Okandamalai	A/H/C/R	Panama	2
45	Velayutha Swamy Kovil	H/C/R	Panama	2
46	Muhudu-Maha-Vihara*	A/H/C/R	Potuvil Div.1	3
47	Arugam Bay Port	A/C	Potuvil Div.1	3
48	Sagamankanda	A/H/C	Komari	9
49	Chitra Velayutha Kandaswamy Kovil	H/C/R	Thirukkovil	10
Batticaloa District				
50	Dutch Fort*	A/H/C	Koddaikallar Div.1,2	113
51	Kannaki Amman Kovil	H/C/R	Eruvil	115
52	Jamiul Lafireen Mosque	C/R	Katankuddi Div.1	167
53	Batticaloa Fort	A/H	Puliyantivu	179
54	Sittandi	A/H/C	Valaichchena Tamil Div.	205
55	Periya Kaduveikarai	H/C	Valaichchena Tamil Div	205
56	Panichchenkerni Historical Site	H/C	Mankerni	211
Trincomalee District				
57	Ilangaturai Port	A/C	Ichchilampattai	214
58	Monastic Site	A/H/C/R	Nawathkanikadu	215B
59	Tampalakamam	A/H/C	Tampalakamam South	228A
60	Tirukoneswaram Kovil	A/H/C/R	Trincomalee Town	244B
61	Fort Frederick	A/H/C	Trincomalee Town	244B
62	Gokanna Viharaya	A/C/H/R	Trincomalee Town	244B
63	Fort Ostenberg	A/H	Trincomalee Town	244B
64	Kuchchaveli	A/H/C/R	Kuchchaveli	239
Mullaitivu District				
65	Mullaitivu Fort	A/H/C	Mullaitivu Town	233
66	Monastic Site Kurundanmalai*	A/H/C	Mullaitivu Town	233
Jaffna District				
67	Pas Pyl Fort	A/H/C	Mulliyan	149
68	Vallipuram Burial	A/H/C	Thunalai North	131
69	Kankesanthurai Fort	A/H/C	Kankesenthurai	67
70	Sambilturai Port	A/H/C/R	Keerimalai	64 A
71	Keerimalai	H/C	Keerimalai	64 A
72	Naguleswaram Sivan Kovil	H/C/R	Keerimalai	64 A
73	Vishnu Kovil	H/C/R	Keerimalai	64 A
74	Monastic Site-Keerimalai	A/H/C/R	Keerimalai	64 A
75	Megalithic Site-Anaicottai	A/C	Anaicottai	40
76	Jaffna Fort*	A/H/C	Columbuturai	8
77	Hammenheil Fort	A/H/C	Karainagar North	10 A
78	Port of Kayts	A/H/C	Allaippiddi	19
79	Fort Eyrie	A/H/C	Allaippiddi	19
80	Allaippiddi	A/H/C	Allaippiddi	19
81	Portuguese Fort (Urindi Kottai)	A/H/C	Allaippiddi	19
82	Naga Pooshani Amman Kovil	H/C/R	Nainativu	04
83	Portuguese Fort	A/H/C	Delft West	01
84	Dutch Fort*	A/H/C	Delft Central	02
85	Monastic Site-Vadiresan Koddai	A/H/C	Delft Central	02
86	Nagadipa Vihara	A/C/H/R	Nainativu	04
87	Nolans Bungalow	A/H/C	Delft Central	02
88	Elephant Pass Fort	A/H/C	Mukavil	153

No.	Place	Type	GN Division	GN Division Number
Mannar District				
89	Mannar Fort	A/H/C	Thoddaveli	194
90	Tambapanni Port	A/H/C	Arippu	198
91	Arippu Dutch Fort	A/H/C	Arippu	198
92	Uruvela	A/H/C	Kokkupadayan	202
93	Megalithic Site	A/H/C	Marichchukaddi	203

* Protected Monument

Type A Archaeological Value
H Historical Value
R Religious Value
C Cultural Value

Each site or edifice possesses its own intrinsic qualities and values, and requires recognition in planning development activities in its vicinity. Buildings included in this category are of national importance for their architectural and artistic qualities. For instance, Buddhist shrines at Telwatta, Batigama, Samudragiri Vihara, Rekawa, depict significant maritime artistic traditions of the Kandyan style in their murals. The architectural design of the cluster of stupas at Veheranamaya is unique. Some of the churches, such as St. Anne's at Talawila dates from about the 17th century.

The location of the Catholic Church and Hindu Shrines in close proximity at Udappuwa, testifies to the close association and togetherness that existed between followers of different faiths in Sri Lanka.

The Fort at Galle is a living town which displays old Dutch character and architectural style to this day. Some of the secular buildings in Colombo, such as the President's House and the old colonial Parliament building are significant vestiges of Colombo architecture. The Dutch hospital in Colombo Fort is a unique piece of architecture and is the finest and only example of its kind in the world. Shipwrecks, though not very old, are of significant historical value.

6. 1. 3 Sites of Religious Significance

a) Definition

Monuments and sites with religious associations belonging to Buddhism, Hindu, Muslim and Christian denominations, dating upto the present.

b) Nature and Significance

Sites of religious significance have been identified in the inventory under cultural sites also. Some religious sites have been selected due to significance for coexistence with other religions. In rare cases due to regional significance and popularity even "B" type monuments are included in the list (St Xavier's Church). In the case of certain monuments and sites, their status has been re-evaluated and consequently the status as appearing in the inventory is altered". Certain monuments bearing status "A" have been excluded from the list as in the present context, no management interventions could be made at these sites (Closenberg; St. Mary's Church, Kepungoda; Church of Our Lady of Mount Carmel).

6.1.4. Sites and Monuments of Cultural Significance

a) Definition

All archaeological and historical sites and monuments are by definition deemed to be cultural sites as well. Places where rituals or other cultural events are enacted are also considered as sites of cultural significance.

b) Nature and Significance Of the identified sites and monuments of cultural significance, some are categorized as high priority sites (Prematilleke, 1989). Of these sites those considered more important from the point of view of age, current public focus and aesthetic and popularity value are indicated in Table 7.1

The numerous statues (Suruwam) of Christian saints and Buddhist devales dedicated to folk deities are designated cultural sites. These edifices have been installed by

fisherfolk for their rituals and vow-making, entreating the deities for safe return from the hi-seas. All Catholic churches, ancient and modern, hold annual feasts. St. Anne's Talawila, Our Lady of Sindratri-Duwa (Passion Play), St. Sebastian's Negonibo, are famous seaside centers of worship. The festivals such as the Passion Play, are closely associated with the sea. The Hindu festivals connected with water-cutting rituals are also associated with the sea at locations such as, Udappuwa (Sri Mariamman and Vishnu Kovils).

6.1.5 Scenic, Recreation and Protected Areas

a) Definition

Scenic areas in the coastal belt constitute places that provide aesthetically appealing views of the beach, with uninterrupted vistas of seascape and landscape.

Recreational areas are natural coastal areas traditionally used both by Sri Lankans and foreign visitors for activities such as swimming, diving, surfing, boating, sport fishing, leisure walks, bird watching and relaxation.

Protected Areas include all areas partially or fully located within the coastal zone which are designated as a National Reserve, Sanctuary or proposed protected area by the Department of Wildlife Conservation.

b) Nature and Significance

The inventory records 100 recreational and scenic sites situated within the Coastal Zone. Most of these are located along the western, southwestern, southern and the eastern coast (Table 6.2). Sri Lanka has many fine beaches suitable for recreation which provide uninterrupted vistas. These scenic vistas still remain in good stead except for a few places where over development has occurred. Sri Lanka's tourism industry is centered around its scenic recreational beaches with nearly 70 percent of Sri Lanka's graded hotels and 80 percent of hotel rooms located along the coast (Table 6. 3) (Anon,1994).

Whilst many of Sri Lanka's Important scenic and recreational areas remain pristine, others have been degraded. For example, beaches in the Mount Lavinia to Dickwella area are littered with garbage, and sewer pipes empty directly on the beach. In Mawella Lagoon and along the Tangalle coasts, coconut husk-ratting pits pollute the water. In some instances, the very quality of the resources which made them significant ha s been degraded by incompatible uses and over exploitation. Coral mining is an example.

Table 6.2 High priority recreational, scenic and protected sites within the coastal zone
(Source:Prematilleke,1989)
The GN division names and numbers are as designated in 1.986

	Place	Type	GN Division	GN Division Number
ZONE 1	(Kalpitiya-Chilaw)			
1.	Kandakuliya	S/R	Kuringanpitti	629
2.	Talawila Beach	S/R	Mudalaipali	625/620
3.	Udappuwa Sand Spit	S	Udappuwa	694
4.	Karukkapone Beach	S/R	Karukkapone	582
5.	Bar Reef Sanctuary	P/S/R	--	--
ZONE 2	(Chilaw-Negombo)			
6.	Chilaw Beach	R	Sea Beach (Chilaw)	577
7.	Teppanpola Beach	S/R	Marawila	512
8.	Wennappuwa Beach	R	Ulhitiyawa	492
9.	Maha Oya Sand Spit	S/R	Sindathriya	481
10.	Lewis Place	S/R	Ettukala/Wellaweediya	73/158
11.	Negombo Duwa	R	Munnakkara	156
ZONE 3	(Negombo - Colombo)			
12.	Talahena Beach	R	Talahena	163
13.	Kepungoda	S/R	Kepungoda	163A
14.	Uswetakeiyawa	R	Uswetakeiyawa	167
ZONE 4	(Colombo - Panadura)			
15.	Galle Face Green	S/R	Slave Island	21
16.	Wellawatta - Mt.Lavinia Beach	R	Wellawatta (South)	47
			Dehiwela	540
			Mt. Lavinia	541
ZONE 5	(Panadura - Bentota)			
17.	Panadura Beach	R	Pattiya (Northwest)	685/686
18.	Wadduwa - Talpitiya Beach	S/R	Talpitiya	697
			Wadduwa(West)	699
19.	Tangerine Beach	R	Kalutara (North)	717
20.	Kalutara Sand Spit	S/R	Kalutara (North)	717
21.	Maggona Bay	S	Maggona (West)	742
22.	Polkotuwa Beach	S	Polkotuwa	748
23.	Kechchimalai Mosque Area	S/R	Paranakade	753/757
24.	Moragalla Beach	R	Moragalla	760/761
ZONE 6	(Bentota - Galle)			
25.	Bentota Spit & Estuary	S/R	Pahurumulla	1
26.	Godagala - Induruwa Beach	S/R	Angagoda	2
			Yalegama	8
27.	Athuruwella Beach	S/R	Yalegama	8
28.	Kaikawala - Naya-Handugala Beach	S/R	Kaikawala	9
29.	Babungala - Arangala Beach	S/R	Induruwa	10

	Place	Type	GN Division	GN Division Number
30.	Kosgoda Sand Spit	S/R	Nape	16
31.	Oruwella Ambalangoda	S/R	Maha Ambalangoda	82
32.	Ambalangoda Hikkaduwa Rocky Islets Sanctuary	P/S	Maha Ambalangoda	82
33.	Akurala Beach	R	Akurala	76
34.	Hikkaduwa Marine Sanctuary	P/S/R	Wewala	57
			Waulagoda	58
35.	Patuwata - Narigama Beach	R	Narigama	56
			Thiranagama	54
			Patuwata	53
ZONE 7 (Galle - Dondra)				
36.	Galle Fort	S/R	Galle Fort	96 D
37.	Closenberg	S	Magalla	99
38.	Rumassala	S	Unawatuna(West)	137
39.	Unawatuna Bay Proposed Sanctuary	P/S/R	Unawatuna (East)	138
			Unawatuna (West)	132
			Talpe(South)	138
40.	Koggala Beach	S/R	Koggala	144 A
41.	Devala Kanda	S	Ahangama (East)	156
42.	Yakkinige Duwa	S	Ahangama (East)	156
43.	Kapparatota	S/R	Kapparatota	386
44.	Weligama Bay	S/R	Galbokka	385
			Mahaweediya	382
45.	Polwatumodara Beach	S/R	Polwatumodara	308
46.	Mirissa Bay	S/R	Mirissa (South)	406
47.	Polhena Beach	S/R	Polhena	412
48.	Beach Park Matara	S/R	Ginigasmulla	416
49.	Wellamadama	S		
ZONE 8 (Dondra - Kirinda)				
50.	Dondra Light House Area	S	Devinuwara (South)	433
51.	Talalla Beach	R	Talalla (South)	438
52.	Naigalkanda-Dickwella Beach	R	Bathigama	451 452
53.	Kudawella Blow Hole	S	Kudawella (West)	466 A
54.	Seenimodara (Mawella Bay)	S/R	Seenimodara	468
55.	Pallikudawa Beach	S/R	Unakuruwa	469
56.	Paravi Wella Beach	R	Kotuwegoda	458
57.	Medaketiya Beach	S/R		
58.	Rekawa Lagoon & Bay	S/R	Rekawa	463
59.	Kalametiya Lagoon & Bay (Kalamatiya Sanctuary)	P/S/R	Hathagala	563
60.	Lunama Lagoon (Kalamatiya Sanctuary)	P/S/R	Lunama	555
61.	Ussangoda	S	Lunama	555
62.	Karagam Lewaya	S	Walawa	586
63.	Hambantota Beach	S/R	Hambantota	584
64.	Bundala National Park	P/S/R	Bundala	604
ZONE 9 (Kirinda - Batticaloa)				
65.	Kirinda Headland	S	Kirinda	601
66.	Nimalawa Sanctuary	S	Kirinda	
67.	Yala National Park/Strict Nature Reserve/ Yala East National Park	P/S/R	Kirinda Kumana	601 1
68.	Kudumbigala Sanctuary	P/S/R	--	--
69	Panama Beach	R	Panama	2
70	Arugam Bay Beach	S/R	Potuvil	3
71	Kalmunai Beach	R	Kalmunai T.C.	61

	Place	Type	GN Division	GN Division Number
ZONE 10 (Batticaloa-Foul Point)				
72	Kalladi Beach	S/R		
73	Punnaikudah Bay	R	Eravur	192 Div 3
74	Palaiyadithona Beach	R	Chanthiveli	200
75	Kiran Beach	R	Kiran	203
76	Kalkudah Bay	S/R	Kalkudah	204
77	Pasikudah Bay	S/R	Kalkudah	204
78	Valachchenai Estuary	S	Valachchenai (Tamil Div)	205
79	Thenadi Bay-Elephant Point	S	Valachchenai (Tamil Div.)	205
80	Irichchal Island	S	Mankerni	211
81	Sallativu Island	S	Mankerni	211
82	Vakarai Sand Spit & Lagoon	S/R	Vakarai	212
ZONE 11 (Foul Point-Chemipattu)				
83.	Seruvil-Allai Sanctuary	P/S/R	--	--
84.	Clapenberg Hill	S	Vellaimanal	229
85.	Trincomalee-Marbel Bay	S/R	Trincomalee Town	244/244A/2
86.	Trincomalee Beach Road	R	Trincomalee Town	244B
87.	Nilaveli Beach	R	Kumpurupiddi, Nilaveli, Sampaltivu	240/241/242
88.	Pigeon Island Sanctuary	P/S/R	--	--
89.	Red Rock Beach	S/R	Kumpurupiddi	239/237
90.	Pirates Cove	R	Kuchchaveli	239/237/2
91.	Kokilai Lagoon Sanctuary	P/S	Kokilai	225
ZONE 12 (Chemionpattu-Mannar)				
92.	Chundikulam Sanctuary	P/S/R	Chundikulam Mulliyan	141/149
93.	Manalkadu Sand Dunes	S	Kudattanai-Karaiyur	142
94.	Senthankulam Beach	S/R	Myliddy Coast	72 A
95.	Casuarina Beach	S/R	Karainagar North	10 A
96.	Castle Beach	S/R	Delft Central	2
97.	Kalmunai Point	S/R	Kavutharimunai	172
98.	Paraitivu Island Sanctuary	P/S/R	Thoddakadu	189 A
99.	Toddakkadu (Mannar Beach)	S/R	Marichchukaddi	203
100.	Wilpattu National Park	P/S/R	--	2

Table 6.3 Graded hotel accommodations in 1996

(Source: Anon,1997)

Region	Number of Hotels	Number of Rooms
Colombo City	20	3,099
Greater Colombo	29	1,952
South Coast	53	4,145
East Coast	1	101
Total in Coastal Zone	103	9,297
Other Regions	41	2,509
Grand Total	144	11,806
Percent in Coastal Areas	71.5	78.7

6.2 Present strategies of protection of sites of special significance

The Coast Conservation Act requires that the CCD Coastal Zone Management Plan address the preservation of important archaeological, historical, religious and cultural sites, as well as the Coastal Zone's scenic beauty and important recreational areas. The Coastal Zone Management Plan of 1990 has addressed this requirement. However, the 1990 Plan fell short of achieving desired objectives in full due to the following constraints:

1. In managing identified archaeological, historical, religious, cultural, and recreational and scenic areas the CZM plan relied heavily on regulation. The main tool was the adoption of a permit procedure to control development activities in the vicinity of the designated sites.

2. The adoption of development and conservation approaches in managing the designated sites in the first generation CZM Plan has been overlooked.

3. Management limitations in some of the designated sites have not been properly addressed in the first generation CZM plan.

6.3 Participatory approaches required for a better management of sites of special significance

Objective 6.3.1 **Conserve and protect Sri Lanka's significant cultural, historical and archaeological sites including ship wrecks within the coastal zone.**

Policy 1 Promote compliance with the existing laws and regulations so as to limit the adverse impacts of development activities on designated sites within the coastal zone.

Action

1 . Permit development in the vicinity of designated sites (see Table 6. 1) only in accordance with guidelines for the preservation of archaeological sites which prohibit development within a limit of 200m of the boundary of the designated sites and CCD actions (as indicated in Anon,1997).

2. Collaborate with the Department of Archaeology to enforce Environmental Impact Assessment or Initial Environmental Examination procedures to avoid potential negative impacts on the Site. Collaborate with other concerned agencies to develop a guide book on permitting development activities in and around the designated sites within the Coastal Zone.

3. Co-ordinate the following development and conservation initiatives for appropriate sites with the participation of Department of Archaeology and other relevant agencies to:
   - Display of sign boards at sites
   - Demarcate boundaries of the sites

- Formulate and implement management and conservation plans

5. Cooperate with the Department of Archaeology to demarcate and prepare site plans of sites listed in Table 6.1
6. Incorporate high priority archaeological, historical and cultural sites in the coastal zone as part of CCD's ongoing awareness programmes.

Policy 2 Protect and conserve Sri Lanka's marine archaeological sites including ship wrecks in the coastal zone.

Actions

1. Comply with the guidelines recommended by the Inter-Ministerial Committee on Ship Wrecks when issuing development permits.

Policy 3 Maintain and enhance the quality of the scenic areas and natural resources within the coastal zone.

Actions

1. Require EIA or IEE procedures for development activities which may adversely affect natural resources and scenic areas in the coastal zone.
2. Identify, demarcate and, where possible, acquire areas with high scenic and recreational value.
3. Formulate development and conservation guidelines for development activities in the vicinity of high priority scenic and recreational areas within the Coastal Zone.
4. Formulate and implement plans for coastal and marine parks with the collaboration of private and public sector institutions.

Policy 4 Develop with the Department of Wildlife Conservation, Forest Department, Ceylon Tourist Board, UDA, CEA, and local authorities and other relevant governmental, non-governmental organizations and private sector agencies appropriate

management plans for scenic sites in the coastal zone consistent with other traditional coastal activities.

Policy 5 Ensure continued public access, consistent with conservation of natural resources along shoreline.

Actions

1. Sponsor a study to identify significant public access points to and along the shoreline.
2. Formulate and implement an effective public access protection programme with other agencies.

Policy 6 Ensure that new developments are compatible with their visual environment by requiring locating such developments in ways that minimize the alteration of natural landforms and existing public views to and along the shoreline.

Action

1.Encourage design and location of development that minimize alteration of land forms or loss of visual access.

Policy 7 Preserve, maintain and, where desirable,, improve and restore shoreline open space.

Actions

1. Initiate a study to assess visual open space and access in the coastal zone.
2. Implement a programme to purchase/acquire development rights to establish open space and or to enhance the environmental quality in identified locations within the coastal zone.

CHAPTER 7
PLAN SUMMARY AND REQUIRED ACTION ON PRIORITY BASIS

Objectives, policies and actions necessary for a national programme for the protection of the coastal and marine environment is summarized in Table 7.1.

Table 7.1 Plan summary and priorities for actio n

Chapter 2 : Coastal Ecosystem management	
Objective 2.3.1 Preserve and enrich the coastal ecosystems and natural features of exceptional value including protected areas (marine, bird and wildlife sanctuaries)	
Policy	**Necessary action on priority basis**
1. Prohibit/ modify development activities if significant degradation is probable in designated protected areas (national reserves, sanctuaries and fisheries conservation areas) in the coastal zone	1.Periodically update the list of areas of exceptional value to protect them by declaring as conservation areas under the Fauna and Flora Protection Ordinance and the Fisheries and Aquatic Resources Act. 2. Regulate development activities through permits and EIAs
2. Ensure sustainability of the coastal ecosystems including protected and designated natural areas of exceptional value	1.Cooperate with other relevant governmental/ NGOs to develop conservation and management plans for SAM sites and identified areas of particular concern 2.Participate in the identification, prioritization and implementation of management plans for SAM sites and identified areas of particular concern
Objective 2.3.2 Promote sustainable development of resources found within coastal habitats	
1.Promote inter-agency cooperation in development planning to minimize adverse impacts on coastal habitats 2.Prohibit or require modification of development activities where there is a reasonable probability that significant degradation or destruction of the coastal habitat is likely to occur 3.Encourage and directly sponsor scientific research on coastal habitats as it relates to CCD management objectives 4 Promote awareness of the nature and significance of coastal habitats	
Objective 2.3.3 Prevent further degradation or depletion of coral reefs	
1. Breaking of reefs/ collecting of off- shore coral debris and mining of coral is prohibited	1.Strictly enforce CCA of 1988 in collaboration with concerned authorities 2.Conduct annual surveys to determine the level of illegal mining activities 3.Amend legislation pertaining to coral mining activities 4.Conduct awareness programmes for target groups and initiate community actions
2. Promote introduction of alternative source of lime to meet the requirements of industry and agriculture	1.Implement the policy paper on alternative sources of lime 2. Coordinate with concerned agencies on the use of alternative sources of lime
3. Identify areas where reef restoration will impede erosion and provide additional habitat.	1.Initiate/assist community based reef restoration and preservation 2. Assist other agencies on reef restoration and preservation
4. Collection of small and limited coral specimens may be permitted for valid scientific research.	1. Issue permits for collection of coral for scientific research provided that the research is in compliance with specified guidelines.
5. Protect and preserve coral reefs as an important coastal habitat for a sustainable marine environment	1. Cooperate with other agencies to develop appropriate coral reef management plans for identified areas
6. Ensure removal of reefs organisms, such as aquarium fish, does not exceed sustainable levels	
7. Promote breeding of marine aquarium fish	

Objective 2. 3.4 Estuary and lagoons-Maintain fishery habitat and water quality, protect recreational Values, and regulate sand mining at levels that do not have an adverse impact on Beach replenishment.	
Policy	**Necessary action on priority basis**
1. Minimize impacts due to encroachment/sedimentation, desalination and pollution in development activities adjacent to estuaries /lagoons 2. Cooperate with other agencies to develop special area management plans for selected estuaries and lagoons	
Objective 2. 3.5 Preserve mangroves as an important habitat for wildlife, a nursery for fish, a nutrient Trap, and to enable extraction at a sustainable level	
1. Prevent further depletion of mangrove Degradation due to excessive fresh water/pollutants	1.Ensure that impacts of fresh water runoff, excessive siltation, oil pollution, and conversion of mangrove habitats are minimized when reviewing proposed developments 2.Revitalize the Sri Lanka National Mangrove Committee 3.Consider guidelines developed by relevant agencies for national development activities within or adjacent to mangrove habitats
Objective 2.3.6 Preserve seagrass beds as fisheries habitat and a habitat for Dugong and sea turtles	
Objective 2.3.7 Ensure sustainable use of salt marshes as an waterfowl habitat as a buffer which Protects coastal settlements from flooding and to prevent pollution	
1. Ensure developments do not degrade bird habitats; seed fish collection sites or obstructs storm water runoff 2. Support activities to map distribution and extent of salt marches, clarify ownership, and identify types/scales of development on particular salt marsh areas in a manner harmonious with ecological and social needs 3. Support research in identifying and rehabilitating sites for mangrove reforestation 4. Study the mangroves in the inter tidal zone to look into their ecological functions	
Objective 2. 3.8 CCD shall conserve barrier beaches, spits and dunes	
1. Alteration of particular barrier beaches, spits and dunes will not be permitted without due regard for their particular ecological function	

Chapter 3: Coastal and marine pollution control	
Policy	**Necessary action on priority basis**
Objective 3. 4.1 Minimize effluent discharges and impacts in the coastal zone to prevent further degradation of coastal water quality and coastal habitats	
1.All development activities in the coastal Zone should comply with standards stipulated by CEA for coastal and marine waters	1.Impose CEA standards on new development activities subject to provisions of the CCA 1. Impose a compliance programme with CEA against existing Developers violating the stipulated standards 3.Implement the guidelines stipulated by the Inter-ministerial Committee on Aquaculture development for all aquaculture projects 4.Initiate awareness programme with the Department of Fisheries and Aquatic Resources Development for fishing communities to encourage proper disposal of oil waste 5. Initiate studies on water quality in collaboration with other concerned agencies and publicize the results
2.Develop strategies in collaboration with other agencies to provide economic incentives to developers to minimize untreated discharges into coastal waterways	1. Develop tax incentives, expedited permit approval process or other Incentives to encourage the private development of waste water treatment systems
3. Encourage the relocation of high/medium polluting industries in industrial zones and encourage more efficient provision of pollution abatement technology 4. Assist relevant agencies to establish a single pollution abatement fund 5. Participate in efforts to obtain technical and financial assistance to establish central sewage treatment systems at appropriate locations within the coastal zone	

Objective 3.4.2 Improve the coastal environment by reducing the types and volumes of solid waste Disposed in the coastal zone	
Policy	**Necessary action on priority basis**
1. Prepare solid waste management plans for Identified urban coastal centers, coastal tourist Centers and fishing harbors	1. Identify urban centers, coastal tourist centers and fishing harbors for which solid waste plans are most urgently needed
2. Discourage local authorities to dispose solid Waste in the coastal zone	Assist local authorities to: 1. Identify dump sites in less vulnerable Locations outside the coastal zone: and 2. Relocate dumping sites out of the coastal zone
3. Collaborate in public education and awareness programs and join with other agencies in promoting public participation in solid waste management	1.Facilitate active public participation in implementation and monitoring of solid waste management programmes 2.Update public education programme on discharges and solid waste in regard to coastal pollution management 3.Involve the communities in designing local community pollution abatement programs adopting the Special Area Management and Areas of Particular Concern approaches
1. Formulate a research agenda for coastal pollution management in collaboration with CEA, NARA and other agencies	1. Develop a research agenda for coastal pollution management for the next four years
2. Support similar research programs on oil waste discharge and solid waste management	

Chapter 4: Coastal erosion management	
Objective 4.3.1 Regulate location of development activities in the coastal zone	
Policy	**Necessary Action**
1. New construction may be permitted only in accordance with the set back standards	1.Enforce coastal set back standards 2.Conduct annual permit compliance monitoring survey 3.Institute legal action against non compliance 4.Build awareness of setback regulations 5.Demarcate coastal segment and display sign boards indicating relevant set back standards
2. Minimize adverse impacts due to construction of maritime structures within the coastal zone	1.Formulate and implement guidelines for the location and construction standards of maritime structures
Objective 4.3.2 Ensure that sand mining does not contribute to unaccepted levels of erosion	
1. Sand mining regulated by guidelines specifying quotas, time limits, setbacks, site rotation and monitoring	1.Enforce guidelines specified in CZM plan 2.Undertake periodic monitoring surveys of sand mining
1. Site specific research to define sustainable limits, sand budgets and identification of alternative sources of sand	1. Implement recommendations of National Sand study
Objective 4.3.3 Identify erosion trends and formulate appropriate mitigation measures that are cost effective and socially and environmentally acceptable	
1. Coast protection programmes consistent with updated MP- CEM	1.Update MP- CEM and design management strategies 2. Research on coastal processes relating to erosion and its control and investigating the feasibility of using soft solutions
2. Permit shoreline protection schemes by other public or private entities if consistent with CCD guidelines	1.Formulate guidelines and criteria to allow construction of private coast protection works in compliance with MP- CEM 2. Prepare monitoring plans to determine impacts of such measures
3. Minimize the social and economic impacts caused by prohibition of coral mining	1. Coordinate inter- agency efforts to provide alternative employment to displaced coral miners

Policy	Necessary Action on priority basis
4. Land acquisition and development rights purchase programmes	1. Identify potential sites 2. Develop financial mechanisms for land acquisition and development right purchase
5. Collection of scientific information on coastal erosion rates and trends	1. Collaborate with Universities/ other agencies to assess erosion trends and patterns 2. Establish fixed locations to monitor erosion trends
6.Collection/ use of scientific and socio-economic information to update CZM plans	1. Establish comprehensive database on coastal processes and socio- economic characteristics 2.Disseminate and exchange data with public and private agencies for research and planning purposes
Objective 4.3.4 Minimize the negative impacts of coastal erosion and possible sea level rise by reclaiming suitable coastal frontage to ensure additional buffers	
1. Promote measures to expand the existing coastal front providing additional buffers against sea erosion/ sea level rise	1.Prepare guidelines on coastal reclamation. 2.Identify potential reclamation sites, prioritize vulnerable places and prepare reclamation plans
Objective 4.3.5 Enhance economic potential of coastal frontages and the capacity to withstand erosion by implementing development schemes based on coastal reclamation	
1. Promote enhancement of economic potential of selected coastal frontages by implementation of acceptable reclamation schemes	1.Encourage development consistent with this objective 2.Implement reclamation schemes at sites where protection costs can be recovered through development consistent with the objective

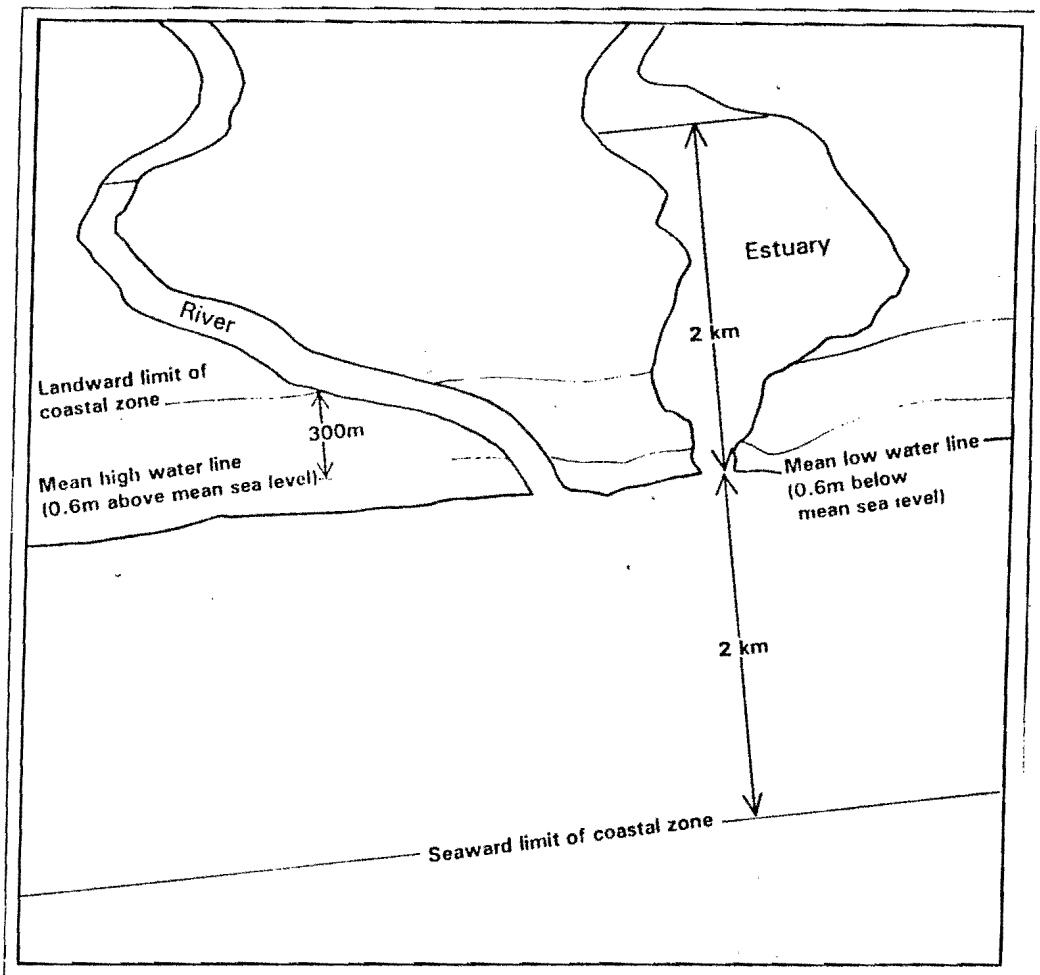
Chapter 5. Biodiversity of the coastal ecosystems	
5.4.1 Objectives to promote the conservation of coastal and marine habitats of the country such as coral reefs, sea grass beds, mangroves, lagoons, estuaries, salt marshes.	
Policy	**Necessary action on priority basis**
1.Conservation and management of coastal and marine habitats of the country such as coral reefs, sea grass beds, mangroves, lagoons, estuaries, salt marshes.	1.Strengthen and expedite the implementation of actions proposed to protect the coastal and marine habitats in the revised Coastal Zone Management Plan of 1997. 2. Enlist support of NGOs and rural communities to establish woodlots in sand dunes adjoining mangroves, with fast growing fuelwood trees such as *Casuarina* to ameliorate pressure on mangrove vegetation. 3.Control the expansion of shrimp farms into mangrove areas and salt to prevent excessive biodiversity loss and preserve all biodiversity rich areas as habitats for aquatic fauna and flora. 4.Develop capacity among entrepreneurs and guidelines for aquaculture that take into account preservation of the natural environment. 5.Initiate action in collaboration with agriculture and irrigation authorities and provincial/regional bodies against siltation of lagoons, estuaries and marine ecosystems due to soil erosion inland.

5.4.2 Objective To promote the conservation of threatened species (eg. Marine mammals) as well as other species which are subject to exploitation for food, for aquarium trade etc.	
1.promote the conservation of threatened species (eg. Marine mammals) as well as other species which are subject to exploitation for food, for the aquarium trade etc.	1.Initiate and strengthen research for *ex situ* cultivation of commercially important coastal and marine species and identify alternatives to selectively exploited species possible; disseminate results to the industrial sector seminars, workshops and training programmes. 2.Initiate a comprehensive programme to study wild stocks of marine mammals in Sri Lankan waters, the catch estimates and the feasibility of alternative income generation through eco-tourism and carry out an islandwide awareness campaign to stop the killing of these species. 3. Preserve sesgrass beds and encourage sustainable use of resources via proper *in situ* culture and harvest practices among local communities and entrepreneurs. 4. Strengthen and enhance current efforts to map the biological resources, including corals, seagrass beds etc. in the coastal waters of Sri Lanka based on Geographical Information Systems. 5.Carry out scientific biodiversity assessment of coral reefs and other important marine systems to identify a minimum network of marine reserves to conserve the totality of marine biodiversity based on principles similar to the National Conservation Review of Forests. 6.In collaboration with relevant state agencies, user groups and communities, prepare management plans for identified marine protected areas to conserve biodiversity and strengthen capabilities for management. 7.By prohibition or strict regulation of collection from the wild and other active measures, promote the conservation of coastal and marine species of fauna and flora under t
5.4.3 Objective To promote sustainability in the use of coastal and marine bio-sources in the fisheries and tourist industries	
1.promote sustainability in the use of coastal and marine bio-sources in the fisheries and tourist industries	1.Strengthen and enhance current efforts to conduct a comprehensive fish resource assessment in Sri Lankan marine waters and an assessment of sustainable levels of harvesting for the food fishery. 2.Promote the preparation of management plans for the sustainable use of the fisheries resource, taking into consideration the establishment of fisheries reserves where necessary and regeneration of the nearshore fishery resource. 3.Promote research programmes to determine the sustainable levels of fish catches. 4.Monitor the extents and sustainability of harvesting coastal resources such as ornamental fish, sea cucumber, molluscs, sponges, beche-de-mer an other species with market demand. 5.Examine and monitor effects of fishing methods that may have adverse effects on biodiversity and take appropriate action. 6. Enforce, strictly, the current laws against the use of explosives, illegal types of fishing gear and harvesting of juvenile and gravid lobsters in the sea. 7. Strengthen capabilities to enforce existing regulations against the slaughter of small cetaceans and turtles (including harvesting of their eggs), and provide better protection for feeding, breeding and nesting grounds of marine species, including licensing and state monitoring of turtle hatcheries.

Objective5. 4. 4 To increase collaborative participation among stakeholders with regard to policies and programmes that affect coastal and marine biodiversity and initiatives that support conservation such as research	
1.To promote participatory approaches to natural resources management	1. Prepare and implement plans and strengthen capability among stakeholders for conservation and rational management of coastal areas and their resources using a community participatory approach. 2. Develop capacity for eco- tourism in selected coastal areas with the participation of communities and local entrepreneurs, for viewing coral life, watching marine mammals etc

Chapter 6: Protection of sites of special significance	
Objective 6.3.1 Conserve and protect Sri Lanka's significant cultural, historical and archaeological sites Including ship wrecks within the coastal zone	
Policy	**Necessary Action**
1.Promote compliance with the existing laws and regulations to limit the adverse impacts of development activities on designated sites within the coastal zone.	1. Permit development only in accordance with guidelines 2. Enforce EIA or IEE procedures to avoid potential negative impacts 3. Collaborate with other agencies to develop a guide book on permitted development activities 4. Coordinate with the Department of Archaeology and other agencies the following for appropriate sites: • Display of sign boards • Demarcate boundaries • Formulate and implement management/ conservation plans 5. Cooperate with the Department of Archaeology to demarcate And prepare site plans for sites listed in Table 5.1. 6. Incorporate high priority archaeology historical and cultural Sites as part of CCD's awareness programs
1. Protect and conserve Sri Lanka's marine archaeology sites including ship wrecks.	1. Comply with the guidelines recommended by the Inter-Miniterial Committee on Ship wrecks when Issuing development permits
3. Maintain and enhance the quality of the scenic areas and natural resources within the coastal zone	1. Require EIA or IEE development activities which may affect natural resources and scenic areas 2. Identify, demarcate and where possible, acquire sites with high scenic and recreational value 3. Formulate development and conservation guidelines for development activities near the high priority scenic and recreational sites 4. Formulate and implement plans for coastal and marine parks with the collaboration of private and public sector
4. Develop with the DWLC, DF, CTB,UDA, CEA and other relavent governmental/private/NGO's appropriate management plans for scenic sites in the coastal zone consistent with other traditional coastal activities	
5. Ensure public access, consistent with conservation of natural resources along shoreline	1. Sponsor studies to identify significant public access points to And along shoreline 2. Formulate and implement an effective public access protection Programme with other agencies

6. Ensure new developments are compatible with visual environment by requiring locating such developments to minimize the alteration of natural landforms and existing public views to the shoreline	Encourage design and location of development that minimize alteration of land forms or loss visual access
7. Preserve, Maintain and, where desirable, improve and restore shoreline open space	1.Initiate studies to assess visual open space and access in the coastal zone 2.Implement a programme to purchase/acquire development rights to establish open space and or to enhance to environmental quality in identified locations



The "Coastal Zone" is defined in the Coast Conservation Act as:

"The area lying within a limit of three hundred 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, lagoons, or any other body of water connected to the sea either permanently or periodically, the landward boundary shall extend to a limit of two kilometers measured perpendicular to the straight base line drawn between the natural entrance points [defined by the mean low water line] thereof and shall include waters of such rivers, streams and lagoons or any other body of water so connected to the sea."

(The coastal zone is shown shaded)

Appendix 1 The Sri Lanka Coastal Zone

(Source: Anon.1997)

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