REGIONAL FISHERIES LIVELIHOODS PROGRAMME
FOR SOUTH AND SOUTHEAST ASIA (RFLP)

An Environmental and Fisheries Profile of the Puttalam Lagoon System

(Activity 1.4.1 : Consolidate and finalize reports on physio-chemical, geo-morphological, socio-economic, fisheries, environmental and land use associated with the Puttalam lagoon ecosystem)

For the Regional Fisheries Livelihoods Programme for South and Southeast Asia

Prepared by

Sriyanie Miththapala (compiler)

IUCN, International Union for Conservation of Nature, Sri Lanka Country Office

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List of Acronyms

ADB	Asian Development Bank
AIA	Archaeological Impact Assessment
BCAP	Biodiversity Conservation and Action Plan
BMZ	German Federal Ministry for Economic Cooperation and Development (Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklung)
BRW	Black and Red ware
CBO	Community-based Organisation
CCA	Coast Conservation Act No. 57 of 1981 and its amendments
CCD	Coast Conservation Department
CEA	Central Environmental Authority
CENARA	Capacity enhancement for the National Aquatic Resources Agency
CPUE	Catch per unit effort
DCB	Decentralised budget
DDSP	District disability strategy
DFEO	District Fisheries Extension Officer
DFS	District Fisheries Society
DLCC	District level Coordinating Committee
DS	District Secretariat
DSD	Divisional Secretariat Division
EEC	Exclusive Economic Zone
EIA	Environmental Impact Assessment
EPL	Environmental Protection License
FAO	Food and Agriculture Organization
FARA	Fisheries and Aquatic Resources Act No. 2 of 1996 and its amendments
FC	Fisheries committees
FD	Department of Fisheries
FD	Forest Department
FFPO	Flora and Fauna Protection Ordinance of 1937 and its amendments
FMA	Fisheries Management Area
FMA	Fisheries Management Authority
FO	Forest Ordinance
FR	Fisheries Reserve
FRF	Fisheries Reward Fund
FRF	Fisheries reward fund
FRP	Fibre-reinforced plastic
FSMP	Forestry Sector Master Plan
GCE AL	General Certificate of Education, Advanced Level
GCE OL	General Certificate of Education, Ordinary Level
GND	Grama Niladhari Division
GSMB	Geological Survey and Mines Bureau
IDP	Internally displaced people
IMUL	In-board multi-day boats
IUCN	International Union for Conservation of Nature
LKR	Sri Lankan rupees
LMA	Lagoon Management Authority
MDG	Millennium Development Goals

MEY	Maximum Economic Yield
MFF	Mangroves for the Future
MoENR	Ministry of Environment and Natural Resources, now Ministry of Environment
MSY	Maximum Sustainable Yield
MTRB	Mechanised traditional boats
NAQDA	National Aquaculture Development Authority
NARA	National Aquatic Resources Development Agency
NBSB	Non-mechanised beach seine boats
NEA	National Environmental Act
NGO	Non-governmental organisation
NTFP	Non timber forests products
NTRB	Non-mechanised traditional boats
NWCFMA	North West Coast Fisheries Management Area
NWP	North Western Province
NWPEA	North Western Provincial Environmental Authority
ORFP	Out-board fibre-reinforced plastic boats
PC	Provincial Council
PHI	Public Health Inspector
RLFP	Regional Fisheries Livelihoods Programme for South and Southeast Asia
RRDA	Regional Resource Development Authority
SAM	Special Area Management
SLO	State Lands Ordinance of 1947
SME	Small and medium enterprises
UDA	Urban Development Authority
USD	United States dollars

Executive Summary

This document reviews the available information about Puttalam Lagoon – the current status of its resources and its people, as well as the threats to its existence – in the context of coastal resource management. It examines the Lagoon from a landscape ecology perspective – understanding that species are not only integral parts of ecosystems, but that many inter-connected and inter-dependent ecosystems form a mosaic in a larger landscape – and focuses on broad-scale environmental and ecological issues.

Information from several IUCN projects was collated and presented in this review with the financial assistance from the Regional Fisheries Livelihoods Programme (RFLP), Sri Lanka Component of the Food and Agricultural Organisation (FAO).

The Puttalam Lagoon – both economically and ecologically important – is located in the North Western Province of Sri Lanka at 70 44'46-80 35'60 North and 790 48'25-79049'17 East. The area around the Lagoon comprises only four Divisional Secretariats: Kalpitiya, Puttalam, Vanathavillu and Mundel.

In 2006, the recorded population of the above DS divisions was 241,624, with 48,986 households, with an average family size of 4.9 in these divisions. In the Lagoon area are permanent residents, seasonal migrants, and refugees. Seasonal migrants – fish both in the Lagoon and in the sea.

The majority of the population in the Puttalam Lagoon area are Muslims (55.6%), with Sinhalese as the second largest ethnic group in the area (31.9%); Sri Lankan Tamils comprise 11.9% and the rest a mix of Burghers, Malays, Indian Tamils and other minorities.

Most government primary and secondary schools are situated close to the main towns in the Lagoon area. School enrolment is only 74%.

Estimates for 2006/07 revealed that approximately 104,000 people (10.6% of the households) in Puttalam were classified as poor households. The national head count index for all districts is 15.2%, indicating that people in the Puttalam Lagoon are much poorer than the national average. The unemployment rate in the Puttalam district is 16.9% for males and 35.6% for females. The percentage distribution of land ownership in Puttalam is 77.1%, with 22.9% households not owning any land. This figure is the highest percentage in Sri Lanka.

The Puttalam Lagoon (hereafter referred to as the Lagoon) is one of the largest estuaries of Sri Lanka, extending over 32,750 ha. Three river basins – Kala Oya, Mi Oya and the very small Moongil Ara – connect with the Lagoon. The Lagoon is open naturally to the sea at the northern end, while southern end is connected to the Dutch canal. This canal is, in turn, connected to the northern end of Mundel Lake. The Lagoon system is very shallow, with depths of no more than 1-2 m, except in the deep channels within the Lagoon, where depths of 4-5 m have been recorded. In the north, the water is of normal oceanic salinity, but is hyper-saline in the south, as a result of high evaporation.

The Lagoon is located in the dry zone of the island, which receives a sharply seasonal average annual rainfall of between 1,000-1,100 mm, derived mainly from the northeast monsoon. Because of this, the area experiences a prolonged dry season of 4-7 months from March to September. The climate characteristics of the area include periods of low rainfall, intense sunlight and seasonal strong winds.

Common soil groups – Reddish Brown Earths, Low Humic Gley Soils, Red-Yellow Latosols, Regosols, Alluvial Soils and Solodized Solonetz – are recorded in the area.

There are three types of water sources: fresh water, saline water and brackish water in the Lagoon area. In the recent past, two events have contributed greatly to the changes in fresh water discharge into the Lagoon, from the Kala Oya, Mi Oya and Moongil Ara. The first is the Mahaweli water diversion into the Kala Oya basin since 1976. This has increased fresh water flow into the Puttalam Lagoon, but because Kala Oya is at the mouth of the Lagoon, this impact is not severe. Construction of various reservoirs in the Mi Oya basin has reduced freshwater input into the Puttalam Lagoon at its southern end. Various other fresh water intakes since 1990 – for aquaculture and salterns – have greatly reduced the fresh water discharge from the Mi Oya into the Lagoon. This has severely affected the water chemistry of the Lagoon.

Puttalam is a district where there is more than 90% dependence on groundwater aquifers through extraction from municipal well fields and private boreholes, with 3,268 tube wells in the district.

The Puttalam Lagoon supports a range of inter-connected and inter-dependent natural habitats that form a mosaic in a larger landscape. Characteristic of the dry zone are tropical dry mixed evergreen forests and tropical thorn forests, which occur inland. The dominant tree species of the tropical dry mixed evergreen forests include *Manilkara hexandra*, *Drypetes sepiaria* and *Chloroxylon swietenia*. The tropical thorn forests include *Ziziphus rugosa*, *Carissa spinarum*, *Flueggea leucopyrus*, *Ziziphus oenoplia*, and *Canthium coromandelicum*.

Located in this area are some of the most extensive tracts of mangroves in Sri Lanka, found in the Kala Oya Lagoon, Mi Oya Lagoon, Dutch Bay and Portugal Bay. The Kalpitiya area still has large tracts of mangrove vegetation, while islands such as Ippantivu, Sinnaarichchalai, Periyarichchalai and Irrimathivu are also surrounded by mangroves. Rare mangrove species such as *Scyphiphora hydrophyllacea* and *Cynometra iripa* are recorded in this area.

Tidal flats, sea grass beds, sand dunes, coral reef and maritime grasslands are other coastal ecosystems that can be found in the Puttalam Lagoon area.

These different ecosystems provide a wide range of ecosystem services, vital for human well-being.

A total of 512 species of flora, including 406 native species, nine endemic, eight threatened species, 108 exotic and 13 invasive alien species were identified in the Puttalam Lagoon area.

A total of 308 faunal species belonging to 112 families were recorded within the Lagoon area. Among recorded species were seven endemic and 12 Nationally Threatened species. Proportionately, birds were the most abundant vertebrate group, while amphibians were the least abundant.

Several organisations have direct jurisdiction over the Lagoon Area. These include the Department of Fisheries, the Forest Department, the Department of Wildlife Conservation, the Coast Conservation Department, the Department of Archaeology, the Tourism Development Authority, the Urban Development Authority and the North Western Provincial Environmental Authority. There are other organisations such as the Department of Fisheries, the National Aquaculture Development Authority (NAQDA), the Provincial Ministry of Fisheries, the Regional Resource Development Authority (RRDA), the Urban Council and Pradeshiya Sabha which have developmental functions. There is also a suite of laws that impact on the Lagoon.

The Lagoon harbours marine, brackish and freshwater species, and is considered one of the most productive 'basin estuaries' in Sri Lanka. There are 15,546 active fishers, 12,680 fishing families and a fishing population of 44,380 people in the area, fishing both in the lagoon and associated coastal waters. There 5,501 full time and 425 part time fishers in the Lagoon. A total of 4,633 fishing crafts are operational in the district for both coastal and lagoon fisheries. The type of fishing craft varies – there are traditional non-motorised boats, traditional motorised boats and boats with out-board motors. Out-board FRP boats are the most prevalent (57%).

With respect to Lagoon fisheries, there are 2,145 registered boats, and the most commonly used type of boat is the traditional non-mechanised boat (56%) – such as outrigger canoes (*oru*), and log rafts (*theppam* and *wallam*). Fishing in the area is seasonal, with more crafts operating in the Lagoon during the southwest monsoon. In Mundel Lake there are 40 boats and 100 fishers.

In coastal areas, there is shrimp trawling, small-meshed gill net fishery, flying fish fishery and beach seine fishery targeting various species, carried out at various times of the year. One hundred and twenty seven species of ornamental fish are also harvested. The abundance of several ornamental species has decreased.

Various fishing gears are used in the capture fishery of the Puttalam Lagoon. The most commonly used method of capture is the gill net, used to catch both fin and shellfish. Bottom-set nets and trammel nets are used for the crab fishery. The predominant combination of gear and crafts are gill nets operated from reinforced plastic (FRP) boats.

With respect to fishery resources, a recent study reported a total of 69 species belonging to 27 families (mainly *Carangids* and *Clupeids*) harvested from the Puttalam Lagoon.

Penaeus semisulcatus and *P. indicus* are the main commercially important shrimp species, with *Portunus pelagicus* comprising about 20% of the total catch. The coastal shrimp fishery of Puttalam focuses on two species, the Green tiger prawn (*Penaeus semisulcatus*) and Moyebi shrimp (*Metapenaeus moyebi*).

Six species of edible bivalves have been recorded in Puttalam Lagoon: *Crassosstrea madrasensis, Modiolus auriculatus, Gafrarium tumidum, Anadara antiquata, Marcia opima* and *M. hiantina*.

Indian Chanks (*Turbinella pyrum*), found in the area, are valued ornamentals for the export industry.

Eight species of sea cucumbers are collected from the Dutch Bay and about 1,500 to 2,000 families are engaged in this fishery in Kalpitiya Peninsula. There are concerns that without proper regulation this fishery will not be sustainable.

Sea horses caught from seagrass meadows are either sold live for the aquarium trade or exported dried. Research is currently on-going to estimate the extent of this exploitation.

Four species of red algae – *Gracilaria edulis, Laurencia* spp*., Geldim* spp. and *Hypnea musciformi*, two species of green algae (*Ulva* spp. and *Enteromorpha* spp.) and two species of brown algae (*Sargassum* spp. and *Padina* spp.) have been recorded in the area. *Gracilaria edulis* collected from Puttalam Lagoon is dried and sold to the traders, however, it has been noted that *Glacilaria* has not been harvested from the Lagoon in the last three years.

Fish processing is also carried out by several households and dried fish is popular in this area. An issue related to this process is the lack of hygienic facilities during processing.

Estimates for 2009 and 2010 from the Puttalam Department of Fisheries show that annual fish production for lagoon fisheries was already 1.2 times and 1.5 MSY respectively

Commercial shrimp farming in the northwest coast of Sri Lanka – took off the ground in the 1980s and 1990s. Some 900 shrimp farms mushroomed in the region, but only about 50% were legal and only a few had carried out the environmental impact assessment required by the law. Recent data indicate the total area of shrimp farms in the Puttalam Lagoon area in 2009 was 1,817 ha, of which 1,167 ha (64%) were unproductive, abandoned farms. The shrimp that is cultured is *Penaeus monodon*, which are reared in earthen ponds.

Agriculture is the second most important economic activity of the district, with 29.3% of the population engaged in it. Coconut, paddy, cashew, vegetable crops, and fruit crops are the main crops cultivated around the Lagoon area. Small-scale home gardens are quite common: within a five kilometre radius of the Lagoon, there are 5195.8 ha of home gardens.

In addition to the fishing and agriculture, animal husbandry plays an important livelihood option in the area. It is practised by both fishers and farmers to provide supplemental income.

At present there are 1,363 ha of salterns in the Puttalam Lagoon area. Like shrimp farming, salterns provide casual employment.

HOLCIM Lanka Limited operates a cement manufacturing plant in the Puttalam district. Limestone is extracted by blasting and the use of heavy earth-moving equipment.

A thermal coal fired power plant, with infrastructure for 900 MW has been constructed in the Kalpitiya peninsula.

Two wind farms are expected to generate 10 MW of electricity, and are being sited in the Kalpitiya area.

Kalpitiya has been identified by the tourism sector as one of several new areas to revitalise the tourist industry after the cessation of the war. Five thousand new rooms are planned in this area.

A considerable number of SMEs are also found in the area.

There is a range of threats affecting the Puttalam Lagoon. Direct threats include habitat destruction, which is by far the biggest threat in the area.

GIS mapping indicates that considerable land use changes have occurred in the Puttalam Lagoon area in the last few decades.

Vast areas of mangroves and salt marsh habitats continue to be cleared for unplanned development activities such as salterns, shrimp farms, coconut cultivation and temporary human settlements. There has been a 26.8% loss from 1981 to 2009 of mangroves. Mud flats are affected by habitat degradation, and barrier beaches, spits and sand dunes are under threat from tourism development. Seagrass meadows and coral reefs are affected by both habitat degradation and use of harmful gear.

Quarrying for limestone and land conversion for coconut cultivation are destroying tropical mixed evergreen forests, while thorn forests are being converted to salterns and shrimp farms.

Habitat degradation is another serious threat to the health of the Lagoon. The productivity of the Lagoon is being choked slowly by pollution that originates in shrimp farms and from agriculture. The water in the Lagoon in many areas has become basic as a result of discharge of ammonia from shrimp farms. Studies have shown that there is a high level of nitrate pollution in the ground water of Kalpitiya, as a result of run off from agrochemicals.

There are serious concerns that hot water discharged from the coal power plant will damage and destroy marine organisms, however no data is currently available to assess the likely impacts.

Solid waste pollution is another unsightly and unhealthy issue affecting the Lagoon area.

Satellite images and community consultations have revealed that some areas of the Lagoon are diminishing as a result of sedimentation. Erosion is common adjacent to shrimp ponds.

There are great concerns that the coal power plant at Nuraicholai will result in air pollution.

Over-exploitation is another threat to the Lagoon. Lagoon fisheries are already at 1.5 times MSY. It is clearly evident is that fishing practices are not being monitored nor regulated sufficiently. Further, many different types of illegal fishing gear are used in the Lagoon, and these increase unsustainable harvest. Another form of over-exploitation is waste from by-catch.

Of the species caught for medicinal and ornamental purposes, sea-horses and molluscs are now exported commercially. There is evidence of turtle poaching.

Current practices of aquaculture and agriculture over-use fresh water.

Invasive alien species are serious threats in any habitat. There is evidence of invasive species spreading in thorn forests, and three in the Lagoon.

Recent studies indicate Kalpitiya and Mundel, both in the Puttalam District, show high levels of vulnerability due to climate change. Increase or decreases in rainfall quantities and patterns across the Puttalam area will alter the salinity of the Lagoon, and will have far-reaching consequences for aquatic food webs.

The intense thrust for development and investment in the Puttalam Lagoon area is changing the scenic beauty of the area.

Underlying the above mentioned direct threats to the Lagoon, there are also indirect drivers of biodiversity loss that include demographic, economic and socio-political issues. Poverty and unemployment are high in the Lagoon area. Lack of land tenure is also a major issue.

Major impediments to conservation of the Lagoon and its surroundings are the complexities of jurisdictions and mandates of the institutions operating in the Lagoon area. There is jurisdictional and functional overlap among 16 laws that impact on the Lagoon. There is also inadequate integrated (cross-sectoral) planning and this leads to a lack of holistic management.

The lack of an over-arching, integrated policy for the Lagoon is hampering conservation and sustainable management of natural resources. Lagoon management is seen as the responsibility of the Department of Fisheries and therefore, the policy focus is extremely narrow. A paradigm shift to an integrated policy is needed urgently. A second lacuna in existing Lagoon policies is the lack of recognition of local communities as partners in conservation and sustainable management.

A range of strategic actions are proposed for the Puttalam Lagoon.

A fisheries management plan for the Lagoon, with a more holistic view that recognises that fisheries cannot be managed in isolation and must be integrated into development planning into local/ district, provincial and national policies needs to be developed urgently.

Mechanisms to enhance active participatory stakeholder engagement in resource-use management decisions must be promoted.

Regulations must be formulated for the newly designated North West Coast Fisheries Management Area.

Habitat destruction is a major threat and therefore, it is essential natural habitats are afforded a greater level of protection, through the declaration of protected areas, with a suitable level of protection. Critical areas for conservation have been identified: the Kala Oya delta; the mangroves of Thirikapallama; the mangroves of Pubudugama; the Mi Oya delta (Anakutti and Seguwantivu); the mangroves of Ettalai; the islands of the Lagoon area and the mangroves and maritime grasslands of Keerimundel.

It is also essential that there is regulation and strict control of development activities - such as aquaculture, agriculture and salt production – that destroy and degrade natural ecosystems.

The prevention of coastal erosion and sedimentation control needs to be ensured.

A water conservation and management strategy, and a solid waste and effluent management plan for the Puttalam Lagoon area need to be developed.

Efforts should be made to influence dialogue on the development of a sustainable tourism development plan.

There is a lack of capacity for management: a dearth of adequate skills, as well as human resources. Strengthening of organisations through capacity building is necessary. This necessarily hampers implementation.

Reliance on the Lagoon can be lessened by strengthening alternate livelihoods.

GIS mapping showed a large are of abandoned shrimp farms surrounding the Lagoon. Restoration of degraded habitats must be integral to the management of the Lagoon.

GIS mapping also highlighted use conflicts in certain areas. These areas will need special management to accommodate land use needs, yet protect natural habitats in the area vital for the health of the Lagoon.

The Lagoon and its surrounding areas must be seen as a landscape of inter-connected and inter-dependent ecosystems, that are impacted by actions both within and without the landscape, and which needs a central, holistic approach of integrated coastal management, recognising that spatial, temporal, sectoral, political and institutional integration are all essential for success. Until this paradigm shift is made, conservation will not be successful, nor will long term sustainability of the Lagoon be assured.

The Millennium Ecosystem Framework needs to be used extensively to create awareness about the importance of the Lagoon to human well-being among communities, government officers, non-governmental organisations and the private sector.

The decrease in government financing and international donor funding for natural resource management has prompted the need for the development of additional sustainable financing mechanisms for the long term conservation and management of the Puttalam Lagoon area.

Many of the recommendations made in previous studies, for several decades, indicate that although issues that damage the Lagoon have been identified for decades, actions to resolve them have not been implemented. Existing laws and policies must be implemented.

Strategic interventions must be formulated and implemented now, as a matter of urgency, before Puttalam Lagoon, like Mundel Lake before it, becomes virtually fishless and unproductive, and before thousands of people are left without the means for living.

Chapter 1. Background

Introduction

The scope of the document

This document reviews the available information about Puttalam Lagoon – the current status of its resources and its people, as well as the threats to its existence – in the context of coastal resource management. In particular, this document examines natural coastal process and current trends influenced by anthropogenic activities.

IUCN in Sri Lanka has worked in the Puttalam Lagoon since 2008. The first of several projects was to rehabilitate and conserve coastal ecosystems in Sri Lanka and Thailand, funded by the German Federal Ministry for Economic Cooperation and Development (BMZ). This project – commonly called the BMZ project – facilitated coastal ecosystem rehabilitation and conservation activities in critically degraded ecosystems in coastal stretches of Puttalam Lagoon in northwest Sri Lanka. Much ecological and sociological information was collected and analysed during this project.

An estuary is a partly enclosed coastal body of water with one or more rivers or streams flowing into it, and with a free connection to the open sea (http://en.wikipedia.org/wiki/Lagoon).

A lagoon is a body of shallow sea water or brackish water separated from the sea by some form of barrier (http://en.wikipedia.org/wiki/Lagoon).

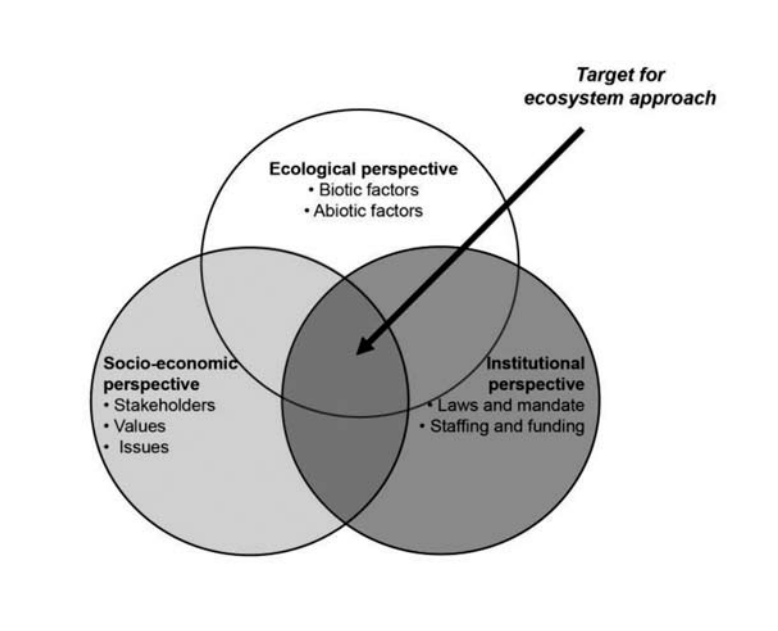
Technically, Puttalam 'Lagoon' is an estuary, because it has three rivers flowing into it. However, the common usage is as Puttalam Lagoon. In order to avoid confusion, this document will use the commonly used phrase 'Puttalam Lagoon', instead of the more technically accurate 'Puttalam Estuary'.

The project for Improving Natural Resource Governance for the rural poor in Sri Lanka (funded by UK Aid) aims to strengthen natural resource rights and promote changes to reduce procedural inequities addressing questions of fair treatment in uniformly applying governing rules, regulations and evaluation criteria. It focuses mainly on issues faced by poor communities dependent on natural resources. Here too, information has been collected and assessed.

The Mangroves for the Future (MFF) programme is regional, and aims to strengthen the environmental sustainability of coastal development, and promote investment of funds and other resources in coastal ecosystem management for sustainable development. MFF has been in operation since mid-2007. MFF seeks to achieve demonstrable changes and results across four key areas of influence: regional cooperation, national programme support, private sector engagement, and community action to build knowledge, strengthen empowerment and enhance good governance in coastal areas. Coastal areas of Puttalam have benefited from MFF small grants.

Information from all the above projects was collated and presented in this review with the financial assistance from the Regional Fisheries Livelihoods Programme (RFLP), Sri Lanka Component of the Food and Agricultural Organisation (FAO). This review examines the Lagoon from a landscape ecology perspective – understanding that species are not only integral parts of ecosystems, but that many inter-connected and inter-dependent ecosystems form a mosaic in a larger landscape – and focuses on broad-scale environmental and ecological issues. It uses an ecosystems approach that recognises that long term sustainability cannot be achieved if an ecological focus overshadows human welfare and *vice versa* (Meffe et al., 1997).

'*Ecosystem management is an approach to maintaining or restoring the composition, structure or function of natural and modified ecosystems for the goal of long-term sustainability. It is based on a collaboratively developed vision of desired future conditions that integrates ecological, socio-economic and institutional perspectives, applied within a geographic framework defined primarily by natural ecological boundaries.*'



Source: (Meffe et al., 1997).

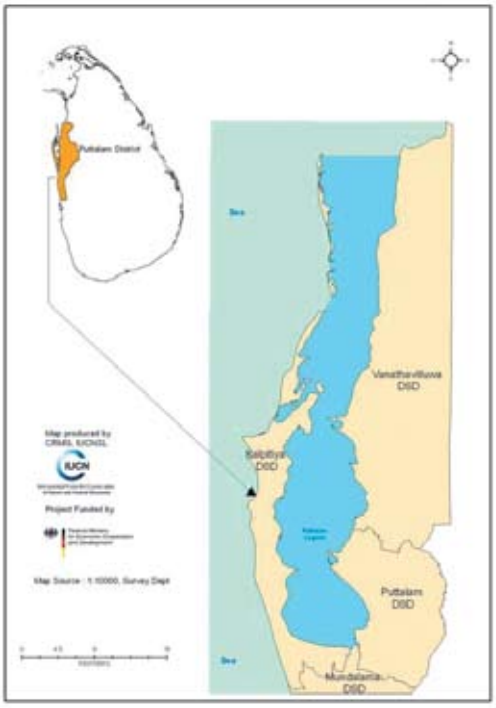
Therefore, this document also presents an institutional analysis for the Puttalam Lagoon and offers a broad-brush picture of livelihoods in the area.

Finally, this review presents conservation and management recommendations for reversal of harmful trends in the Lagoon.

The Puttalam Lagoon: location and characteristics

The Puttalam Lagoon – both economically and ecologically important – is located in the North Western Province of Sri Lanka at 7^0 44'46-8^0 35'60 North and 79^0 48'25-79^0 49'17 East (Figure 1).

Figure 1. Location of the Puttalam Lagoon
(Source: Weragodatenna, 2010)



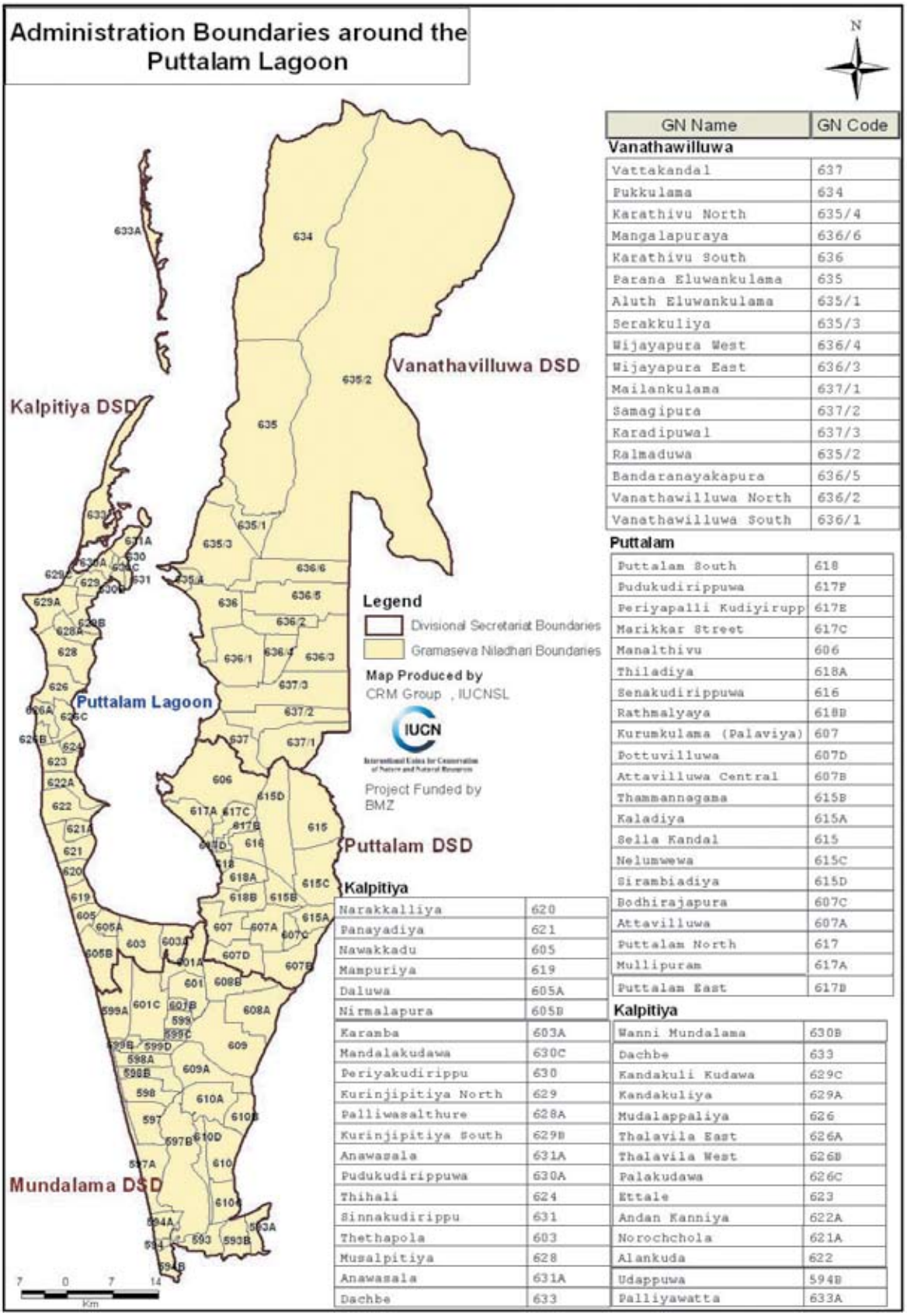
The township of Puttalam is in Puttalam district[1] of the Northwestern Province of Sri Lanka. The Puttalam district has 16 Divisional Secretariat Divisions[2] and 548 *Grama Niladhari* Divisions[3] (Department of Census and Statistics, 2011). But the area around the Lagoon comprises only four Divisional Secretariats: Kalpitiya, Puttalam, Vanathavillu and Mundel (See Table 1, Figure 2).

Table 1. Administrative Divisions surrounding the Puttalam Lagoon area
(Source: Department. of Census and Statistics 2011)

Divisional Secretariat	Grama Niladhari Divisions	Extent (km²)
Vanathavillu	17	715.3
Puttalam	22	173.3
Mundel	31	234.4
Kalpitiya	31	154.2

1 A District is the layer of administration below the Provincial level.
2 Sub-divisions of a district. Planning activities at district level are largely confined to coordination and monitoring of all projects and programmes in the area. Actual planning processes and implementation were decentralised to the Divisional Secretariats.
3 *Grama Niladhari* divisions (GN divisions) are the lowest level of administration.

Figure 2. Administrative Divisions surrounding the Puttalam Lagoon
(Source: Department of Census and Statistics 2011)



GN Name	GN Code
Vanathawilluwa	
Vattakandal	637
Pukkulama	634
Karathivu North	635/4
Mangalapuraya	636/6
Karathivu South	636
Parana Eluwankulama	635
Aluth Eluwankulama	635/1
Serakkuliya	635/3
Wijayapura West	636/4
Wijayapura East	636/3
Mailankulama	637/1
Samagipura	637/2
Karadipuwal	637/3
Ralmaduwa	635/2
Bandaranayakapura	636/5
Vanathawilluwa North	636/2
Vanathawilluwa South	636/1
Puttalam	
Puttalam South	618
Pudukudirippuwa	617F
Periyapalli Kudiyirupp	617E
Marikkar Street	617C
Manalthivu	606
Thiladiya	618A
Senakudirippuwa	616
Rathmalyaya	618B
Kurumkulama (Palaviya)	607
Pottuvilluwa	607D
Attavilluwa Central	607B
Thammannagama	615B
Kaladiya	615A
Sella Kandal	615
Nelumwewa	615C
Sirambiadiya	615D
Bodhirajapura	607C
Attavilluwa	607A
Puttalam North	617
Mullipuram	617A
Puttalam East	617B
Kalpitiya	
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Dachbe	633
Kandakuli Kudawa	629C
Kandakuliya	629A
Mudalappaliya	626
Thalavila East	626A
Thalavila West	626B
Palakudawa	626C
Ettale	623
Andan Kanniya	622A
Norochchola	621A
Alankuda	622
Udappuwa	594B
Palliyawatta	633A

Narakkalliya	620
Panayadiya	621
Nawakkadu	605
Mampuriya	619
Daluwa	605A
Nirmalapura	605B
Karamba	603A
Mandalakudawa	630C
Periyakudirippu	630
Kurinjipitiya North	629
Palliwasalthure	628A
Kurinjipitiya South	629B
Anawasala	631A
Pudukudirippuwa	630A
Thihali	624
Sinnakudirippu	631
Thethapola	603
Musalpitiya	628
Anawasala	631A
Dachbe	633

The Puttalam Lagoon (hereafter referred to as the Lagoon) is one of the largest estuaries of Sri Lanka, extending over 32,750 ha (IUCN and ADB, 2003). Three river basins – Kala Oya, Mi Oya and the very small Moongil Ara – connect with the Lagoon (Figure 4). The Kala Oya provides the largest freshwater volume, but is located at the mouth of the Lagoon, where the impact is less (Figure 4). The catchments of these three river basins are as follows: Kala Oya 2,772 km^2, Mi Oya 1,516 km^2 and Moongil Ara 44 km^2 (IUCN, 2010).

The Lagoon is open naturally to the sea at the northern end, while the southern end is connected to the Dutch canal. This canal is, in turn, connected to the northern end of Mundel Lake. During the dry season, this Dutch canal carries brackish water from the Lagoon towards Mundel Lake; in the wet season, this flow is reversed with water from Mundel Lake carried towards the Lagoon (IUCN and CEA, 2006).

The Lagoon system is very shallow, with depths of no more than 1-2 m, except in the deep channels within the Lagoon, where depths of 4-5 m have been recorded (Dayaratne et al., 1997). In the north, the water is of normal oceanic salinity, but is hyper-saline in the south, as a result of high evaporation. Bathymetry reveals that the Lagoon comprises two basins separated by islets east of Kalmunai (CEA, 1994). Both basins are more or less level at the Lagoon floor, expect at the channel between Kalpitiya and Serakkuliya, which is the deepest part of the Lagoon, and where there are strong currents (CEA, 1994).

Figure 3. Bathymetry of the Puttalam Lagoon
(Source: Perera and Siriwardene, 1982, in litt. CEA, 1994)

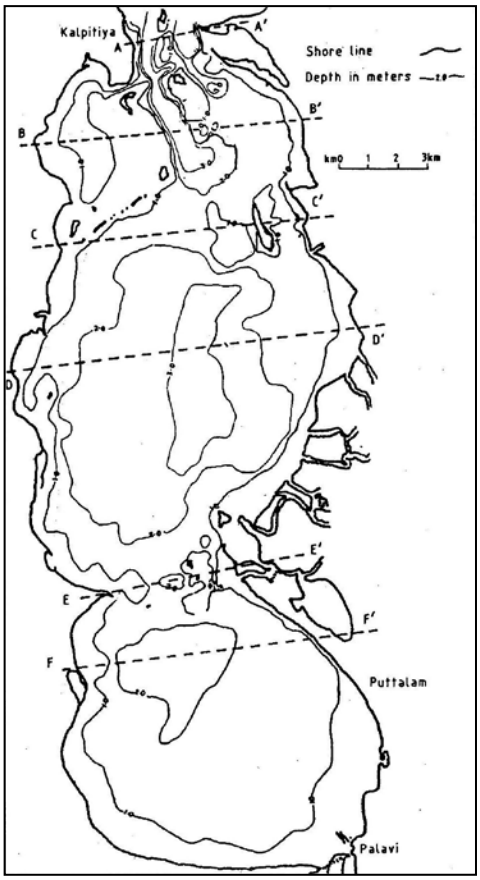
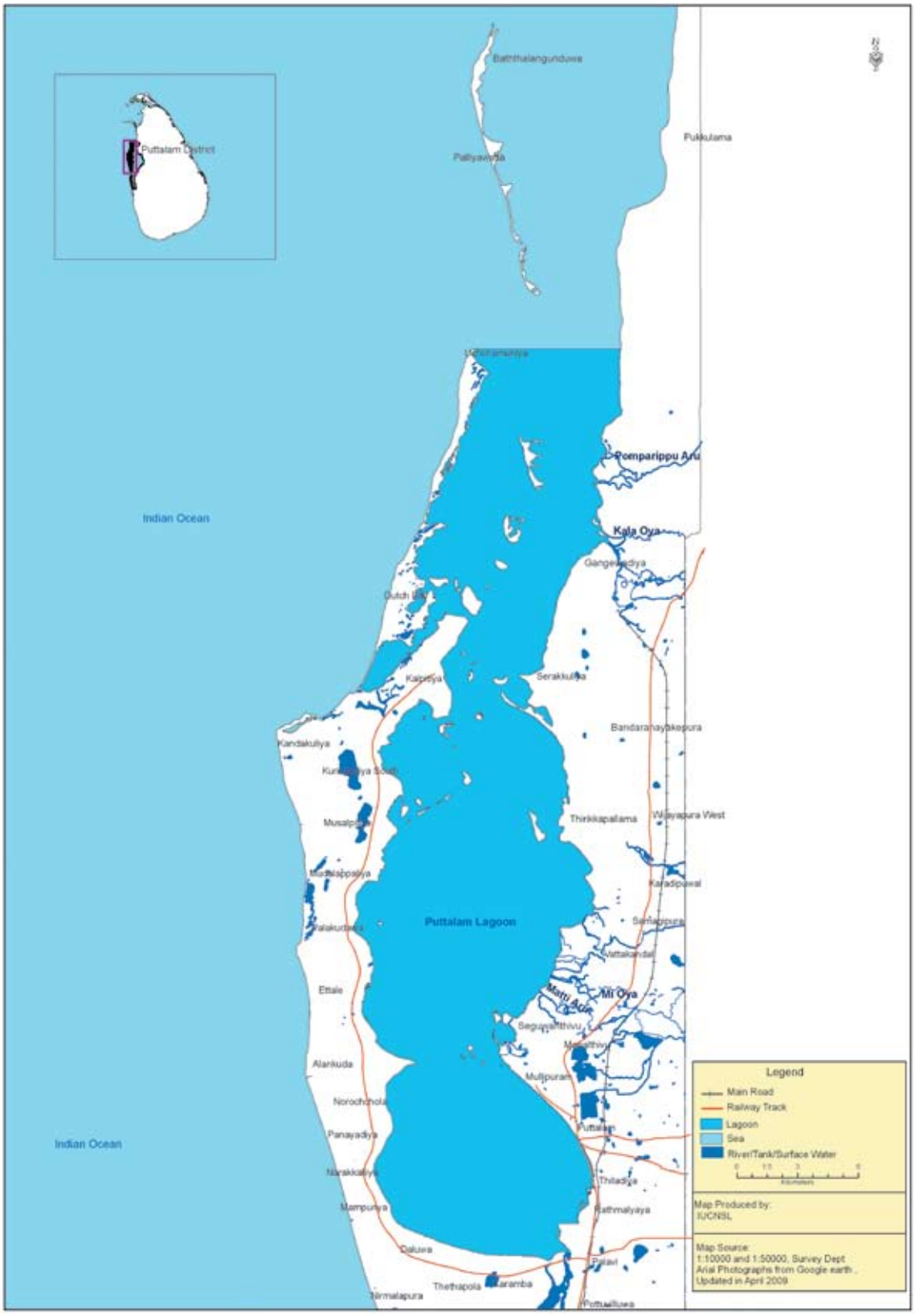


Figure 4. Rivers and waterways of the Puttalam Lagoon area
(Source: Weragodatenna, 2010)



The average discharges of the Kala Oya and Mi Oya are estimated to be about 2.2 m^3/s and 8.1 m^3/s respectively (Dayaratne et al., 1997). Two ground water basins – Vanathavillu and Madurankuli – are located close to Puttalam Lagoon system.

A semi-diurnal tidal pattern[4] occurs in the Lagoon. The average tidal range is about 25 cm (Ekanayake et al, 1995 in litt. IUCN, 2010), while the maximum tidal range recorded is 79 cm (Perera and Siriwardene, 1982, in litt. IUCN, 2010). Although the Lagoon is connected to the Indian Ocean through the Dutch Bay at the northern end, its tidal pattern does not match the rhythm of the open ocean. Monsoon winds play a significant role in tidal movement in this shallow lagoon and the tidal range is highest during the northeast monsoon and lowest during the southwest monsoon (Perera and Siriwardene, 1982, in litt. IUCN, 2010). Surface water salinities vary between 0.00 ppt (at the Kala Oya Lagoon) and 55.0 ppt (Arulananthan et al, 1995, in litt. IUCN, 2010).

The Lagoon is located in the dry zone of the island, which receives a sharply seasonal average annual rainfall of between 1,000-1,100 mm, derived mainly from the northeast monsoon. Because of this, the area experiences a prolonged dry season of 4-7 months from March to September.

[4] The tide rises and falls twice a day.

Chapter 2. The People of Puttalam Lagoon area

Demography

In 2006, the recorded population of the four DS divisions was 241,624, with 87,579 in Kalpitiya Divisional Secretariat Division, 76,132 in Puttalam, 17,627 in Vanathavillu and 60,286 in Mundel (Department of Census and Statistics, 2006). The two former divisional secretariat divisions are more densely populated, while Vanathavillu is the least populated (Department of Census and Statistics, 2006). (Table 2, and Figure 5).

Table 2. Population and population density in the Puttalam Lagoon area
(Source: Census and Statistics Division, Puttalam, 2009)

Divisional Secretariat Division	Population	Population Density (people/ km²)
Vanathavillu	17,627	24.6
Puttalam	76,132	435.0
Mundel	60,286	272.8
Kalpitiya	87,579	524.4

In these four divisional secretariat divisions there are 48,986 households, with an average family size of 4.9 (Census and Statistics Division, Puttalam, 2009). (See Table 3)

Table 3. Number of households, houses and family size in the Puttalam Lagoon area
(Source: Census and Statistics Division, Puttalam, 2009)

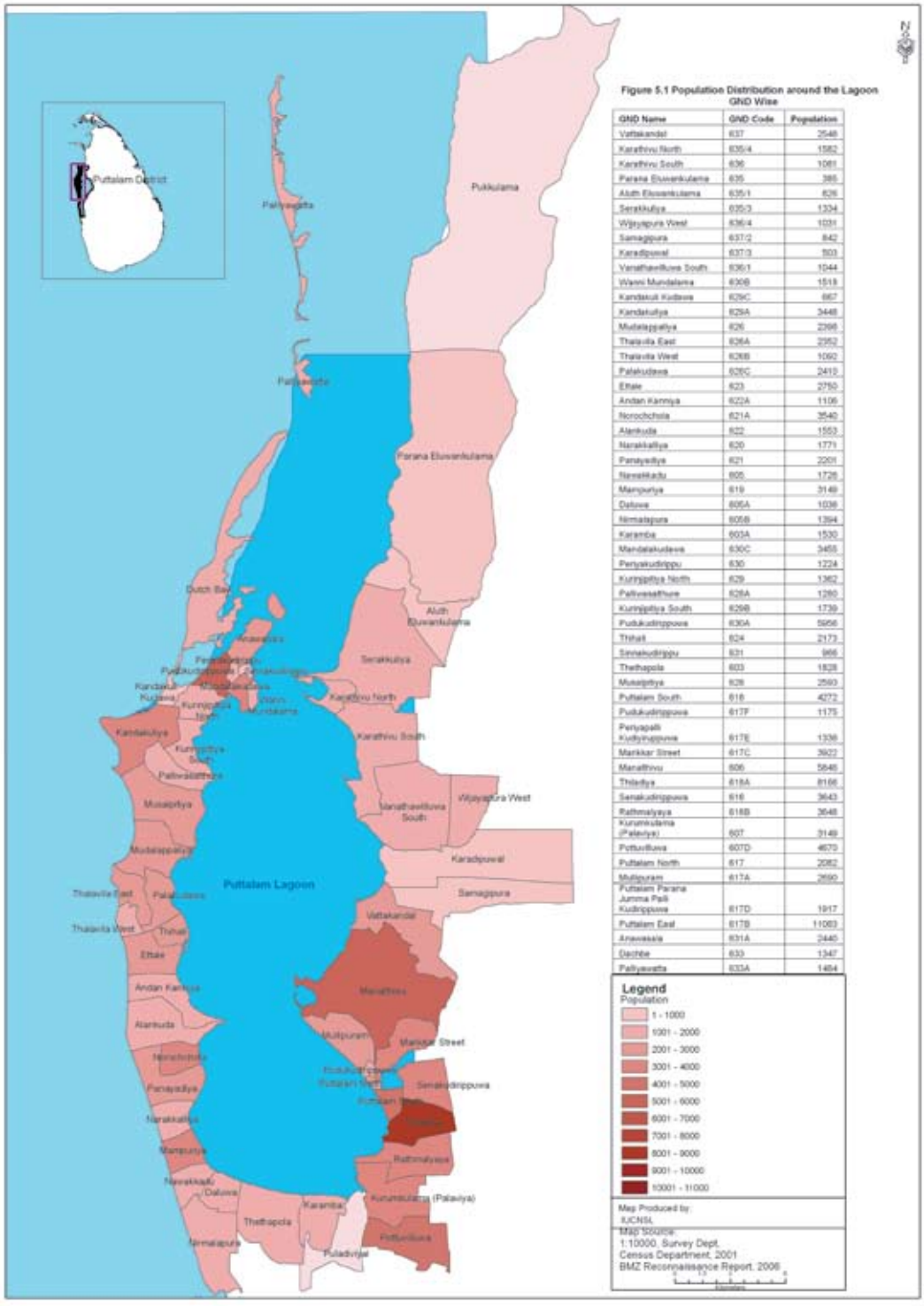
Divisional Secretariat Division	Households	Number of houses	Average family size
Vanathavillu	4,774	4,377	4.0
Mundel	14,525	14,022	4.3
Puttalam	16,486	15,839	4.8
Kalpitiya	13,201	12,883	6.8

Gender ratios in this area are at parity, except in the Vanathavillu DS division (See Table 4).

Table 4. Population in the Puttalam Lagoon area by gender
(Source: Census and Statistics Division, Puttalam, 2009)

Divisional Secretariat Division	Male		Female	
	Number	Percentage	Number	Percentage
Vanathavillu	9,242	52.4	8,385	47.6
Puttalam	38,037	50.0	38,095	50.0
Mundel	30,196	50.1	30,089	49.9
Kalpitiya	44,095	50.3	43,484	49.7

Figure 5. Population density in the Puttalam Lagoon area
(Source: Weragodatenna, 2010)

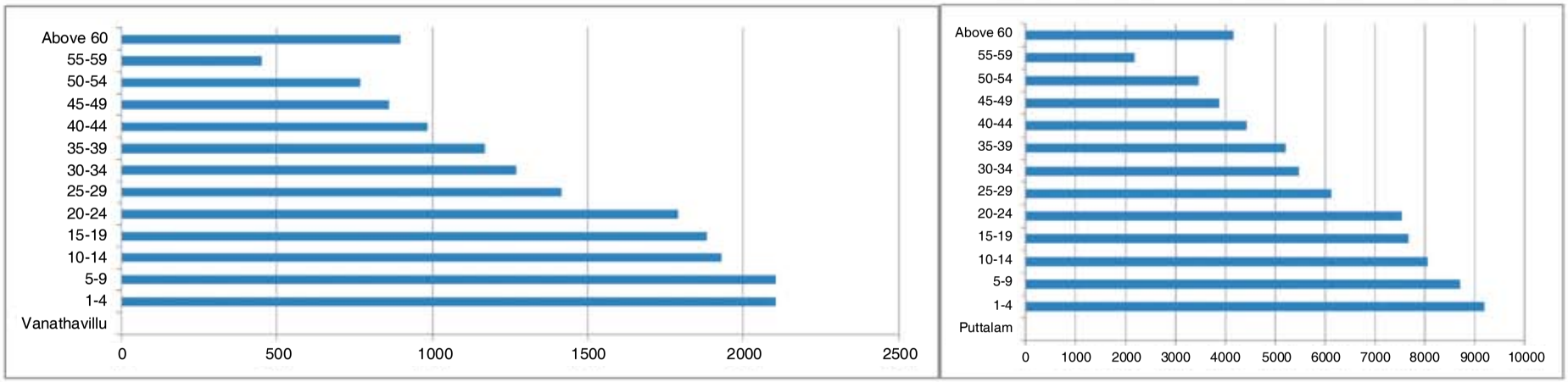


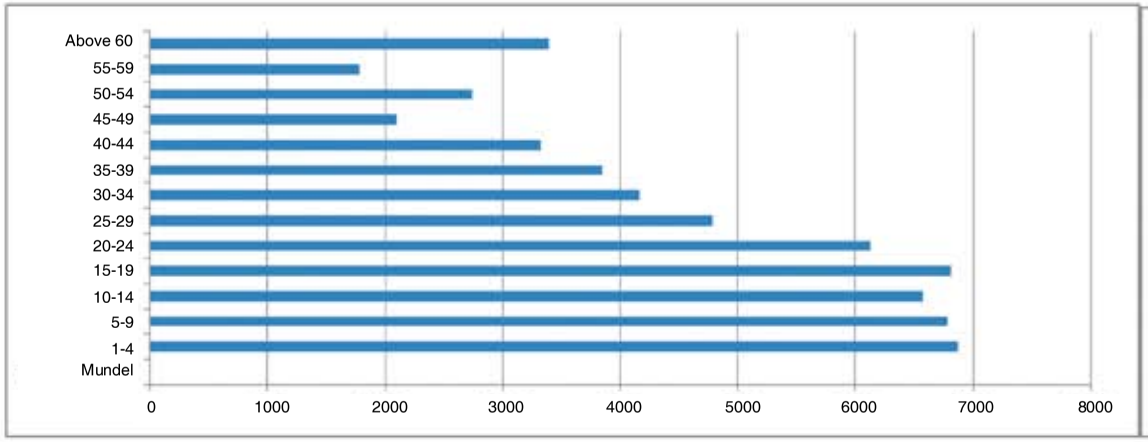
The population distribution by age shows that there is a larger than expected cohort of aging people in this area (Table 5, and Figure 6).

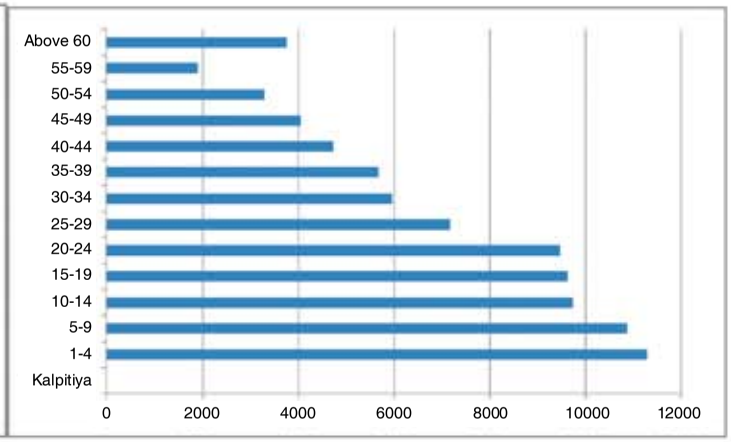
Table 5. Population by age distribution in the Puttalam Lagoon area
(Source: Census and Statistics Division, Puttalam, 2009)

Divisional Secretariat Division	Age												
	0 - 4	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	Above 60
Vanathavillu	2,105	2,104	1,930	1,884	1,792	1,414	1,270	1,168	983	861	767	451	898
Puttalam	9,192	8,701	8,065	7,681	7,540	6,126	5,471	5,207	4,436	3,887	3,458	2,180	4,188
Mundel	6,870	6,778	6,573	6,807	6,129	4,786	4,166	3,843	3,325	3,093	2,744	1,783	3,389
Kalpitiya	11,295	10,865	9,729	9,637	9,472	7,176	5,957	5,683	4,745	4,056	3,297	1,906	3,759

Figure 6. Population pyramids of the four divisional secretariat divisions
(Source: Census and Statistics Division, Puttalam, 2009)







The number of dependent persons is presented in Table 6. The total number of dependants in the four relevant DS divisions is 96,442 and the dependency ratio[5] is 39.8, which is less than the national dependency ratio (46 in 2010).

[5] The dependency ratio tells us how many young people (under 16) and older people (over 60) depend on people of working age (16 to 64).

$$\text{Dependency ratio} = \frac{(\%\text{under } 15) + (\%\text{over } 60)}{(\%\ 16\text{-}64)} \times 100$$

Table 6. Number of dependents in the Puttalam Lagoon area
(Source: Census and Statistics Division, Puttalam, 2009)

Divisional Secretariat Division	Total Population	Dependents	Dependency ratio
Vanathavillu	17,627	7,038	39.9
Puttalam	76,132	30,146	39.6
Mundel	60,286	23,610	39.1
Kalpitiya	87,579	35,648	40.7

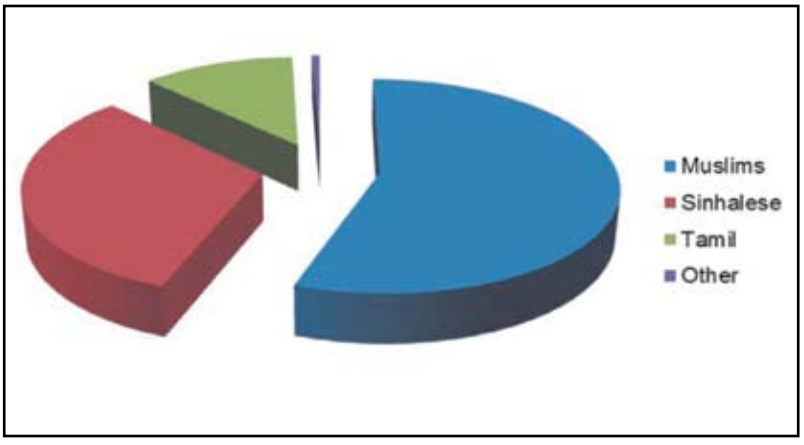
In the Lagoon area are permanent residents, seasonal migrants, and refugees. Seasonal migrants – found mainly in Battalangunduwa, Uchchmunai, Wella, Paramunai and Wellama – fish both in the Lagoon and in the sea.

Since the early 1990s, the population in the Puttalam district has increased greatly, as an influx of internally displaced persons (IDP), fleeing from the North and East, have found refuge in the district. Most of them live around the Lagoon and have settled down in Kalpitiya, Mandalakudawa, Kurakkanhena, Kuringipitti and Musalapitiya. Reports indicate that there are approximately 63,145 displaced families settled in Puttalam. Although the different communities have shared the area for over 17 years, there still are tensions between the IDPs and the original inhabitants, over the use of limited resources and competition for labour opportunities (DDSP, 2008). (Figure 8.)

With the cessation of the war, former refugees are going back to the North and East (Anura Jayasekera, person. comm.), and this is likely to affect population statistics, which will need to be re-assessed in a few years' time.

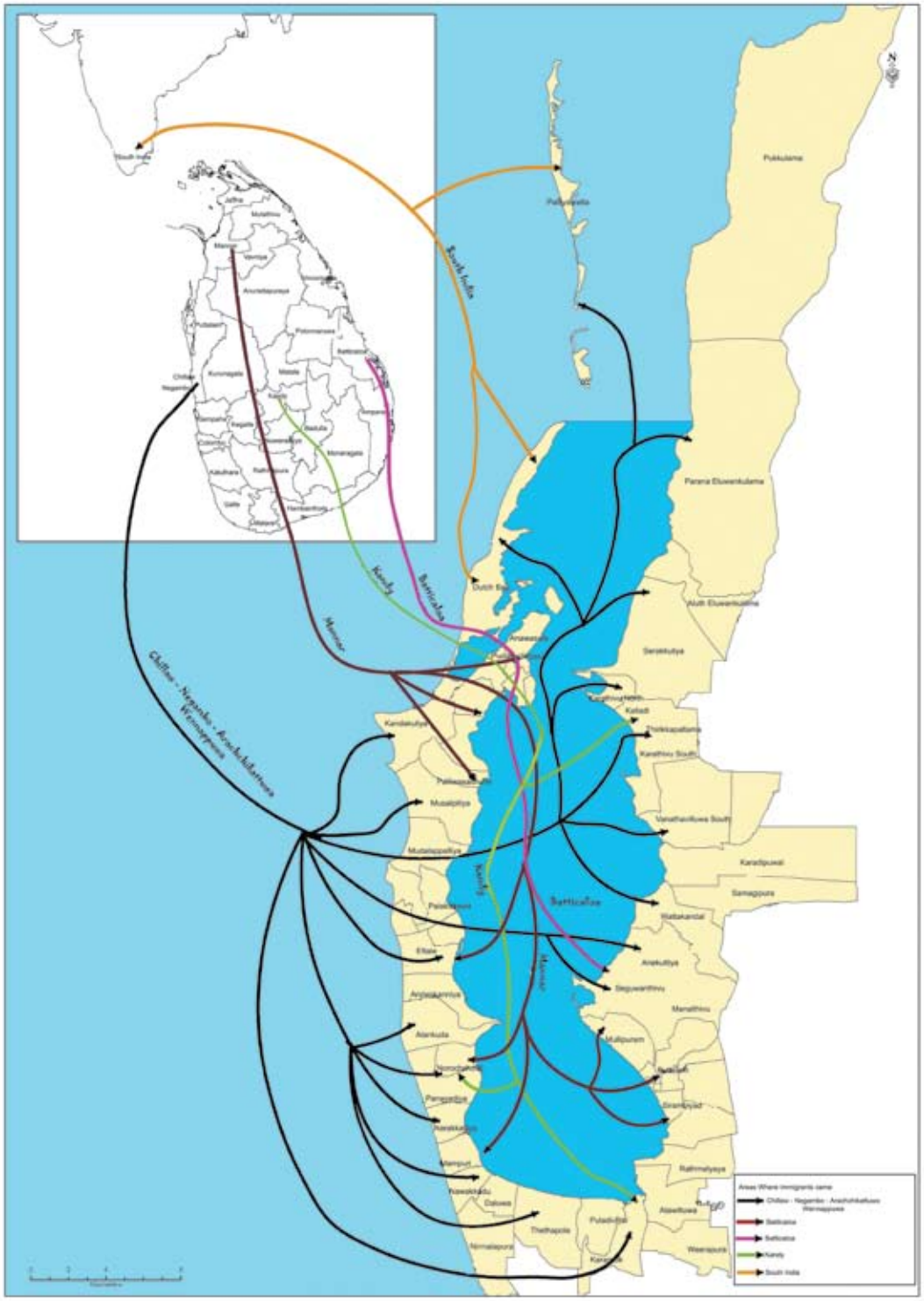
The majority of the population in the Puttalam Lagoon area are Muslims (55.6%), with Sinhalese as the second largest ethnic group in the area (31.9%); Sri Lankan Tamils comprise 11.9% and the rest a mix of Burghers, Malays, Indian Tamils and other minorities (IUCN and ADB, 2003).

Figure 7. Population of the Puttalam Lagoon area by ethnicity
(Source IUCN and ADB, 2003)



The most common religious group are Muslims, aggregated in the town areas of Kalpitiya, Nuraicholai, Palavi and Puttalam. The second largest religious group are the Catholics, scattered around the Lagoon area. Buddhists and Hindus are distributed in the interior of the western side to the Lagoon.

Figure 8. Internal migration to the Puttalam Lagoon area
(Source: Weragodatenna, 2010)



Education

Most government primary and secondary schools are situated close to the main towns in the Lagoon area. The number of school children (aged 6-9) was 21,176 in 2008, although the number of children eligible for primary education was 28,448, indicating a school enrolment only of 74% (Census and Statistics Division Puttalam, 2009). It is reported that that nearly 3,812 students studied up to GCE Ordinary level (OL) and 2,117 up to GCE Advanced level (AL) in the DS divisions of Puttalam, Kalpitiya, Vanathavillu and Mundel. Secondary education is provided through national schools (*Maha Vidyalas),* situated close to the main towns.

Table 7. Number of schools in the Puttalam Lagoon area
(Source: Census and Statistics Division, Puttalam, 2009)

Divisional Secretariat Division	Total Schools	National school	IAB[6] schools	IC[7] schools	2nd grade level[8] schools	3rd grade level[9] schools
Vanathavillu	12	0	0	3	9	0
Puttalam	25	2	2	7	11	3
Mundel	33	0	0	12	16	5
Kalpitiya	34	1	0	10	16	7

Table 8. Teacher and student population in the Puttalam Lagoon Area
(Source: Census and Statistics Division, Puttalam, 2009)

Divisional Secretariat Division	School children				Total school children	Teachers	Pupil-teacher ratio
	Grade 1-5	Grade 6-9	OL	AL			
Vanathavillu	1,557	1,533	220	53	3,363	127	26.5
Puttalam	10,985	7,917	1,569	1,226	21,697	812	26.7
Mundel	7,011	5,016	849	318	13,194	538	24.5
Kalpitiya	10,223	6,710	1,174	520	18,627	618	30.1

The pupil-teacher ratio is lowest for Mundel, which is the most urbanised area, and highest for Kalpitiya, indicating that access to towns is an important factor in the number of teachers.

There are no private schools in the Dutch bay and Palliyawatta GNDs, which are situated in the northern part of the Kalpitiya DSD and connected by a sand bar with the main land. This area has no education facilities for many children who are eligible for schooling (Census and Statistics Division, Puttalam, 2009).

Employment

The majority of the population of the Lagoon area depend on fishing. They also engage in agriculture (including cash crop cultivation and subsistence farming). Animal husbandry (cattle, goats, poultry, and pigs) is also a popular activity in the area. Large groups of people are engaged in the salt industry and shrimp farming.

Self-employment and small and medium enterprises (SMEs) are attractive livelihoods among communities in the area. Household members are often engaged in several subsistence level

6 Schools up to AL with math, science and arts subjects
7 Schools up to AL but no math and science
8 Schools with grades up to O/L only
9 Primary grades only

activities (such as animal husbandry, farming, and small-scale businesses), in addition to their main employment.

Most of the population engaged in trade are Muslims, dwelling near urban areas in the DS divisions of Puttalam and Kalpitiya. According to the available data from the Census and Statistics Department, the labour force in the Puttalam Lagoon area is 49% and the unemployment rate in this area is 5% (Census and Statistics Division, Puttalam, 2009).

Income

Estimates for 2006/07 revealed that approximately 104,000 people (10.6% of the households) in Puttalam were classified as poor households, with a mean income of 98.44 USD per household per month (Department of Census and Statistics, 2009). On average, five family members share a household, and this translates to a mean income per person per day of less than one dollar.

Poverty in the Lagoon area is described in Table 9 below.

Table 9. Poverty indicators for the Puttalam Lagoon area
(Source: http://www.statistics.gov.lk/poverty/small%20area%20reportNEW.pdf
http://www.statistics.gov.lk/poverty/monthly_poverty/index.htm)

Divisional Secretariat Division	Number of families	Head Count Index[10]	Household Population Below Poverty Line[11]	Number of *Samurdhi*[12] recipient Families	Government Transfers (Charity allowance)
Kalpitiya	13,201	45.34	36,197	5,524	1,292
Puttalam	17,965	25.08	16,864	4,398	1,102
Vanathavillu	4,772	40.31	6,373	2,074	688
Mundel	15,397	41.08	22,503	7,510	1,573

The national head count index for all districts is 15.2%, indicating that people in the Puttalam Lagoon are much poorer than the national average (Department of Census and Statistics, 2011).

The majority of the population living along the coastal belt are poor, especially in the Dutch Bay area at the tip of Kalpitiya and in the Palliyawatta GN Division, isolated from the peninsula. This portion of the population does not have access to alternative livelihoods.

The unemployment rate in the Puttalam district is 16.9% for males and 35.6% for females (Department of Census and Statistics 2008). Based on the Millennium Development Goals (MDG) indicators for 2008, 59.4% males and 63.2% females consumed less than the minimum level of dietary energy consumption in 2006/07 (Department of Census and Statistics, 2008).

The percentage distribution of land ownership in Puttalam is 77.1%, with 22.9% households not owning any land. This figure is the highest percentage in Sri Lanka (Department of Census and Statistics, 2009). Of the total households in Puttalam district, 62.8% are in debt (Department of Census and Statistics, 2009).

[10] The Poverty Head Count Index is the proportion of poor population to total population as a percentage.

[11] The official poverty line for the Puttalam district in August 2011 is Rupees 3,267 (minimum expenditure per person per month to fulfill basic needs, 29.6 USD). The national poverty line is 3,241 for August 2011 (29.4 USD; Department of Census and Statistics, 2011).

[12] The main poverty alleviation programme in Sri Lanka.

Lack of employment opportunities, child labour, child trafficking, poor participation of women in community development, marginalisation of some communities and disabled persons, as well as a limited awareness about environmental and conservation issues, are some of the serious social issues facing the Puttalam District (Ranasinghe, 2010).

Health

A summary of health facilities for the four DS divisions in presented below.

Table 10. Health facilities in the Puttalam Lagoon area
(Source: Census and Statistics Division, Puttalam, 2009).

Divisional Secretariat Division	No. of wards	No. of beds	Out-patients	In-patients	Ayurveda hospitals	Out-patients
Kalpitiya	5	108	92,382	4,795	1	5,248
Puttalam	13	347	138,145	37,337	1	14,354
Vanathavillu	3	5	19,260	48	1	6,620
Mundel	9	110	94,293	4,661	1	3,755

Anaemia (defined as haemoglobin levels below 11.0 g/dl – comprising severe, moderate and mild anaemia) among children 6-59 months in Puttalam district is recorded as 27.4%, but as high as 80.3% for mild anaemia (10.0-10.9 g/dl) (Department of Census and Statistics, 2011). In women, the prevalence is higher – 40.3% (for any type of anaemia) and 91.6% for mild anaemia (Department of Census and Statistics, 2011).

Housing

In the Lagoon area there are four types of settlements: small towns, villages, internally displaced persons' camps and fishing camps (IUCN, unpublished data).

Most of the houses are situated along the major roads, such as the Puttalam-Kalpitiya Road and Puttalam-Vanathavillu Road. Villages are in outlying hamlets.

Table 11. Number of type of housing units in the Puttalam District
(Source: Statistical Abstract, 2010)

Total no. of housing units	Permanent		Semi-permanent		Improvised	
	Number	%	Number	%	Number	%
174,737	107,965	61.8%	55,263	31.6%	9,908	5.7%

Even though most of the people living in Dutch bay and the Palliyawatta GN Division have a house, they do not have land title deeds for their land. All deeds are currently being processed by the government. Many houses around the Lagoon are made with *cajans*[13] (IUCN, unpublished data).

Transport and communication

Transport in the Puttalam DS Division is much better than facilities in the Vanathavillu DS Division. The Colombo-Puttalam, Anuradhapura-Puttalam, and Kurunegala-Puttalam main roads traverse through this Division. In addition, the Puttalam-Colombo railway line also runs through this Division. Therefore, people in the Puttalam DS Division have easy access to public transport facilities.

[13] Dried and woven coconut leaves.

The transport facilities in the Kalpitiya DS Division are also satisfactory, and public and private transport services now operate between Kalpitiya and Colombo. Hence, the residents of Kalpitiya have access to commercial and service centres located on the coastal belt between Puttalam and Colombo.

In contrast, the situation for both transport infrastructure and transport services in the Vanathavillu DS Division is very poor (IUCN and ADB, 2003).

Table 12. Vehicles by DS Division
(Source: Department of Census and Statistics, Puttalam, 2009).

Divisional Secretariat Division	No. of cars	No. of motorcycles	No. of trishaws	No. of private buses	No. of bicycles	No. of lorries	No. of agricultural vehicles	Other
Vanathavillu	7	802	123	11	49	75	56	4
Puttalam	224	6,562	1,644	52	476	806	266	49
Mundel	65	3,274	807	16	201	481	237	6
Kalpitiya	74	3,077	1,021	13	259	575	81	24

Communication facilities are provided by government post offices, as well as private telecommunication centres in urban areas. There are 37 sub-post offices in the area, (Kalpitiya: 12; Puttalam: 7; Vanathavillu: 5; Mundel: 13) (Census and Statistics Division, Puttalam, 2009).

Electricity and Water

Electricity and water facilities are available for the mainland area in Kalpitiya and Puttalam DS divisions and along the main road in Puttalam-Vanathavillu. The islands off the coast of Kalpitiya – Mohattuwaram, Uchchmunai, and Baththalangunduwa – lack both electricity and water; as does the coastal area of Vanathavillu DS division. The rest of the divisions have access to mains (pipe-borne) water. The main sources for this pipe-borne water are the Kala Oya and Mi Oya (Kapila Gunarathne, person. comm.).

Land use

Coconut cultivation is the main land use in the area. A total area of 8,399 ha is under coconut cultivation in Kalpitiya, Puttalam and Vanathavillu DS Divisions. The interior of the eastern border of the Lagoon is cultivated predominantly with paddy cultivation with little human settlement. North of the Vanathavillu DSD is an unpopulated area with monsoon and thorn forests. The Kalpitiya DSD is densely populated and intensively cultivated. There is a congested settlement on the western and northern border of the Lagoon and many home gardens can be seen in this area.

The terrestrial and wetland ecosystems in and around the Lagoon comprise mangroves, tropical dry mixed evergreen and thorn forests, salt marshes, rivers, seagrass meadows, and coral reefs. Natural habitats have been converted to home gardens, coconut, cashew, paddy and banana cultivation, shrimp farms and salt production areas called salterns, covering a significant part of the terrestrial area (IUCN, 2010).

Table 13. Individual and household land use in the Puttalam Lagoon area
(Source: Census and Statistics Division, Puttalam, 2009)

Divisional Secretariat Division	Population	Land area (ha)	Land Use (per individual) (ha)	Households	Land use per household (ha)
Kalpitiya	87,579	15,420	0.18	87,579	1.20
Puttalam	76,132	17,330	0.3	76,132	1.09
Vanathavillu	17,627	71,530	4.06	17,627	16.34
Mundel	60,286	23,440	0.39	60,286	1.67

Within the Vanathavillu DS division, there are platation forests monsoon and thorn forests, shrimp farms, salterns, mangroves, paddy, coconut, cashew and vegetable cultivation, inland waterbeds and uncultivated land. Under different government land allotment programmes, nearly 7,724 ha was distributed for settlements (IUCN and ADB, 2003).

In the Kalpitiya DSD, there is cultivation of coconut, vegetables (mainly onion and chillies) and tobacco; salterns and shrimps farms are also found in the area. Natural habitats such as mangroves, salt marshes and thorn forests can also be found in this area.

The land of the Puttalam DS Division is used for residences and homesteads. Large scale salt industry and shrimp farming operations are found close to the Lagoon in the DSD. A number of inland water bodies (tanks) are also found within the area.

Considerable land use changes have occurred in the Puttalam Lagoon area.

Table 14. Land Use changes from 1985 to 2010 in the Puttalam Lagoon area
(Source: Weragodatenna, 2010)

Land Use Type	Areas in hectares					
	Vanatavillu DSD		Puttalam DSD		Kalpitiya DSD	
	1985	2009	1985	2009	1985	2009
Associated non-agricultural land	153.89	0.00	596.25	0.00	63.38	0.00
Barren Land	1,849.86	1,063.00	1,050.85	249.77	5,551.35	1,413.00
Built-Up Land	102.52	0.00	395.14	N/A	35.19	0.00
Cashew	150.20	1,767.48	0.00	297.21	181.44	0.00
Coconut cultivation	3,092.04	4,688.91	4,539.02	4,994.72	4,465.18	3,865.15
Crop Land	22.81	411.94	108.54	0.00	1,128.49	1,398.24
Dense Forest	44,204.40	40,580.50	0.00	0.00	0.00	0.00
Forest Plantations	262.74	0.00	1,771.34	0.00	0.00	0.00
Grassland	1,027.45	789.66	692.50	353.33	171.12	258.82
Homestead	1,935.29	2,534.74	3,245.39	5,234.34	2,050.64	2,530.47
Mangrove	1,136.44	662.59	478.87	416.74	694.53	612.35
Mixed Tree and Other Perennial crops	141.93	22.85	10.67	412.77	13.66	524.17
Open Forest	7,674.10	6,063.00	259.66	148.74	17.08	0.00
Paddy Cultivation	558.82	646.27	651.91	1,152.51	0	0.00
Scrub Land	7,484.76	6,177.00	684.09	650.00	968.45	1,221.24
Sparsely Used Crop Land	3,236.55	4,823.00	3,106.65	1,749.23	211.53	191.45
Marshy Land	0.00	23.30	76.10	27.54	628.90	0.00
Water Bodies (Tank/River/Streams)	2,725.16	2,365.71	873.82	653.68	1,047.57	694.35
Shrimp Farm	N/A	78.73	N/A	9.75	N/A	563.66
Abandoned Shrimp Farm	N/A	259.00	N/A	641	N/A	267.67
Saltern	N/A	0.00	N/A	1,042.93	N/A	316.83
Salt Marsh	N/A	165.04	N/A	143.53	N/A	393.42
Beach Area	N/A	0.00	N/A	0	N/A	1,337.47
Riverine Vegetation	N/A	117.13	N/A	55.50	N/A	0.00

Figure 9. Land use of the Puttalam Lagoon Area in 1981
(Source: Weragodatenna, 2010, from 1:100,000 Puttalam District map. Survey Department)

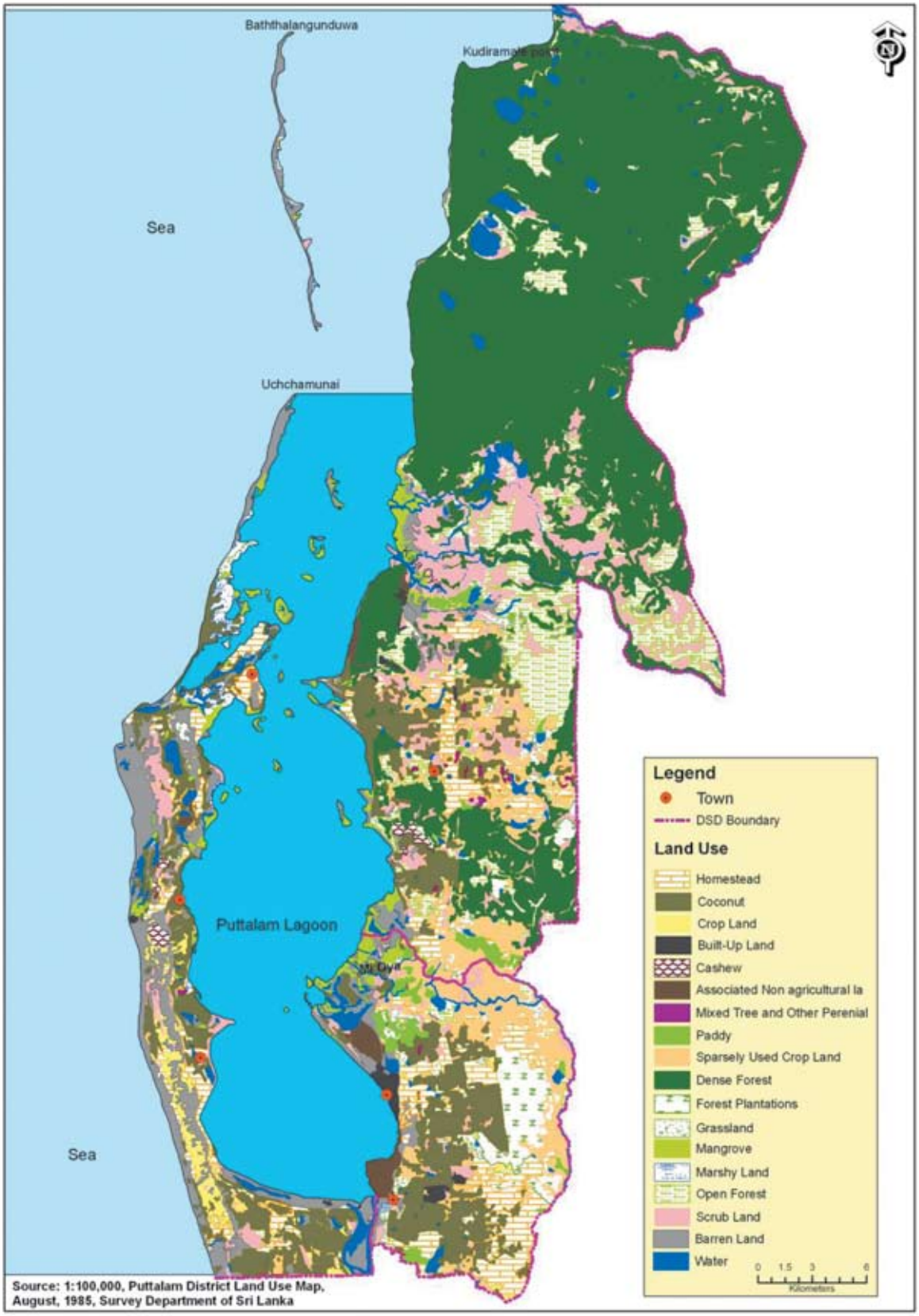


Figure 10. Land use of the Puttalam Lagoon Area in 2009
(Source: Weragodatenna 2010, from Goggle Earth maps April 2009)

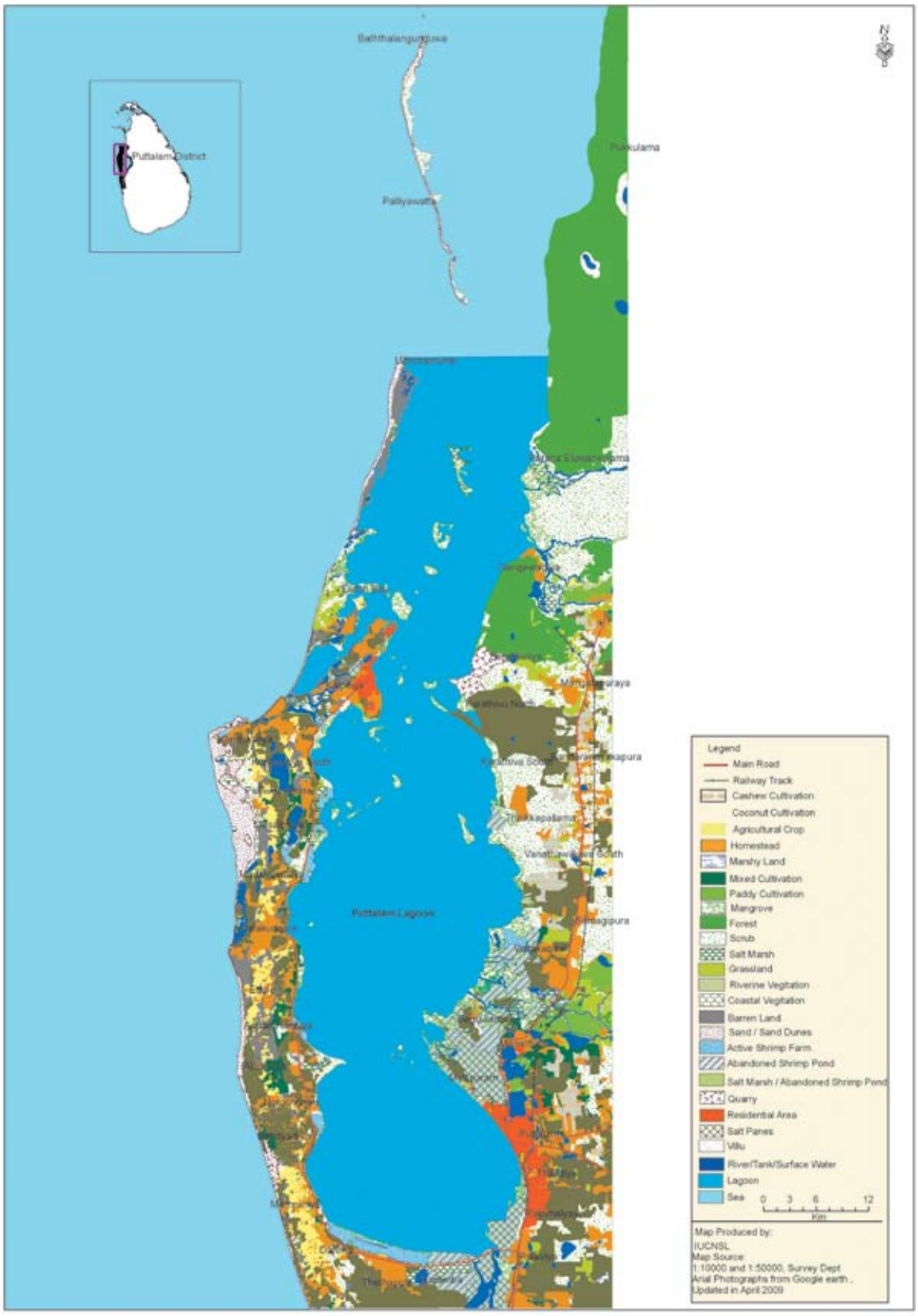
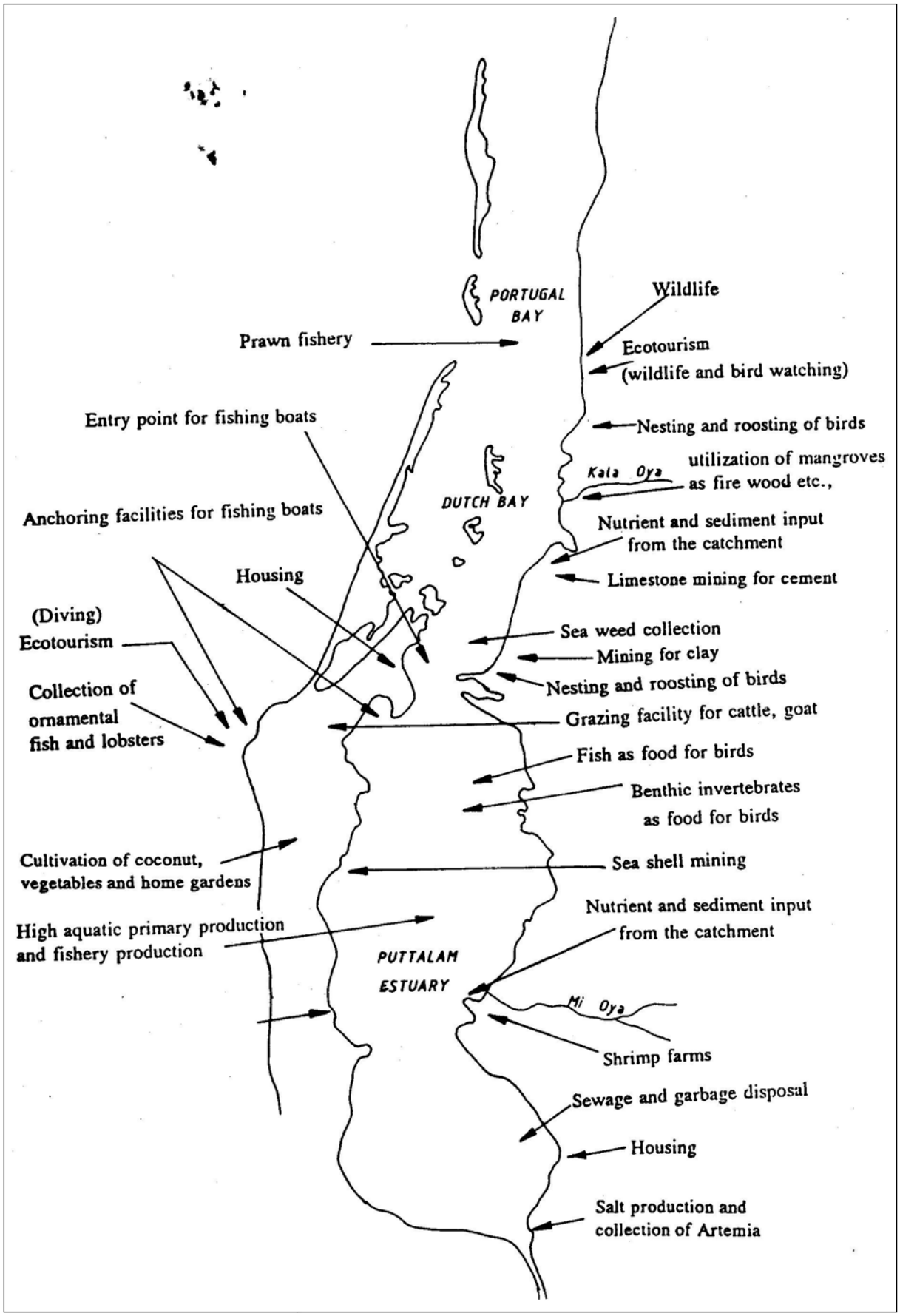


Figure 11. Resource use in the Puttalam Lagoon Area
(Source: CEA, 1994)



Chapter 3. The history of Puttalam

On the east, the Puttalam Lagoon is bordered by the Kudiremalai and Aruwakalu mountain ranges, comprising two strata of tertiary sandstone and Jaffna limestone (in the upper layer). These are overlaid with red littoral sands forming dunes that were deposited during the Pleistocene period. Further inland, towards the Lagoon, the rocks change from Jaffna limestone to the Vijayan series (Cooray, 1984; Modder, 1908a). The Kalpitiya peninsula consists of regosols and recently, beach and dune sands with flat terrain (Panabokke, 1996).

Fossils

Tertiary rocks of the Miocene age[14] (26 to seven million years BP) are found along the sea coast (Deraniayagala, 1955). Miocene fossil sites have been identified at the top of the Kudiremalai point, the Palugahatura fishing camp site, the Aruwakalu quarry site, Arnakallu beach, Uchchamunai and Karaitivu islands, and at several sites in and around the peninsula and the islands. Over 60 fossilised gastropods, corals and vertebrate species have been identified along these Miocene sea beds (Cooray 1984; Deraniyagala, 1955; Goonatilake, 2006).

On the surface are red soils deposited during the Pleistocene[15] (three million years BP), containing two recent land snail species (*Nania tranqueberica* and *Criptozona bristralis)* at the surface. Another snail *Vasum cornigerum* has been was found in the lower layers near the tidal level (Goonatilake, 2006, Modder, 1908b).

Pre-history

Stone implements, which belong to Palaeolithic[16] and Mesolithic[17] period, were recorded along at Kudiremalai and then further southward up to Serakkuli. This discovery supports the theory that early human migration to the island took place along the coastal belt during the Pleistocene period. These tools, cherts[18], clear quartz and pebbles were along the open sandy dunes, open scrublands and around natural and artificial water bodies. In addition to these tools, there are geometric and non-geometric cutting blades and grinding and chopping tools. Pottery fragments and iron slag were found at several sites (Goonatilake, 2006). Unfortunately there are no detailed surveys of pre-historic sites of the area.

Legends

The ancient history of the area dates back to the commencement of the Vijayan dynasty, to 543 BC. Puttalam is said to have originally borne the name of *Magul Totamuna*, or '*Port of Marriage'*, as it is believed that Viyaja disembarked at Kudiremalai, and married the princess Kuweni.

Tammana Nuwara, the first capital of Sri Lanka, is supposed to have been a few kilometres to the east of Puttalam (Chitty, 1834). Early Arab and Greek settlers as well as people of

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14 The Miocene was a time of warmer global climates than those in the preceding Oligocene, or the following Pliocene. The word Miocene is derived from the Greek words 'meiōn' meaning 'less' and 'kainos' meaning 'new', meaning 'less recent'.

15 The Pleistocene is the world's most recent period of repeated glaciations. The name Pleistocene is derived from the Greek 'pleistos' meaning 'most' and 'kainos' meaning 'new'.

16 This is a pre-historic era categorised by the development of the most primitive stone tools made by human yet discovered, and extends over roughly 99% of human technological prehistory. The word Paleolithic is derived from Greek: 'palaios' meaning 'old' and 'lithos' meaning stone literally meaning 'old age of the stone' or 'Old Stone Age'.

17 The Mesolithic is a period in human history between the Paleolithic (the Old Stone Age) and the Neolithic (the New Stone Age). The word Mesolithic is derived from the Greek 'mesos' meaning 'middle' and 'lithos' meaning 'stone', meaning 'Middle Stone Age.'

18 A hard, brittle sedimentary rock consisting of micro-crystalline quartz.

Malabar descent immigrated to Sri Lanka as early as the 8th century and settled in the outskirts of the Kudiremalai hill. They fished for pearls off the coast and supplied traders in Mannar and Matota. There is an abundance of old shells on the beach of the Lagoon, indicating that extensive pearl fisheries were once carried out here.

Roman coins have been discovered at the mouth of the Kala Oya.

Baobab trees (*Adansonia digitata*), are found along the coast and mouth of the Kala Oya; Native to the African continent, these trees were brought to the island by early Arabian traders around 700 AD (Goonatilake, 2006, Vandercone, et al., 2004).

According to another legend, the gulf of Kalpitiya had no opening to the north, but was connected to the sea by a canal running through in the line with the present Chilaw canal. A queen named Allirani used to proceed from Kudiremalai to Akkaripattu by land. When a great flood came, it buried her palace under the waves, and burst through a neck of land, converting the lake into a gulf. It still retains this form (Modder, 1908a and 1908b).

Yet another legend holds that in 140 BC King Saddathissa invited *Nala Mudaliya,* the commander of the *Kaka Mukuwas* from North India to assist in the war effort against the Malabars who had invaded from South India. These *Mukuwas* first landed on Karaitivu Island and then appeared to have proceeded towards the interior of the country (Chitty, 1834; Ranasinghe, 1998; Modder, 1908a).

However, according to another legend, the *Mukuwas* (a tribal people) migrated in to Kudiremalai from India, and then emigrated to other parts of the Island, and over the course of time formed several settlements in both Kalpitiya and the mainland (Modder, 1908a and 1809b). During the Kotte period, several *Mukuwas* were favoured by King Rajasingha and were given Sinhala names; the rest converted to Islam under the influence of Arab sailors. There are several unusual, sub-cylindrical large tombs in the Kalpitiya peninsula and in the mainland called '*Mukkaru sohon'* which are believed to be the domes of ancient *Mukuwas* who died as a result of ship wrecks (Goonatilake, 2006). Today, the *Mukuwas* descendants still hold their traditional ceremonies at these sites.

History and archaeology

Much of the coast of Sri Lanka is indented by many lagoons, most of which are now quite shallow. Numerous large and small bays, as well as roadsteads served to anchor sailing vessels of ancient and medieval times. The south, southwest and west coasts are exposed to the southwest monsoon from May to October. To shield boats from these monsoons, in ancient times, the main concentration of shipping was anchored in the sheltered ports of Puttalam and Mannar districts, as well as the Jaffna peninsula – all of which faced the shallow, northwestern seas (Nicholas, 1963).

There are several inscriptions belonging to 1st to 3rd centuries at *Magana nakara* found near the Modaragam Ara mouth. This is identical to Ptolemy's Margana (Nicholas, 1963). This location is also mentioned in the Sigiri graffiti[19] as *Maganava,* and *Magun* (Paranavitana, 1956). Historians note that this location is maybe the *Tammanna Nuwara* which Prince Vijaya had built.

In the 1st century BC, a Greek sailor named Hippalos discovered the route to sail directly from the mouth of Red Sea across the Indian Ocean to India. According to Pliny the Elder (23-77 AD) Annius Plocamus, while coasting off Arabia, was carried by the winds for 15 days and made land at *Hippuri* or *Hippuros*, a port of *Taprobane*, accidentally using the same route that Hippalos took. Plocamus was entertained for six months by the King whose capital was

[19] Poetry written on the mirror-wall of Sigiriya the rock fortress sited in north Central Sri Lanka.

at Palaesimundus, a city situated near a harbour which faced south (Nicholas, 1963, Modder, 1908a). In Greek '*Hipporos'* means horse and this is supposed to be Kudiremalai (meaning for Horse Mountain in Tamil).

Kollankanatta, located few miles southward of the Kudiremalai point, is an ancient port, which Roman and Arabic ships reached early during the Anuradhapura period (Brohier, 1929). Fragments of pottery, bricks and freshwater wells still exist in the site.

Megalithic black and red ware (BRW) and burial sites have been recorded near the Pomparippu, the eastern boundary of Kala Oya, said to be an ancient Uruvela Village which was built by a minister of Prince Vijaya (Seneviratne, 1984; Sitramplam, 1990). Later, the name Uruvela appears in the *Mahāvamsa* during the period of King Dutta Gamini Abaya (161-137 BC), and period of King Suba (60-66 AD). During 2nd century BC, pearls from Uruvela were sent to Anuradhapura for the construction of the Ruwanweli Stupa (Paranavitana, 1956; Geiger, 1960), indicating that pearl fisheries were occurring in the Puttalam Lagoon as far back as the 2nd century BC. Sadly, there are no pearl oysters in the area now.

The ancient *Antharpara Samuddha Vihara* was situated inside Kalpitiya peninsula. This is marked in Ptolemy's map as '*Anarismundi'*. Ruins of Antharpara Samuddha Vihara have been identified near the east of Gangae tank at Kuringipitti (Silva, 2002).

Kalpitiya is mentioned in the Sigiri graffiti as '*Kalapiti-kuli'* (Paranavitana, 1956).

BRW fragments, burials, iron slags, ruined structures of the monasteries, belonging to proto-historic[20] and historic[21] period, were recorded along the peninsula as well as the mainland. However, without further investigation, it is difficult to date them into relevant time periods.

During the Kandyan period, a chronicle called '*Nampotha*' mentioned the ancient temples situated around the Puttalam Lagoon as *Eth Hala, Makkama, Malvila* and *Pomparippuva* which can be traced to the same present names. It is also believed that the Lord Buddha's sacred footprint is also located at a place called *Makkama* (Sarananda and Saranankara, 1956).

In 1544, Kalpitiya was taken by Portuguese and retained under their control until 1640, when the Dutch invaded. Shortly afterwards, in the vicinity, they erected a very large church, which they used as a headquarters for their missionaries and a location for holding their annual meetings. This is the first recorded church in Sri Lanka and is located at *Marippo* (Modder, 1908a). This name appears first in the Dutch maps of Ceylon dating from the end of the 17th century, siting Marippo at the southwest end of the peninsula. It is believed that the former name of *Kuringiputti* is *Marippo*. However the exact position of *Marippo* remains in doubt (Chitty, 1834; Modder, 1908a).

In 1666, the Dutch colonised the Kalpitiya area and soon afterwards built a mud fort, surrounded by a moat, on the south side of the town (Modder, 1908a). They established a court, magistrate's office, custom house, stores, and jetty to support the trade of their merchandise from within the peninsula (Chitty, 1834). Kalpitiya had become very important in the trade of areca nuts and cotton goods produced in the area. The Lagoon was used as a pearl fishery and the natural ports used for the export of elephants and other treasures.

In 1795, British troops captured Kalpitiya and made it their centre for the export of areca nuts and cattle. The Dutch canal – which links Kalpitiya and Colombo – was originally planned and partly opened by the Dutch, but was only brought into effective use in the 1850s by the British (Chitty, 1834, Modder, 1809a).

[20] Proto-history refers to a period between prehistory (before recorded history) and history.
[21] The period after writing was invented.

During the colonial period several churches were built in and outside the peninsula. The Talawila St. Anne Church is still a popular church. There are two legends of the origin of this church. The first is about an European trader, who was shipwrecked off the coast of Talawila, while travelling in a ship dedicated to St. Anne in the early half of the 18th century. The second story states that during the 17th century, a poor Portuguese man journeyed from Mannar to Colombo in order to seek a livelihood. However, he failed to do so and was returning by the coast, when he fell asleep under a large tree at Talavila, at the site of the present church. There, he dreamed that he saw an image at the foot of the tree, with lighted tapers burning on each side. Waking up from his sleep, he saw with astonishment that the image was actually there. The poor man set out to build a small Chapel and later, he built a larger one in the same place. The image now exhibited in the church is said to be the identical statue discovered by the Portuguese man (Fernando, 1999).

St Peter's church, about a half-mile west of the Kalpitiya port, is Dutch in origin, although it is now displays the architecture of the British, who rebuilt the church in 1840.

A detailed archaeological investigation is needed to understand the ancient sociological, cultural, and religious importance of the Puttalam Lagoon.

Shell fishing has been practised by humans since ancient times in different parts of the world. It has been recognised as a major industry during the protohistoric period in the Indian subcontinent. Many trade routes of ancient people have been identified by archaeologists on the basis of the sources of shells found during explorations. Kalpitiya has played an important role in Indian Ocean trade and internal shell industries.

Jayasooriya (2006) has identified uses of shells in Uchchmunai area and categorises them into six main categories: ritual uses; building material; traditional games; for food; pearl fishery and as ornaments. The shell species used for the above mentioned purposes are: *Turbinella pyrum* (chank), *Pleuroploca trapezium, Bulla striata, Trochus* sp*., Cypraea* (cowries), *Terebralia* sp*., Babylonia spirata*, *Dentalium* sp., *Gafrarium tumidum, Tapes aureus, Lima lima, Stombus canarium, Pinctada magaritifera* and *Placuna placenta*.

Chapter 4: The Physical Environment

Climate

A country's climate[22] is affected by global, regional and local environmental conditions, issues such as deforestation and land degradation, pollution of marine and fresh waters, depletion of the ozone layer, and the above all, greenhouse gas-induced global warming[23]. Climate change – an impact of global warming – and global warming are rightly viewed with grave anxiety by both the scientific community and the public at large. Climate change will have wide-ranging consequences at global, regional and local environments, affecting storm and flood frequencies, plant and animal distribution, as well as sea levels. The key feature of this human-induced climate change is that its impacts are uneven – spatially, temporally and socially. The poor and marginalised are at most risk from the increased frequency of natural disasters (an impact of climate change), and Asia, is also at greater risk (Miththapala, 2008).

Spatially, among the most sensitive areas are those on or close to natural margins, such as ecotones[24]. Another vital margin is the coastline, with some coastal areas – such as coral atolls, mangroves, wetlands and low-lying deltas – more vulnerable than others to any future sea level rise.

Sea level rise is one of the most visible impacts of climate change, affecting all coastlines of the world. Coastlines formed of unconsolidated sediments backed by coastal lowlands and human populations that inhabit them will be particularly vulnerable. These impacts will affect coastal communities who are already under great demographic pressure.

The Asian regional climate

Over the past few million years, the dominant weather pattern in South Asia has been the bi-yearly monsoons. During the last glacial age, 18,000 years before the present time, the climate was drier and windier; there was less rain in the summer and strong monsoonal rains in the winter. When the ice age ended and glaciers melted, the post glacial period saw a marked change in the sea level, and a major marine transgression, submerging the continental shelf – the extension of the lowest peneplain[25].

The climate of Sri Lanka

The climate Is Sri Lanka is defined primarily by rainfall. Temperature in the lowlands is largely homogenous and increases rapidly with elevation (Survey Dept. 2007).

Four climatic seasons can be identified in Sri Lanka (Survey Dept. 2007). However, there are only two cropping seasons.

[22] Defined as weather over time (typically, 30 years).
[23] The progressive gradual rise of the earth's surface temperature caused by the greenhouse effect and responsible for changes in global climate patterns.
[24] A transition area between two adjacent, but different patches of landscape, such as forest and grassland.
[25] Land worn down by erosion to a more or less level plain.

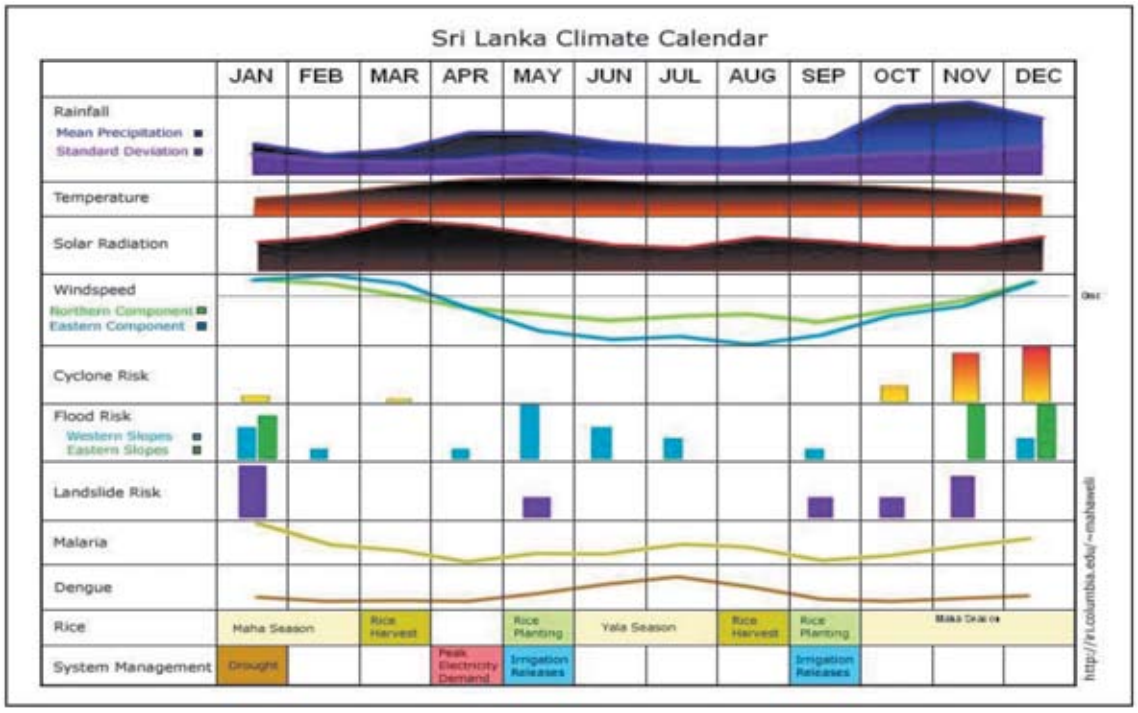
Table 15. Climatic seasons of Sri Lanka
(Source: Survey Dept. 2007)

Season	Cropping Season	Period	Rainfall (mm)	Percentage
First inter monsoonal period		March to April	268	14%
Southwest monsoon	Maha season (wet season)	May to September	556	30%
Second inter monsoonal period		October to November	558	30%
Northeast monsoon	Yala season (dry season)	December to February	479	26%

Rainfall in Sri Lanka can be from monsoonal, convectional and depressional sources (Survey Dept. 2007). Monsoonal rains are a result of seasonal changes in atmospheric circulation and precipitation, associated with the asymmetric heating of land and sea. Convectional rain occurs as a result of heating of the ground. Air near the ground surface is heated by conduction. This heated air expands, and rises in a strong upwards air current. When the temperature of the rising air begins to fall, water vapour forms and collects into thick clouds and falls as convectional rain. Depressional rain occurs during the inter monsoonal periods, particularly during the second inter monsoon (October to November) (Survey Dept. 2007).

As can be seen from the above table, both monsoons occupy a significant part of the year - 7.5 months (62.5% of the whole year). The inter-monsoonal seasons extend for 4.5 months or 37.5% of the year. Rainfall from the southwest monsoon ranges from 100 mm to 3,000 mm, with the highest amount of rain falling on the western slopes at mid-level elevations (Survey Dept. 2007). Rainfall from the northeast monsoon varies from 177-1,281 mm, with the highest rainfall falling on the eastern slopes of the Knuckles range and the lowest on the western coast from Colombo to Puttalam (Survey Dept. 2007).

Figure 12. Sri Lanka's climate calendar
(Source: http://www.ldeo.columbia.edu/~lareef/tsunami/climate.html)



Climate in the Puttalam Lagoon

The Puttalam Lagoon is located in the northwest part of the dry zone of Sri Lanka. The climate characteristics of the area include periods of low rainfall, intense sunlight and seasonal strong winds. In fact, less than 25% of each year is rainy.

Rainfall

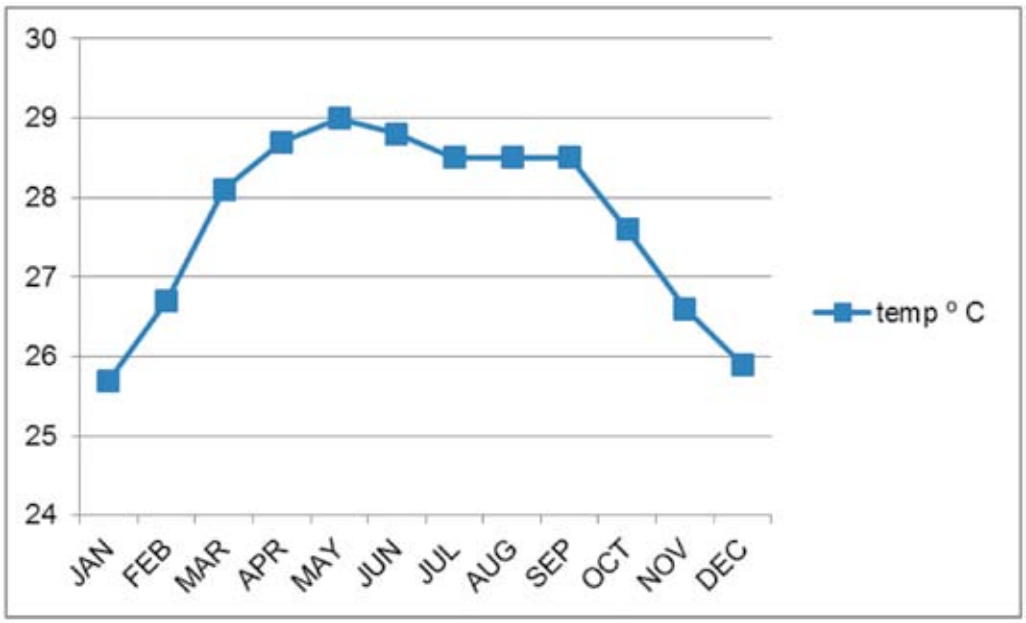
The average rain fall is 1,143 mm per year. Two periods of heavy rainfall can be distinguished, April and May, and October to December; the latter period is wetter, averaging about 225 mm of precipitation per month. June, July and August are the driest months, with less than 25 mm of rain per month. The average daytime humidity is 75.9% saturation and average nighttime humidity is 88%. The lowest humidity is during March with 69.7% saturation. As is to be expected, humidity increases during the rainy season, with the highest values recorded in November, averaging 92.5%.

Records from the Department of Meteorology over the last 100 years show that this area has experienced lengthy droughts ranging from 120 to 200 days. There is also high rainfall variability, which affects cropping patterns and animal husbandry (Survey Dept. 1988).

Temperature

The average temperature is 28.2 ^{0}C and the warmest months are from March to September with a peak in May (29.7 ^{0}C). Lower temperatures are experienced from October until February, with the lowest in January (21.7 ^{0}C). The average monthly maximum temperature is 31.0 ^{0}C with a peak in April or May (33.8 ^{0}C). The average monthly minimum temperature is 24.5 ^{0}C in January.

Figure 13. Annual temperature variation in Puttalam
(Source: EML, 2008)



Sea Surface Temperatures

The average monthly surface temperatures in the Puttalam Lagoon vary from 27.6 ^{0}C to 30.8 ^{0}C (Durairatnam, 1963). The highest temperatures were recorded in April, May and June and the lowest, in November, December and January (Durairatnam, 1963). The temperature gradually falls from April to September and again from October to January (Durairatnam, 1963). The former lowering of sea surface temperatures is a probable result of high winds during the southwest monsoon that cause water turbulence, resulting in mixing of warm surface and cool sub-surface water (Durairatnam, 1963). The lowering of temperature from October to January is a result of the onset of the northeast monsoon (Durairatnam, 1963).

Coastal Winds

Winds largely control the location of coastal fisheries (Long et al., 2010). The wind climate of the island is characterised mainly by two monsoons, the northeast monsoon and the southeast monsoon. Of these two monsoons, the southwest monsoon has the stronger winds.

Puttalam Lagoon experiences winds from both monsoons: northeasterly winds and southwesterly winds. The southwest monsoon begins in May and intensifies during June; from July to the end of September, strong southwesterly winds blow inland, and weaker northeasterly winds prevail from December to February (Long et al., 2010). During the first inter monsoonal period, there are moderate winds from different directions. The monthly average values of wind speed (based on 1992-2002 period) are presented in Figure 14 while the monthly average directions (based on 1997-2002 period) are tabulated in Table 16). Wind speeds are highest from May to September during the southwest monsoon, peaking in August, at a monthly average of 12 km/h, and lowest in November (5.2 km/h).

Figure 14. Monthly Variation of Average Wind Speed in Puttalam
(Source: EML, 2008)

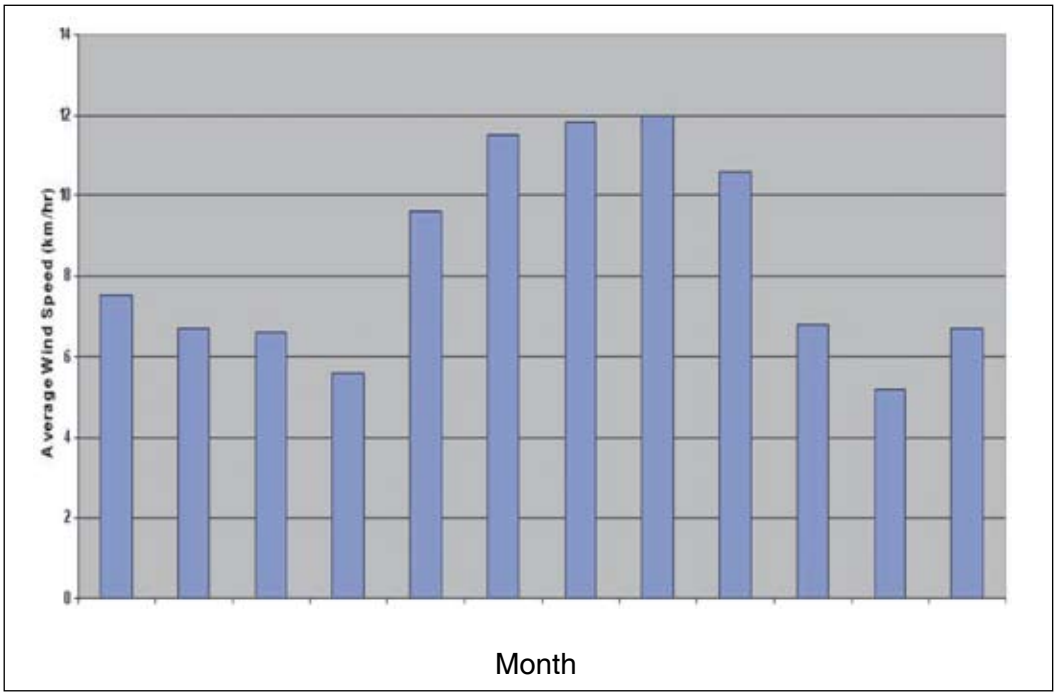


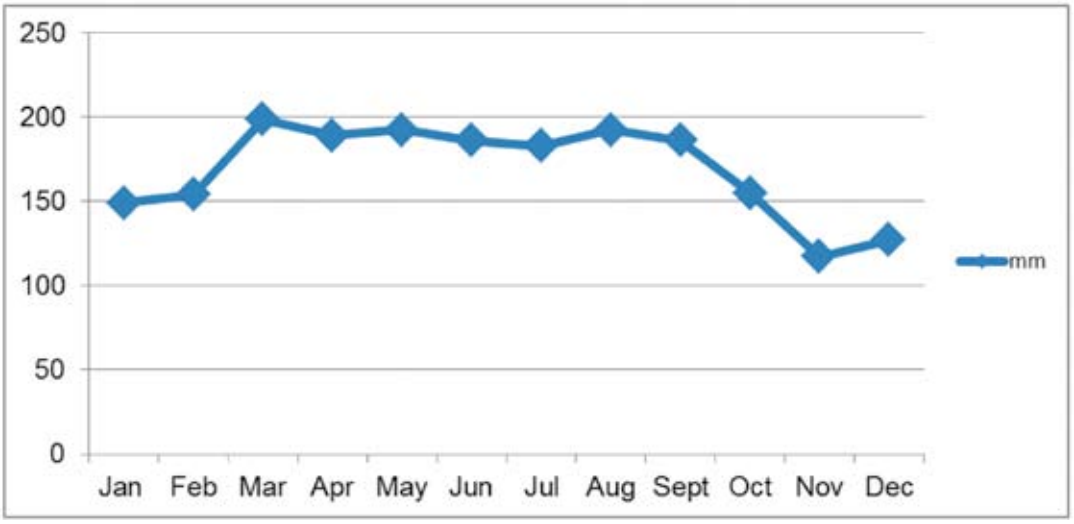
Table 16. Monthly wind direction of Puttalam Area
(Source: EML 2008)

Month of the Year	Average Direction
January	NNE
February	NE- NNE
March	Variable
April	SW-SSW
May	SW
June	SW
July	SW
August	SW
September	SW
October	SW
November	Variable
December	NE-NNE

Evaporation

Evaporation also has a direct relationship with the water quality of the Lagoon. As it is located in the dry zone, Puttalam generally has high temperatures. The winds also ensure faster water evaporation than in other areas. This is one of the key reasons that so many salterns are found in the dry and arid parts of the island. The higher temperatures in the Lagoon easily evaporate brackish water, making it hyper-saline.

Figure 15. Evaporation in Puttalam
(Source: EML 2008)

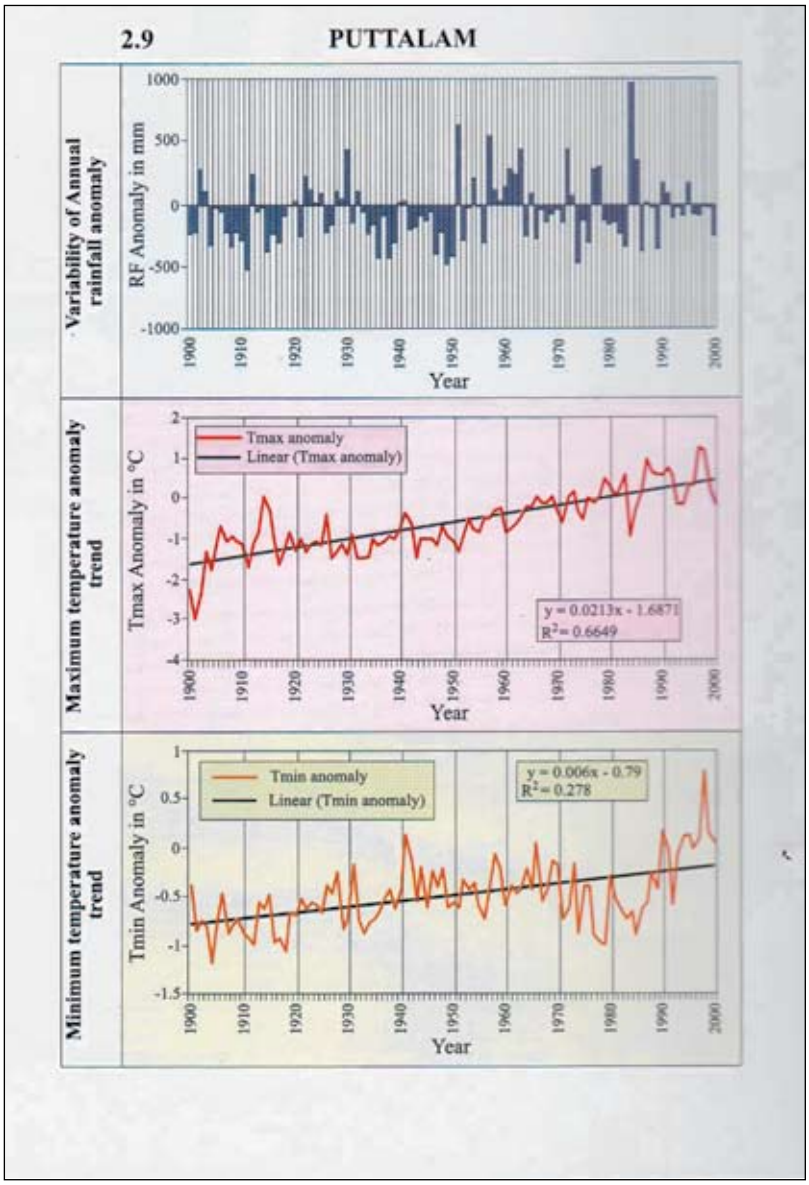


The above figure shows that water evaporation in the Puttalam area is maintained at around 200 mm during most months from March to September. High winds during this period add to this evaporation.

Climate Change in the Puttalam Lagoon

Climate change impacts are being observed in Sri Lanka: average rainfall has decreased by 144 mm (7%) between 1961-1990 compared to 1931-1960; average air temperature has shown increasing trends (0.016 ^{0}C per year between 1961-1990), with a maximum rate of increase of 0.02 ^{0}C per year in the Puttalam area (Survey Dept. 2007). Figure 16 below shows the changes in climate in Puttalam district.

Figure 16. Climate change in Puttalam
(Source: Survey Dept., 2007)



Geology

Sri Lanka and India were once part of the super-continent Gondwanaland, which included Antarctica, Australia, Madagascar, Africa and South America. Beginning about 200 million years ago, the Deccan Plate (comprising India and Sri Lanka) started breaking off and moving northwards. About 45 million years ago, the Deccan Plate rammed into Asia, raising the Himalayan mountain range. This process was accompanied by the spreading of the sea floor, which created the Indian Ocean (Swan, 1983).

During the Jurassic[26] Era the first signs of an Indo-Sri Lankan rift appeared. This rift created the Palk Strait, Palk Bay and the Gulf of Mannar (Swan, 1983).

More than 85% of Sri Lanka's surface lies on Pre-Cambrian[27] strata, some of it dating back two billion years. Jurassic (140-190 Mya) sediments are found in very small areas near the western coast (in the Puttalam district), while Miocene[28] (5-100 Mya) limestone is found in the northwest coast. Overlying this Miocene limestone are Pleistocene[29] (1 Mya) deposits. The northwest coast is part of the deep Cauvery (Kaveri) River Basin of southeast India, which has been collecting sediments from the highlands of India and Sri Lanka since the break-up of Gondwanaland (http://en.wikipedia.org/wiki/ Geography _o f_Sri_ Lanka #Geology).

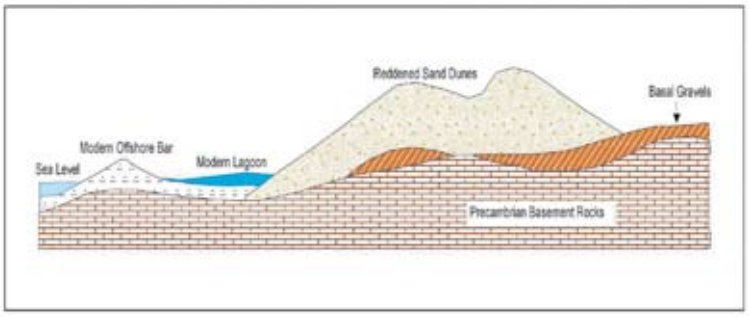
According to Deraniyagala et al. (1958, in litt. Madduma Bandara, 1989) earlier sedimentary deposits have disappeared from most of the island, but there are some large rivers and sunken forests bounded externally by the 100 fathom depth isobars. The current coastline is a recent emergence, whereas the 100 fathom depth isobars would approximately correspond to the former drowned coast line.

An ancient fringing reef that is now about a mile from the sea and part of a raised beach is evidence of this submergence, particularly as many vertebrates have been found in the *Malu* deposits at Aruwakalu, 1.6 km south of the Kala Oya mouth. The most common fossil is the fish *Labrodon sinhaleyus* (Deraniyagala, 1958, in litt. Madduma Bandara, 1989).

Geology of the Puttalam Lagoon

The Kalpitiya peninsula and Puttalam Lagoon and the islands off the peninsula have been formed as a result of long-term geological processes.

Figure 17. Geological profile of the Puttalam Lagoon
(Source: Cooray, 2003)



Sedimentary Miocene limestone rock, containing fossils, lies beneath the western part of the Lagoon. Over this are Quaternary sedimentary deposits. These Quaternary deposits can be divided roughly into two groups, an older group of the Pleistocene epoch and a younger group of the recent Holocene[30] period. The older group consists mainly of sea beds, while the younger group comprises alluvium, lagoonal and estuarine deposits, unconsolidated sands and beach rocks.

[26] The Jurassic era is a geologic period that extends from about 199.6± 0.6 million years ago (Mya) to 145.5± 4 Mya.
[27] The Pre-Cambrian era spans from the formation of earth around 4600 Mya ago to the beginning of the Cambrian Period, about 542 Mya.
[28] The Miocene spans from about 23.03 to 5.332 Mya
[29] The Pleistocene epoch spans from 2,588,000 to 11,700 years before present BP that and represents the world's recent period of repeated glaciations.
[30] The Holocene is a geological epoch which began 11,700 years ago (around 10,000C years ago) and continues to the present.

Pleistocene Deposits

These deposits form a number of low, narrow elongate ridges, or domes aligned consistently in a north-south direction. These are generally less than 10 m high, 3-5 km long and 0.6-2.4 km wide (CEA, 1994).

Holocene deposits

Holocene deposits can be divided into two major categories: i) Alluvium lagoonal and estuarine deposits, and ii) unconsolidated sands (CEA, 1994).

i) Alluvium, lagoonal and estuarine deposits

Alluvium is formed by detritus, silt and sand brought down by the rivers and deposited on the river flood plain and delta. These deposits, understandably, are most extensive at the points where the Mi Oya and Kala Oya discharge their waters into the Lagoon (CEA, 1994).

The lagoonal and estuarine deposits within the study area can, again, be categorised into two groups: exposed beds (now above water level), and submerged substrate deposits on the lagoon floor (CEA, 1994).

Exposed beds

In the east and south of the Puttalam Lagoon, and around Puttalam town, lagoon flats or barrier flats can be seen (CEA, 1994).

Submerged substrate

The floor of the Lagoon is composed of black, coarse mud with sand and shells, limestone and sands and the deeper parts are generally covered by a layer of soft mud. There is a hard limestone bottom close to Kalladichenai and the area between Nuraicholai and Kalmunai. The southern, shallow part of the Lagoon has a very thick layer of soft mud, probably accumulated by the tides during the northeast monsoon (CEA, 1994).

ii) Unconsolidated sands

Unconsolidated sands are extensively of Quaternary deposits. These are important as carriers of freshwater aquifers and as deposits of economically valuable minerals sands. Two main types of sands can be recognised: beach sands and sand dunes (CEA, 1994).

Beach Sands

Beach sands cover the western coastal border of the Lagoon. These sands have been built up of a succession of beaches, barrier bars[31] and sand spits[32], which have grown in several directions, and which were formed during the most recent geological times. These features are still changing the morphology of the area (CEA, 1994).

Sand Dunes

Sand dunes often rise up to 4.5-6 m and more, varying in width from 8 km to 4.8 km. There is a low-lying swampy, clayey ground in the middle of the Kalpitiya peninsula between these

[31] Barrier bars or beaches are exposed sandbars that may have formed during the period of high-water level of a storm or during the high-tide season.

[32] A sand spit is a linear accumulation of sediment that is attached to land at one end.

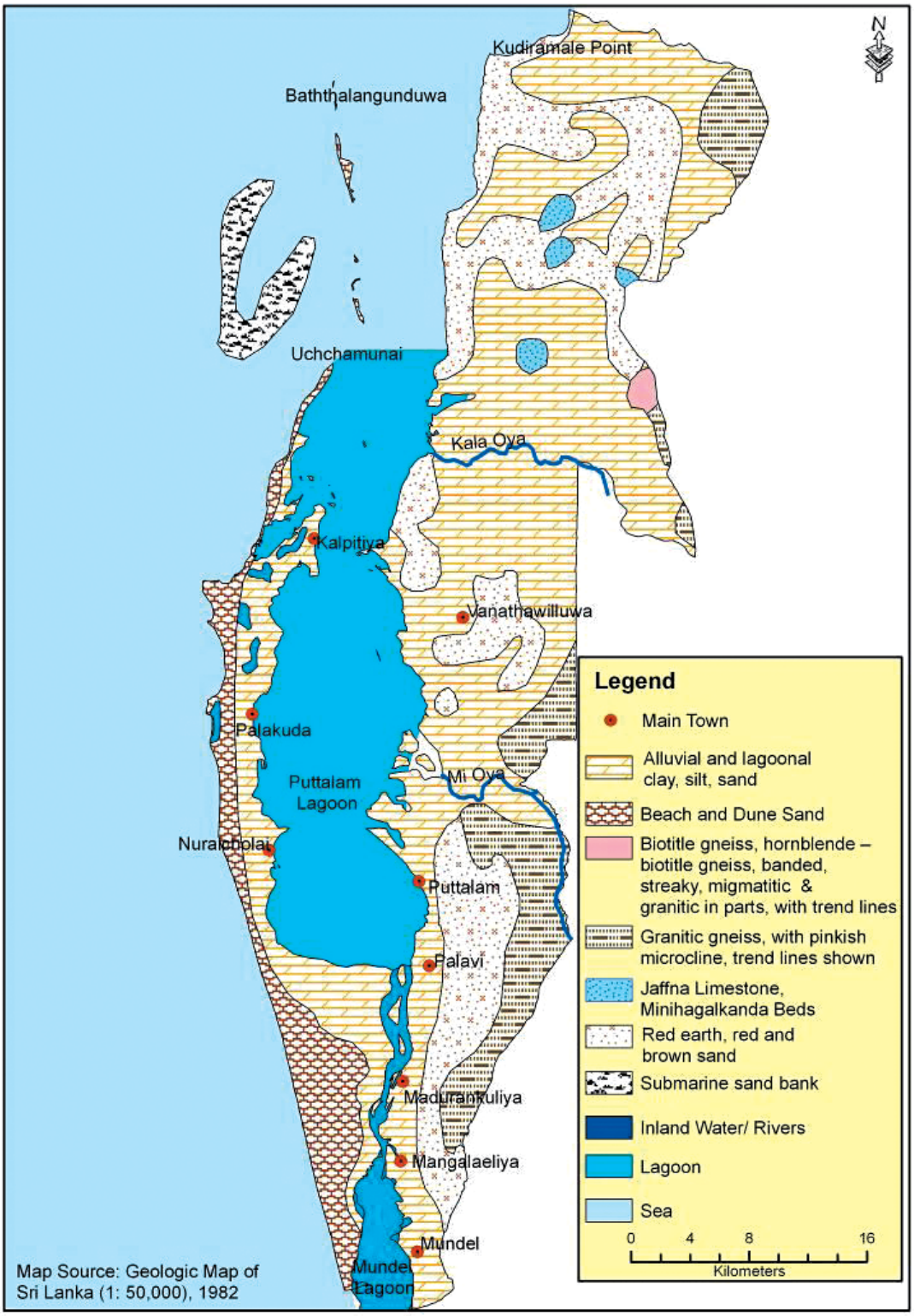
dunes, which is probably a former area of the present Lagoon. Further north of Kalpitiya, in the Dutch Bay area, most of sand dunes have a northeast/southwest orientation resulting from the dominating influence of the two monsoons (CEA, 1994).

Beach rock

Most of the Karaitivu area is covered by beach rock above the sea level. It is composed of granite and quartz, with shell fragments present in some areas and in other areas also with grains of garnet and ilmenite. The sand grains are cemented together with calcium carbonate (CEA, 1994).

The Kalpitiya peninsula, including the islands north of Kalpitiya, Palavi, and the southern part of the Lagoon where the Dutch canal is connected to the Mundel Lake are all covered by Holocene beaches and dunes. The Mi Oya Lagoon in the eastern part of the Lagoon and Kala Oya catchment in the northeast part of the Puttalam Lagoon are covered with Holocene alluvium, lagoonal and estuarine deposits. The Vanathavillu and Puttalam Town area are covered by old beaches belonging to the Pleistocene era (CEA, 1994).

Figure 18. Geological map of the Puttalam Lagoon
(Source: Geological Map of Sri Lanka, 1982)



Past and future trends in geological process in the Puttalam Lagoon

Cooray and Katupotha (1991) postulate that a sequence of events led to the formation of the Puttalam Lagoon.

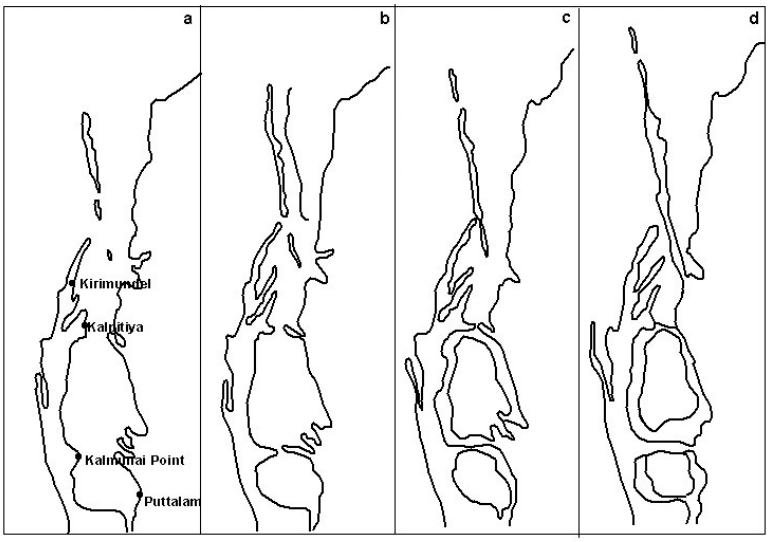
1. Formation of off-shore sand bars and spits along an early coastline (Dutch Bay barrier spit grows northwards from the Kalpitiya peninsula);
2. As a result of this growth, the formation of Mundel Lagoon between the barrier spit and the mainland;
3. Conversion of Mundel 'lagoon' into Mundel Lake by deposition of layers of fine silt and mud from the Mi Oya and Kala Oya, gradually filling up the area to form mud flats and swamps in southern and the eastern part of Mundel lake;
4. Development of the Puttalam Lagoon;
5. Growth of the Kalpitiya peninsula in stages; and
6. Formation of sand spits, sand bars and islands of Keerimundel, Karaitivu, Ippanativu and Periya Arichchalai.

These authors also predict future changes as follows:

1. Closing of the cuspate[33] lowland at the Kalmunai point in the Kalpitiya peninsula and the lowland opposite on the mainland (Figure 19b);
2. Formation of Puttalam 'lake' and Kalpitiya 'lagoon' north of it (Figure 19c).
3. Closing up of cuspate lowlands at Kalpitiya and the opposite mainland to form Kalpitiya 'lake' (Figure 19c);
4. Formation of barrier islands south of Karaitivu resulting in the formation of two lagoons (Figure 19c);
5. Extension of Keerimundel spit to form a third 'lake' (Figure 19c);
6. Silting up of Puttalam 'Lake' and conversion of Mundel Lake into marshy land; and,
7. Finally deposition of peat similar to that at Muthurajawela (Figure 19d).

Figure 19. Predicted growth stages of Puttalam Lagoon

(Source: Cooray and Katupotha 1991)



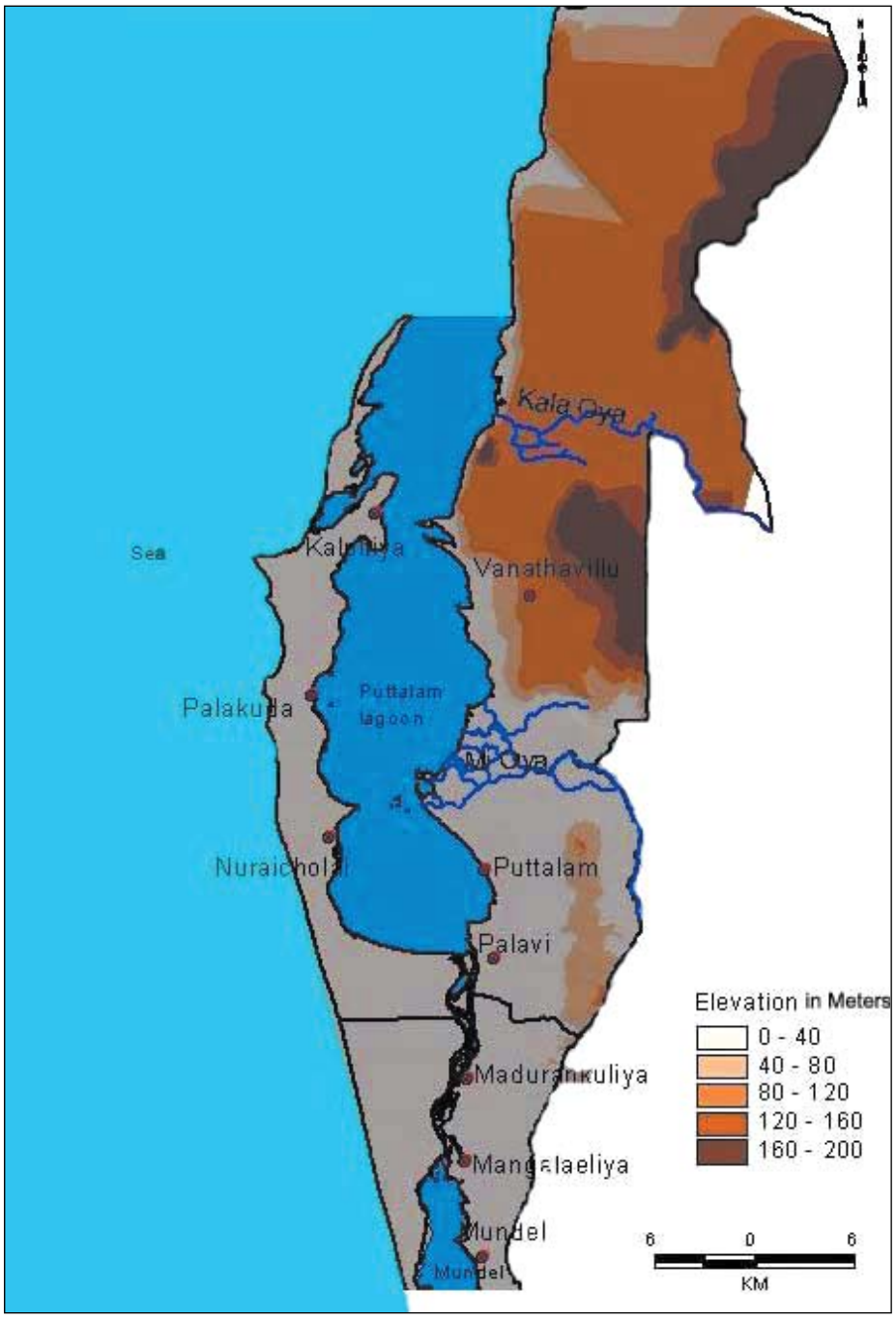
[33] In a triangular shape,

Topography

The Puttalam coastal stretch is easily recognisable by the distinctive Kalpitiya Peninsula.

Generally, the land is flat in the Puttalam Lagoon area, but towards northeastern part of the area – in Vanathavillu and Eluvankulam, the elevation rises to about 70 m. Apart from this, most of the land is below 10 m elevation. From Mundel Lake to Kalpitiya, the land is low-lying with marsh and wetlands prevalent. Soil erosion is heavy in these areas and sediments washed from the eastern hilly area are trapped in the Lagoon border, where they are deposited, and become mud flats.

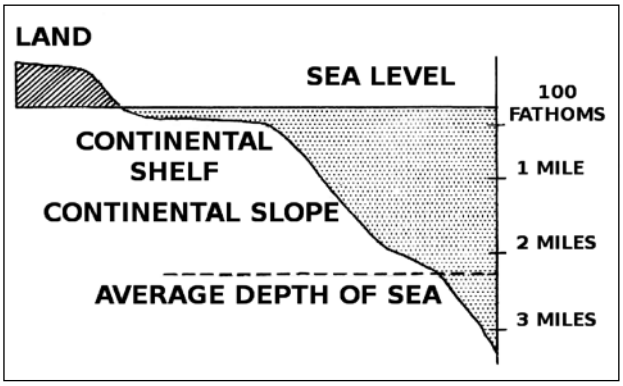
Figure 20. Topography of the Puttalam Lagoon
(Source: Weragodatenna, 2010)



Sub-marine morphology

Around Sri Lanka is a continental shelf, once part of the land, but now submerged by shallow seas. This continental shelf is an undersea extension of the island, extending until the shelf break, along which the slopes get much steeper. By convention, many countries defend their continental shelves as territorial waters.

Figure 21. Cross section of a continental shelf



The continental shelf around Sri Lanka is estimated to cover an area of 31,250 km^2, but its width varies around the coastline. On average, it is 20 km wide and 65 m deep, narrower and shallower than the world average (75 km and 120 m) (Survey Dept. 2007). The shelf is narrowest at Kalpitiya (only 2.8 km), and in the south, between Matara and Dondra (6 km). It is relatively narrow (10-20 km) off the east coast. North of Mullaittivu on the east and Kalpitiya on the west, the shelf widens considerably and merges with the continental shelf of India (Survey Dept. 2007).

Figure 22. The continental shelf round Sri Lanka
(Source: Survey Dept. 2007)

Prominent troughs, ridges and valleys are found on the shelf around the coastline. Most of the fish resources are found within the continental shelf.

The shelf is covered with various detrital organic materials, mainly calcareous, with shell and coral fragments of quartzose[34] sand and some coarser materials. Given below are the various materials and different depths.

- At 0-8 m terrigenous[35] silt and fine sand-rich heavy minerals are found;
- At 8-15 m terrigenous sands with strong biogenic[36] components are found;
- At 15-30 m coarse biogenic sand are predominant; and
- At 30–60 m where the slope steepens, muds and silty shell debris occur (Long et al., 2010).

Soils

Six common soil groups are recorded in the area. These are: Reddish Brown Earths, Low Humic Gley Soils, Red-Yellow Latosols, Regosols, Alluvial Soils and Solodized Solonetz (Panabokke, 1996).

Reddish Brown Earth

Reddish Brown Earth is the most common soil group in Sri Lanka, extending across a greater part of the inland area. They are mainly found in the dry zone. These earths are reddish brown when dry, and darken when moistened. They are extremely hard when dry, and sticky when wet. Reddish Brown Earths have low water holding capacity. In the Puttalam Lagoon, they are found in small isolated patches in the southeast (Panabokke, 1996).

Low Humic Gley Soils

The next most common type of soil in the island is Low Humic Gley Soils. These soils are wet below the surface, coloured dark greyish brown to dark brown on the surface. Like Red Brown Earths, these soils are extremely hard when dry, and sticky when wet. Their water holding capacity is fairly good. In the Puttalam district, they are found with Reddish Brown Earths (Panabokke, 1996).

Red-yellow Latosols

These soils are found in the coastal areas of the northwest, north and northeast of the island. They extend to great depth and are very permeable. They are a dark reddish brown and crumble easily. The inner boundary of the soils in the coastline represents an old coastline – perhaps of the Quaternary period. These soils are prominent on the eastern side of the Lagoon, above and below the valley basins of Kala Oya and again below the basins of the Mi Oya. These soils are used for cultivation of coconut, cashew and mango (Panabokke, 1996).

Regosols

Regosols are sand, recently brought to the coastline, and usually occurring in long strips. The colour of Regosols is yellowish brown to a very pale brown. These soils lack a structure and occur as single, loose grains. They do not hold water, but can support deep-rooted crops because of stored underground water. Regosols are found in most of the Kalpitiya peninsula

[34] A very hard mineral composed of silica.
[35] Sediments on the sea bottom derived directly from the neighbouring land.
[36] Substance produced by life processes

and islands, and small isolated fringes of the eastern coast of Lagoon. Regosols found on flat land are very good for coconut cultivation.

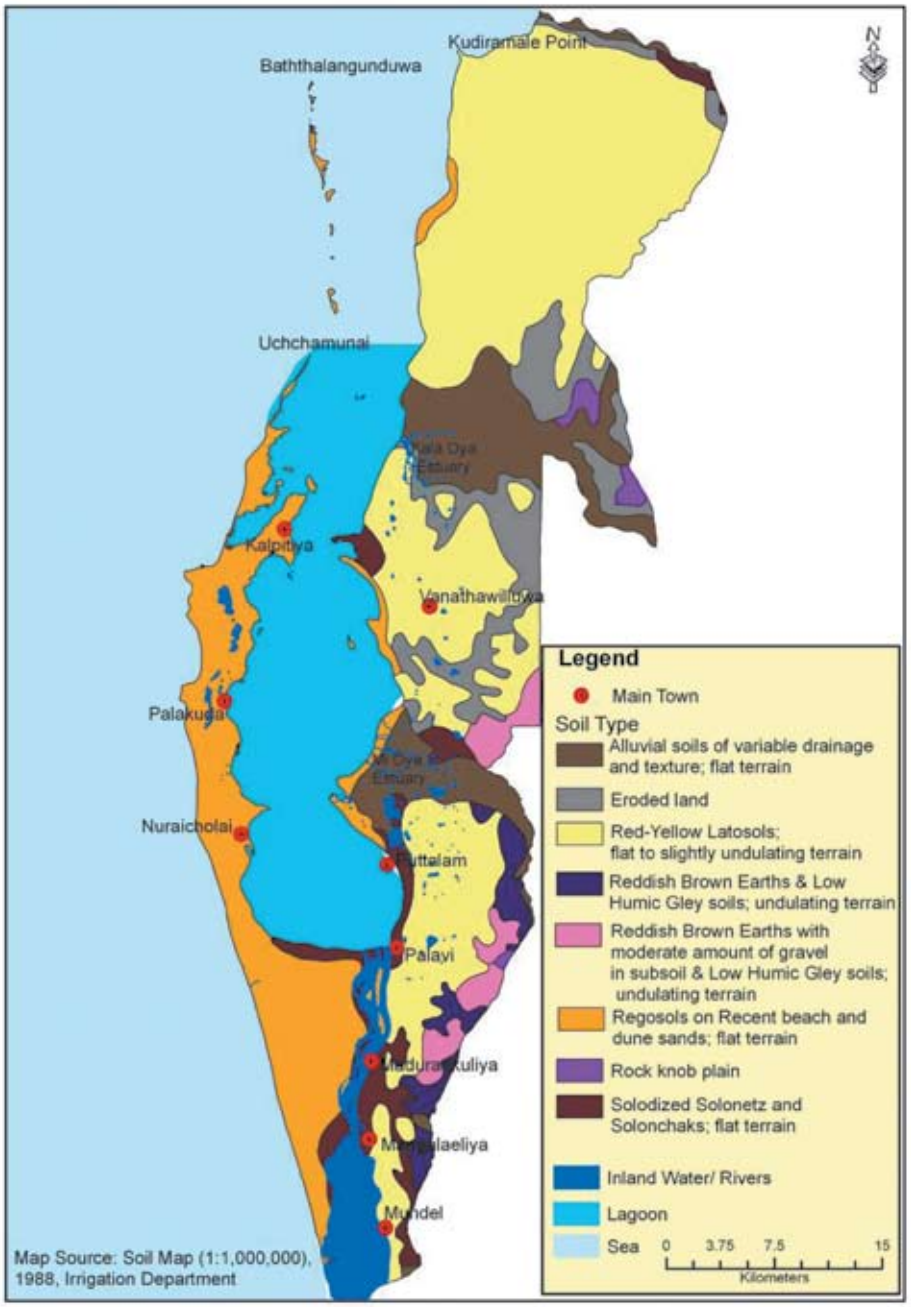
Alluvial Soils

Alluvial soils are found along valley basins of the Mi Oya and Kala Oya. These are mineral rich soils and extensive tracts of mangroves are found growing in these soils (Panabokke, 1996).

Solodized Solonetz

Solodized Solonetz occurs on marine deposits of tidal flats and estuaries mainly in Mundel Lake and on the southern margin of the Puttalam Lagoon. Vegetation in the tidal flats and estuaries is predominantly grassland with thorny scrubs and a few scattered trees (Panabokke, 1996).

Figure 23. Soils of the Puttalam Lagoon
(Source: Irrigation Department, 1988)



Water resources

In the Puttalam Lagoon area, there are three types of water sources: fresh water, saline water and brackish water. Potable fresh water is obtained from surface and ground water. The salinity level in the Lagoon depends on the amount of fresh water that drains into it. Hence, it is important to discuss both sources.

Surface water

Estuaries are always open to the sea and fresh water flows into the estuary continuously from one or more rivers or canals, with permanent or temporary water sources continually and periodically feeding this estuary without allowing the formation of a sand bar at the estuary mouth. Because of this, estuaries are permanently open and there is exchange of water, fauna and flora between ocean and terrestrial, saline water and fresh water systems, creating a brackish water environment from the estuary mouth up to the inner side of the water body. These estuaries are continually influenced by tidal impact. They depend on fresh water flows, and sometimes wind, to establish the salinity fields and degree of mixing which are their characteristic features. They act as conduits between land and ocean and serve as sinks for sediment and other substances transported into them. While these overall processes are occurring, the semi diurnal tidal ebbs and flows cause water to move back and forth several kilometres in a tidal excursion. Each partially mixed estuary has its own particular set of characteristics, but the general processes are similar. The tide makes nutrition and water flows.

Two major rivers – Mi Oya, Kala Oya – drain from the terrestrial, eastern side to the Puttalam 'Lagoon'. The minor Moongil Ara – also drains into the Lagoon. The southern end of the Lagoon is connected to the Dutch canal. This canal is, in turn, connected to the northern end of Mundel Lake. During the dry season, this Dutch canal carries brackish water from the Lagoon towards Mundel Lake; in the wet season, this flow is reversed and water from Mundel Lake flows towards the Lagoon (IUCN and CEA 2006).

Also in the area, is the Tabbowa tank, part of the Mi Oya diversion scheme, constructed across the Nanneri Oya which is a tributary of Mi Oya. The Tabbowa tank can store 9.7 million m^3 of rain water, and can irrigate 650 ha of agricultural land (Manchanayake and Bandara, 1999).

There are also seasonal streams and artesian flowing wells.

The productivity of the Lagoon depends primarily on the amount of fresh water discharged into it. If the fresh water discharge flow exceeds the tidal and waves forces, there will be no sea water intrusion as is seen in the Kelani River and Maha Oya.

If the fresh water discharge does not exceed the tidal and wave forces, then there is intrusion of sea water, which mixes with fresh water to create a brackish[37] water environment.

When elevation and fresh water flow are both low, suspended sediments from inland are deposited near the edge of the sea, supported by submerged landscape features, forming barriers and deltaic conditions, where the area of fresh water and sea water mixing is wider. Such conditions are seen in Negombo, Jaffna and Puttalam.

In the recent past, two events have contributed greatly to the changes in fresh water discharge into the Lagoon. The first is the Mahaweli water diversion into the Kala Oya basin since 1976. This has increased fresh water flow into the Puttalam Lagoon. Though water is extracted for paddy cultivation, generally, there has been an increased flow of fresh water since the

[37] More saline than freshwater, but less saline than full strength sea water.

diversion scheme (CEA, 1994). The change in discharge volume with and without cultivation has not been studied. However, because the Kala Oya mouth is at the northern end of the Lagoon, this does not have a major impact on the Lagoon.

Table 17. Catchment areas of relevant rivers and streams entering Puttalam Lagoon and precipitation and discharge volume
(Source: CEA, 1994)

Name of the river/stream	Catchment area km^2 $m^3x\ 10^6$	Precipitation volume m^3x10^3	Discharge volume m^3x10^6	Discharge as a % of precipitation
Kala Oya	2,772	4,424	587	13%
Mi Oya	1,516	2,176	338	16%
Moongil Ara	44	60	09	14%

At the same time a second event occurred: an irrigation development programme was carried out within the Mi Oya basin. Construction of various reservoirs such as the Inginimitiya Reservoir in 1980, the Tabbowa Reservoir in 1993 and various minor tanks within the Mi Oya catchment area reduced freshwater input into the Puttalam Lagoon at its southern end. Various other fresh water intakes since 1990 – for aquaculture and salterns – have greatly reduced the fresh water discharge from the Mi Oya into the Lagoon. This has greatly affected the water chemistry of the Lagoon and the salinity level of the southern area was as high as 55 ppm in 1997, while it was about 40 ppm prior to the 1980s and below 30 ppm in 1960s.

The Kala Oya basin development programme increased fresh water flow, while the Mi Oya development programme decreased fresh water flow into the Lagoon.

Ground water

Ground water resources are extracted from shallow dug wells, as well as from deep tube wells and shallow wells (Manchanayake and Bandara 1999). There are three major river basins associated with the area – Kala Oya, Mi Oya and Moongil Ara – which have a bearing on the ground water basin of the area.

Surface water – used originally for drinking and other domestic use – has now been extended to industrial use, livestock and irrigation agriculture. This has occurred in Puttalam district. Puttalam is a district where there is more than 90% dependence on groundwater aquifers[38] through extraction from municipal well fields and private boreholes. This ground water has been exploited for domestic use, industrial use, livestock and irrigated agriculture (Panabokke and Perera, 2005).

The area has three main aquifers types.

Deep Confined Aquifer

Deep confined aquifers occur on the sedimentary Miocene limestone base of the northwest area; the Palavi basin and Vanathavillu basin have been identified as deep confined aquifers (Panabokke, 2007).

The Vanathavillu basin has the largest and most well-studied limestone aquifers on the island (Manchanayake and Bandara, 1999). It is a major source of potable groundwater on the

[38] The word aquifer comes from the Latin words, *'aqua'* meaning water, and *'fer'* meaning to carry. It is described as a sub-surface geologic formation(s) (either of solid rock and/or unconsolidated sediments) that contains ground water in sufficient quantities to be used, or has the potential to be used.

island (Panabokke and Perera, 2005). The Vanathavillu basin is spread over some 40 km^2, and has been used intensively used for irrigated agriculture of high value crops since 1978. Manchanayake and Bandara (1999) estimate that groundwater resources available in the Vanathavillu basin vary between 5,000 and 20,400 million litres per annum.

By 1993, it was observed that chemicals from the cultivated soil had leached into the groundwater table (Panabokke and Perera, 2005).

Recently, the most intensively used aquifers have been those around Puttalam, such as the Palavi aquifer, which have been used for aquaculture of shrimps, as the quality and quantity of water was ideally suited for the purpose (Panabokke, 2007).

Shallow to moderately deep aquifers on unconsolidated coastal sand

Two types of these aquifers have been recorded:

Shallow aquifers

These occur on coastal spits and bars in Kalpitiya peninsula, one of the main coastal sand aquifers recognised in Sri Lanka. These lie on unconsolidated coastal sands (coastal sands aquifers) and support concentrated human habitation, intensive agriculture and a growing tourist industry. The over-extraction of fresh water from these sources will result in the entry of underlying brackish water into the fresh water aquifer and salinisation of the fresh water. In addition, these aquifers are at risk of becoming depleted, and/or eutrophied[39].

Moderately deep aquifers

These occur on the northwest coastal plain, on the Pleistocene deposits in Puttalam.

Alluvial aquifers

Alluvial aquifers are deeper and larger, and occur along the lower reaches of the major rivers across the various coastal pains surrounding the low country regions. Among them, Mi Oya has broad and deep alluvial beds of variable texture and gravel content.

Ground water extraction and degradation

There are 3,268 tube wells in the Puttalam district. The surface water and ground water supply to urban, rural and industrial sectors is estimated as 270 m^3 per day and 8,424 m^3 per day, respectively (Panabokke and Perera, 2005).

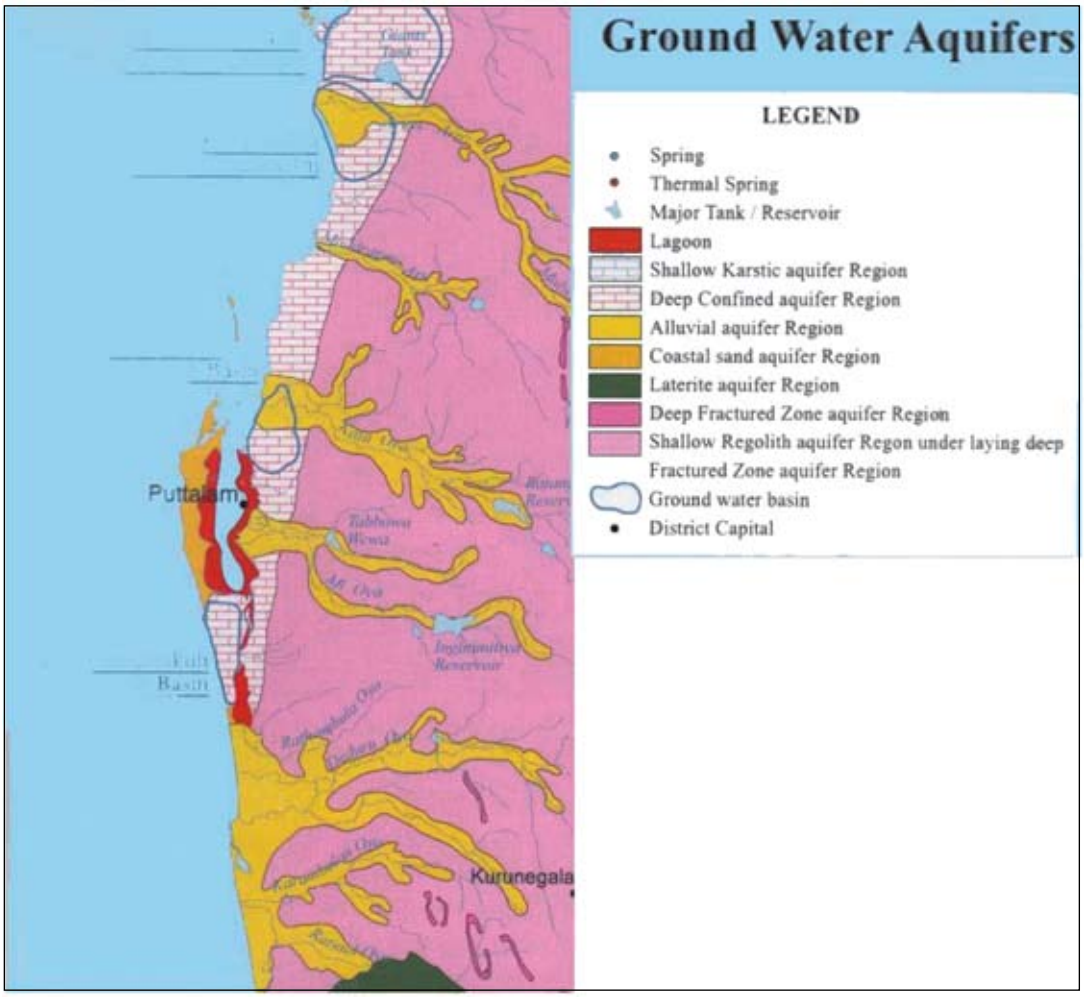
Salt water is used mainly for shrimp culture and the salt industry. Puttalam and Mannar are major salt producing areas in Sri Lanka. Saline water from the Lagoon is collected to make the salt.

There are increasing threats to ground water posed by pollution from intensive agriculture and the careless disposal of domestic and industrial waste. All aquifers are vulnerable and some are already contaminated by agro-chemicals which have leached from agricultural and domestic sources (Panabokke and Perera, 2005).

The huge increase in population, burgeoning commercial industrial and agricultural activity, climate change and atmospheric pollution have all contributed to an impending disaster of ground water resources (Mendis, 2002).

[39] Eutrophication is a process by which water bodies receive excess nutrients that stimulate excessive plant growth.

Figure 24. Ground water aquifers in the Puttalam Lagoon
(Source: Survey Department, 2007)



Salinity and Tides

The salinity level of estuarine water defines the context of communities of flora and fauna that are associated with it. The salinity level is determined by the tidal impact in the Lagoon.

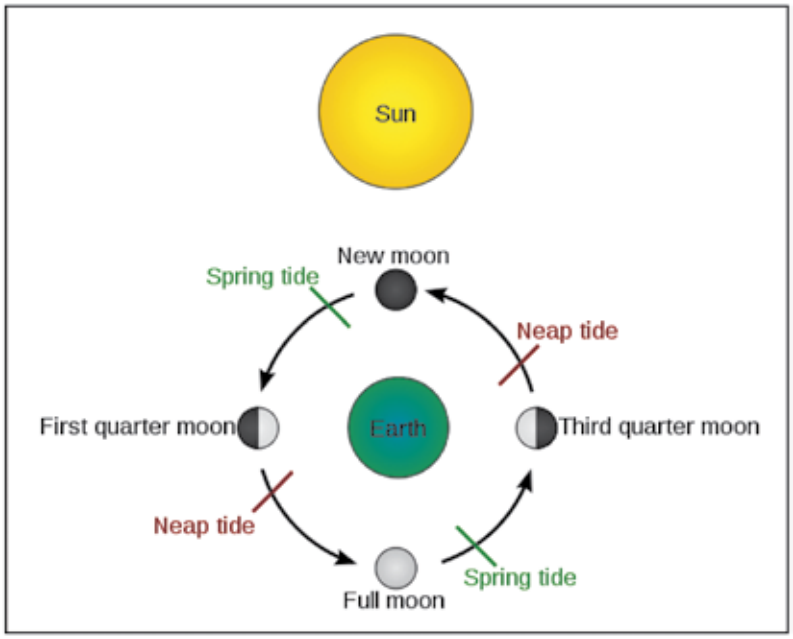
Tides are a key factor in determining the salinity of a Lagoon. The inflow of fresh water from rivers is one input into the Lagoon; the tide bringing in salt water is the other.

Tides are the rise and fall of sea levels caused by the combined effects of the gravity exerted by the moon and the sun, as well as the rotation of the earth. Many coastal areas go through a high tide (when the sea level is high) and low tide (when the sea level is low) once a day, usually with a time difference of 12 hours. Areas close together – for example Colombo and Negombo, go through high and low tides around the same time. Such tides are called semi-diurnal.

The tidal range varies in a two-week cycle. About twice a month, at new moon and full moon, the sun, moon and the earth form a line. Then, the tidal force due to the sun strengthens the tidal force of the moon. At this time, the tide is at its maximum, and is called the spring tide. When the moon is at first quarter or third quarter, the sun and the moon are separated by a 90° angle relative to the earth; at this time, the solar tidal force works against the moon's forces, partially cancelling it. At this time, the tide is at its minimum, and is called the neap tide. There is about a seven-day interval between spring and neap tides.

Figure 25. Spring and Neap Tides

(Source: http://en.wikipedia.org/wiki/Tide#Range_variation:_springs_and_neaps)



The magnitude of the tides varies from place to place and is a function of coastal morphology and the ocean floor. In Sri Lanka, the tidal range is within 75 cm at spring tide and 25 cm at neap tide.

Tides also vary due to other influences such as wind and barometric pressure changes, resulting in storm surges in shallow seas.

Although the Lagoon is connected to the Indian Ocean through the Dutch Bay at the northern end, its tidal pattern does not match the rhythm of the open ocean. Monsoon winds play a significant role in tidal movement in this shallow Lagoon and the tidal range is highest during the northeast monsoon and lowest during the southwest monsoon (Perera and Siriwardene, 1982, in litt. IUCN, 2010).

North and slightly west of the Puttalam Lagoon is Adam's Bridge, a chain of limestone islands covered with sand, as well as sand islands, stretching from India's Pamban Island (also known as Rameshawaram Island) to Sri Lanka's Mannar Island. Evidence from the past shows that Adam's Bridge once connected India and Sri Lanka but now there is sea between the limestone and sand islands. The sea level in the past was much lower; therefore, there was a connection. Wave currents move the sand so that some sand islands disappear during certain parts of the year (SSCP experts' committee documents, undated).

Adam's Bridge is 30 km long. The sea in this area is very shallow (1.5 to 3.5 m only), with sand shifting and resettling with wave currents.

Even though the size and depth of Adam's Bridge seems small, this chain plays a very important role in controlling the amount of water that moves between the Bay of Bengal (east of India) and the Arabian Sea (west of India) (SSCP experts committee documents, undated). Because Adam's Bridge is small, it does not allow the daily tide to move across it. As a result, the tides in the Gulf of Mannar and the tides in Palk Bay are very different: there is almost a twelve-hour difference in the tides, although they are close together. Because of this, there are huge differences in the water levels on either side of Adam's Bridge, driving strong currents through

the gaps between the islands. These currents change direction as the tide changes (SSCP experts' committee documents, undated).

During the southwest monsoon, strong winds blow large quantities of water from the Gulf of Mannar to Palk Bay, sending warmer, more salty water into Palk Bay. During the northeast monsoon, the opposite happens: cool, less salty water is moved to the Gulf of Mannar (SSCP experts' committee documents, undated).

Surface water salinities vary between 0.00 ppt (at the Kala Oya end of the Lagoon) and 55.0 ppt (Arulananthan et al, 1995, in litt. IUCN, 2010).

In the north, the water is of normal oceanic salinity, but hyper-saline in the south, as a result of high evaporation.

Waves and currents

When wind blows across the water there is a transfer of energy from the wind to a water body and a wave is created.

Waves are characterised by their form, dimension and frequency. Wave length (the distance between successive crests) and wave frequency (the intervals in seconds between successive waves) are important.

When waves are generated, there are short waves (short in wave length and short in frequency), and long waves (long in wave length and long in frequency). Short waves are called sea waves and long waves are called swells. Swells can travel far.

The wave periods of swell waves are about 11 seconds, while sea waves are about 5-6 seconds.

Swells come directly from the south and wrap around the coastline as they travel. Therefore, the direction of a swell may be southerly in Matara, and south-westerly in Colombo (Ranjit Galappatti, person.comm). Swells are produced in Bay of Bengal and the Arabian Sea during the monsoons, originating in stormy mid-latitudes in the southern Indian Ocean (40^0-55^0), under the influence of westerly depressions and storms. Swells are associated with relatively low wave heights (less than 1.0 m) throughout the year.

Sea waves on the other hand, occur close to the shore and dissipate their energy quickly. Sea waves approach the coast from a relatively narrow directional segment of 240^0-270^0 N during the southwest monsoon, and are associated with relatively higher wave heights (0.6-1.6 m).

Table 18. Summarised wave characteristics off the Kalpitiya Coast
(Source: EML, 2008)

Period of year	Wave Type	Directional Spreading			Wave Height Spreading		
		Dominant Direction Range(^{0}N)	Average Mean Wave Period(s)	Percentage of Occurrence	Dominant Height Range(s) (m)	Average Mean Wave Period(s)	Percentage of Occurrence
Whole year	Overall	230-270	7.4	86.6	0.2-1.4	6.5	74.9%
	Sea	230-270	5.9	76.3	0.0-1.4	5.1	90.5%
	Swell	230-260	10.0	93.3	0.0-0.6	11.6	76.2%
Northeast Monsoon	Sea	230-270	5.9	76.3	0.0-1.4	5.1	90.5%
	Swell	230-260	10.0	93.3	0.0-0.8	11.3	85.1%
Southwest Monsoon	Sea	240-270	5.8	89.7	0.6-1.6	5.5	81.7%
	Swell	230-260	10.2	93.8	0.2-1.0	10.4	78.9%

Currents are formed under the influence of both the tide and wind. The tidal movement in and out, creates weak currents parallel to the coastline.

During the southwest monsoon, wind-driven currents move from the south to the north and from the north to the south during the northeast monsoon. The predominant current maker is wind.

Sri Lanka is situated in the middle of two main ocean water bodies, the Bay of Bengal in the east and the Arabian Sea in the west. Each of these seas has distinct current patterns which influence the tides of the island. Currents are stronger in the east coast and weaker around the Puttalam area.

Mineral Resources

Miocene mineral resources have had a great impact on the land use pattern and the ecological status of the area.

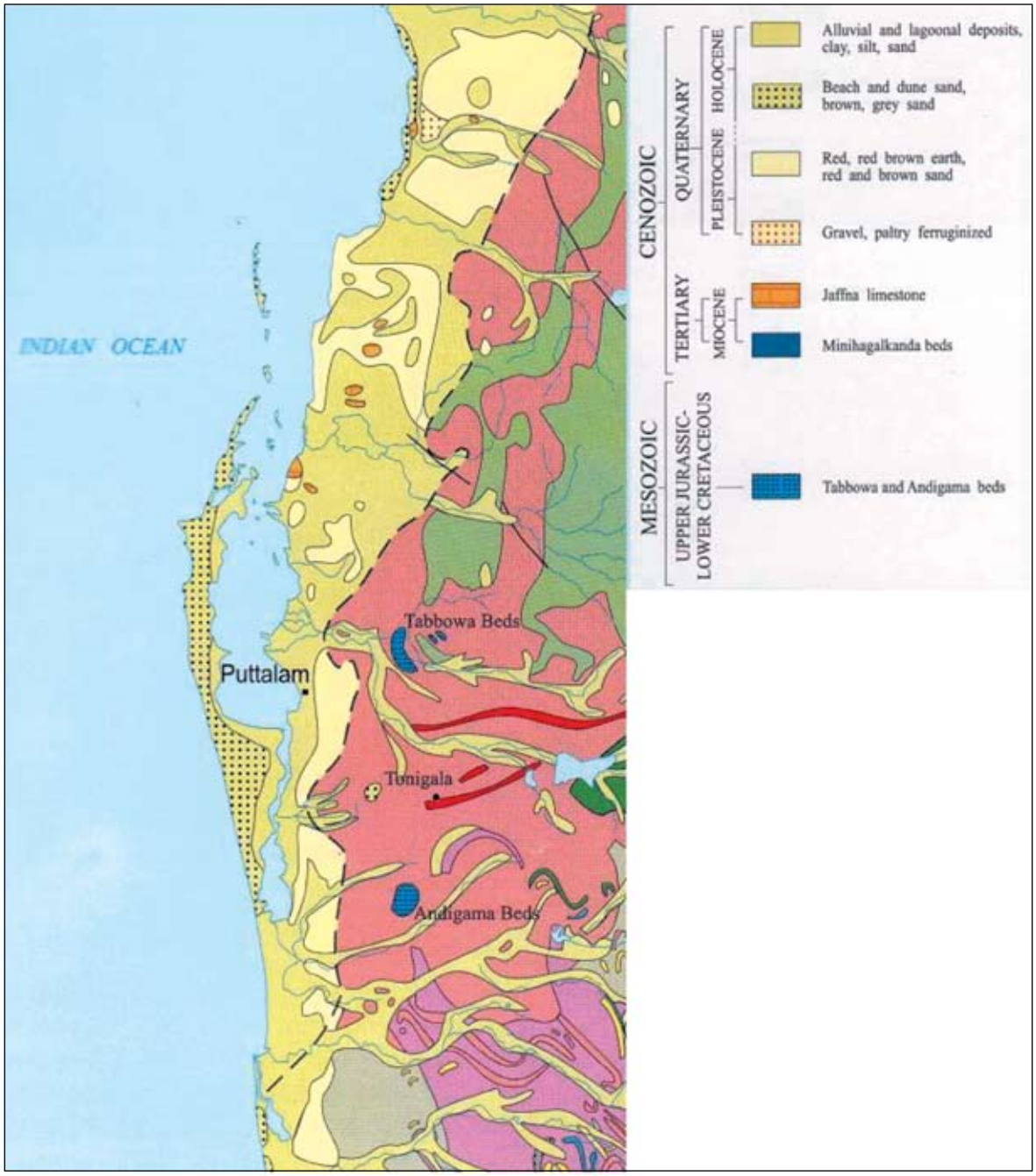
Some golden-yellow Monazite[40] has been recorded around Kudiremalai point within the border of Willpattu National Park. There are abundant Kaolinite[41] and Montmorillonite[42] clays which are used for building. This clay contains a high proportion of iron minerals and a low refractoriness. Most of these clays have been used for manufacturing bricks, tiles, and cements throughout history, and they are being extracted in the Puttalam Lagoon area.

There are some records of quartz sands deposits in southern Puttalam, deposited when the sea levels rose. Many types of limestone have been recorded in the area, deposited as sedimentary limestone, coral and sea shells. An estimated 18 million metric tonnes of sedimentary limestone is reported to be deposited at Arukkalu. This deposit is being extracted by a cement factory.

Mineral mining practices cause damage to the natural environment.

[40] Monazite is a reddish-brown phosphate mineral containing rare earth metals
[41] Clay minerals are divided into major groups – Kalolinite is one of them.
[42] Clay minerals are divided into major groups – Montmorillonite is one of them.

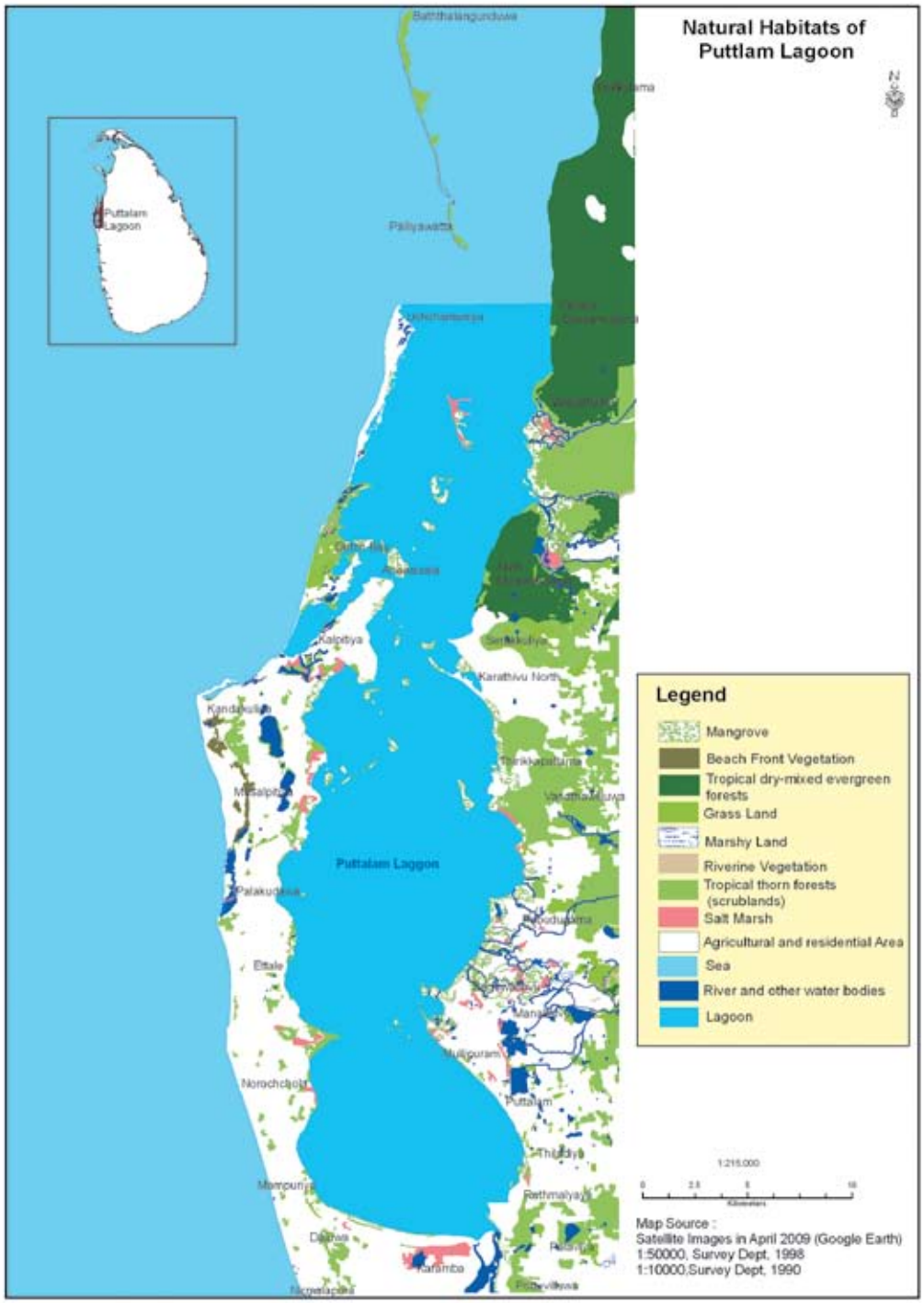
Figure 26. Map of the mineral deposits in the Puttalam Lagoon
(Source: Survey Department 2007)



Chapter 5: The Natural Environment

The Puttalam Lagoon supports a range of inter-connected and inter-dependent natural habitats that form a mosaic in a larger landscape.

Figure 27. Natural habitats of Puttalam Lagoon
(Source: Weragodatenna, 2010)



Habitats

Tropical mixed evergreen forests

Tropical mixed evergreen forests are found as degraded types in a large patch and some isolated locations on the landward side of the Puttalam Lagoon (See Figure 27). The largest contiguous tract of tropical dry mixed evergreen forest is located in the Aluth Eluvankulama area in the Vanathavillu DS division.

These tracts are composed of four recognisable strata of vegetation: an 8-10 m high continuous tree canopy, a sub canopy up to 7 m, shrubs up to 5 m and herbaceous plants below 1 m. Trees grow densely in well-developed sites, while shrubby and herbaceous forms grow poorly in the ground layers.

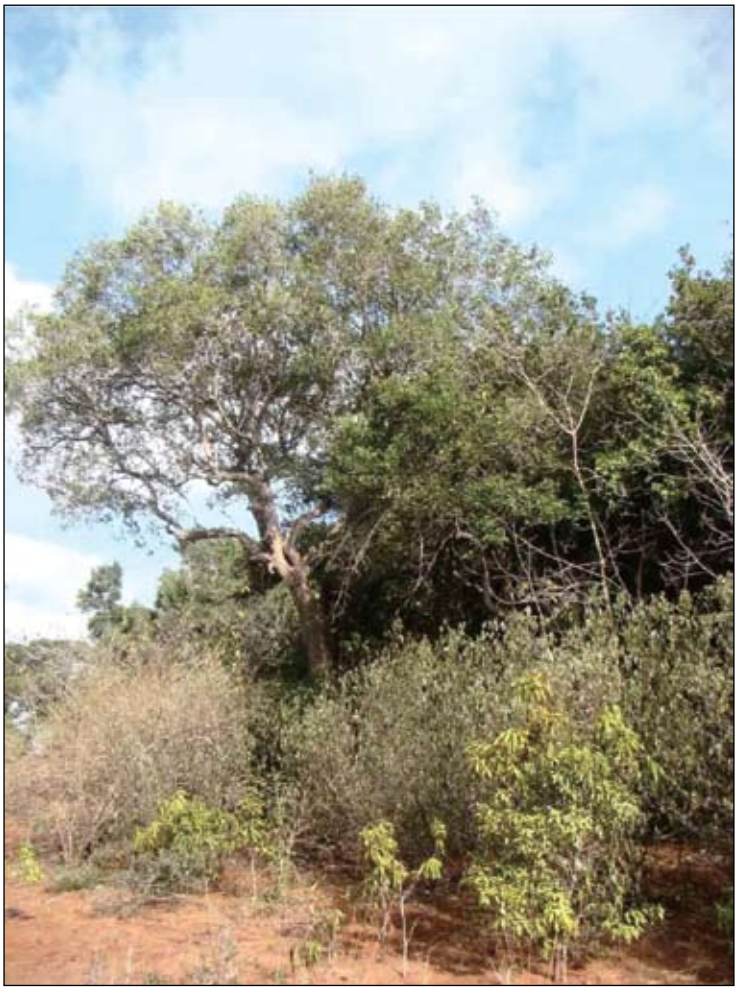
Leaves of the plant species found in this habitat are generally fleshy and small – an adaptation to water scarcity. Exposed ground is common and forest regeneration can be observed in many places. Dominant species of the tropical dry mixed evergreen forest habitat are *Manilkara hexandra, Mischodon zeylanicus, Drypetes sepiaria, Hibiscus eriocarpus, Tarenna asiatica* and *Stenosiphonium cordifolium* (IUCN, 2010).

In small patches of disturbed forests, the ground layer is dominated by *Stenosiphonium cordifolium*, a herb usually found in association with dry zone forests. The presence of *Hibiscus eriocarpus* in these forests is an indication of disturbance in the recent past, as this is a light-demanding, fast-growing plant that readily invades disturbed sites. Forest regeneration is indicated by the presence of a large number of *Mischodon zeylanicus* saplings as small shrubs. The presence of *Manilkara hexandra* as the dominant tree species is positive, as it shows that the forest is still not very badly damaged. Usually *Diospyros ebenum, Pleurostylia opposita, Cassine glauca and Manilkara hexandra* are the first to disappear because of their value as high quality timber and for firewood (IUCN, 2010).

The use of forest resources has not been documented properly. Opportunistic IUCN observations during the BMZ project revealed that illegal extraction of timber (of *Pleurostylia opposita*, *Diospyros ebenum*, *Cassine glauca and Chloroxylon swietenia*) is on-going in the Vanathavillu area. The second largest forest use is consumption for firewood, housing and other domestic activities. In addition, medicinal plants – such as *Vernonia zeylanica*, *Capparis zeylanica*, *Diospyros malabarica*, *Sapium insigne*, *Strychnos potatorum*, *Ixora coccinea, Salacia reticulata* and *Atalantia ceylanica* – are collected. Fishers collect *Pterospermum suberifolium* to make fishing rods. Fruits are collected from *Manilkara hexandra, Drypetes sepiaria, Toddalia asiatica* and *Syzygium cumini;* vegetables, from *Momordica charantia* and *Momordica dioica;* leafy vegetables, from *Hygrophila schulli, Wattakaka volubilis* and *Coccinia grandis.* The nut of *Strychnos potatorum* is used for water purification. The tubers of some yam species are also used as food.

Miocene limestone extraction for cement production in Aruwakalu is a serious threat to these forests. The forest area is denuded to extract the mineral. Encroachment for coconut cultivation is another threat. *Chena* cultivation was also a threat, but now has decreased as a result of the civil war. There is an increasing threat of illegal logging of valuable timber species.

Figure 28. Tropical mixed evergreen forests of the Lagoon area
(© Dilup Chandranimal)



Tropical thorn forests

Thick, impenetrable tropical thorn forests are found in the Puttalam Lagoon area, but are not contiguous, and are located in small patches, except for a large tract near Pubudugama.

Three major strata can be recognised in these forests: the scrublands are thick, impenetrable, thorny or spiny, shrub vegetation growing up to 4-6 m in height; scattered trees up to 10 m and a layer of herbaceous plants (up to 1 m). Many plants have microphyllous[43] leaves. The ground layer flourishes with herbaceous life forms, as it receives direct sunlight. Many plant species are well-adapted to xerophytic[44] conditions because of the dry climate (IUCN, 2010). These adaptations include thick and small leaves with well-developed surfaces, succulent stems of *Cissus quadrangularis*, *Sarcostemma brunonianum* and *Euphorbia tirucalli.* Seeds are produced during the rainy season. The scrubland is completely different at the peak of the dry season, as leaves fall or dry out and brown in the heat.

The vegetation in the scrublands is dominated by *Euphorbia tirucalli, Phoenix pusilla*, *Salvadora persica*, *Cynodon dactylon* and *Dichrostachys cinerea*. Unlike the thorn forests of interior areas, coastal thorn forest patches are dominated by *Phoenix pusilla* as a shrub species. This species

[43] Having small leaves.
[44] Showing adaptations for water scarcity.

seems to tolerate frequent fire, moderately saline soil and the severe dry conditions of the area. *Euphorbia tirucalli* is also dominant among the shrubs, with similar characteristics. This tough scrub has the ability to withstand heavy structural damage caused by herbivores, drought or wind, and has the ability to regenerate rapidly during the wet season (IUCN, 2010).

Woodlands of *Borassus flabellifer* are found with associated scrublands.

The scrubland forest resources are also important in the Puttalam area. The major use is consumption for firewood, housing and other domestic activities consumption by adjacent communities. Medicinal plants – such as *Euphorbia tirucalli, Cassia auriculata, Vernonia zeylanica*, *Capparis zeylanica* and *Sarcostemma brunonianum* – are collected. *Borassus flabellifer* is a multi-purpose species: leaves are used for roofing, stems for wood, nuts as fruit and the young buds as food. Wild fruits of *Carissa spinarum*, *Ziziphus oenoplia*, *Ziziphus mauritiana* – are also collected. Green leaves of *Canthium coromandelicum*, *Wattakaka volubilis* and *Coccinia grandis* are used as leafy vegetables. The roots of *Salvadora persica* are valued for the production of toothpicks, as a traditional practice of the Muslim community.

These thorn forests are deforested for the creation of coconut plantations, salterns and shrimp farms and are also encroached for settlement. The release of cattle and goats has also severely affected this habitat. Because of this, grass species such as *Cynodon dactylon* and *Eragrostis* sp. that can tolerate heavy grazing, survive in the ground layer (IUCN, 2010).

Figure 29. Tropical thorn scrubs of the Lagoon area
(Naalin Perera © IUCN)

Mangroves

Mangroves are the most extensively distributed habitat in the Puttalam Lagoon area and are found along sheltered lagoons, estuaries and the islands.

Two types of mangrove communities are recorded in the Puttalam Lagoon area, namely riverine mangroves and fringing mangroves. The former are more structurally complex than fringing mangroves. Riverine mangroves, as their name implies, occur along rivers and streams and are flooded daily by the tides. They receive nutrients from both inland and estuarine sources, and fresh water flushing lowers salt stress. These favourable conditions make riverine mangroves very productive. Riverine mangroves are found in the estuaries of Mi Oya and Kala Oya.

Fringing mangroves are found along protected coastlines, islands and the exposed waters of bays and lagoons (Amarasinghe and Balasubramanium, 1992). They are flooded periodically by tides. These mangroves are mostly found on alluvial deposits (mainly containing silt and fine clay) but they can also be found on sandy soil also (Jayasuriya et al., 2006).

Mangroves are highly productive systems that recycle nutrients and serve as nursery grounds for commercially important species. They provide firewood, timber, construction materials, fishing, agriculture, and forage for livestock, medicines, dyes and food items to communities.

Other services that they provide are critical: they provide a physical barrier against extreme weather events, control the inflow of fresh water into the Lagoon, prevent sedimentation and filter the water. They also play a vital role in land-stabilisation and land accretion.

Figure 30. Mangroves at Kalpitiya
(© Sriyanie Miththapala)

The mangroves of the Puttalam Lagoon have been estimated at nearly 1,200 ha of inter-tidal land (Kanakaratne al., 1983). The largest mangrove tracts in Sri Lanka are recorded from this area (Karunathilake, 2003). The riverine mangroves of Kala Oya Lagoon are extensive and less disturbed, located on the southern boundary of Wilpattu National Park. They are vulnerable to developmental activities (Amarasinghe, 2004).

Rhizophora mucronata and *Avicennia marina* are the major constituent species of mangroves of the Lagoon area and Dutch bay. Monospecific stands of *Avicennia marina* are commonplace

in the Lagoon and *Rhizophora mucronata* dominates the water-front areas of the riverine mangroves of Kala Oya and Mi Oya.

A total of 13 true mangrove species and 18 mangrove-associated species have been reported from Puttalam Lagoon and islands. In Sri Lanka, *Bruguiera cylindrica* is restricted to Chilaw, the Lagoon area the islands of the Kalpitiya area and Trincomalee. The population of *Bruguiera cylindrica* is in better condition in the Lagoon area than at other locations. *Sonneratia* is recorded from Chilaw to Puttalam including Kalpitiya area, but is rare elsewhere. *Xylocarpus rumphii* is also a rare species restricted to a few islands of the Puttalam Lagoon area, Wilpattu National park and Unawatuna beach (Dassanayake and Fossberg, 1980-2002). Among mangrove associate species, *Scyphiphora hydrophyllacea* is a rare and critically endangered species (IUCN and MoENR, 2007), that is recorded in a few locations in the Puttalam Lagoon area. *Cynometra iripa,* another critically endangered mangrove associate (IUCN and MoENR, 2007), is restricted to mangroves of the Seguwantivu area.

Rhizophora mucronata is the most dominant large shrub; while *Avicennia marina* (a small tree) and *Excoecaria agallocha* (a large tree) are also dominant within their stratum. *Excoecaria agallocha* and *Sonneratia alba* also were recorded as the other dominant species in the area. These species are ideal for future restoration of degraded mangrove habitats. The herbaceous layer is dominated by a mixture of salt mash plants and mangrove seedlings.

Zonation of species is observed, *Rhizophora mucronata*, *Rhizophora apiculata, Sonneratia alba* and *Bruguiera cylindrica* are at the water front and mixed mangrove communities of *Aegiceras corniculata, Ceriops tagal, Xylocarpus granatum* and *Lumnitzera racemosa* are on the landward *side.* All the above are true mangrove species. Associate mangrove species - such as *Acanthus ilicifolius, Clerodendrum inerme, Thespesia populnea*, *Hibiscus tiliaceus and Tamarinus indica* – are also found on the landward side.

The most extensive and undisturbed tracts of mangroves are found in the Kala Oya area. Undisturbed patches of mangroves are also found in Kuringipitti, Pubudugama, Gangewadiya, Thirikkapallama, Ettalai and most of islands such as Ippantivu, Sinnaarichchalai, Periyaarichchalai and Irrimathivu.

Mangroves are associated with other habitat types such as seagrasses, salt marshes and sea shore vegetation.

Most mangrove plants of the area are used as firewood. In fact, about 55% of the households around the Lagoon use mangrove plants as firewood (Dayaratne et al., 1995). *Sonneratia alba* and *Thespesia populnea* are used as fodder for goats in the western part of the Lagoon. In a few islands, the mangrove bark of *Rhizophora mucronata* and a few other species is collected for tannin extraction. This tannin is used for preservation and colouring of nets and other fishing equipment. The twigs and branches of *Avicennia marina* are used for brush pile construction in a few areas of the Lagoon. *Cynometra iripa* seeds were used traditionally instead of Areca nut in the Seguwanthivu area. A few species, such as *Acrostichum aureum* and *Suaeda maritima* are used as leafy vegetables.

In the last few decades, mangroves have been affected severely as a consequence of the rapid expansion of the shrimp farm industry. Their distribution was been reduced from 1,181.5 ha in 1981 to 431.6 ha in 1992 (63.47% decrease in area) (Senerath, 1998). (Figure 31).

Currently, the threat is from the expansion of salterns. Shrimp farms and salterns have affected mangroves in Seguwantivu, Thirikkapallama, Palavi, Mampuriya and Anawasala.

The natural habitats of Kalpitiya and its islands are also under threat from a rapidly expanding tourist industry. Natural habitats, especially mangroves, are under threat due to clearing for expansion of the tourism industry in Kalpitiya peninsula and most of the islands.

In addition, the discharge of effluents containing fertilisers, nutrients, organic sediments, antibiotics and hormones has polluted the water in the areas. It has been noted that that *Avicennia marina* in the Kuringipitti area and some areas in the Kalpitiya peninsula are extremely stunted, and this may be a result of pollution.

Mangroves are also subjected to the heavy grazing by cattle and goats, especially during the dry season.

Cynometra iripa and *Scyphiphora hydrophyllacea* are threatened because they are extracted as fuelwood by local communities in the Puttalam Lagoon. In the mid-1980s the consumption of fuelwood increased with internal migration to the area of refugees (Senerath and Visvanathan, 2001).

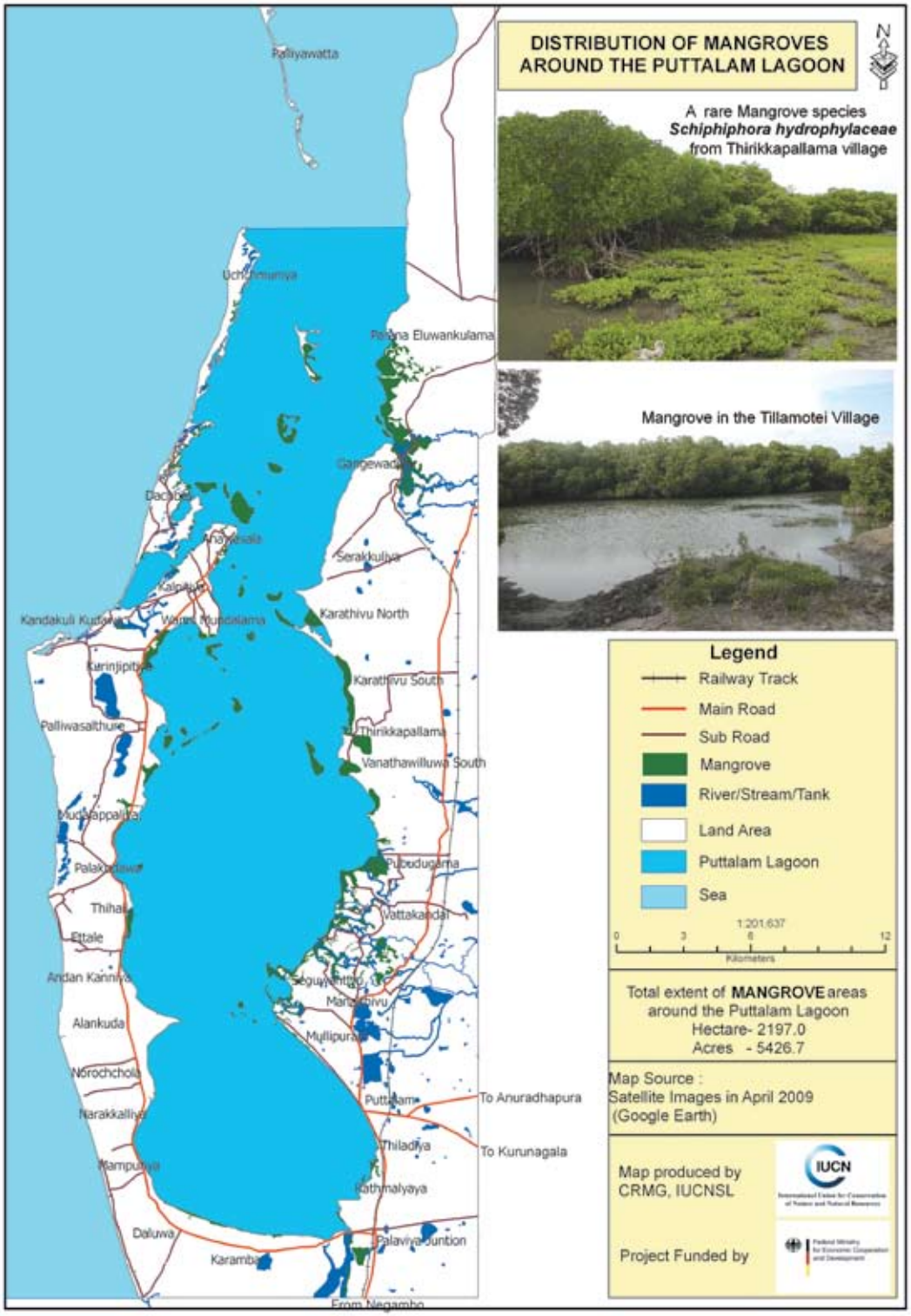
Salt marshes

A salt marsh is an inter-tidal plant community dominated by herbs (growing to a height up to 0.25 m) and low-growing small shrubs (up to 1.5 m). Usually, salt marshes and mangroves are located close to each other or gradually merge into one another, depending on the edaphic[45] conditions. However, there is a clear structural distinction between salt marsh and mangroves – which is an intertidal community dominated by trees. Salt marsh sites become extremely dry during the prolonged dry period (April-August) and consequently, excessive evaporation intensifies salinity. Often, crystallized free salt can be observed. Plant communities in these habitats include perennial herbs such as *Salicornia brachiata* and *Suaeda monoica* as the dominants that cover the bare ground, with prostrate and upright shoots. Generally, the ground is 75% bare soil and sedges – such as *Cynodon dactylon* and *Eragrostis* spp. – can be found intermixed over the rest of the ground cover. *Halosarcia indica* is predominant in Thirikkapallama, Manpuriya and Kuringipitti. These *Halosarcia* hammocks trap wind-borne sand, preventing wind-induced erosion and enhancing the nutrient status of the habitat. (Figure 32).

There is also an algal mat called '*lab lab'*, dominated by nitrogen fixing *filamentous cyanobacteria* such as *Lyngbya* sp. that exists on the soil surface. During high tides, when the marsh becomes flooded, these algal mats start floating. Because of their photosynthetic ability, during the day these marsh waters become oxygen-rich. Salt marshes with algae form the habitat for the juveniles of a number of fish and shellfish, particularly those of Milkfish (*Chanos chanos)*, the fry of which are collected in large numbers.

[45] Edaphic is a general term referring to characteristics of the soil.

Figure 31. Distribution of mangroves in Puttalam Lagoon area
(Source: Weragodatenna, 2010)



Extreme environmental conditions such as dry atmospheric conditions, increased soil salinity, desiccating salt spray, perennially high temperatures and excessive evaporation are not conducive to the growth of other plant species in locations in which salt marshes are found.

Salt marshes function as a very important habitat for coastal aquatic and migratory birds because there is a high abundance of benthic invertebrates. *Suaeda monoica* is used by some communities to make sambols[46].

Expansions of salterns and shrimp farming, as well as encroachment for human settlement, are serious threats to this habitat. In particular, salt marshes of the Mi Oya area have been subject to destruction as a result of shrimp farm expansion. The extent of salt marshes in the area was estimated, based on aerial photographs, to be 1,515 ha (Kanakaratne et al., 1983). Forty six percent of salt marshes in the area were estimated to have been destroyed between 1981 and 1992 (Dayaratne et al., 1997). Nearly 50% of the total recorded extent of salt marshes in the Mi Oya basin has been lost in a decade (Dayaratne et al., 1997).

Figure 32. Salt marshes of the area with mangroves in the background
(Naalin Perera © IUCN)

[46] Spicy salads.

Barrier beaches, spits and dunes

Barrier beaches are long and narrow beaches of sand that run parallel to the coastline and are not submerged by the tide. They accumulate from sediments washed ashore and are moulded to a form 'that lies across a body of water isolating it from the sea' (CZMP, 2004).

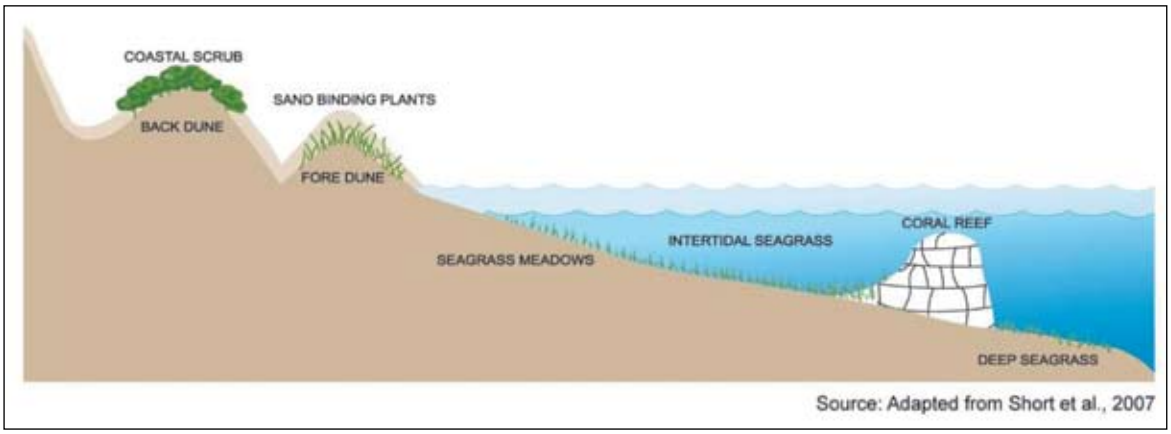
A spit is a long and narrow accumulation of sand and/or gravel that projects into a body of ocean water and is free at one end. These features form as a result of the deposition of sediments by water currents moving parallel to the shore. Spits are developing barrier beaches (CZMP, 2004).

Soil washes from inland rivers and finds its way to the sea. When this happens, soil layers – for example, humus, clay and sand – separate. Sand deposits on beaches, while clay, which is heavier, reaches open oceans. This deposited layer of sand is shifted constantly by wind and waves. Waves wash sand onto the beach. At low tide, this sand dries and the finest fraction of sand is blown further landward by winds, and cannot now be reached by normal waves. The wind keeps pushing this sand landwards in a motion like a sheet moving. The moment the sand reaches the side away from the wind, it settles and forms sand dunes. Some of this sand collects behind rocks or clumps of seaweed. Here, the roots and underground parts of grasses and other vegetation trap the sand from being blown away. The wind then starts eroding sand particles from the windward side and depositing them on the side protected from the wind. Gradually, this action causes the dune to move inland, accumulating more and more sand as it does so. Subsequently, more vegetation grows on these dunes (Hesp, 2000).

Sand dunes are spectacular coastal features in the Kalpitiya area: rising up to 4.5-6 m and sometimes more. These are called high dunes. These high dunes extend for the length of the Peninsula and the width varies from 1-4 km extending up to the Uchchamunai area. There are also dunes extending along the Kalpitiya peninsula from Palavi, where the dune height is not so high and where there is vegetation growing up to 2-3 m in height, between which are clumps of shrubs and grass. In Palavi, on the eastern part of these dunes, there is on-going cultivation.

Figure 33. Cross section of a seashore showing different habitats

(Source: Adapted from Short et al. 2007)



Beach vegetation is found as patches in the immediate land belt surrounding the Lagoon where the land is gently sloping towards the sea. The composition of the plant species on the beach and associated sand dunes depend on the extent and steepness of the shore and the degree of ground stability.

Vegetation located in the zone beyond the direct impact of waves and tides supports a few tree species, shrubs and herbs, which help consolidation of surface soil by restricting wind induced erosion and by providing resistance to removal of sand by occasional sea water. Trees are characterised by stuntedness, a feature that can be attributed to the impact of strong wind action, salt spray and insulation. Depending on the steepness and width of the shore, the beach vegetation zone may extend up to 50 m. Species in sand dunes and beaches are well adapted to drought and grazing. Dominant species are *Cynodon dactylon, Phoenix pusilla* and *Borassus flabellifer* (IUCN, 2010).

The sediment in sand dunes protects the land behind them from storm erosion and potential sea level rise. Sand dune vegetation traps sand and prevents it from being blown further inland. The constant changing of erosion and accretion of sand dunes – their self-repairing dynamics – are extremely important in hazard mitigation (Dahm et al., 2005). Sand dunes are essential components of coastal vistas and biodiversity. They also harbour endangered species – such as marine turtles – that return to the sites where they were born to lay their eggs on sandy beaches. The lower slopes of sand dunes with natural vegetation such as *Ipomoea pes-caprae* and *Spinifex* are ideal nesting sites for turtles (Choudury et al., 2003).

Species such as *Phoenix pusilla* and *Borassus flabellifer* provide many resources such as food, thatch and wood.

Sand mining and water extraction pose threats to sand dunes and beaches. Invasive species such as *Lantana camara, Xanthium indicum* and *Opuntia* sp., even in moderate abundance, are likely to become a problem for these habitats.

Figure 34. Sand dunes in the Lagoon area
(Naalin Perera © IUCN)

Mudflats

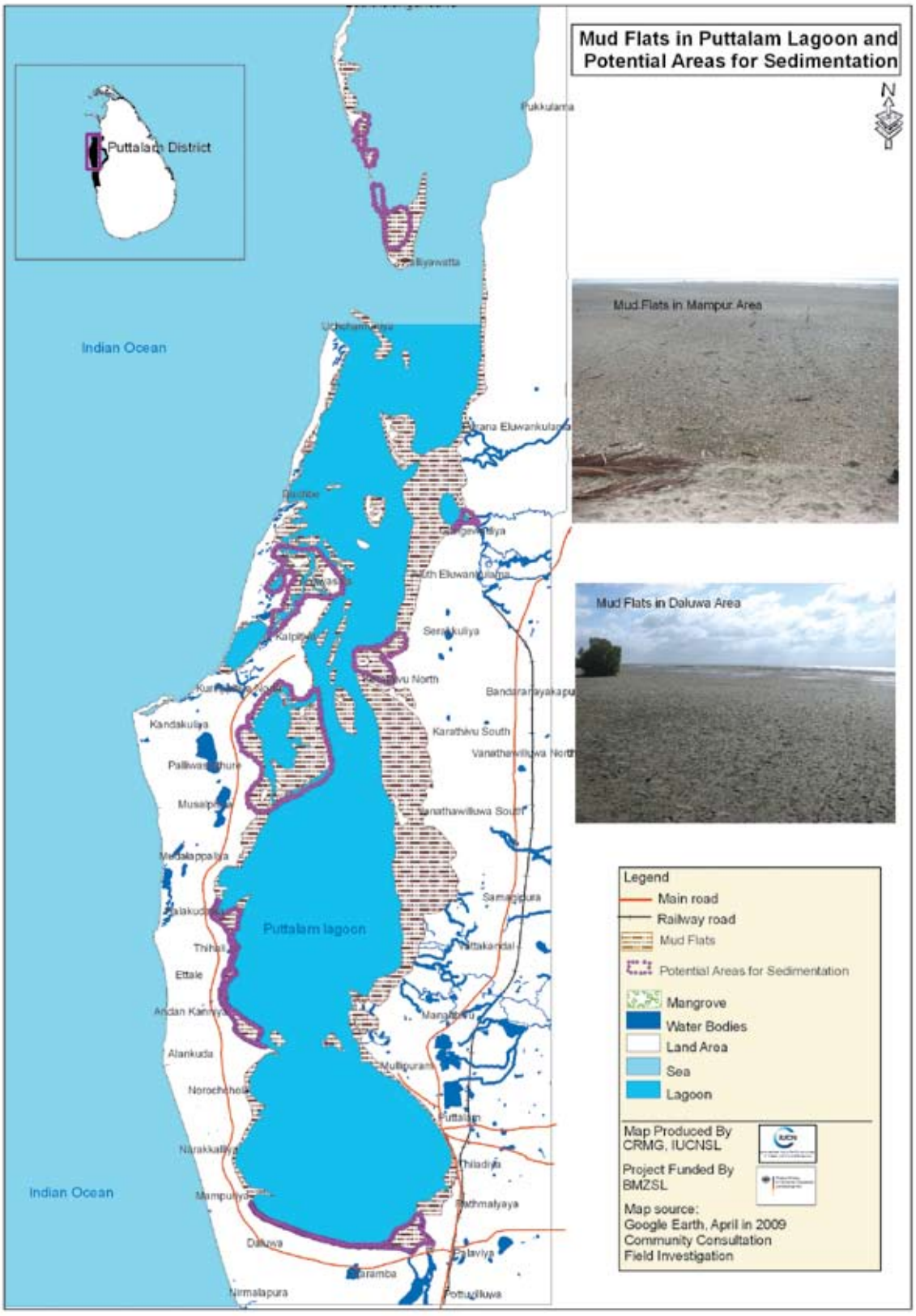
Mudflats are sedimentary inter-tidal habitats created by mud deposition in low energy coastal environments, particularly in sheltered areas. Their sediment consists mostly of silts and clays with a high organic content. During low tide, mudflats in the Lagoon area are exposed as the Lagoon is very shallow.

These mud flats are important in processing nutrients for the ecosystem and providing feeding areas for fish at high tide and for birds at low tide. Mudflat habitats commonly appear in the natural sequence of habitats between sub tidal areas and terrestrial inland vegetation. Several species of plants – mainly washed over sea grasses and algae – were observed in these habitats. Mudflats, like other inter-tidal areas, dissipate wave energy and thereby contribute to minimise the impacts on salt marshes and flooding low-lying lands. They also prevent erosion. Mudflats are characterised by high biological productivity and abundance of organisms, but are low in plant species diversity. These are extremely important habitats for water birds, and especially migratory birds (IUCN 2010).

Irresponsible anchoring of boats is damaging these habitats.

Figure 35. Mudflats of the Puttalam Lagoon area
(Naalin Perera © IUCN)

Figure 36. Distribution of mudflats in the Puttalam Lagoon area
(Source: Weragodatenna, 2010)



Seagrasses and seaweeds

Seagrasses

Seagrasses are seed-bearing, flowering, rooted plants, which grow submerged, exclusively in marine coastal waters and coastal wetlands. Seagrass meadows are widely distributed in the shallow areas of the Puttalam Lagoon (Johnson and Johnstone, 1995). There are thick and dense meadows on muddy, sandy, clay soil of the Lagoon, as the Lagoon is favourable for seagrass growth because of limited water movement and shallowness. Seagrass meadows constitute approximately 23.9% of the total Lagoon area (Johnson and Johnstone, 1995).

Eight species of seagrasses have been identified in the Lagoon area. These are *Enhalus acoroides, Thalassia hemprichii, Halodule uninervis, Syringodium isoetifolium, Cymodocea rotundata, Cymodocea serrulata, Halophila ovalis* and *Halophila decipiens*. The dominant species in these meadows are *Cymodocea rotundata, Halodula uninervis, Enhalus acoroides, Halophila sp, Cymodocea rotundata* and *Halodule uninervis* (Jayasuriya, 1991).

These habitats are extremely productive and contribute to the sustenance of lagoon and near-shore fisheries, functioning as nurseries and habitats for many commercially important species of fish and crustaceans. They form a complex ecosystem, supporting many forms of life – ranging from Dugongs to plankton – hence, contributing to the increased biodiversity associated with the Lagoon.

Seagrass meadows in Mannar bay, Portugal and Dutch bay have been reported to provide habitats for Dugongs (*Dugong dugong*).

Many edible fish are found living in seagrass beds. Seagrass meadows, like mangroves, are nursery areas for many finfish and shellfish. Because of this, they are critical in coastal fisheries (Heck et al., 2003). Seagrasses act as a filter of coastal waters, and cleaning water (Short and Short, 1984). The underground stems of seagrasses prevent the sediment trapped by leaves from being re-suspended, thereby stabilising the sea bed and preventing sand from being washed away and churned up by wave action (Bjork et al., 2008). Seagrasses absorb carbon dioxide from the oceans when they photosynthesise. Like forests on land, they function, therefore, as carbon sinks, removing carbon dioxide from the sea (Spalding et al., 2003).

Importantly, seagrasses have been called 'biological sentinels' or 'coastal canaries' (Orth et al., 2006). Like canaries that were taken into coal mines to test the quality of the air, seagrasses respond to changes in the quality of water, indicating deterioration of the environment by degrading and declining before dying. These changes are visible very quickly so that it is possible to take management action (Orth et al., 2006).

The use of harmful and unsustainable fishing methods has led to the reduction of fish varieties in the Lagoon and in the degradation of the seagrass meadows (Pathirane, 2008). Pollution damages seagrass meadows. Mooring, propellers and jet skis are emerging as a major threat to seagrass meadows (Fonseca et al., 1998). When boats – either for fishing or recreation – enter into areas where there are seagrass meadows, their propellers can slash leaves as well as rhizomes of seagrass, leading to fragmentation of the habitat, which, in turn, leads to erosion (http://www.sms.si.edu/IRLspec/Seagrass_Habitat.htm). The same applies when illegal nets are used.

Seaweeds

Multi-cellular green and brown algae – also found in marine environments – are usually called seaweeds or kelps. Although they can photosynthesise and make their own food, seaweeds lack complex specialised cellular tissues for transport of food and water that are found in

seagrasses. They also lack flowers and fruits – structures that are specialised for reproduction – as well as roots.

The Kalpitiya area is a source of agar and alginates. Ceylon Moss (*Gracilaria edulis)* is a marine red alga that occurs in the Puttalam Lagoon. Major *Gracilaria* beds are found among the seagrass meadows near Udayarpidi Island. Since the early 19th century, fishers have collected this seaweed in the off season for fishing. An estimated 50-60 tons of dried seaweed has been exported annually from the Puttalam Lagoon (Durairatnem and Medcof, 1954). Up to 90% of the people in the Puttalam Lagoon area use Ceylon Moss for making sweets (Dayaratne et.al. 1995).

Figure 37. Seagrass beds of the Lagoon area
(© Dilup Chandranimal)

Coral reefs

Some of the most extensive coral reefs of Sri Lanka are found in the Gulf of Mannar. Four major coral reefs are found in the seas around Puttalam district: the Bar Reef Marine Sanctuary, Kandakuli Reef, Talawila Reef and Mampuri Reef (Ranasinghe, 2010).

The Bar Reef Marine Sanctuary – the largest marine protected area in Sri Lanka – runs parallel to the coast from the northern end of the Kalpitiya peninsula to the islands which separate Portugal Bay from the Gulf of Mannar. It has high ecological, biological and aesthetic significance, being the home of 156 species of coral and 283 species of reef fish. The Bar Reef was declared a Marine Sanctuary in 1992, the area of the reserve being 306.7 km² (http://en.wikipedia.org). The core zone of 70 km² supports reef-building coral and true coral reefs, with about 300 species of reef-associated fish (Ranasinghe, 2010).

The Bar Reef Marine Sanctuary consists of two distinct habitat types: shallow coral reefs and the deeper sandstone reefs. Coral reefs are situated about 10 m from the surface of the water, while sandstone reefs are located in areas deeper than 18 m. Coral reefs here are dominated by branching and tabulate corals including *Acropora (*accounting for 90% of the total species) and the foliaceous[47] *Echinopora.* However, most of these died due to coral bleaching in 1998 (ADB and IUCN, 2003). The deeper sandstone reefs are mainly sandstone substrate with corals growing upon it (Ohman et al., 1997).

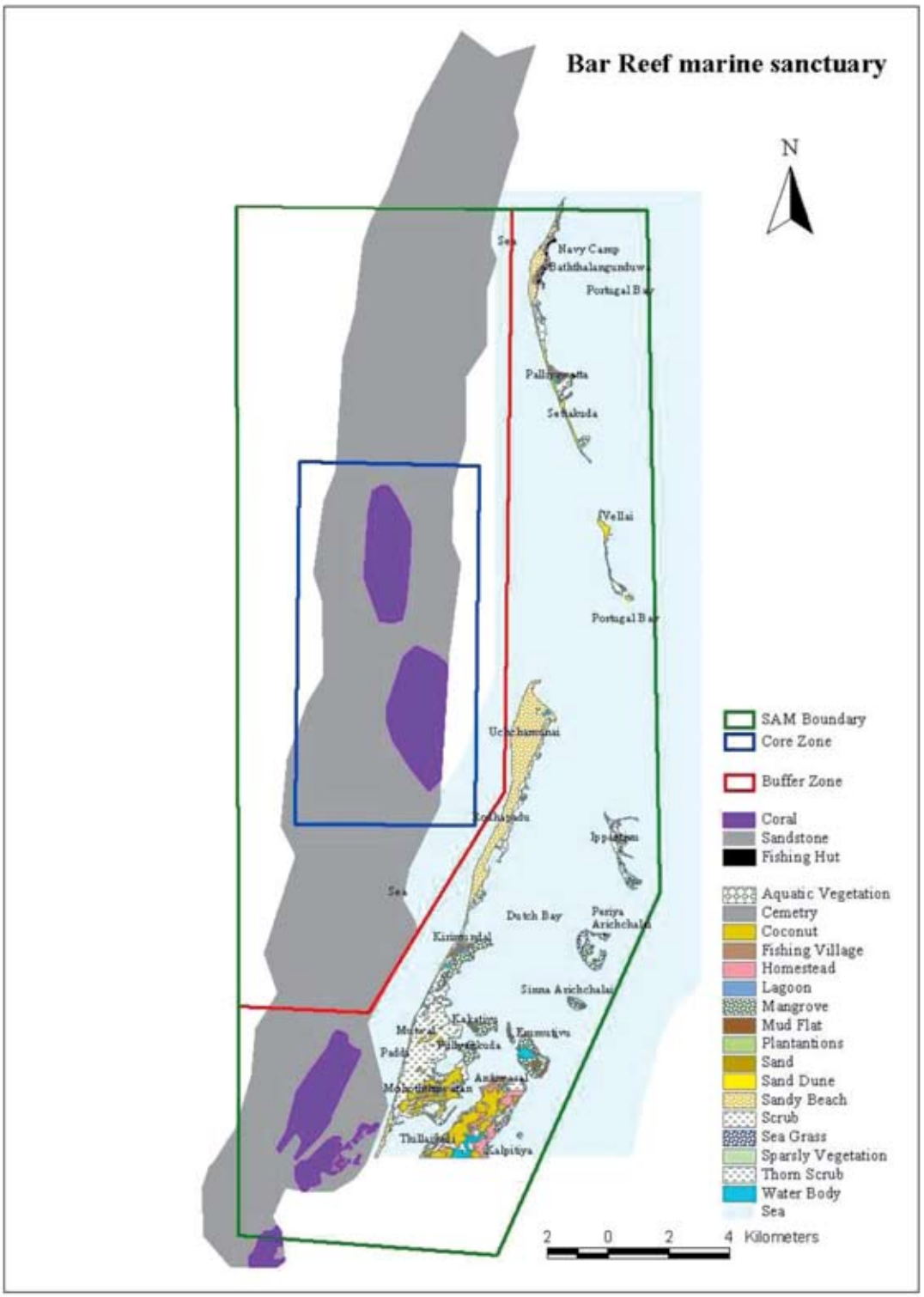
In 1998, coral bleaching severely affected the Bar Reef resulting in nearly 100% mortality of corals up to the depth of around 10 m. Corals beyond 10 m depth were also bleached, but most of them later recovered. Small colonies of branching *Pocillopora* and *Acropora* as well as tabulate *Acropora* were recorded 2002 (Rajasuriya et al., 2002). Coral cover in areas deeper than 7 m is approximately 14% with *Acropora, Montipora, Favites, Favia, Pavona, Cyphastrea, Hydnophora, Galaxea* and *Podabacia* being the most common types (Rajasuriya *et al.*, 2002*).* Coral cover increased form 0% in 1998 to 19% in 2003 and 41% in 2004. This recovery was largely due to growth by branching *Pocillopora damicornis* and tabular *Acropora cytherea* (Rajasuriya *et al.*, 2006).

The Bar Reef was declared part of a Special Management Area (SAM) composed of the northern part of the Kalpitiya peninsula and the islands in Portugal Bay; all areas where human activity impinges directly on the welfare of the reef ecosystem.

The threats to the habitats of the Bar Reef have been identified as over-exploitation of fish resources, unsuitable fishing methods (such as deep purse-seining, which damages coral and depletes fish resources) and pollution from human activities (shrimp farms and agriculture).

[47] Forming a whorl.

Figure 38. Coral distribution in the Puttalam Lagoon Area
(Source: Weragodatenna, 2010)



Ecosystem Services

The ecosystems of the Lagoon play a vital role in ensuring human well-being. They support livelihoods, protect inland communities from extreme weather conditions, regulate the local climate, prevent sedimentation and are culturally important to local communities. In Sri Lanka, these estuarine ecosystems play a major role in the local economy and domestic livelihoods of the surrounding communities.

A general summary of the ecosystem services provided by the ecosystems in the Lagoon area is presented below.

The Millennium Ecosystem Assessment
(Source Millennium Ecosystem Assessment, 2005)

At the turn of this century, the then secretary of the United Nations, Kofi Anan, called for a global assessment of the state of the Earth. One thousand three hundred and sixty scientists from 95 countries participated in this assessment that was carried out between 2001 and 2005. It focused on developing and presenting a framework that linked clearly all the services that ecosystems provided to human well-being.

Ecosystem services - as the benefits that ecosystems provide for human well-being are varied:

- Provisioning services that cover the natural resources and products – goods – obtained from ecosystems. Such goods include food, wood, medicines, fuel and fuel wood, fibre and non-timber forest products (NTFP). Ecosystems, therefore, provide, the basis for many industries: agriculture, livestock, fisheries, lumber, and pharmaceuticals, to name but a few. They also provide the basis for a multitude of livelihoods.
- Regulating services are the benefits obtained from the regulation of ecosystem processes, such as, for example, climate and flood regulation.
- Supporting services are ecosystem services that are necessary for the production of all other ecosystem services. For example, the production of biomass, balancing gases in the atmosphere, formation of soil, degradation of waste, nutrient and water cycling and pollination.
- Cultural services are non-material benefits people obtain from ecosystems through spiritual enrichment, development of learning, recreation and aesthetic experience.

All these ecosystem services are not only of direct value to humans, but they also offer indirect benefits by supporting and promoting the natural resource base upon which livelihood and economic activities are based.

The assessment examined relatively untouched ecosystems as well as intensively managed and highly modified systems. It examined how ecosystem well-being affects the services it provides and therefore, affects human well-being. This framework links clearly ecosystem well-being to human well-being, and shows explicitly that humans are integral parts of ecosystems. In its review, the Millennium Ecosystem Assessment also identified major anthropogenic threats to ecosystems or drivers of ecosystem change (Millennium Ecosystem Assessment, 2005)

Table 19. Summary of the ecosystem services provided by the ecosystems in the Lagoon area

(Source: Adapted from Miththapala, 2008)

Ecosystem	Services provided			
	Provisioning	**Supporting**	**Regulating**	**Cultural**
Tropical mixed evergreen forests	Timber, fuel wood, NTFPs.	Supporting coastal biodiversity, carbon sequestration, primary production.	Prevention of erosion, climate and flood regulation.	Tourism.
Tropical thorn forests	Timber, fuel wood, NTFPs.	Supporting coastal biodiversity, carbon sequestration.	Climate regulation.	Tourism.
Mangroves	Food, timber, fuel wood, medicines, NTFPs.	Supporting coastal biodiversity, carbon sequestration, primary production, enriching nutrients.	Protection of the shoreline, promotion of accretion, absorption of pollutants, flood regulation.	Tourism, supporting traditional fisheries.
Salt marshes		Supporting coastal biodiversity, absorption of pollutants, replenishing underground aquifers, carbon sequestration.	Flood and climate regulation, absorption of pollutants.	
Sand dunes	Sand and other minerals.	Supporting coastal biodiversity.	Stabilisation of the shoreline, flood protection.	Supporting traditional fisheries, recreation.
Mud flats	Food.	Supporting coastal biodiversity in particular migrant water birds, organic decomposition, nutrient cycling.	Protection of the shoreline, absorption of pollutants.	Supporting traditional fisheries.
Seagrass meadows	Food, aquaculture and aquarium trade.	Supporting coastal biodiversity, primary production, enriching nutrients in coastal waters.	Prevention of pollution, stabilisation of coastal sea beds, biological sentinels – indicating deterioration of the quality of water.	Supporting traditional fisheries.

Assessments carried out under the aegis of the BMZ project, ranked ecosystem services at 15 selected sites, and these rankings are presented in the table below.

Table 20. Ranked ecosystem services at 15 selected sites
(Source: IUCN 2008)

Ecosystem Services	Kandakuliya - Kudawa	Serakkuliya	Alaththakanniya	Palaviya	Thiladiya	Kuriningampitiya	MampuriyaSouth	Mampuriya North	Thirikkapallama	Pubudugama	Mullipuram	Soththupitiya	Eththale	Anakuttiya & Sewwanhiu	Gangewadiya
Provisioning															
Food	4	5	4	1	1	4	2	2	2	4	3	3	2	4	5
Water	2	3	3	1	2	3	1	2	1	2	4	2	2	2	3
Fiber	1	1	1	0	0	0	0	0	1	0	0	1	0	1	1
Fuel	2	2	4	1	4	3	1	1	2	2	2	1	4	4	2
Medicinal Plants	0	1	1	1	0	1	1	1	2	1	0	0	1	2	1
Sub Total	**9**	**12**	**13**	**4**	**7**	**11**	**5**	**6**	**8**	**9**	**9**	**7**	**9**	**13**	**12**
Regulatory															
Climate regulation	1	2	1	1	4	4	2	1	3	3	1	3	4	3	2
Erosion control	0	3	1	1	4	3	2	1	3	4	1	4	3	4	3
Water quality	3	3	1	1	3	3	2	2	3	2	2	3	3	4	3
Community Protection	0	2	2	2	3	4	2	1	3	2	1	4	4	4	3
Flood Control	0	3	1	3	4	4	3	1	4	4	2	2	4	4	3
Sub Total	**4**	**13**	**6**	**8**	**18**	**18**	**11**	**6**	**16**	**15**	**7**	**16**	**18**	**19**	**14**
Cultural															
Aesthetic value	3	4	1	3	1	2	1	1	4	3	2	1	3	2	5
Spiritual	2	3	1	2	1	2	1	1	3	3	1	3	1	2	3
Recreation/Tourism (current/potential)	3	4	1	3	1	2	1	1	4	3	2	1	2	2	5
Education and research (current/potential)	3	5	2	2	1	2	1	1	5	3	2	2	3	2	5
Sub Total	**11**	**16**	**5**	**10**	**4**	**8**	**4**	**4**	**16**	**12**	**7**	**7**	**9**	**8**	**18**
Supporting															
Primary production (photosynthesis)	2	4	2	3	3	4	2	1	3	4	2	2	4	4	4
Soil formation	1	3	0	2	3	3	1	1	3	3	1	1	3	4	4
Nutrient cycling	2	4	2	3	3	4	2	1	3	3	1	2	3	4	4
Fish Breeding	2	4	1	1	2	4	1	1	4	4	2	3	3	4	5
Biodiversity Protection	2	4	3	3	3	3	2	1	5	4	1	2	4	4	5
Sub Total	**9**	**19**	**8**	**12**	**14**	**18**	**8**	**5**	**18**	**18**	**7**	**10**	**17**	**20**	**22**
Grand Total	**33**	**60**	**32**	**34**	**43**	**55**	**28**	**21**	**58**	**54**	**30**	**40**	**53**	**60**	**66**

Scale

0 - No impact
1 - Very low
2 - Low
3 - Moderate
4 - High
5 - Very high

Protected areas in the Puttalam Lagoon area

There are 17 protected areas in and around the Lagoon.

Table 21. Protected areas in the Lagoon area

(Source: Ranasinghe, 2010)

Beat	Village	Name of the protected area
Attavilluwa	Tikali (Teli)	Welikandiya Conservation Forest
Attavilluwa	Tikali (Teli)	Nawalaoitikadu and Kalliyakuda Conservation Forest
Attavilluwa	Tikali (Teli)	Kalliyakuda Conservation Forest
Attavilluwa	Kalpitiya and Kuringipitti	Tattawelli Taravai Kany Conservation Forest
Attavilluwa	Tillaimotai	Thavalapittikadu Conservation Forest
Attavilluwa	Tillaimotai	Marikkarathora Conservation Forest
Attavilluwa	Tillaimotai	Thivu Conservation Forest
Attavilluwa	Tillaimotai	Tillamotaikani Conservation Forest
Attavilluwa	Karukkativu and Uslantivu	Karukkatiev Favave Kany and Yataravai Conservation Forest
Attavilluwa	Uslantivu	Yataravai Conservation Forest
Attavilluwa	Seguwantivu	Nagativu and Seguwantivu Kadu Conservation Forest
Attavilluwa	Seguwantivu	Seguwantivu Kadu, Uppukaravi and Kottaditivu Conservation Forest
Attavilluwa	Seguwantivu	Seguwantivu Kadu Conservation Forest
Attavilluwa	Seguwantivu	Kurusadi Conservation Forest
Attavilluwa	Manativu	Kurusadi Conservation Forest
Vanathavillu	Kelutodaikadu and Karaitivu	Kelutodaikadu Conservation Forest
Vanathavillu	Kelutodaikadu and Karaitivu	Periyakudakadu Conservation Forest

Flora

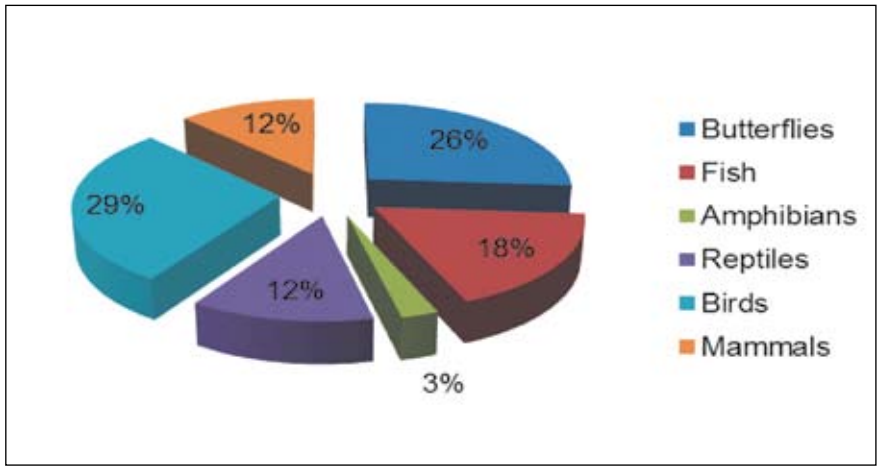
A total of 512 species of flora, including 406 native species, nine endemic, eight threatened species, 108 exotic and 13 invasive alien species were identified in the Puttalam Lagoon area.

Fauna

A total number of 308 faunal species belonging to 112 families have been recorded within the Lagoon and its adjacent habitats (IUCN, 2010). Proportionally, birds were the most abundant vertebrate group, while amphibians were the least abundant. Among the recorded species, seven species were restricted to the islands. The highest endemicity was found among reptiles (four species) followed by mammals (two species) and butterflies (one species). There were 16 nationally threatened species (six reptile, five mammal, four butterfly, and one bird species) among the recorded species (IUCN, 2010).

Figure 39 below shows the proportional representation of fauna in the Lagoon area. The highest species richness (i.e., the most number of species) was recorded among mangroves and associates (34 species) with the lowest species richness (three species) recorded in sand dune and mudflat habitats (IUCN 2010).

Figure 39. Proportional representation of fauna in Lagoon area
(Source IUCN 2010)



Butterflies

Among the terrestrial invertebrates, butterflies were the most well-studied faunal group. Eighty one butterfly species belonging to five families were recorded from the Lagoon area. These species represented 33% of Sri Lanka's butterfly fauna. Sri Lanka's largest butterfly, its national butterfly, the endemic Ceylon Birdwing (*Troides darsius)* was the only endemic species recorded during the survey. Four threatened species of butterflies were also recorded within the area, including the Critically Endangered Bright Babul Blue *(Azanus ubaldus)* (IUCN and MoNER, 2007*).* Because butterflies have a seasonal distribution, the total number may be higher than that recorded (Woodhouse 1950; D'Abrera 1998). A detailed long-term study is necessary to identify all the butterfly species in the area.

The highest species richness of butterflies (34 species) was recorded from mangroves and their associates; the lowest (three species), in sand dune and mudflat habitats. Mangroves contain several butterfly host plants – such as *Derris trifoliata, Cerbera mangus, Lumnitzera racemosa* – on which for caterpillars of butterflies such as Indian Sunbeam (*Curetis thetis*), Redspot (*Zesius chrysomallus*), Great Indian crow (*Euploea phaenareta*) feed.

Figure 40. The Critically Endangered Bright Babul Blue (*Azanus ubaldus*)
(Sam path Goonatilake © IUCN)

Fish

Aquatic habitats of Puttalam Lagoon area are occupied by marine and brackish water species of fish and shellfish, which are important resources for the people living in the area, as the main livelihood in the area is fishing (Pathirana, et al., 2008).

A total of 55 fish species were recorded from the Lagoon area (IUCN, 2010). Among them seven species are freshwater species that can tolerate brackish water conditions. Hence, they are found both in freshwater habitats and brackish water habitats. The Level Fin Eel (*Anguilla bicolor)* is a catadromous[48] species that normally inhabits fresh water habitats and spawns at sea. This fish is found in fresh water bodies in Kala Oya and Mi Oya and enters the Lagoon to migrate to the sea to breed. The shallow Lagoon, which has dense seagrass meadows is an ideal environment where incoming juvenile eels hide and protect themselves from predators. Therefore, the Lagoon plays a major role in sustaining Level Fin Eel populations within these two major river systems in the dry zone of Sri Lanka.

There are many finfish species in Puttalam Lagoon. The most commercially valued Lagoon fish are the sea bass (*Lates calcarifer),* and Etroplus (*Etroplus suratensis)*. In addition, Tarpon (*Megalops cyprinoides)*, Milk fish (*Chanos chanos)*, Lady fish (*Albula vulpes)*, Half beaks (*Hemiramphus* spp.*)*, Gar fish (*Belonidae)*, Pony fish (*Leognathidae)*, Silversides (*Athrerinidae)*, Cat fish (*Siluridae)* and Grey mullet *(Mugil cephalus*) are found in the Lagoon. According to the available data, there are more than 100 edible species of brackish water fish and shellfish species in the Lagoon, of which, 65% are migrants from the sea, 30% are

[48] Living in fresh water, but migrating to marine waters to breed.

confined exclusively to the Lagoon, and the balance, are migrants from fresh water sources. Shellfish include shrimps, crabs, gastropods and bivalves species (Dayaratne et al.,1997). Six species of crustaceans are commercially valuable: *Penaeus monodon, Penaeus indicus, Penaeus semisulcatus, Penaeus canaliculates, Metapenaeus monoceros,* and *Metapenaeus dobsoni.* Mud crabs (*Scylla serrata*) and Flower crabs (*Neptunus pelagicus*) are harvested as are two species of bivalves *Gafrarium tumidum* and *Marcia opima* (Fernando, 2010).

Tilapia (*Oreochromis mossambicus*) is distributed widely in the wetland habitats of the Lagoon area. This is an exotic freshwater species which was introduced to inland freshwater water bodies from southern Africa. It is listed as an invasive species in Sri Lanka (Bambaradeniya, 2001).

Moony (*Monodactylus kottelati)* is known only from Kalpitiya and the Lakshadweep Archipelago in India. This is similar to *Monodactylus argenteus* but differs in body depth. Both these species are found with the same habitats around sunken logs and branches. They are not known in local markets. However, juveniles are caught for the ornamental fish trade (Carpenter, and Niem, 2001).

In addition to finfish, several invertebrates and sea horses are also collected for export-oriented trade for ornamental and medical purposes (Dayaratne *et. al.,* 1997).

Figure 41. Indian Anchovy (*Stolephorus indicus)* harvested in the area
(© Sriyanie Miththapala)

Amphibians

The saline conditions of the Lagoon area do not support many amphibian species, which need fresh water to survive. A total of eight species (two toads and six frogs) representing three families were recorded within the Lagoon area (IUCN, 2010). No endemic or threatened amphibian species were found in the area.

Most of the species were abundant during the early rainy season, especially in the well-shaded canopy-covered areas. Several species were also associated with the home gardens dominated by coconut (*Cocos nucifera*) plantations. Among the eight species recorded, the Chunam tree Frog (*Polypedates maculatus)* is the only species of tree-dwelling frog recorded in the study. The most abundant species present in Puttalam Lagoon area are the Skipper Frog *(Euphlyctis cyanophlyctis)*, Six-toed Green Frog *(Euphlyctis hexadactylus)* and Common Paddy Field Frog *(Fejervarya limnocharis)* respectively.

Figure 42. Chunam Tree Frog (*Polypedatus maculatus*) found in the area
(Sampath Goonatilake © IUCN)

Reptiles

Three non-marine turtles, two marine turtles, three lizards, four geckos, five skinks, two monitor lizard species and 16 snake species, totalling 39 species, representing 18% of the reptile fauna of the Sri Lanka, were recorded in the Lagoon area (IUCN, 2010). Of the 39 species recorded, seven are nationally threatened and two species are endemic to the island. Green turtles (*Chelonia mydas)*; Olive Ridley sea turtles *(Lepidochelys olivacea)*; Hawksbill turtles (*Eretmochelys imbricata*); Indian Star tortoises (*Geochelone elegans)*; Wart snakes (*Acrochordus granulates)*; Dog-faced Watersnakes (*Cerberus rynchops)*; and Striped Flying snakes (*Chrysopelea taprobanica)* are Threatened species recorded (IUCN and MoNER, 2007). The Striped Flying snake *(Chrysopelea taprobanica)* and the Chequered Keelback (*Xenochrophis cf. piscator)* were the only endemic species recorded during the current survey.

The globally threatened Olive Ridley, Hawksbill turtle and Green Turtle use coastal stretches of Kalpitiya area and the surrounding islands as their nesting grounds (IUCN, 2010 and Ramanathan *et al*. 2010).

The most abundant reptile species in Puttalam Lagoon area are the Common House-gecko (*Hemidactylus frenatus),* the Common Garden Lizard *(Calotes versicolor),* the Fan-throated Lizard (*Sitana ponticeriana)* and the Hook-nosed Sea Snake (*Enhydrina schistosa)*.

The slaughter of freshwater terrapins, land tortoise and sea turtles has been widely reported around the Lagoon area and islands (Currey and Mathew, 1995). Although this slaughter is illegal, evidence of killing – abandoned carapaces – was found during IUCN's assessments. A large number of turtles also found tangled with fishing nets (Ramanathan et al., 2010). Because the practice is illegal, it is difficult to identify whether they are killed accidentally as by-catch, or killed deliberately for their flesh. According to Jayasekera (person. comm.) this practice is now decreasing as a result of vigilance by the Department of Wildlife Conservation and the Navy.

Figure 43. Blotched Ground Gecko *(Geckoella yakhuna)* found in the area
*(*Sampath Goonatilake © IUCN)

Birds

A total of 89 bird species in 31 families were recorded during the survey (IUCN, 2010). This included 69 breeding resident species, 19 migrant and one species whose status was unknown (Kotagama, and Ratnavira, 2010). The bird assemblage in the Lagoon area did not contain any endemic species, which is generally usual for arid coastal habitats. Instead, the assemblage is dominated by migrants and aquatic birds.

A single Nationally Threatened bird species namely, the White-naped Woodpecker *(Chrysocolaptes festivus)* is found in terrestrial habitats.

The highest species richness was recorded in the scrublands-grass mosaic (45 species) followed by mangrove-salt marsh (41 species), beach-mudflat (39 species), fish landing site-home garden (29 species), shrimp pond-saltern (24 species) and perennial plantations (17 species) (IUCN, 2010).

Of the migrant birds, the most abundant was the Lesser Sand Plover *(Charadrius mongolus)* which can be seen in flocks of 350-600 birds. Other wading birds were only recorded in small numbers (<50 birds). The highest species richness (25 species) of migratory birds can be observed at Kandakuliya sand bar, which connects the Dutch Bay and the Kalpitiya peninsula. A single Lesser Frigate bird *(Fregata ariel),* which is a vagrant species, was also recorded once during the BMZ study near Puttalam town.

About 30 islets that are located in the Lagoon area support large numbers of water birds. This area is crucial for migratory birds as it lies along one of the main western flyways used by migrant birds to enter Sri Lanka (Kotagama and Ratnavira, 2010). Winter visitors entering into the country through the western route of the central Asian flyway use the Puttalam Lagoon area as a stopover, where they rest and feed before they disperse into the other areas of the country. Some of these migrant birds move further southwards, while some remain in the area and use it as their major wintering ground (Dayaratne *et.al.* 1997).

In tropical thorn forests, White-browed Bulbuls *(Pycnonotus luteolus)*, Yellow-billed Babblers *(Turdoides affinis)*, and Common Mynas *(Acridotheres tristis)* are the most common and are abundant, while in mangrove habitats the bird assemblage was dominated by House Crows *(Corvus splendens)* and Common Tailorbirds *(Orthotomus sutorius)*.

The Seguwantivu mudflat of the Lagoon area has been declared one of the 111 Important Bird Areas of Sri Lanka (Kaluthota, 2003), because of its importance for bird life, especially migrant birds. Other, numerous, similar mudflats are found around the Lagoon and also support a large number of migrant birds.

Thus, the Lagoon area and its associated habitats are vital for maintaining diversity of avifauna not only at a local level, but also at a global scale.

Figure 44. Lesser Sand Plovers *(Charadrius mongolus)*
(© Gehan de Silva Wijeyeratne)

Mammals

A total of 35 mammal species, from 17 families were recorded from the study area (IUCN, 2010). Among them two are endemics – the Toque monkey (*Macaca sinica),* and the Mouse deer (*Moschiola meminna*) and five Nationally Threatened species. Indirect evidence suggests that three Nationally Threatened mammal species – the Eurasian Otter (*Lutra lutra*), Jungle cat *(Felis chaus)* and Fishing cat *(Prionailurus viverrinus)* are widespread in the undisturbed mangrove habitats of Puttalam Lagoon area.

Feral donkeys *(Equus asinus)* are the most common mammal in the area, especially in the Kalpitiya peninsula. These donkeys were introduced to the island many centuries ago, probably by Arab traders. They were later used extensively by gypsies in the northwestern part of Sri Lanka.

In general, there are fewer species of mammals in the dry coastal zone than in the wet zone. In addition, there are intense human activities in the area, which can negatively impact on wild mammal populations.

In the Bar Reef marine sanctuary Minke Whales (*Balaenoptera acutorostrata*), Blue Whales (*Balaenoptera musculus*), Sperm Whales (*Physeter macrocephalus*), Dwarf Sperm Whales (*Kogia sima*), Melon-headed Whales (*Peponocephala electra*), Spinner Dolphins (*Stenella longirostris*), Bottlenose dolphins (*Tursiops truncatus*) and Indo-Pacific Humpback dolphins (*Sousa chinensis*) have been recorded (Illangakoon, 2008). The northern and central parts of the Sanctuary can be termed as 'cetacean hotspots' because of the high species richness and year-round abundance (Illangakoon, 2008).

The globally threatened Dugong *(Dugong dugon),* which were common a few decades ago, are now rare (Rajasuriya *et al.* 1995). According to the fishing community, dugongs are still present in the Puttalam Lagoon area.

Figure 45. Spinner dolphins (*Stenella longirostris*) off the coast of Kalpitiya
(© Anouk Illangakoon)

Chapter 6: The Institutional Environment

(This whole chapter is extracted directly from IUCN 2010a)

Overview of existing policies and Laws for the conservation of the Puttalam Lagoon

Policy Context

Land resources

Currently, a national land use policy is in draft form. It draws from several already formulated strategies, listed as follows. The following list is extracted directly from FAO (1999):

- '*The National Agricultural, Food and Nutrition Strategy (1984) which reviewed the state of agriculture and food supply and prioritized future sectoral development.*
- *The National Conservation Strategy (1988) provided the objectives of conservation and outlined the strategic principles to be followed in conserving the land resources. It also proposed the rationalization of laws through the drafting of a single comprehensive Land Use, Soil and Water Conservation Act.*
- *The National Environmental Action Plan (1992), which identified the main environmental issues and different Government sectors with responsibilities for them.*
- *The National Policy Framework (1995) was prepared by the Ministry of Agriculture, Lands and Forestry. It proposed the development of a National Land Use Policy and of systematic methods and techniques of land use planning and a lessening of the haphazard allocation of state land'.*

The goal of the policy is to have '*rational utilization of land as a resource, in the national interest, while ensuring a high quality of life, equity and ecological sustainability'* (Ministry of Lands undated).

The policy has been formulated after key stakeholder consultations, and deals with three main areas:

- Land and people;
- Agriculture and food security and
- Land and nature (Survey Dept., 2007).

The policy will promote an integrated approach towards land management, and land use will be based on the principle of zoning, in turn, based on a land suitability evaluation. The legal framework will be reviewed and modified and there will be decentralised land management (Ministry of Lands, undated).

However, this is still not operational and there continues to be a pressing need for an acceptable basis for land allocation that will, at the same time, safeguard the environment.

The National Involuntary Settlement Policy of 2002 ensures:

- That negative impacts will be minimised and that resettled people will be adequately compensated to enable them to occupy new settlements with minimum hardship.

The National Watershed Management Policy of 2004 seeks to encourage:

- Environmentally-friendly land use practices in upper watersheds to minimise soil erosion and other environmental problems.

Forestry

The current National Forestry Policy dates back to 1995, and is part of the Forestry Sector Master Plan (FSMP) of 1995. It recognises the promotion of multiple-use forestry and that natural forests outside the protected area system should be used sustainably to provide for the growing demand for bio-energy, wood and non-wood forest products, and various services, especially for the benefit of the rural people, while ensuring that the environmental objectives are also met. It recommends reforms which include those aimed at empowering people and rural communities to manage and protect multiple-use forests, mainly for their own benefits, building partnerships in forestry development activities and developing and strengthening forestry institutions, both State and non-government.

Based on the above, the Policy recognises the enhancement of the contribution of forestry to the welfare of the rural population, and strengthening the national economy, with special attention being paid to equity in economic development.

However, significantly, 15 years after the FSMP, no legislative amendments have taken place to implement those components of the Policy and the FSMP, requiring greater participation in decision-making and management of the forest resource.

The policy acknowledges that the natural forests are heavily depleted and expresses concern for safeguarding the remaining natural forests for posterity in order to conserve biodiversity, soil and water resources. It emphasises the importance of retaining the present natural forest cover and increasing the island's overall tree cover. The institutional mandate for achieving these aims, however, is far from clear, especially given that the forestry sector has traditionally focused on serving as a producer of timber. The transition of the Forest Department into an agency primarily responsible for biodiversity conservation within its forest estate remains to be made, both in institutional and legal terms.

Wildlife

The National Wildlife Policy of 2000 renews the commitment of the government to conserve wildlife resources for the benefit of present and future generations, while assuring the sustainable use, education, recreation and research in a transparent and equitable manner. Several commitments made by the government in ratifying the Convention on Biological Diversity in 1994, such as benefit-sharing and use of genetic resources, however, remain to be addressed in the policy and legislative frameworks because of a lack of commitment to these principles, both among environmental advocacy agencies and the relevant policy-making agencies.

Sri Lanka is renowned for biological diversity, as it is rich in genetic, species and ecosystem diversity. However, recent decades have seen the proliferation of threats to species and habitats from human activities leading to high rates of extinction. A framework Biodiversity Conservation Action Plan (BCAP) was prepared in 1998 for the purpose of conservation of the country's species and genetic diversity, as well as the ecosystems of which they form part (this is presently being revised and updated).

Fisheries, Marine and Coastal Resources

There is no specific policy for fisheries. In the absence of a National Fisheries Policy, the Fisheries and Aquatic Resource Act of 1996 introduced several new measures for the protection of threatened aquatic species. It also recognised the need for involvement of the local communities in the management of fisheries resources.

A series of special area management plans prepared by the Coast Conservation Department attempted to address the key environmental issues affecting the coastal zone in an integrated manner. The issues include coastal erosion, sand mining, coral mining, pollution and destruction of natural habitats.

The Coastal 2000 Action Plan addresses coastal zone management more holistically by accounting for social and economic factors, while identifying measures to manage and conserve coastal resources for sustainable use.

Urban Planning and Solid Waste

The National Solid Waste Management Strategy was developed in 2000 to address the issue of solid waste. It focuses on waste reduction, re-use and recycling and provides for environmentally-sound minimum levels of residual waste. Local authorities are mandated to manage solid waste in their own areas of operation, but due to the lack of resources and expertise solid waste has become the most important environment problem, especially in the urban areas.

Legal context

The National Environment Act

The National Environmental Act (NEA) No. 47 of 1980 can be viewed as the primary legislation on environmental matters. The NEA makes provisions for the protection and management of the environment and for the establishment of a Central Environment Authority (CEA) to administer the provisions of the Act. It also provides for the establishment of district environmental agencies with government agents (District Secretaries) for the supervision and coordination of environment at district level. The NEA also provides the legal framework for the approval of new development projects and the preparation of environmental impact assessment reports. However, with the enactment of the North Western Province Environmental Statute, No 12 of 1990 NEA is inoperative within the North Western Province.

Land-related legislation

Crown Lands Ordinance

The Crown Lands Ordinance of 1947 provides for declaration of state lands as reservations for the protection of streams, reservoirs, foreshore and erosion of soil, and the preservation of water supplies.

Land Development Ordinance

Section 8(f) of the Land Development Ordinance of 1935 provides for the mapping out of state land for the prevention of soil erosion, for forest resources and for the preservation of catchments and other ecological purposes. It also provides for the formulation of regulations on the management of state lands over 5,000 foot elevation so that soil erosion is minimised.

The Land Development Ordinance provides for the systematic development and alienation of State land. The Land Commissioner and the other officers are appointed under this Ordinance. Alienation of State land under this Ordinance is commenced by the issuing of a permit and payment of the purchase fee. Upon completion of the permit conditions a grant is issued to the permit holder in respect of the holding.

Soil Conservation Act

The Soil Conservation Act No 25 of 1951 empowers the Minister to declare and acquire areas exposed to erosion and carry out measures to prevent such erosion. With the amendment in 1996, emphasis on land resource management has increased.

Land Reclamation and Development Corporation Act

The Sri Lanka Land Reclamation and Development Corporation Act No. 15 of 1968 (amended in 1976 and 1982) provides for the declaration of reclamation and development areas, which are defined as low-lying, marshy and swampy areas for building industrial, commercial or agricultural purposes. There are, however, no environmental considerations incorporated to this Act, which covers the activities of local and other authorities with whom the Land Reclamation and Development Corporation shares interests in declared areas. The Corporation is also responsible for the maintenance of canals in Colombo.

State Lands Ordinance of 1947

The State Lands Ordinance of 1947 (SLO) provides for the grant and disposition of State land, for the management and control of State land and of the foreshore and for the regulation of the use of the water of public lakes and public streams. The Land Commissioner administers this law. The Ordinance provides for the making of absolute or provisional grants of State land, for the sale, lease or other disposition of State land, for the issuing of permits for the occupation of State land and for the issuing of licenses to take or obtain any substance or thing found in State land.

Forests

The Forest Ordinance No 16 of 1907 was amended in 1966, 1979 and 1982 (further amendments are now being drafted). It provides for the prohibition of several activities in forest areas such as unlawful felling, clearing, encroachment, cutting and sowing.

The Forest Ordinance No. 16 of 1907 was enacted to consolidate the law relating to forests and the felling of trees for timber. The Forest Ordinance (FO) recognises three categories of forests, i.e., reserved forests, village forests and conservation forests. In addition, the FO also applies to forests not included within a reserved, village or conservation forest. The FO outlines the actions that are prohibited within reserved and conservation forests.

Wildlife

The Fauna and Flora Protection Ordinance No 2 of 1937 was amended in 1964, 1970, 1993 and 2009 to provide, essentially, for the protection of fauna and flora and includes the protection and conservation of the environment and its management. There are provisions under the Act for the declaration of national reserves and sanctuaries by the Minister in charge of wildlife. The Act provides protection of important flora and fauna. Commercial exploitation of protected species is prohibited.

Fisheries

Fisheries and Aquatic Resources Act

The Fisheries and Aquatic Resources Act No 2 of 1996 promotes measures for the integrated management, regulation, conservation and development of fisheries and aquatic resources.

National Aquatic Resources Research and Development Agency Act

The National Aquatic Resources Research and Development Agency act No. 54 of 1981 provides for the development, management and conservation of aquatic resources in inland waters, coastal wetlands and offshore areas.

Coastal Resources

Coast Conservation Act

The Coast Conservation Act No. 54 of 1981 and its 1988 amendment provide the legal foundation for coastal zone activities. The Coast Conservation Act No. 54 of 1981 is mandated to regulate and execute plans and programmes for coast conservation, regulate all development activities within the coastal zone, and call for environmental impact assessment for those development activities on the coastal environment.

Mines and Minerals Act

Under the Mines and Minerals Act No 33 of 1992, the Geological Survey and Mines Bureau (GSMB) was established and is charged with administering a licensing scheme for the mining, transport, processing and trade of minerals. GSMB also has powers under the Act to issue permits for within the defined coastal zone which has functional overlaps with CCD. However, GSMB is to obtain the prior consent of the Director General CCD before granting any permit in the coastal zone.

There are functional overlaps with this Act and the Coast Conservation Act.

Water

National Water Supply and Drainage Board Act

The National Water Supply and Drainage Board Act No. 12 of 1974 prohibits causing any pollution of water by disposing of rubbish, dirt etc. in any water source. The Board is also required to develop and operate an efficient pipe-borne water supply for public, domestic and industrial purposes.

Water Resources Board Act

The Water Resources Board Act No. 29 of 1964 has provisions to advise the Minister in charge of water resources on control of soil erosion, promotion of afforestation, prevention of pollution of rivers, and streams etc. The Board is also responsible for the management of ground water.

Tourism

Tourist Board Act

The Tourist Board Act No. 10 of 1966 gives powers to the Tourist Board to acquire and alienate lands for tourist development purposes. The act gives precedence in its provisions over other laws and authorises the Tourist Board to regulate activities including the building and running of tourist infrastructure. There are functional overlaps with the Coast Conservation Act.

Urban Development

Urban Development Authority Law

According to the Urban Development Authority Law No 41 0f 1978, the Urban Development Authority has jurisdiction over 1 km landwards from the mean high water line (Gazette 223/16, 17/12/1982) as an urban development area and the Urban Development Authority also has powers to engage in environmental improvement and development planning in areas coming under its purview.

This law overlaps with the Coast Conservation Act and its jurisdictions.

Devolution of powers

Sri Lanka is a democratic republic and is governed under a unitary system of Constitution. It inherited an administrative framework based on the British system of civil service (Oberst 1986).

13th amendment to the Constitution

In 1987, an Indo-Sri Lanka Peace Accord was signed, under which the Sri Lankan government agreed to devolve power to the provinces, the purpose being to concentrate resources and to allow for greater autonomy (Slater 1997 in litt. Varma et al., 2007).

At present, there are nine provinces within which there are 25 administrative districts. Below the level of district is the divisional secretariat division and below that, local government and village level administration (http://www.unescap.org/huset/lgstudy/country/srilanka/srilanka.html).

Under the 13th amendment to the Constitution, the centralised structure is modified by Provincial Councils that provides for a devolved political system. With devolution functions of government are allocated and shared between the Centre and the Provinces. Devolution introduces a multi-level (three-tiered) system of government with Local Government as the third tier. It transfers decision-making powers on service delivery to provincial and local levels.

The 13th amendment to the Constitution of 1987 has special relevance to power sharing between the central government and the provincial governments. Under these amendments, subjects and functions for central and provincial governments have been identified in three scheduled lists, (1) the Central Government list, (2) Provincial Government list and, (3) powers concurrent among Central and Provincial Governments.

The central government can set national policies on all subjects and functions, and has the power to approve legislation on the concurrent list of subject areas that have been listed as provincial subjects in the scheduled list.

Legislative powers have been given to Provincial Councils to enact legislation on devolved subjects and preclude the operating of existing laws pertaining to those subjects.

In the case of concurrent subjects, provincial legislation may only be made after consultation with parliament.

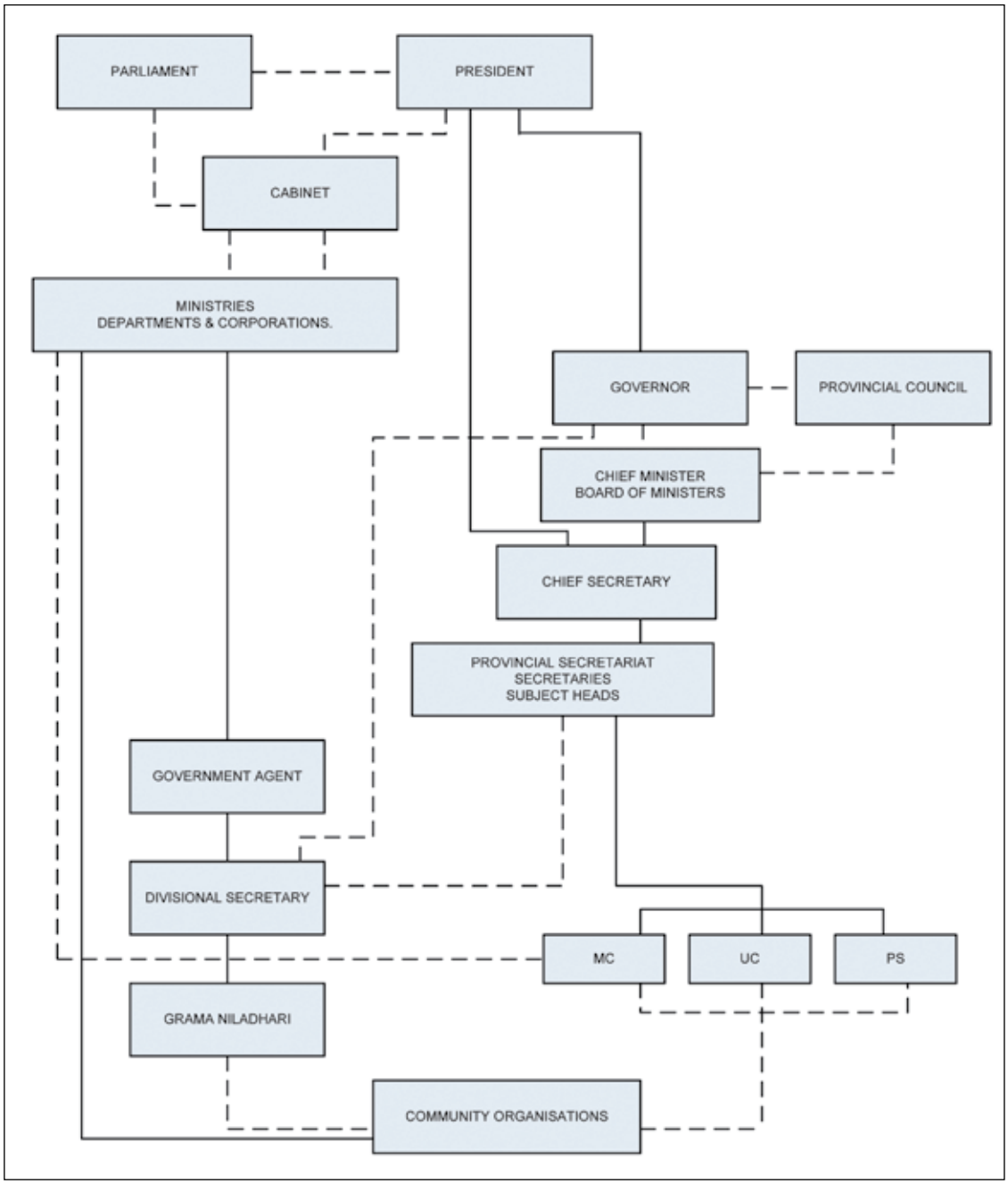
For example, Planning, Agriculture and Agrarian Services, Land (Land that is to say, rights in or over land, land tenure transfer and alienation of land, land use, land settlement and land improvement, to the extent set out in Appendix 2 of the 13th amendment) and protection of the environment within the province comes under the Provincial Council list.

North Western Provincial Environmental Statute

The North Western Provincial Environmental Statute (North Western Provincial Council Environmental Statute, No 12 of 1990) has been enacted and the North Western Provincial Council Environmental Authority was established to implement the provisions of the statute.

Therefore, the National Environmental Act is inactive in the province.

Figure 46. Structure of government administration
(Source: MoENR, 2007)



Overview of existing organisations responsible for the Puttalam Lagoon Area

(Source: IUCN 2010b)

Name of the organisation	Mandate and jurisdictions	Institutional capacities/ coordinating capacities	Financial incentives/ provisions	Comments and shortcomings
Department of Fisheries	Fisheries and Aquatic Resources Act no. 2 of 1996 (FARA) basically provides provisions for management, re-organisation, conservation and development of fish and aquatic resources. Under FARA, policy making and management of the fisheries sector including Exclusive Economic Zone (EEC) (517,000 km^2) 45 lagoons and estuaries in the coastal area (158,000 km^2) and reservoirs, tanks (155,000), seasonal water bodies (100,000) and inland tanks (255,000). The Department of Fisheries is an implementing arm of the FARA. The Department of Fisheries (FD) role is mainly on sector development. Vision: To provide an optimum contribution to the national economy through the sustainable management of fisheries sector using new technologies and within the national and international fisheries laws and regulations. Mission: Sustainable fisheries sector management within national and international laws and conventions, increase national and foreign investments, introduce new technology, and improve the quality and safety of exported fish. Functions of the Department of Fisheries: • Enforcement of the Fisheries Act and its regulations. • Licensing of fishing operations: bans on use of certain fishing methods and specifies what fishing operations require fishing licenses. • Registration of issuing licenses for local fishing boats: registration of local boats, ownership and changes, mortgage instruments. • Protection of fish and other aquatic resources: Prohibition against the use or possession of poisonous or explosive substances; prohibiting fishing gear and fishing methods; catching and possession of prohibited fishing, harvesting of prohibited species; prohibition or regulation of export and import of fish; declaring Fisheries Management Areas (FMA), fisheries committees (FC) and Fisheries Management Authority (FMA); declaration of Fisheries Reserves (FR). • Strengthening of cooperative societies and work for the welfare of fishing societies of the area: registering of fisheries cooperative societies, assistance to fisher folk. • Settlement of fishing disputes. • With regard to decentralisation of fisheries, the Provincial Secretary is to be consulted on matters affecting fishing operations within a province. • FMAs allow for participatory management by creating a fisheries management authority formed of the elected members from the registered fishers (fisheries committees).The Fisheries Management Authority under the FMA is a basically granted right for fisheries communities representing multi-stakeholder planning process and plays an advisory role (regulation of fishing methods, closed and open seasons, number of fishing gears etc.). • With regard to Lagoon, Fisheries Management Areas can include the adjacent terrestrial ecosystem (beyond the water surface area of the Lagoon) under Fisheries Management Areas (FMAs).	Puttalam and Chilaw Fisheries areas are covered under the District Fisheries Office under the Assistant Director of Fisheries. District level fisheries activities are coordinated through the District Fisheries Development Committee which is chaired by the District Secretary, Puttalam District covering Puttalam and Chilaw fisheries areas. The respective provincial and central state agencies in the above fisheries areas and the representatives of Fisheries Cooperative Societies participate at the meeting.	Financial resources are basically allocated by the treasury through the Ministry of Fisheries and Aquatic resources. Earnings in the sector: • Fees charged for boat registration. • Fisheries Reward Fund (FRF). • Imposition of cess (a local tax) on the import of fish or fish products (that can be returned to the industry). • Donor funded projects.	Issuing of fishing licenses is based on an administrative basis and not on fisheries management. No power to limit the number of fishing licenses, except for inland fisheries. The registering of fishing boats is mainly for administrative purposes, rather than from a fisheries management perspective. No adequate representation of the different type of fisher communities and their organisations in the District Fisheries Development Committees. Reasons for FMA, objectives and outcomes of FMA are unspecified. FMA can recommend fishing times, gear and area, but the decision-making process is not identified. Very specified use of Fisheries Committee only recognises the membership of fishers. Broadening of membership is required, including women members, to allow for other communities/stakeholders involvement in fisheries management. Relationship of Fisheries Committees (FC) and Fisheries Cooperative Societies in existence is not clear under the FMA. Attention needs to be given to make linkages in the FMA. Lack of convergence and coordination in operating Fisheries Cooperative Societies: Fisheries Cooperative Societies are registered under the Cooperative Department and societies are directly working with Department of Fisheries. This causes delays in registering of fisheries societies and they have become more disorganised.

National Aquaculture Development Authority (NAQDA)	This was established by the National Aquaculture Development Authority Act no 53 of 1998. Accordingly its mandate is to develop inland aquatic resources and aquaculture to increase fish production, employment and foreign exchange. Vision: While improving, the people's well-being, develop inland and aquaculture fisheries for increasing its contribution to the GDP. Mission: Increase employment through aquaculture. Increase aquaculture production, promote foreign exchange through high value aquaculture fish, incentives for small and medium scale aquaculture; facilitate marketing and conservation of biodiversity. Objectives: • To manage, regulate, conserve, and develop fisheries activities in a sustainable manner in conformity with national and international laws and conventions. • To promote local and foreign investment in the fishing sector. • To introduce new technologies for the exploitation of fishery resources in national and international waters. • To uplift the socio-economic status of fishing communities. • To ensure quality and safety of fish and fishery product exports in conformity with international standards. • To minimise post-harvest losses and improve the quality of local fish products. Its functions are mainly for production; breeding of aquaculture fish, the introduction of aquaculture techniques/methods, promotion of ornamental fish, issuing of permits for aquaculture (According to the amendment to the FARA-2006, no 22) and National Aquaculture Development Authority Act -2006 no 23.			It has been estimated that at present there are about 1,434 shrimp farms with a total area of 4,539 ha in the region of which more than 90% are around the Puttalam Lagoon Area. Farm Category numbers Farms under 2 ha: 1,099 Farms over 2 ha: 335 Authorised farms: 530 Unauthorised farms: 904 Aquaculture is largely productivity-oriented and ecosystem principles are seldom considered when planning the introduction of aquaculture. For example, in the licensing for aquaculture, allocation of state lands is decided through the land use planning committee; however, private lands are not subjected to this process. The ownership status of state lands allocated to entrepreneurs under license under licence is unclear and there are abandoned unproductive shrimp farms that could be rehabilitated.
National Aquatic Resources Research and Development Agency (NARA)	Established by the National Aquaculture Resource Research and Development Act no 54 of 1981. Its mandate is to undertake research and research application on all living and non-living aquatic resources for the development and management of the fisheries and oceanic resource sector. Vision: Be an excellent resource centre for aquatic resource research, development, management and conservation in the South Asia Region. Mission: Research and service provision for sustainable use of aquatic resources. The Agency shall have power – • To conduct and render research and technical services; • To advise and make recommendations to any ministry; any Government department, or branch thereof, or any public corporation or any other person, on research, management, development and regulations, including the conservation and utilisation of the aquatic resources of Sri Lanka, and, the formulation of national policies relating to the management and development of the national aquatic resources of Sri Lanka; • To institute and conduct surveys of national aquatic resources and off shore areas of Sri Lanka; • To take all measures as may be necessary for the fulfilment and performance of its objects and functions. This is the principle national agency charged with the responsibility of carrying out and coordinating research, development and management activities on the subject of aquatic resources.	Regional Research Centre (one out of four) is established in Kalpitiya. Technical staff comprise of two research officers, one lab attendant and seven non-technical employees attached to the research centre. NARA is a member of the District Fisheries Society held under the District Secretary. Once in two months they participate at the meeting and brief the DFS on NARA activities.	Treasury allocations, donor funded projects, fees for technical services.	Lack of convergence and coordination between other agencies relevant to Puttalam Lagoon management. Missing links between the input of research findings and management approaches as an output. Lack of resources and inadequate staff .

	National aquatic resources include all living and non-living resources contained in or found beneath the medium of water and which are subject to the sovereignty, jurisdiction or control of Sri Lanka. With regard to coastal resources these include coastal wetlands, such as salt water, coastal fresh waters, mashes and mud flats including estuaries, lagoons and mangrove swamps. Currently provide technical services to promote (a) sea weed culture, (b) crab fattening, (c) ornamental fish, (d) mangrove planting, (e) shrimp culture, and, (f) cage culture. Research includes oceanography (marine and lagoon) studies, breeding of species such as red shrimp, sea bass, sea cucumbers (recommended for a ban on the catch based on research conducted by NARA).			
Coast Conservation and Coastal Resource Management Department	Coast Conservation Act no. 57 of 1981 (CCA) recognised the Coast Conservation Department (CCD) as the primary government agency responsible for management of Coastal Zone. Mission: Sustainable development of coastal zones through coastal zone management for the improvement of environmental quality and social security. Objectives: • Improve coastal environment quality. • Develop and manage the coast line. • Improve the standard of living of the coastal communities and communities dependent on coastal resources. • Promote sustainable development based on coastal resources. CCD is mandated to regulate development activities and planning and implementation of activities for coast conservation. Its functions include: • Coastal zone management planning (Preparation of Integrated Coastal Zone Management Plan-Special Area Management Plan); • Implementation of coastal conservation activities (protective structures, coastal parks etc.); • Regulation and control of development activities in the coastal zone (issuing of permits for development activities, removal of un-authorised buildings/ structures, sand mining etc. as provisions in the CCA); • Environmental Impact Assessment of development projects; • Coastal engineering research and surveys; • Research and monitoring; and, • Coastal information data base. CCD's jurisdiction over the coastal zone is defined by CCA as the area within 300 m landward of the mean high water line, and up to 2 km seawards. Where another water body is permanently or seasonally connected to the sea, the land ward limit is extended to 2 km to include the waters of such bodies as measured perpendicular to the straight baseline drawn between the natural entrance points.	No CCD office has been established or staff assigned to cover the Puttalam Lagoon area. In the absence of a CCD office, the powers have been delegated to the respective District Secretary as per CCA provisions.	Treasury allocations to the Coast Conservation Department. Various projects. (For example, Coastal Resource Management Project implemented in Kalpitiya coastal region).	Only a part of the Puttalam Lagoon water body is covered under the jurisdiction of the CCD Act. While the special area management plan for Kalpitiya has been prepared, its implementation has been constrained by a lack of resources (funding plus human resources). No stakeholder ownership for plan implementation. No CCD office or officers in the area and their functions are delegated to Divisional Secretary, which is one of the reasons for not implementing the prepared plans.

Department of Wildlife Conservation	The Department of Wildlife Conservation comes under the Ministry of Environment established in 1990. The Department of Wildlife Conservation is mandated with managing the protected areas established in terms of the Fauna and Flora Protection Ordinance of 1937 (FFPO) and species protection. The changing role of the Department of Wildlife Conservation is reflected in the amendments to the long title of the ordinance from protection of fauna and flora to protection, conservation and preservation of fauna and flora and prevention of commercial exploitation in 1993. Vision: Ensure wildlife conservation in Sri Lanka for future and current generations through participation, management, and sustainable use. Mission: Conservation of biodiversity and protection of wild life resources by education, researches, participation of people and by laws to environmental development for prosperity of the future generation. Kalpitiya Bar Reef is under the jurisdiction of the Department of Wildlife Conservation (~307 km^2)	Karuwalagaswewa beat office oversees the area. The Wildlife Department has established a coordinating committee called '*Gaga Mathura*' to coordinate activities relating to human-elephant conflict. Wildlife officers attached to the beat office participate at other coordinating meetings conducted by the District Secretariat.	Source: Treasury allocations through the Department of Wildlife Conservation – national agency. No project implemented in Puttalam Lagoon periphery in past few years.	More involvement of the Wildlife Department in Lagoon conservation is needed to ensure species protection.
Department of Forests	The Forest Department comes under the Ministry of Environment which was established in 1990 and its mission is to provide 'leadership to manage the environment and natural resources in order to ensure national commitment for sustainable development for the benefit of the present and future generations.' Its vision is 'a healthy and pleasant environment, sustaining nature for the well-being of the people and the economy.' The main responsibility of the Forest Department is the management of forest areas declared in terms of the Forest Ordinance and also the regulation of activities within State land in general. Main functions: • Enforcement of the Forest Ordinance and its regulations. • Planning and implementation of mangrove re-planting programs. • Issuing permits for timber transport. • Controlling encroachments to mangrove reserves. • Demarcation of boundaries of Forest Reserves. • The Forest Department has jurisdiction over Forest Ordinance has declared three categories of forests, i) reserved forests, ii) village forests and iii) conservation forests. According to FO the FD has jurisdiction over forests on state land not declared as reserved, conservation or village forests, although the explicit legal provisions in the ordinance are not clear (needs verification). As per the legal gaps, the Ministerial circular no 05/2001 (Ministry of Forestry and Environment) has given directions to manage forests in other state lands by the Forest Department and decisions to grant permission for allocating state forest land for development purpose lies with the inter-ministerial committee chaired by the Secretary, Ministry of Forestry and Environment. The Forest Department's relevance from a coastal zone management standpoint stems from the inclusion of mangroves in the definition of forests, whereby any coastal activity involving mangrove areas requires this department. Watershed management is another powerful reason for links with the Forest Department for coastal zone management, where coastal wetlands are fed by fresh water flows from beyond the coastal zone.	FD activities are implemented through the Puttalam District Forest Office, under the District Forest Officer, the Assistant District Forest Officer and the Forest officer. It is further divided to ranges (Puttalam, Chilaw and Anamaduwa) - Puttalam range, is further divided into beats. Puttalam, Palavi and Vanathavillu are the relevant beats which cover the Lagoon area.	Finances are mainly from Treasury allocations through the Forest Department -national agency. Natural Resource Management Project funded by AusAid implemented in Puttalam from 2006-2009. Forestry Resource Management project was implemented in the area from 2002-2009.	Ownership/title of land in the coastal area is unclear. No clear information on land under the LRC. The lack of marked boundaries has constrained enforcement by the FD and resulted in encroachment into forest areas.

	Main functions in Puttalam Lagoon: • Management and conservation of mangrove forests surrounding the Lagoon. • Enforcement of law (FO) against illegal activities. • Initiate participatory forestry programs. • Demarcation of the boundaries of mangrove forests. Under Land acquisition Act No 7 of 1979 and the amendment Act No. 29 of 1983, the FD has provisions to acquire illegally occupied state land.			
Department of Archaeology	Archaeological Act of 1940 and amendment Act no. 24 of 1998 and 2000. The Department of Archaeology's mandate is basically to: • Undertake surveys; • Excavation of archaeological sites; • Preservation of antiquities; • Maintenance of archaeological sites; • Awareness and education; • Museum services; and, • Undertake Archaeological Impact Assessment (AIA). The Department of Archaeology has jurisdiction over 15 miles from the coastal line. According to section 43 (amendment) of the Archaeological act, any proposed development activity covering more than 2.5 ha of land in an archaeological area (identified archeologically important areas) should be subjected to an archaeological impact assessment. The total expenditure for the assessment will be charged to the project proponent.	Puttalam Sub regional office under the Regional Office at Panduwasnuwara, functions as the focal point for all Divisional Secretariats of the District. Powers of the Director General, Archaeology are devolved to the District Secretary under the amendment to the Archaeological Act of 1998.		Very powerful laws and tools to address resource management issues are rarely applied when addressing management issues.
District Land Use Planning Office	District Land Use Planning Offices are established in each District attached to the District Secretariat and operated under the Director, Land Use Policy Planning Division of the Ministry of Land and Land development. Its mandate as given in the Land Use Policy of Sri Lanka is: Rational use of land as a resource for national benefit ensuring high standards of living of the people, equity and environmental sustainability. Principles: • State being the custodian (trustee) to utilize land on behalf of people for the benefit of present and future generations; • Land use based on zoning principles; • Use of land only based on its physical suitability; • Regulate the land use and management for balanced regional development; and, • All agencies relevant to land and land use take an integrated approach. The main functions include: • Surveying and preparing District Land Use Planning; • Hold land use planning committee meeting and provide land use reports for planning and land allocation for development purposes. • No clear jurisdiction given under any Act. Draft land use Act is in preparation. • Puttalam Land Use Policy Planning Division is attached to the District Secretariat covering 16 Divisional secretariats.	Puttalam District Land Use Policy Planning Division has a total 10 staff including one Land Use Policy Planning Officer, and nine Land Use Planning assistants (for land use planning) and one planning officer (mapping).	Financial resources are allocated to the District Land Use office from the respective Ministry: treasury allocations	The Land Use Planning Committee is one of the best institutional arms for addressing natural resource management issues in the area. However there are no legal provisions or regulations on land use. No representation of civil society organisations/ communities at this committee. Lack of adequate technical capacities and resources at the District Land Use Policy Planning Division. Land use planning committee and land use planning office capacities need to be strengthened.

District Secretariat, Puttalam	District Secretariat Legislative powers given to Divisional Secretary under the legislations, Forest Ordinance, National Environmental Act , NWP Environment statute, Fisheries and Coast conservation Acts and amendments Provincial Councils. Land commissioner powers given to the Divisional Secretary - Basically coordination function at Divisional level and public welfare services. Registering and coordination of CBOs and NGOs. Other central Government legislations. With regard to resource management, Divisional secretary has powers to Issue permits for state lands. Certain powers given under other Laws concerning environmental management. For resource management, the District Secretary has more coordination functions through various coordination committees. Puttalam District Secretariat has under its powers the three Divisional Secretariats of Vanathavillu, Mundel and Kalpitiya.	There are various coordinating committees to coordinate activities among stakeholders namely: District coordinating Committee (development); District environment committee; District land use planning committee; District planning committee; District agricultural committee; and, NGO coordinating Committee.	Financial resources are provided by Treasury allocations through sector agencies, Provincial Councils and decentralised budget.	District Secretariat is the focal point for coordinating all the functions of the different agencies and stakeholders with regard to Lagoon management.
Divisional Secretariat	Basically it factions as the sub national office to implement national agency programs. Legislative powers are given to the Divisional Secretary under the legislations: Forest Ordinance; • National Environmental Act; • NWP Environment statute; • Fisheries and Coast conservation Acts and amendments; Other central Government legislations: CCD Act, Mines Minerals Act Land commissioner powers given to the Divisional Secretary Functions: • Management of crown land including mangrove areas. • Allocation of crown land to development – industries etc. • Control of illegal activities within the *Grama Niladhari* Divisions. • Attend to livelihood initiatives under the *Samurdhi* programme. • Coordination of development and conservation activities with stakeholders. • Registering of CBOs and NGOs. With regard to Lagoon resource management, Divisional Secretaries play a role in coordination with stakeholders at local level and support enforcement of regulations. Puttalam, Vanathavillu, Mundel Divisional Secretariats are the relevant Divisional Secretariats for Puttalam Lagoon conservation.	There are various coordinating committees to coordinate activities among stakeholders for example - For example, Divisional environment committee Divisional agriculture committee	Financial resources are provided by Treasury allocations through line ministries/agencies, Provincial Councils and decentralized budgets (For example Vanathavillu DS financial sources: financial allocations from 2006-200,, PC Rs. 12.8 Million, DCB Rs. 3.9 Million, *Samurdhi* 14 million, line Ministries).	Divisional Secretariat is the agency getting the government services ultimately to the people. There are legislative powers for conservation regulations under various legislations. Puttalam, Vanathavillu, Kalpitiya, Mundel are the relevant Divisional Secretariats for Puttalam Lagoon management.
Provincial Ministry of Fisheries	Provincial Fisheries Authorities have the powers to instigate fisheries management.			

Regional Resource Development Authority (RRDA) (under the Provincial Ministry of Fisheries)	Regional Resource Development Authority (RRDA) is operated under the provincial Ministry of Fisheries and has provisions for decentralisation under the 13th amendment to the constitution. Fisheries is a concurrent subject where powers are concurrent among the central and provincial governments. Therefore, the Regional Resource Development Authority plays a role in providing technical support – basically services for sector development - for the fisheries sector in the province. North Western Provincial Council has been set up RRDA to provide technical support for fisheries in the province. Technical support includes: aquaculture development, production of fishing crafts, and provision of related services.		Financial resources are allocated through the Provincial Council (Finance Commission), revenues from service provision.	
North Western Provincial Environmental Authority	Powers given to the North Western Provincial Environmental Authority under the North Western Provincial council Environmental Statute, No 12 of 1990. Authority established for the enforcement of the provisions of the North Western Province Environmental Statue. Accordingly the functions are: (a) Environment conservation, management and promotion. • CEA Act is inactive in the province and has been replaced by the Provincial Environmental statute; • EIA and EPL process is undertaken to minimise environment impacts due to development; • EPL process is delegated to local authorities and the process is under the directions of the North Western Provincial Environmental Authority (NWPEA); • EIA process is directly under control of the NWPEA; and, • Provincial specific EPL, EIA regulations and industrial standards are gazetted.	Technical Coordinating Committee established in order to consult on technical matters and the EIA Coordinating Committee was established for EIA processes.	Provincial council allocations for staff salaries and capital expenditures. Operating expenses are basically born with the revenue to the authority through the EPL, and EIA processes.	Shifted the role of Divisional Secretariat on implementation of CEA Act. The environmental regulation has been delegated to local authorities under the provincial statute. Lack of clarity on the roles and responsibilities of the North Western provincial environmental authority among other organizations. Local authority capacities are inadequate and need to be strengthened to implement the Provincial environmental statute regulations.
Urban Development Authority, Chilaw Office	Urban Development Authority (UDA) Act No. 41 of 1978 amended in 1984 and 1988. Designates all areas within 1 km of the coastline as 'Urban areas' subject to the planning and regulatory requirements of the Act. All building construction within the coastal area requires a permit from the UDA or *Pradeshiya Sabha*.	The regional office is established in Chilaw and Deputy Director is attached to oversee delegated functions to local authorities. Powers delegated to Municipal Councils, *Pradeshiya Sabhas*.		There are jurisdictional overlaps with the CCD, and the Tourist Board for coastal zones which require improved coordination.

Urban/ Municipal Council	According to Municipal council Ordinance no 61 of 1939, powers given to Urban councils: • Provide trade license; • Provision of Infrastructure within the urban council area; • Provision of solid waste management services; According to UDA Law the functions below are delegated to Urban Councils: • Implementation of Urban development Plan (prepared by UDA); • Building certificates; and, • Approving of building plans; • North Western Provincial Council Environmental Statute, No 12 of 1990 • Environmental Protection License (EPL) • Health department functions are delegated to Urban councils and *Pradeshiya Sabhas* through the Public Health officer and functions are as provisions in: Public nuisance Ordinance No. 15 of 1862 and subsequent amendments (in 1939, 1946); • Food Act No. 26 of 1980 and amendments (No. 20 of 1991.); • Slaughter house Act no 9 of 1894 and amendments; and, • Prevention of spread of Mosquito law – 2008. • Puttalam Urban Council Areas Urban l councils basically provide public infra-structure services and are authorised to acquire lands for public purposes within their jurisdictions. Urban councils have very important functions with regard to environmental health as responsibilities assigned to the Public Health Officer.	Puttalam Urban council has 10 elected members including a Chairperson, Administrative staff (26), PHIs (3), Technical Officer (I), Labourers (101). The coordinating committees are chaired by the Chairperson and respective officers are: (1) Building planning committee – the Assistant Director, UDA (2) Technical committee-Technical Officer (3) Health Committee-PHI (4) Environmental Committee-Environment officer With the council members (elected members) Environmental Officer for each Urban Council is attached under the provincial administration.	Revenue allocated for capital investment - Finance Commission through Provincial Council (Rs. 6,650,000) Provincial Ministry allocations for staff. Charges for services and permits and taxes. For example, Puttalam UDA: salary (Rs. 22,708,627), tax revenue (Rs. 20, 895,197), Donations for composting project started in year 2009 (Holcim with the help of IUCN (Rs. 8 million), Central Environmental Authority (Rs. 1.8 million).	There are legal powers which can be effectively used in natural resource management on areas (a) Land use regulation, (b) Environmental health, (c) Public nuisance and (d) Environmental conservation and management, regulation of industrial pollution etc. Capacities are under-utilised with regard to natural resource management. Lack of awareness and knowledge on the roles and responsibilities of the organisations and the processes of natural resource management.
Pradeshiya Sabha	Provisions under the *Pradeshiya Sabha* act, no 15, 1987, basically provide utilities services, and infra-structure such as roads. Under the same Act, *Pradeshiya Sabha* can act on public nuisance. Implement Provincial Council decisions and policies. Implement *Pradeshiya Sabh*a Council decisions. Implementation of regulatory activities under the direction of North Western Provincial Council Environmental Authority as directed by the Environmental Statute No 12 of 1990. Powers similar to urban and Municipal councils with regard to administering of non-urban areas.	The Environmental Officer attached to the *Pradeshiya Sabha*, is directly responsible to the Provincial Council and North Western Provincial Environmental Authority.		Vanathavillu, Puttalam and Kalpitiya *Pradeshiya Sabhas* are the three *Pradeshiya Sabhas* with jurisdiction within the Lagoon and its impact area for resource management. Capacities are under-utilised (For example Environmental officers) with regard to natural resource management. Lack of awareness and knowledge on the roles and responsibilities of the organisations and the processes of natural resource management.
Police	Police has powers under the following legislations: • Under Criminal Law of 1979 NO 15, section IX; • Under public nuisance Ordinance to prevent public nuisance; • Provisions under Police Act, 56 section; • Police circular no. 1155/94 and 1196/95 with regard to enforce the National Environment Act; • Provisions under other acts Ex. CCD Act, the police has powers to enforce regulations - sand mining, Under Forest ordinance.	Vanathavillu, Kalpitiya, Puttalam.		

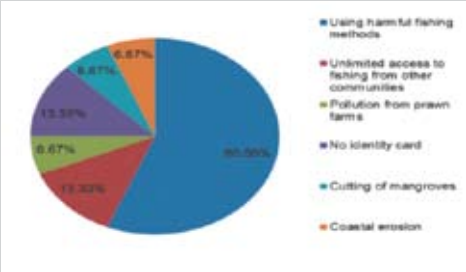
SRI Lanka Navy	Sri Lanka Navy in patrolling the sea belonging to Sri Lanka in the Puttalam Lagoon as per regulations imposed to restrict unnecessary movements in sea and the Lagoon through permits issued to fishing communities as the area is considered of importance to state security considering previous terrorist activities. Fishing boats are registered and permits are issued to the members of the fisheries cooperative society. The Navy monitors the movements in the Lagoon and the sea and, only the fishing vessels and fishing communities with permits are allowed for lagoon and sea fishing.			The regulation is purely on the basis of state protection. The Sri Lanka Navy can be more effectively utilised in resource conservation.
Fisheries cooperative societies	As per Provincial Council Gazette notification 1304 iv (a), all the fisheries societies must be registered as cooperative societies under the Cooperative Act No 32 of 1983 and the amended Act No 11of 1992 and Cooperative Society Act No 05 of 1972. Only fisheries societies registered under the above are eligible for any Government benefits for fishing communities (by the Department of Fisheries). Cooperative Department plays an important role in operating the Fisheries Cooperative Societies (registration, auditing etc.). Fishing community perception on priority issues needing intervention: 	There are 20 registered fisheries cooperative societies in the Lagoon area. Six societies have applied/intention to apply for registration.	Membership fees collected: Are used mainly for Fishing community welfare. No resources for conservation.	Lack opportunities to participate in decision making. Relationship with related state agencies is confined to access to the agency services. The limited use of consultative approaches and consensus with communities, has constrained their participation in law enforcement (illegal fishing, no limitations on access to fishing and unauthorised fishing etc.) and has aggravated the pressure on the Lagoon (extended to conflicts among community groups on access to the lagoon fishery). Networking and empowering of 26 fisheries cooperative societies is a key to lagoon resource management.
Local NGOs	With various objectives and missions.			
Private sector	Private industries dependent on lagoon resources. The main industries are: • Salt companies; • Shrimp farms: 1995, the area under shrimp farms was 2,000 ha and after 1995, it increased to 4,539 ha. • Minerals and sand: for example, Holcim to produce cement , and sand mining. • Tourism industries. • Small industries: small scale salt pans, ice plants			

Figure 47. Institutional Mapping of a lagoon management system in Puttalam Lagoon Area
(Source: IUCN, 2010b)

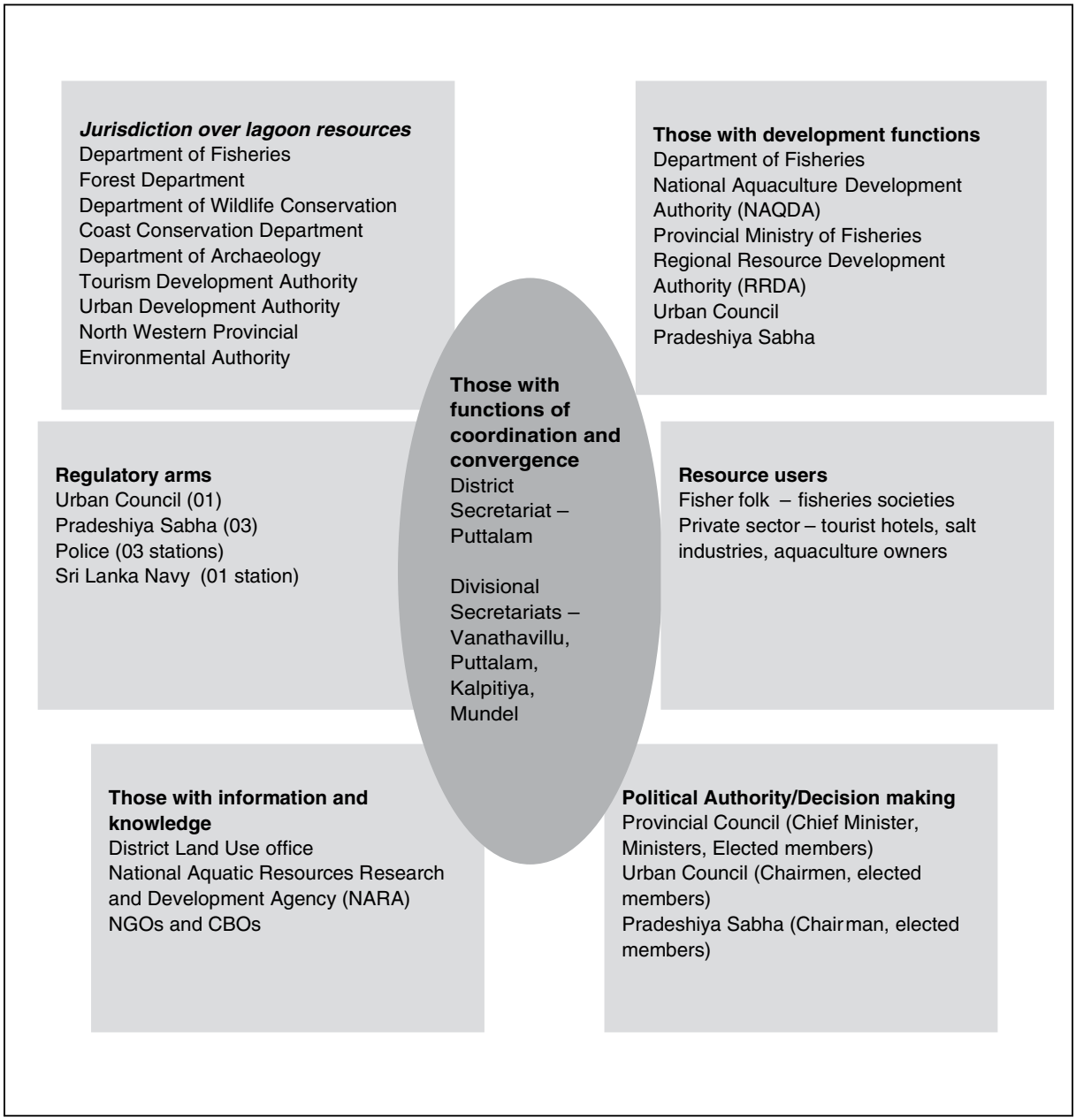


Figure 48. Stakeholder influence and importance (+ and -) for natural resource conservation
(Source: IUCN, 2010b)

More influence less impact Department of Fisheries (+ or -) Forest Department (+) Department of Wildlife Conservation (+) Coast Conservation Department (+) Department of Archaeology (+) Urban Development Authority (+) North Western Provincial Environmental Authority (+) District Secretariat-Puttalam (+) Divisional Secretariats - Vanathavillu, Puttalam, Kalpitiya, Mundel (+)	**More influence more impact** Tourist Board (+ or -) Urban Council (01) (+ or -) Pradeshiya Sabha (03) (+ or -) Police (03 stations) (+) Sri Lanka Navy (01 station) (+) Provincial Council (Chief Minister, Ministers, Elected members) (+ or -) Urban Council (Chair-person, elected members) (+ or -) Pradeshiya Sabha (Chair-person, elected members) (+ or -) Private sector -Tourist hotels, salt industries, aquaculture owners (-)
Less influence more impact District Land Use office (+) National Aquatic Resources Research and Development Agency (NARA) (+) NGOs and CBOs (+) National Aquaculture Development Authority (NAQDA) (+ or -) Provincial Ministry of Fisheries (+ or -) Regional Resource Development Authority (RRDA) (+ or -) Fisher folk- fisheries societies (-)	**Less influence less impact** Fisher folk (+) Nonfishing local community (+ or -)

Chapter 7: Fisheries

With a surface area/ water area of 32,700 ha, and famous for good quality fish, the Puttalam Lagoon harbours marine, brackish and freshwater species, and is considered one of the most productive 'basin estuaries' in Sri Lanka (Dayaratne et al., 1997). There are about 165,000 people directly or indirectly dependent on the Puttalam Lagoon, including nearly 15,000 active fishers, and 5,938 fishing directly in the Lagoon. There are 108 fishing villages in the District (88 around the Lagoon) and 12,680 households engage in fisheries (Department of Census and Statistics, 2009; Fernando, 2010).

Fishing is the sole income of 67.4%, the main income of 21.4% and the secondary income of 9.5% of lagoon fishers (Fernando, 2010).

Growth of fisheries has been rapid in the District.

However, with the end of the civil war, refugees who have lived in the district for nearly two decades are now returning to the North and East (Jayasekera, person. comm.). This is likely to change the number of direct and indirect dependents on the Lagoon.

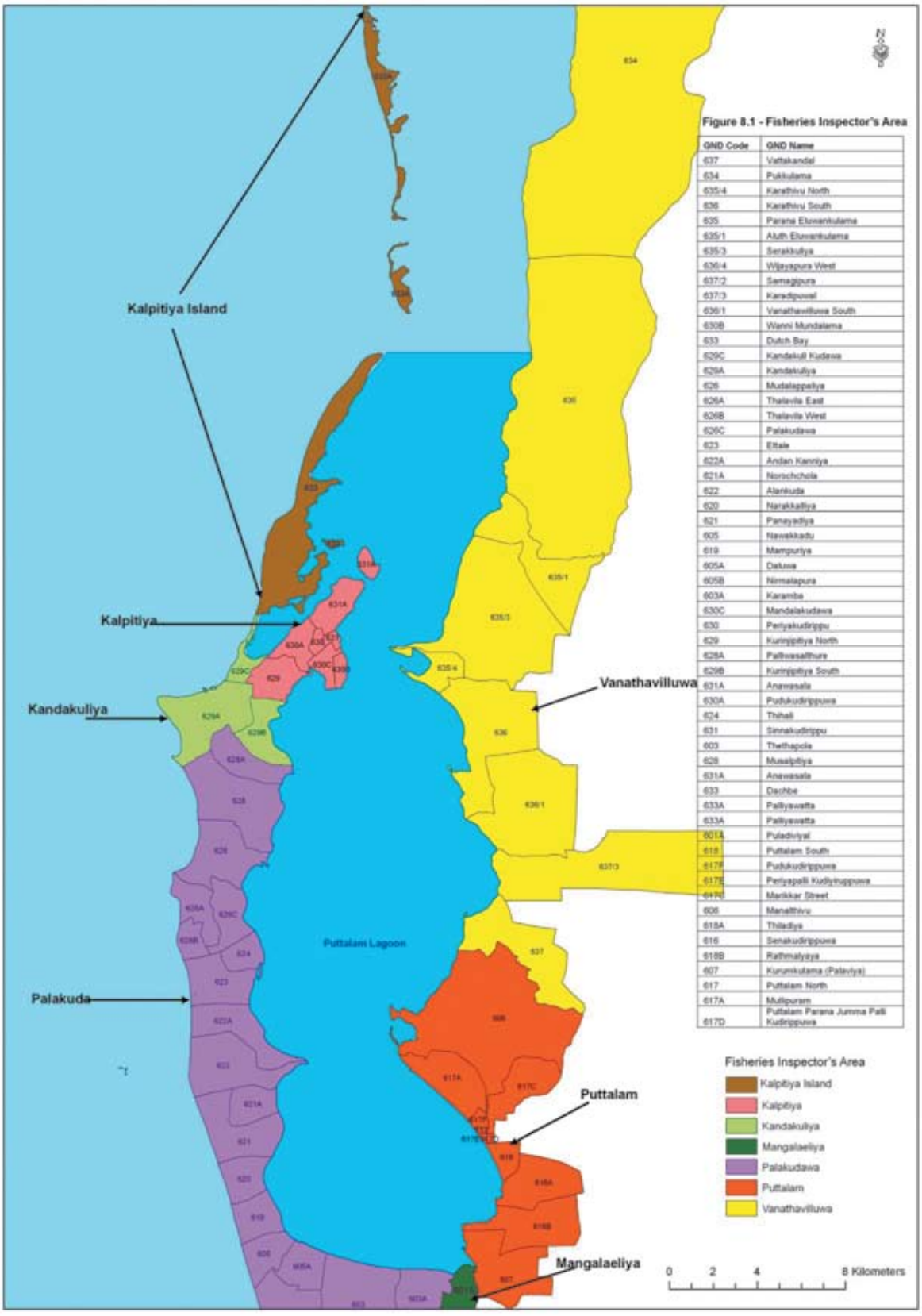
Number of fishers

For administrative purposes, the district is divided into eight Fisheries Inspector (FI) areas: Vanathavillu, Puttalam, Mangalaeliya, Battuluoya, Palakuda, Kandakuliya, Kalpitiya mainland and Kalpitiya Island. (See Figure 49).

Table 22. Number of fishers in Puttalam District
(Source: Department of Fisheries, Puttalam, 2011)

Fisheries inspector division	Active fishers	Fishing families	Fishing population
Vanathavillu	1,595	1,307	4,575
Puttalam	767	629	2,201
Mangalaeliya	2,714	2,225	7,787
Battuluoya	1,686	1,382	4,837
Palakuda	3,488	2,826	9,891
Kandakuliya	2,153	1,768	6,188
Kalpitiya land	2,024	1,626	5,691
Kalpitiya Island	1,119	917	3,210
Total	**15,546**	**12,680**	**44,380**

Figure 49. Fisheries Inspector areas in the Puttalam Lagoon Area
(Source: Weragodatenna, 2010)



The number of fishers in Puttalam District has increased since 1989.

Current estimates indicate that the number of fishers in Puttalam District is 15,546 (Department of Fisheries, Puttalam District, 2011).

Figure 50. Increase in the number of fishers in the Puttalam District

(Source: Long et al., 2010)

Data obtained from the District Fisheries Office indicate that the total number of fishers operating in the Puttalam Lagoon as at August 2011 was 5,926 with 93% full-time and the rest part-time fishers (Department of Fisheries, Puttalam, 2011).

Table 23. Number of fishers involved in Puttalam Lagoon fisheries

(Source: Department of Fisheries, Puttalam)

	No of fishers		
FI division	**Full-time**	**Part-time**	**Total**
Vanathavillu	1,505	90	1,595
Puttalam	736	31	767
Battuluoya	90	10	100
Palakuda	1,554	190	1,744
Kandakuliya	661	57	718
Kalpitiya land	750	23	773
Kalpitiya Island	205	24	229
Total	**5,501**	**425**	**5,926**

In the Puttalam Lagoon area, two kinds of fishery are practised: capture fisheries and aquaculture.

Capture Fisheries

Fishing fleet

It is mandatory that the fishing crafts operational in the Puttalam District obtain an operational license from the respective FI area offices. In 2003, a total of 4,105 fishing crafts were operational, of which some fishing craft were solely engaged in sea fishing and some in lagoon fishing (ADB and IUCN, 2003). In 2011, this figure is 4,633. (See Table 24).

The type of fishing craft varies – there are traditional non-motorised boats, traditional motorised boats and boats with out-board motors. The table below gives a breakdown of types of fishing crafts in each FI area as at August 2011.

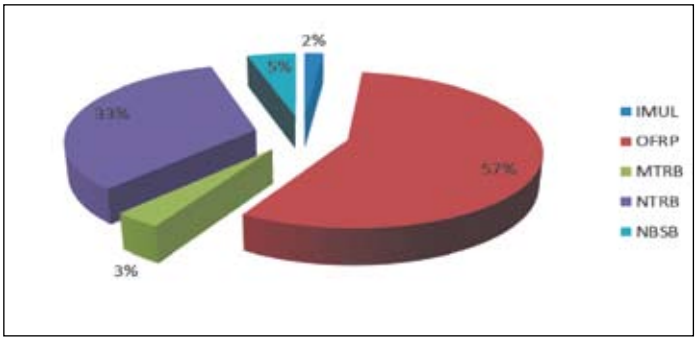
Table 24. Type of boat and fishing fleet in Puttalam District (both coastal and lagoon fisheries)
(Source: Department of Fisheries, Puttalam, 2011)

	No. and type of boats*					
Fisheries inspector division	**IMUL**	**OFRP**	**MTRB**	**NTRB**	**NBSB**	**Total**
Vanathavillu		230	24	196	1	451
Puttalam		18	104	125	1	248
Mangalaeliya		265		172	55	492
Battuluoya		193		145	69	407
Palakuda	21	625	3	405	92	1,146
Kandakuliya	32	406		201		639
Kalpitiya land	32	580	1	265		878
Kalpitiya Island		309	32	27	4	372
Total	85	2,626	164	1,536	222	4,633

* IMUL: In-board multi-day boats
OFRP: Out-board fibre-reinforced plastic boats
MTRB: Mechanised traditional boats
NTRB: Non-mechanised traditional boats
NBSB: Non-mechanised beach seine boats

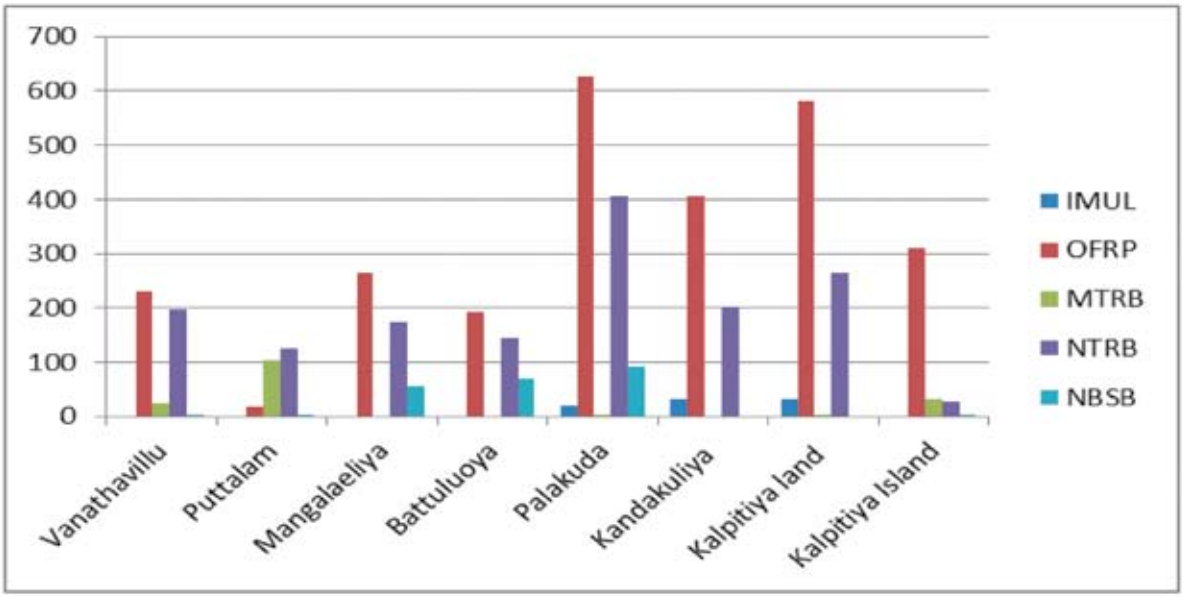
The percentage of registered fishing crafts by type of craft shows that out-board FRP boats are the most prevalent (57%) (Department of Fisheries, Puttalam District, 2011).

Figure 51. Percentage of registered fishing craft types
(Source: Department of Fisheries, Puttalam, 2011)



Distribution of the types of fishing crafts in each Fisheries Inspector (FI) area in 2011 is depicted in the following figure. Outboard FRP boats and non-mechanised traditional boats in all eight FI areas and the operation of mechanised traditional vessels are limited to Puttalam, Kalpitiya mainland and Vanathavillu FI areas. In Palakuda, Kandakuliya and Kalpitiya Land FI areas, there are multi-day boats (Department of Fisheries, Puttalam District, 2011). In no division, are only traditional non-mechanised boats used.

Figure 52. Distribution of fishing craft types in each Fisheries Inspector area
(Source: Department of Fisheries, Puttalam, 2011)

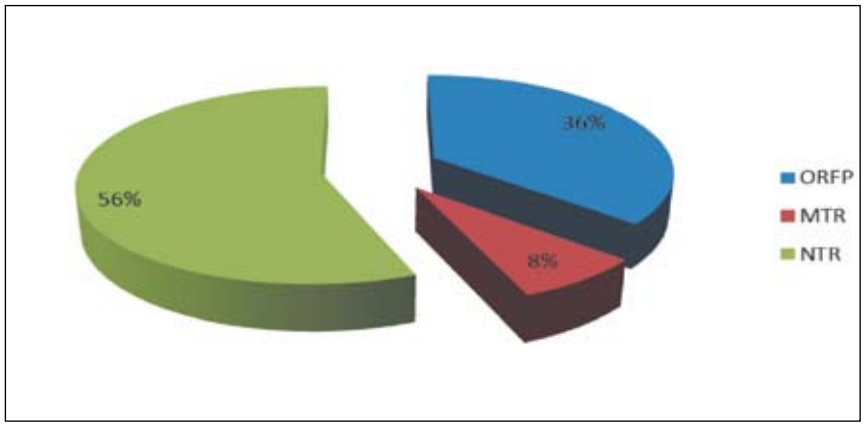


With respect to Lagoon fisheries, there are 2,145 registered boats, and the most commonly used type of boat is the traditional non-mechanised boat – such as outrigger canoes (*oru*), and log rafts (*theppam* and *wallam)* (Department of Fisheries, Puttalam, 2011).

Table 25. Type of boat and fishing fleet in the Puttalam Lagoon
(Source: Department of Fisheries, Puttalam, 2011)

	ORFP	MTR	NTR	Total
Vanathavillu	230	24	196	450
Puttalam	18	104	125	247
Battuluoya	0	0	40	40
Palakuda	190	0	350	540
Kandakuliya	20	0	201	221
Kalpitiya land	250	32	265	547
Kalpitiya Island	70	3	27	100
Total	**778**	**163**	**1,204**	**2,145**

Figure 53. Proportion of fishing craft types in Lagoon fisheries
(Source: Department of Fisheries, Puttalam, 2011)

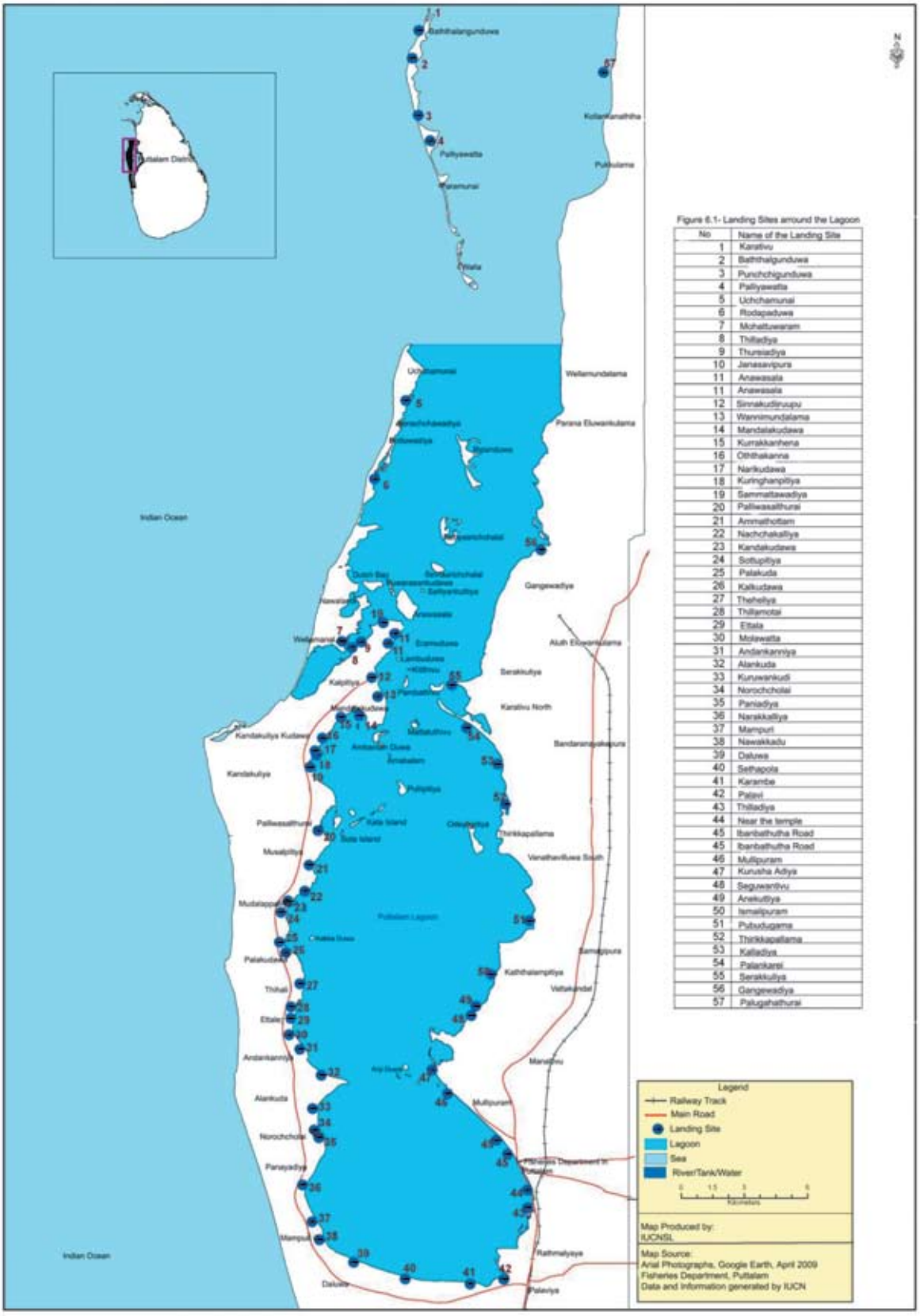


There are many fish landing sites around the coast of the Puttalam Lagoon area. A map showing these sites is presented below. The main fishery harbour is located at Kalpitiya, while there are 62 fish landing sites have located around entire Lagoon, the major ones at Gangewadiya, Serakkuliya, Pubudugama, Anaikutti, Puttalam, Soththupitiya, Kuringipitti, Kandakuliya, Nallur, Palliyawatta and Battalangunduwa.

Table 26. Distribution of landing sites, co-op societies and ice factories round the Lagoon
(Source: Department of Fisheries, Puttalam, 2011)

Fisheries inspector division	Fish landing sites	Fishing co-op societies	Ice factories
Vanathavillu	8	5	0
Puttalam	5	5	0
Mangalaeliya	5	7	0
Battuluoya	4	11	1
Palakuda	21	5	0
Kandakuliya	6	7	2
Kalpitiya land	10	8	2
Kalpitiya Island	3	4	0
Total	**62**	**52**	**5**

Figure 54. Fish landing sites around Puttalam Lagoon
(Source: Weragodatenna, 2010)



Fishery types

Dayaratne et al., (1997) categorised fisheries in the area into a) lagoon fishery and b) coastal fishery.

Lagoon fisheries

The Puttalam Lagoon area comprises two major estuarine systems: the Puttalam Lagoon and the Mundel Lake (Dayaratne et al., 1997). The Dutch Canal connects the two.

The Puttalam Lagoon fishery

Dayaratne et al. (1997) estimated the number of crafts operating in the Lagoon in 1995 after the influx of refugees from Mannar due the civil unrest as 1,600 crafts, of which 50% were mechanised. The figure for 2003 is estimated as 1,776 (ADB and IUCN, 2003).

Data from the Department of Fisheries in Puttalam (2011) indicate that currently there are 2,145 boats operating in the Lagoon of which 56% are non-mechanised. The number of fishers in the Lagoon has almost tripled since 1997. (See Table 28.)

Table 27. Development of the Lagoon fishing fleet

(Source: Dayaratne et al., 1997; IUCN and ADB, 2003; Department of Fisheries, Puttalam, 2011)

	1997	2003	2011
Total no. of boats	~1,600	1,776	2,145
Total no. of fishermen	~2,000	NA	5,926

The most common gear types are gill nets and trammel nets (Dayaratne et al.,1997). Fishing in the area is seasonal, with more crafts operating in the Lagoon during the southwest monsoon, from June to September, when the sea is too rough for coastal fisheries (Dayaratne et al. 1997).

The main fisheries resources in Lagoon fisheries are finfish (74%) and shellfish (26%) (Dayaratne et al., 1997). Species harvested are discussed under the section on fisheries resources.

The Puttalam Lagoon capture fishery is reported to have been managed naturally, restricted to seasons, but with the influx of migrant fishers, there has been an increase in fishing effort (Dayaratne et al., 1997).

The Mundel Lake fishery

Here, most fisheries are carried out at a subsistence level. Dayaratne et al. (1997) reported that approximately 100 families are dependent on the lake for their livelihoods. Dayaratne et al. (1997) estimated 70 wooden or fibre-glass outrigger canoes and 20 log rafts (90 boats) in this area, using gill nets and trammel nets. Because the lake is shallow, some fishing is carried out without crafts, using fish kraals, brush piles and traps (Dayaratne et al., 1997). Dayaratne et al. (1997) reported that 70 net-traps, 23 fish kraals and 4 brush piles were found in the Dutch Canal.

Current data indicate that there less than half the number of boats active in 2011.

Table 28. The Mundel Lake Fishery
(Source: Dayaratne et al., 1997; Department of Fisheries, Puttalam, 2011)

	1997	2011
Total no. of boats	100	40
Total no. of fishers	100 fishing families	100 (90 full-time and 10 part-time)

Coastal fishery

The coastal fishery in this area comprises a) trawl fishery; b) small-meshed gill net fishery; c) flying fish fishery; d) beach seine fishery; e) coral reef associated fishery and f) fishery for ornamental species (Dayaratne et al. 1997).

Trawl fishery

During the last few decades, shrimp trawling has occurred in Portugal Bay, north of the Puttalam Lagoon. About 75% of the trawl effort consisted of by-catch, mainly of Silver bellies (*Leiognathus* spp.) (Dayaratne et al., 1997).

Dayaratne et al. (1997) reported 15 trawlers in 1984, but the table below shows a marked increase – a doubling of the number by 2009.

Table 29. Fishing vessels engaged in shrimp fishery in the area
(Source: Long et al., 2010)

Fishing craft		Number
ADB type	11 ton 3.5 ton	12 19
FRP boats		UKN
Log rafts		UKN
Small dugout canoes		UKN

Usually, trawl nets and trammel nets are used to catch shrimp and the season of harvest is from the end of September to the end of April (Long et al., 2010).

Annual production of this shrimp fishery was estimated as 585 MT and 2,568 MT of Silver Bellies (Jayawardana and Dayaratne, 1995; Dayaratne et al. 1995 in litt. Dayaratne et al., 1997).

Small-meshed gill net fishery

This is the most popular type of coastal fishery in the area, where the mesh size ranges from 30-50 mm (Dayaratne et al. 1997). Fishing is from Udappuwa to the islands north of Kalpitiya along the coast. A total of 1,600 FRP boats and 370 log crafts were reported to have been engaged in this type of fishery in 1997, operating between August and February (Dayaratne et al. 1997).

This fishery harvests species such as Spotted Sardinella (*Amblygaster sirm*), Smoothbelly Sardinella (*A. clupeoides*), Sardinella spp., Barracuda (*Sphyraena* spp.), and Mackerel (*Rastrelliger* spp.) (Dayaratne et al. 1997).

Annual production of this fishery was estimated as 2,160 MT (Jayawardana and Dayaratne, 1995). The maximum sustainable yield[49] (MSY) estimated for Spotted Sardinella was 7,350 MT (Dayaratne et al. 1997). Dayaratne et al. (1997) recommended that harvest of this species could increase but that monitoring is required. It should be noted however, that these data are now over a decade and a half old; newer estimates are needed.

Flying fish fishery

This is a seasonal fishery, carried out from October to April, commenced by the fishing community in Kandakuliya. This fishery is specifically to catch flying fish (*Hirundichthys oxycephalus*). About 40% of the catch is flying fish and the rest comprising Half Beaks (*Hemiramphus* spp.).

Fishers from other areas (from Chilaw, Wennappuwa and Negombo) migrate to the area during this season to engage in this fishery.

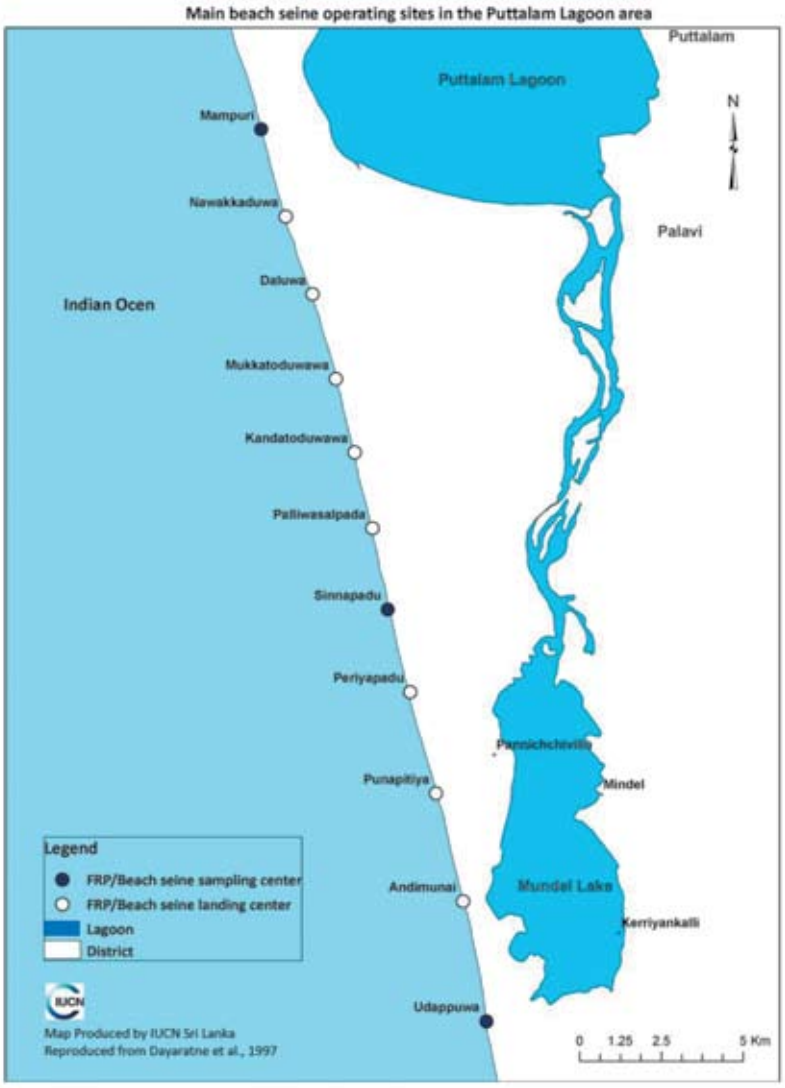
Dayaratne et al (1997) reported 150 FRP boats engaged in this fishery. Annual production of this fishery was estimated as 1,276 MT (Jayawardana and Dayaratne, 1995) and the MSY estimated as 4,890 MT (Dayaratne et al. 1997). Dayaratne et al. (1997) recommended that harvest of this species could increase. It should be noted however, that these data are now over a decade and a half old; newer estimates are needed.

Beach seine fishery

This traditional fishing method is carried out by migratory fishers from Negombo and Wennapuwa, from October to April, when the sea is not rough. There are approximately 120 beach seine sites located on the western coast of the peninsula.

[49] 'Theoretically, the largest yield (or catch) that can be taken from a species' stock over an indefinite period. Fundamental to the notion of sustainable harvest, the concept of MSY aims to maintain the population size at the point of maximum growth rate by harvesting the individuals that would normally be added to the population, allowing the population to continue to be productive indefinitely' (http://en.wikipedia.org/wiki/Maximum_sustainable_yield).

Figure 55. Main beach seine operating sites along the Puttalam Lagoon area
(Source Dayaratne et al., 1997)



During the southwest monsoon, fishers either go back to their homes in the south, or migrate to the east coast of the Lagoon (Dayaratne et al. 1997).

Annual production of this fishery was estimated to be about 4,340 MT (Dayaratne et al. 1997). Major species harvested in this fishery are: Indian Mackerel (*Rastrelliger kanagurta*), sardines (*Sardinella* spp.), anchovies (*Stolephorus* spp.) and Silver bellies (*Leiognathgus* spp.) (Gunaratne et al., 1995 in litt. Dayaratne et al. 1997).

Coral reef associated fishery

Many fishers from Mampuri, Ilantaiyadi, Talawila, Kandakuliya, Kudawa, Uchchamunai, Palliyawatta, Battalangunduwa and Karativu fish from the coral reefs in the area (Dayaratne et al. 1997).

About 150 FRP boats and 40 log rafts engage in this fishery throughout the year, but the peak season is from February to June. Hand lines and bottom-set gill nets are used. Groupers *(Epinephelus* spp.*),* snappers (*Lutjanus* spp.), sea crabs *(Portunus* spp.), emperor fishes (*Lethrinus* spp.) and sweetlips (*Plectorhinchus* spp.) were the dominant species in this fishery (Dayaratne et al. 1997).

Fishery for ornamental species

This fishery occurs in Kandakuliya, Talavila and the Bar Reef. Divers, operating from temporary huts on the beach from November to April, during the non-monsoon months (Dayaratne et al., 1997). Currently, there are 16 scuba divers operating in the area (Long et al., 2010). Hand nets and moxy nets are used to harvest species (Dayaratne et al., 1997). Scarlet shrimps (*Lysmata debelius*), painted shrimps (*Lysmata amboinensis*), angel fishes (Pomacanthidae), clown fishes (Pomacentridae), wrasses (Labridae), anthids (Serranidae) and gobies (Gobiidae) are targeted by scuba divers, while snorkellers harvest butterfly fishes (Chaetodontidae) (Dayaratne et al., 1997). Dayaratne et al. (1997) reported a total of 57 species of fish collected for ornamental purposes, but Long et al. (2010) reported 127 species (See table under the section on Fisheries Resources for a complete list).

The majority of divers are migrants from other coasts.

Both Dayaratne et al. (1997) and Long et al. (2010) reported that most harvesting methods for ornamental fish collection are very damaging to coral reefs, especially where fragile live corals are present. Tamelander and Rajasuriya (2008) noted that although all damaging fishing methods are illegal, they are still widespread as a result of poor enforcement.

Sea cucumber, lobster and chank are also fished in the area (CENARA 2010).

Capture methods

Various fishing methods are used in the capture fishery of the Puttalam Lagoon. These are described in Table 30. The most commonly used method of capture is the gill net, used to catch both fin and shellfish. Bottom-set nets and trammel nets are used for the crab fishery. The predominant combination of gear and crafts are gill nets operated from reinforced plastic (FRP) boats (ADB and IUCN, 2003).

Table 30. Types of fishing gear and target species
(Source ADB and IUCN 2003, S. Chandranayake, person.comm.)

Gear	Description	Target species	Season	Lagoon or Coastal
Trammel nets	This is a three layered gill net; floats are attached to the head rope and lead sinkers to the bottom rope. The net is laid across the tide using a lagoon canoe or a log raft by two fishers (IUCN, in preparation).	Shrimps and fish. This net is less selective than a gill net and catches non-target species.	All year round.	Used both in lagoon and coastal fisheries.
Gill nets	The name illustrates the method used to snare fish. Fish try to swim through particular sized mesh openings, but are unable to squeeze through. They cannot back out as their gills become caught in the net. Small-meshed gill nets have a diameter of 30-50 mm. Bottom set gill nets are set on the Lagoon or sea bed, weighted in place and held vertically. Encircling gill nets are set vertically but are used to encircle fish.	Mixed species. Targets small pelagic fish. Common for coral reef fish.		
Cast nets *(Visidela)*	This is a circular net with small weights distributed around its edge. The net is cast or thrown by hand in such a manner that it spreads out on the water and sinks.	Mixed fish.	Very few in Palawi and Etththale, only about 40 fishers use this gear.	Used only in the Lagoon. Seasonally used in coastal areas for shrimp.
Crab traps (‘*kakulu thatti*’)	Bamboo is woven around a circular frame and this is baited and sunk with a buoy.	Crabs.	Only during the south west monsoon, but during this time, about 80% of the fishers use this gear.	Used mainly in Lagoon during the monsoonal months, but occasionally used also in coastal areas.

Crab nets	3.5-4” meshed bottom set nets.	Crabs.	Throughout the year.	Used both in lagoon and coastal fisheries.
Murali nets	3.5-4’ gill nets specific for a target species.	Half-beak (called *Muralla* in Sinhala, hence the name of the net).	Only during peak monsoonal months.	Used in Lagoon during the monsoonal months, and also in coastal areas.
Sooda dela	1.5-1.75” gill net specific for a target species.	White Sardine (*Sooda*).	This is a seasonal fishery, ranging from Dec – April.	Used both in lagoon and coastal fisheries.
Monofilament trammel nets (*Yaka dela)*	Very small-meshed net.	High mixed catch. A harmful fishing method as it catches fry and fingerlings. Illegal.	All year.	Used only in lagoon fisheries
Bottom long lines	There is a long line, called the main line, with baited hooks attached at intervals by means of branch lines. Hundreds or even thousands of baited hooks can hang from a single line. These are set at the bottom.	For yellow fin tuna and scads and *Liza* spp.	Seasonal/small scale.	Used mainly in coastal fisheries, and very little, seasonally near the mouth of the lagoon.
Hand lines	Fishing with a single baited fishing line, which is held in the hand.	Used most commonly for cuttlefish.	Cuttlefish harvest is seasonal, from January to March. Other small-scale fisheries are throughout the year.	Used only in coastal fisheries.
Push nets	Push nets are triangular fishing nets, made by tying three sticks together at the ends to form a triangle. The net is pushed by a wading fisher.	Used in shallow waters. A harmful fishing method; illegal. Push nets, like drag nets, are damaging to benthic and demersal flora and fauna.	Throughout the year/small scale.	Used only in lagoon fisheries.
Sangili del (chain nets)	This is a trawl net.	A harmful fishing method; illegal.	Used in the Kalpitiya area for shrimps.	Used only in lagoon fisheries.
Pull nets (*Kadippu dela*)	This is a traditional drag net with poles and bag type cod end. Poles help to keep the net mouth open, while the fish and crustaceans collect at the cod end.	A harmful fishing method; illegal. These nets damage the Lagoon bed, disturb benthic fauna and catch all size of fish and shellfish. Used to catch shad.	Throughout the year.	Used only in lagoon fisheries.

Hand nets	A hand held net used by divers.	Ornamental fish	November to April	Used only in coastal fisheries.
Moxy nets	This cone shaped net is closed at the top. The bottom is about a metre or more in diameter. A float is attached on the top and lead weights are fastened around the perimeter of the base. Moxy nets are often used on shallow reef tops by snorkelers. The net is spread on top of coral heads where the fish take refuge. Fish are then chased out by banging the coral heads with a tickler stick until they are caught in the net.	Ornamental fish. A harmful fishing method. Illegal.	November to April	Used only in coastal fisheries.
Tungus nets	Nylon nets with a small gauge.	Illegal.	Throughout the year.	Used both in lagoon and coastal fisheries.
Purse seine nets (*Hambili del*)	A seine is a large fishing net that hangs in the water due to weights along the bottom edge and floats along the top. A purse seine has a number of rings at the bottom, through which a rope is passed and pulled, drawing the rings close to one another, preventing the fish escaping from below.	Illegal. Used to catch scad and tuna.		Used only in coastal fisheries.
Fish kraals and brush piles	Traditional fishing methods using mangrove sticks	Used mainly in the Dutch canal. Affects water exchange and restricts migration.	Very scarce in the Lagoon, with only 4 fishers currently practising this.	Used only in the Lagoon.

Fishery resources

Finfish and shellfish are the main fishery resources found in the Lagoon and the associated coastal waters. The adjacent sea also harbours bivalves and sea cucumbers.

Finfish

The finfish species comprise of small pelagic, mackerels and flying fish while most of the common shell fish species found include shrimps, lobsters and crabs. Fishing activity is seasonal and the fishing season lasts from October to April.

The Central Environmental Authority (CEA,1994) listed 54 fish species belonging to 28 families recorded within the Lagoon, dominated by family Carangidae[50]. A survey carried out in 2003 recorded 59 species belonging to 32 families inhabiting the Puttalam Lagoon, with the commonest species from the families Clupeidae[51], Sciaenidae[52] and Carangidae (ADB, 2003). Weragodatenna (2010) reported a total of 69 species from the Puttalam Lagoon based on interviews with the fishing community in the area. She reported 69 species belong to 27 families dominated by family Carangidae and Clupeidae followed by Lutjanidae[53].

Table 31. List of species recorded from the Puttalam Lagoon (based on interviews with fishers)
(Source: Weragodatenna, 2010)

Scientific Name	English
Aetobatus narinari	Spotted Eagle Ray
Alectis ciliaris	African Pompano
Ambassis sp.	Perchlet
Amblygaster clupeoides	Bleeker's Smoothbelly Sardinella
Anguilla bicolor	Shortfin Eel
Argyrops spinifer	King Soldier Bream
Arius sp.	Long-Whiskered Catfish
Atule mate	Yellowtail Scad
Caranx sexfasiatus	Bigeye Travally
Caranx sp.	
Chanos chanos	Milkfish
Dendrophysa russelli	Goatee Croaker
Drepane punctata	Spotted Sicklefish
Dussumieria acuta	Rainbow Sardine
Eleutheronema tetradactylum	Fourfinger Threadfin
Elops machnata	Tenpounder
Ephippus orbis	Spadefish
Epinephelus sp.	
Escualosa thoracata	White Sardine
Etroplus suratensis	Pearl Spot
Gazza minuta	Toothpony

[50] This is a family of marine fish which includes the jacks, jack mackerels, and scads.
[51] This is a family of marine fish that includes herrings, shads and sardines.
[52] This is a family of marine fish that includes drums, croakers, or hardheads so called for the repetitive throbbing or drumming sounds they make.
[53] The snapper family.

Gerres filamentosus	Whipfin Silverbiddy
Gerres oyena	Common Silverbiddy
Glossogobius giuris	Goby Silverbiddy
Hemiramphus sp.	Halfbeak
Hyporhamphus dussumieri	Dussumier's Halfbeak
Ilisha elongata	Bigeye Ilisha
Johnius carouna	Caroun Croaker
Lates calcarifer	Sea Perch
Lethrinus sp.	Emperors
Liza sp.	
Lutjanus argentimaculatus	Mangrove red Snapper
Lutjanus fulviflamma	Blackspot Snapper
Lutjanus rivulatus	Blubberlip Snapper
Monodactylus argenteus	Silver Moony
Mugil cephalus	Flathead Mullet
Nematalosa nasus	Bloch's gizzard shad
Opisthopterus tardoore	Tardoore
Oreochromis mossambicus	Tilapia
Otolithes ruber	Tigertooth Croaker
Parastromateus niger	Black Pomfret
Parupeneus indicus	Indian Goatfish
Plotosus sp.	Stinging Catfishes
Protonibea diacanthus	Spotted Croaker
Rastrelliger kanagurta	Indian Mackerel
Sardinella albella	White Sardinella
Sardinella gibbosa	Goldstripe Sardinella
Sardinella longiceps	Indian oil Sardine
Scarus russelii	Eclipse Parrotfish
Scatophagus argus	Spotted Scat
Scomberoides commersonianus	Talang Queenfish
Secutor insidiator	Pugnose Ponyfish
Siganus canaliculatus	Whitespotted Spinefoot
Siganus javus	Streaked Spinefoot
Sillago sihama	Silver Sillago
Solea elongata	Elongate Sole
Sphyraena jello	Great Barracuda
Stolephorus commersonii	Commerson's Anchovy
Stolephorus indicus	Indian Anchovy
Strongylura strongylura	Spottail Needlefish
Tenualosa toli	Toli Shad
Terapon jarbua	Jarbua Terapon
Terapon puta	Smallscaled Terapon
Thryssa hamiltonii	Hamilton's Thryssa
Triacanthus biaculeatus	Shortnosed Tripodfish
Triacanthus sp.	Cutlass fishes

According to ADB and IUCN (2003), the commonly harvested finfish species were *Nematolosa nasus*, *Hilsa kelee*, *Mugil cephalus*, *Chanos chanos*, *Sardinellla* spp. and *Leiognathus* spp. However *Hilsa kelee* and *Leiognathus* spp. are not mentioned by the fishers as being harvested. (See Table 31.)

Ramanathan reported in 1969 that Milkfish (*Chanos chanos*) fry and fingerlings were collected during April and May each year, from the middle part of the Lagoon (from Kalpitiya southwards to Kalmunai). She estimated that the potential for collecting *Chanos* fry in the Puttalam Lagoon was about 200,000,000 fry per year, and recommended intensive collection from April to June each year (Ramanathan, 1969). However these data are now over four decades old and should be re-assessed before action.

Half beaks are harvested in the Lagoon during the southwest monsoon (IUCN and ADB, 2003).

Figure 56. Half-beaks (*Hemiramphus sp.)* harvested in the Puttalam Lagoon area
(© Sriyanie Miththapala)

Shellfish

Shrimps and lobsters are also economically important resources. Forty percent of the 98 million USD of fishery export income is from shrimp and shrimp-related products (Long et al., 2010).

Penaeus semisulcatus and *P. indicus* are the main commercially important shrimp species, and a good portion of the catch is either exported or sold in other areas especially in Colombo. *Portunus pelagicus* is another crustacean that comprises about 20% of the total catch and is transported out of the area either to Colombo or for export.

Four different studies of harvested crustaceans present different species, as depicted in the table below.

Table 32. Crustaceans recorded in Puttalam Lagoon and associated coastal waters

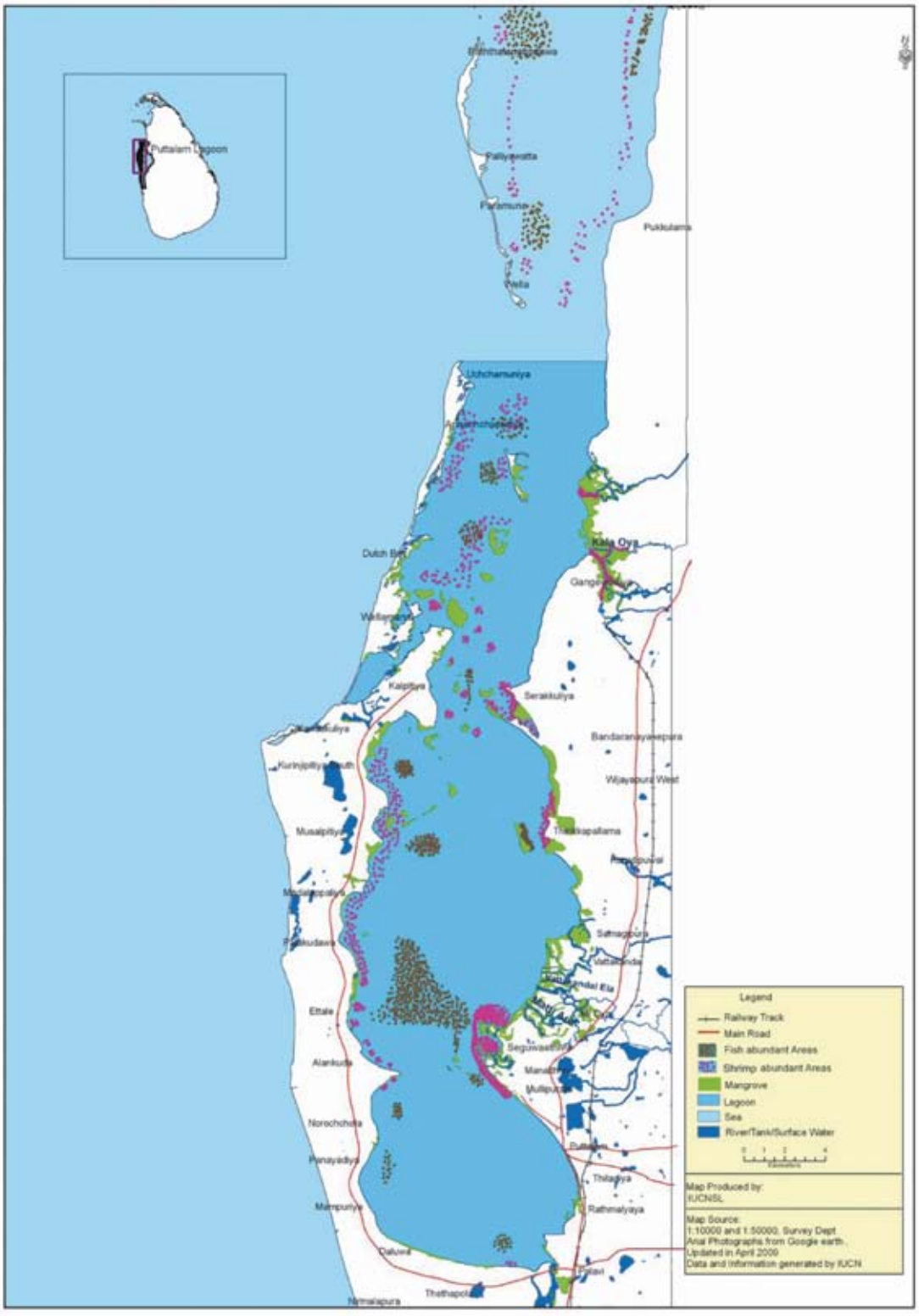
CEA (1994) (lagoon only)	ADB and IUCN (2003) (lagoon only)	Weragodatenna (2010) (lagoon only)	Long et al. (2010) (only shrimp, includes coastal fishery)
Penaeus indicus (Indian white prawn)	*Penaeus indicus* (Indian white prawn)	*Penaeus indicus* (Indian white prawn)	*Penaeus semisulcatus (*Green tiger prawn)
Penaeus semisulcatus (Green tiger prawn)	*Penaeus semisulcatus* (Green tiger prawn)	*Penaeus semisulcatus* (Green tiger prawn)	*Metapenaeus moyebi* (Moyebi shrimp)
P. latidulcatus (Western King Prawn)	*Penaeus monodon* (Giant tiger prawn)	*Penaeus monodon* (Giant tiger prawn)	*Penaeus indicus* (Indian white prawn)
Metapenaeus dobsoni (Kadal shrimp)	*Metapenaeus dobsoni (*Kadal shrimp)	*Metapenaeus dobsoni (*Kadal shrimp)	*Penaeus monodon* (Giant tiger prawn)
Metapenaeus berconroadii	*Fenneropenaeus merguiensis* (Banana Prawn)	*Macrobrachium rosenbergii* (Giant river prawn)	*Metapenaeus dobsoni* (Kadal shrimp)
Scylla serrata (Mud crab)	*Scylla serrata* (Mud crab)	*Scylla serrata* (Mud crab)	*Metapenaeus affinis* (Jinga shrimp)
Portunus pelagicus (Blue swimming crab)	*Portunus pelagicus* (Blue swimming crab)	*Portunus pelagicus* (Blue swimming crab)	*Metapenaeus elegans* (Fine shrimp)
	Thalassina anomala (Mud lobster)		*Metapenaeus ensis* (Greasyback shrimp)
			Metapenaeus moneceros (Speckled shrimp)
			Fenneropenaeus merguiensis (Banana prawn)
			Solenoccera sp.
			Parapenaeopsis stylifera

Figure 57. Mud Crab (*Scylla serrata)*
(© Dilup Chandranimal)

All studies record three out of the 15 species: *Penaeus indicus*, *Penaeus semisulcatus, and Metapenaeus dobsoni.* Long et al's (2010) study, which includes coastal waters as well, records nine more species of shrimp. The three studies that recorded crabs identified *Scylla serrata* and *Portunus pelagicus* in catches.

Areas important for shrimp fisheries are shown in Figure 58.

Figure 58. Areas of shrimp harvest in the Puttalam Lagoon area
(Source: Weragodatenna, 2010)



The coastal shrimp fishery of Puttalam focuses on two species, the Green tiger prawn (*Penaeus semisulcatus*) and Moyebi shrimp (*Metapenaeus moyebi*). The former accounts for 87% of the catch and the latter comprises 77% of smaller shrimps (Long et al., 2010).

The average catch per unit effort is estimated at 15.79 kg/haul (Long et al., 2010).

Current data indicate that the shrimp stocks in the coastal region of Puttalam are being exploited heavily (Long et al., 2010). A recommendation has been made during the preparation of a management plan for the shrimp fishery to restrict harvest during the breeding season (Long et al., 2010).

Ornamental fish

Many ornamented fish are harvested in this area. The most commonly recorded are surgeon fishes (Acanthuridae), triggerfishes (Balistidae), blennies (Blenniidae), butterfly fishes (Chaetodontidae), dragonets (Callionymidae), gobies (Gobiidae), wrasses (Labridae), moray eels (Muraenidae), angelfishes (Pomacanthridae), damselfishes (Pomacentridae), groupers (Serranidae), and scorpionfishes (Scorpaenidae) (Dayaratne at el., 1997).

Important crustaceans for the ornamental fish trade include reef shrimps such as Scarlet Shrimps (*Lysmata debelius)*, Painted Shrimps (*Lysmata amboinensis)* and Banded Coral Shrimp (*Stenopus hispidus)* (Dayaratne at el., 1997, CENARA 2010).

There are two main landing sites for ornamental fish catch: Kandakuliya and Wannimundal (CENARA 2010).

Table 33. Ornamental fish harvested from the region

(Source: CENARA 2010)

Scientifc name	Common Name
Abudefduf vaigiensis	Indo-Pacific Sergeant
Acanthurus leucosternon	Powder Blue Tang (Surgeonfish)
Acanthurus lineatus	Striped Surgeon
Acanthurus mata	Elongate surgeonfish
Acanthurus spp.	Surgeon fish
Aethaloperca rogaa	Redmouth Grouper
Amphiprion clarkii	Clark's Anemonefish
Amphiprion nigripes	Blackfinned Anemonefish
Amphiprion sebae	Sebae Anemonefish
Anampses lineatus	Lined Wrasse
Apogon spp.	Flame Cardinal
Apolemichthys xanthurus	Yellowtail Angelfish
Balistapus undulatus	Orange-lined Triggerfish
Balistoides conspicillum	Clown Triggerfish
Bodianus diana	Diana's Hogfish
Bodianus neilli	Bay of Bengal Hogfish
Caesio xanthonota	Yellowback Fusilier
Cantherhines pardalis	Honeycomb Filefish
Caranx spp.	Jacks
Centropyge eibli	Blacktail Angelfish
Centropyge flavipectoralis	Yellowfin Angelfish

Centropyge multispinis	Dusky Angelfish
Cephalopholis argus	Peacock Hind
Cephalopholis miniata	Coral Hind
Cephalopholis sonnerati	Tomato Rockcod
Chaetodon auriga	Threadfin Butterflyfish
Chaetodon collare	Redtail Butterflyfish
Chaetodon decussatus	Indian vagabond Butterflyfish
Chaetodon gardineri	Gardner's Butterflyfish
Chaetodon guttatissimus	Peppered Butterflyfish
Chaetodon kleinii	Sunburst Butterflyfish
Chaetodon lineolatus	Lined Butterflyfish
Chaetodon lunula	Raccoon Butterflyfish
Chaetodon melannotus	Blackback Butterflyfish
Chaetodon meyeri	Meyers Butterflyfish or Scrawled Butterflyfish
Chaetodon octofasciatus	Eightband Butterflyfish
Chaetodon plebeius	Blueblotch Butterflyfish
Chaetodon triangulum	Triangle Butterflyfish
Chaetodon trifascialis	Chevron Butterflyfish
Chaetodon trifasciatus	Melon Butterflyfish
Chaetodon vagabundus	Vagabond Butterflyfish
Chaetodon xanthocephalus	Yellowhead Butterflyfish
Cheilinus undulatus	Humphead Wrasse
Chlorurus rhakoura	
Chromis dimidiata	Chocolatedip Chromis
Chrysiptera leucopoma	Surge Damselfish
Cirrhilabrus rubrisquamis	Red Velvet Wrasse
Cirrhitichthys oxycephalus	Coral Hawkfish
Coris frerei	Formosa Wrasse
Ctenochaetus striatus	Striated Surgeonfish
Dascyllus aruanus	Whitetail Dascyllus
Dascyllus carneus	Cloudy Dascyllus
Dascyllus trimaculatus	Threespot Dascyllus
Ecsenius bicolor	Bicolor Blenny
Epinephelus fasciatus	Blacktip Grouper
Epinephelus faveatus	Barred-chest Grouper
Epinephelus fuscoguttatus	brown-marbled Grouper
Epinephelus malabaricus	Malabar Grouper
Epinephelus merra	Honeycomb Grouper
Epinephelus quoyanus	Longfin Grouper
Epinephelus spp.	
Forcipiger flavissimus	Yellow Longnose Butterflyfish
Gnathanodon speciosus	Golden Trevally
Gomphosus caeruleus	Green Birdmouth wrasse
Halichoeres hortulanus	Checkerboard Wrasse
Halichoeres leucoxanthus	Yellow and Purple Wrasse

Halichoeres marginatus	Dusky Wrasse
Halichoeres spp.	
Hemigymnus fasciatus	Barred Thicklip
Hemigymnus melapterus	Blackeye Thicklip
Heniochus acuminatus	Pennant Coralfish
Heniochus pleurotaenia	Phantom Bannerfish
Heniochus singularius	Singular Bannerfish
Kyphosus cinerascens	Blue Sea Chub
Labroides dimidiatus	Bluestreak Cleaner Wrasse
Lethrinus nebulosus	Spangled Emperor
Lutjanus argentimaculatus	Mangrove red Snapper
Lutjanus decussatus	Checkered Snapper
Lutjanus fulviflamma	Dory Snapper
Lutjanus lunulatus	Lunartail Snapper
Lutjanus malabaricus	Malabar blood Snapper
Lutjanus quinquelineatus	Five-lined Snapper
Lutjanus rivulatus	Blubberlip Snapper
Macropharyngodon ornatus	Ornate Leopard Wrasse or False Leopard
Naso hexacanthus	Sleek Unicornfish
Neopomacentrus azysron	Yellowtail Demoiselle
Odonus niger	Red-toothed Triggerfish
Ostracion cubicus	Yellow Boxfish
Paracirrhites forsteri	Blackside Hawkfish
Parapercis clathrata	Latticed Sandperch
Parupeneus indicus	Indian Goatfish
Parupeneus macronema	Long-barbel Goatfish
Parupeneus spp.	Red Mullet
Plectorhinchus ceylonensis	Sri Lanka Sweetlips
Plectorhinchus schotaf	Minstrel Sweetlips
Plectorhinchus vittatus	Oriental Sweetlips
Pomacanthus annularis	Blue Ring Angelfish
Pomacanthus imperator	Emperor Angelfish
Pomacanthus semicirculatus	Semicircle Angelfish
Pomacentrus similis	Similar Damsel
Pseudanthias squamipinnis	Lyretail Anthias, Blue/Purple Eye Anthias, Sea Goldie
Pseudochromis fuscus	Brown Dottyback
Ptereleotris evides	Blackfin Dartfish
Ptereleotris heteroptera	Blacktail Goby
Ptereleotris spp.	Adult Dartfish
Pterocaesio chrysozona	Goldband Fusilier
Pterocaesio tile	Dark-banded Fusilier
Pterois volitans	Red Lionfish
Sargocentron spp.	Squirrelfish

Scarus ghobban	Blue-barred Parrotfish
Scarus spp.	
Scomberomorus spp.	Spanish Mackerel
Siganus javus	Streaked Spinefoot
Siganus lineatus	Golden-lined Spinefoot
Stethojulis spp.	
Sufflamen bursa	Triggerfish
Sufflamen chrysopterus	White Tip Trigger Fish
Synchiropus stellatus	Red Scooter Blenny
Thalassoma hardwicke	Sixbar Wrasse
Thalassoma jansenii	Jansen's Wrasse
Thalassoma lunare	Moon Wrasse
Valenciennea puellaris	Orange Diamond Goby
Valenciennea strigata	Blueband Goby
Variola louti	Yellow-edged Lyretail
Zanclus cornutus	Moorish Idol
Zebrasoma desjardinii	Desjardin's Sailfin Tang or Red Sea Sailfin Tang
Zebrasoma scopas	Twotone Tang

Fishing operations are carried out mainly through small FRP boats and bottom set gill nets (Jayawardane and Dayaratne, 1996). There is open access to this fishery (Long et al., 2010).

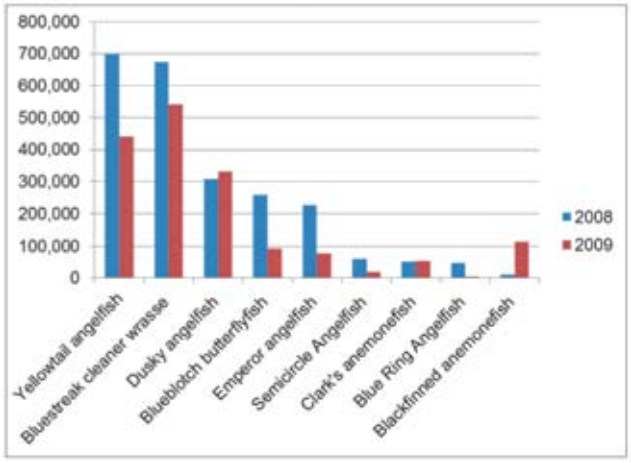
Table 34. Abundance of aquarium fish in 2008 and 2009 in Puttalam district

(Source: Long et al., 2010)

Fish abundance	2008	2009
Yellowtail Angelfish (*Apolemichthys xanthurus)*	698,367	442,046
Bluestreak Cleaner Wrasse (*Labroides dimidiatus)*	674,183	540,840
Dusky Angelfish (*Centropyge multispinis)*	307,839	331,068
Blueblotch Butterflyfish (*Chaetodon plebeius)*	258,373	91,802
Emperor Angelfish (*Pomacanthus imperator)*	225,948	77,623
Blue Ring Angelfish (*Pomacanthus annularis)*	47,453	4,599
Semicircle Angelfish (*Pomacanthus semicirculatus)*	60,596	19,709
Clark's Anemonefish (*Amphiprion clarkii)*	52,206	52,771
Blackfinned Anemonefish (*Amphiprion nigripes)*	10,483	112,483

Figure 59 shows clearly that for most species, the abundance has decreased.

Figure 59. Decline in species abundance in a year
(Source: Derived from Long et al., 2010)



A recommendation was made during the preparation of a management plan for the aquarium trade fishery that adults of selected species should not be collected to prevent further over-exploitation (Long et al., 2010).

Polythene discarded by collectors is now a major issue at collection centres (Long et al., 2010).

Molluscs

Six species of edible bivalves[54] have been recorded in Puttalam Lagoon. These are the edible oyster (*Crassostrea madrasensis*); a mussel (*Modiolus auriculatus*); cockles (*Gafrarium tumidum* and *Anadara antiquata*); and clams (*Marcia opima* and *M. hiantina*) (Dayaratne at el., 1997).

The Window Pane oyster (*Placuna placenta*), a non-edible species, has also been recorded (Dayaratne at el., 1997).

Kithsiri et al (1995, in litt Dayaratne et al., 1997) reported that the distribution of *Gafrarium tumidum, Marcia opima* and *M. hiantina* depended on salinity, soil texture and the extent of seagrass beds.

Indian Chanks (*Turbinella pyrum*), found in the area, are valued ornamentals for the export industry (CENARA 2010). The chank fishery has been on-going since the early 19th century. It was reported that 1,669,745 chanks were exported in 1937 and 1,592,120 in 1939 (Deraniyagala, 1938 and 1940 in litt. CENARA 2010). Most chanks are used for ornamental purposes – to make bangles and baubles. They are also considered religious objects (De Bruin et. al., 1994 in litt. CENARA 2010). Chanks that have left-handed whorls are extremely valued (as a lucky charm) and rare. It is reported that only one left-handed chank was found among thousands harvested in the last two years (Long et al., 2010). These are known as the Sacred Chank of India (*Valampuri*) and fetch extremely high prices in the market (CENARA 2010; Long et al., 2010).

Chanks lay their eggs in egg cases anchored to the ground at one end. Because chank collectors believe (incorrectly) that each egg case contains an immature left-handed chank, they collect every egg case and every chank they find, resulting in damage to chank populations (Long et al., 2010).

[54] A mollusc with two hinged shelves.

There is a total of 800-950 chank fishers in the area (CENARA 2010). The fishery is carried out in FRP boats from October till the end of the following April.

Long et al. (2010) estimated 443,057 chank in the Puttalam coastal waters in 2008 and 238,373 in 2009, representing a significant decrease.

Recommendations have been made during the preparation of a management plan for this fishery that there is a restriction on collection of small-sized chanks and on the collection of egg cases (Long et al., 2010).

Figure 60. Collection of molluscs in the Lagoon
(© Dilup Chandranimal)

Sea cucumbers

Sea cucumbers (Holothurians) are collected from the Dutch Bay and the entire catch is exported. About 1,500 to 2,000 families are engaged in this fishery in Kalpitiya Peninsula (Long et al., 2010). Mostly, FRP boats are used for this fishery, and sea cucumbers are harvested by diving (either skin or scuba) and hand picking. The fishing season is from the middle of October till the following April (Long et al., 2010).

Eight species have been recorded in the Lagoon and associated coastal waters:

- *Holothuria fuscogilva*
- *H. nobilis*
- *Actinopyga echinites*
- *Bohadschia argus*
- *Bohadschia marmorata*
- *An unidentified Bohadschia* spp.
- *Thelenota ananas* and
- *Thelenota anax.*

Bohadschia marmorata is the most predominant in catches in the Lagoon area (Dissanayake and Wijeyaratne, 2007). Other species such as *H. atra*, *H. edulis*, *A. miliaris*, *A. mauritiana* and *Stichopus chloronotus* have also been recorded, but not very frequently (Dissanayake and Wijeyaratne, 2007). Fishers harvest sea cucumbers by diving and hand picking individuals, only from middle October to the end of the following April (Dissanayake and Wijeyaratne, 2007). During a seven month period from October 2002 and April 2003, Dissanayake and Wijeyaratne (2007) recorded that 45,507 individuals were caught. These authors suggested that *B. marmorata* and *A. miliaris* are over-exploited, while the unidentified *Bohadschia* sp. and *A. echinites* are under-exploited. They recommended that a minimum permissible size for collection must be declared to ensure the long-term sustainable harvest of these Holothurians (Dissanayake and Wijeyaratne, 2007).

Long et al. (2010) estimated 25,400 *Actinopyga miliaris* (medium-value) in 2008 and none in 2009. *Holothuria atra* (low-value) was estimated at 7.8 million in 2008 and 45.7 million individuals in 2009, with a density of 860.2 individuals per ha.

Records indicate that fishers are selectively harvesting high-valued species as the abundance of low-value sea cucumbers is increasing dramatically, while high-valued species are decreasing (Long et al., 2010). (See above paragraph.) Fieldwork carried out under the aegis of CENARA, for the last two years indicated a very sharp decline in catches, and therefore, export: divers reported 10-15% for most species collected; collectors reported a 40% drop and processors (for preparing beche-de-mer) reported a decrease for all species (Long et al., 2010). Exports dropped by 27% between 2007 and 2008 (Long et al., 2010).

There are concerns that without proper regulation this fishery will not be sustainable (Long et al., 2010). Several recommendations have been made during the preparation of a management plan for sea cucumber fishery. These include limiting the number of licences issued, adding a time limit to these licences, increasing the licence fee, restricting the time of harvesting, setting a minimum size limit to specimens and registration of divers (Long et al., 2010).

Figure 61. Harvested sea cucumbers from Puttalam Lagoon area
(Kumudhini Ekaratne © IUCN)

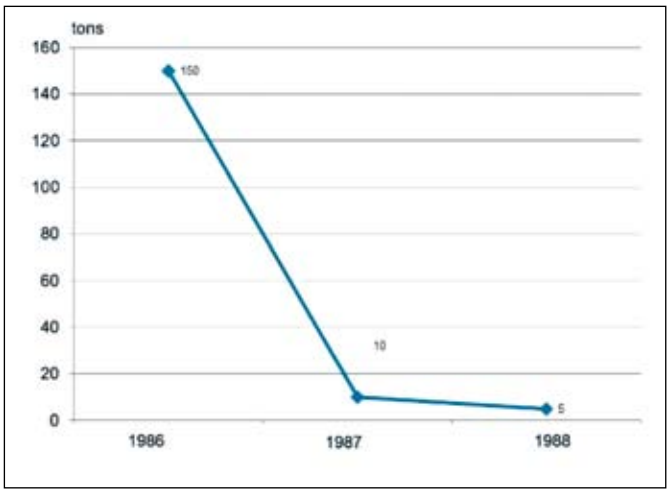
Seahorses

Sea horses caught from seagrass meadows are either sold live for the aquarium trade or exported dried. Research is currently on-going to estimate the extent of this exploitation.

Seaweeds

Gracilaria spp. have been exported from Sri Lanka since as far back as the 1800s (FAO, 1991). Some 2,591 kg and 6,818 kg were exported to England in 1831 and 1840 respectively. Exports dropped sharply in the 1980s. (See Figure 62.)

Figure 62. Export of *Gracilaria* in the 1980s
(Source: Subasinghe and Jayasuriya, 1989)



Four species of red algae – *Gracilaria edulis, Laurencia* spp., *Geldim* spp. and *Hypnea musciformis* – have been recorded in the area. Two species of green algae (*Ulva* spp. and *Enteromorpha* spp.) and two species of brown algae (*Sargassum* spp. and *Padina* spp.) have also been recorded (Dayaratne et al., 1997).

Major beds of *Glacilaria edulis* are found near Kalpitiya, Serakkuli, Ettalai and Anjithivu islands (Dayaratne et al., 1997). These beds grow well from May to November, during which period, seaweeds are harvested (Subasinghe and Jayasuriya, 1989). This period is the southwest monsoon, during which there is increased shrimp fishing in the Lagoon.

Gracilaria edulis collected from Puttalam Lagoon is dried and sold to the traders in Colombo. It is also popular locally, particularly during the Islamic annual fasting period, as a porridge made out of it is considered very nutritious (Subasinghe and Jayasuriya, 1989).

This is considered an under-utilised resource, as interest – other than at a subsistence level of harvesting – has been piecemeal and sporadic (Subasinghe and Jayasuriya, 1989). A pilot project for culturing this seaweed through spore-setting was commenced in the Lagoon (Jayasuriya, 1989) but has never flourished as shrimp culture did. Jayasekera (person. comm.) notes that *Glacilaria* has not been harvested from the Lagoon in the last three years.

Subasinghe and Jayasuriya (1989) noted that harvesting of the species is always secondary to fin or shell fish fishery, and was always used to supplement income. They estimated that 200 tons can be harvested using traditional practices, in Kalpitiya alone (Subasinghe and Jayasuriya, 1989). However, harvest is dependent on demand from middle-traders, and therefore, fishers cannot depend on this income (Subasinghe and Jayasuriya, 1989).

Figure 63. Collected *Glacilaria*
(© Upali Mallikarachchi)

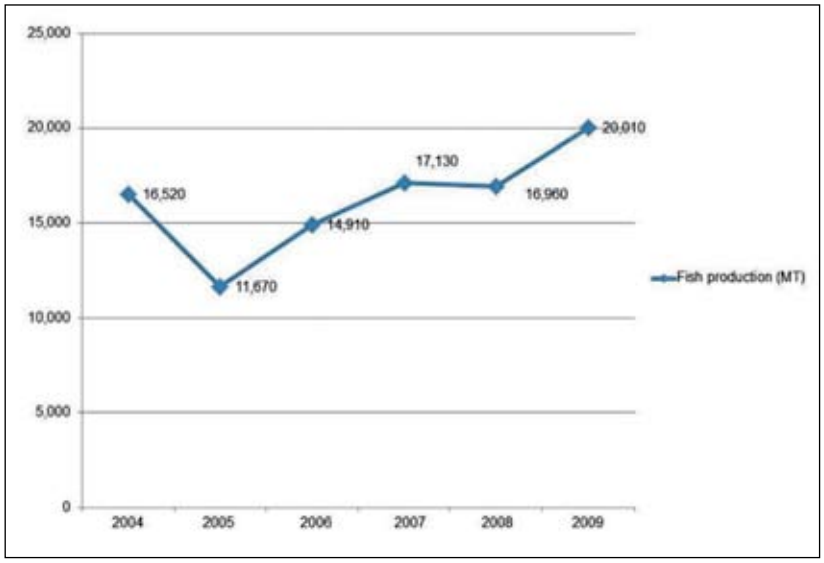
Fish processing is also carried out by several households and dried fish is popular in this area. (Dayaratne *et. al*., 1997). An issue related to this process, is the lack of hygienic facilities during processing as seen in Figure 64 below.

Figure 64. Dried fish production in Kalpitiya
(Naalin Perera © IUCN)

Fish production and trends

The current estimate of coastal sector fish production for the Puttalam District is shown in Table 35 below.

Figure 65. Marine fish production for the Puttalam district from 2004-2009
(Source: Statistical Abstract, 2010)

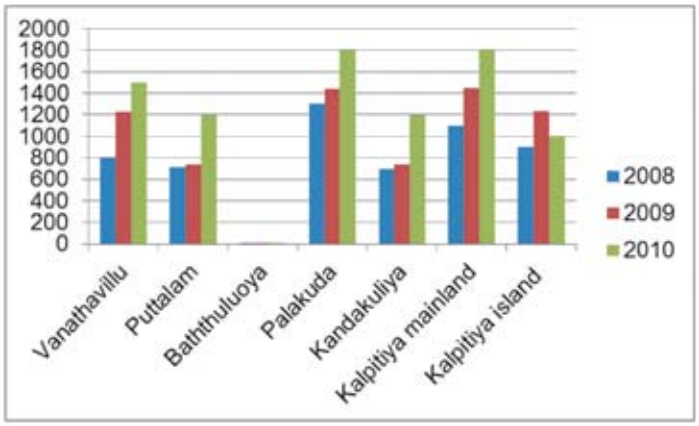


Alwis and Dayaratne (1992) reported the fish production for Puttalam Lagoon for the period 1990–1991 as 4,800 MT. Of this, fin fish comprised nearly 75% of the catch while the balance is accounted for by shellfish. The production values for 2008 and 2009 obtained from the District Fisheries Office are presented in the table below. The production figures for 2009 showed an increase trend in fish catch when compared with those of 1991 and 2008.

Table 35. Fish production in the Fisheries Inspector areas of Puttalam
(Source: District Fisheries Office, Puttalam, 2011)

	Fish Production (MT)		
Fisheries Inspector Area	**2008**	**2009**	**2010**
Vanathavillu	800	1,225	1,500
Puttalam	715	733	1,200
Baththuluoya	8	9	12
Palakuda	1,300	1,442	1,800
Kandakuliya	696	736	1,200
Kalpitiya mainland	1,100	1,450	1,800
Kalpitiya island	900	1,234	1,000
Total	**5,519**	**6,829**	**8,512**

Figure 66. Fish production in the Fisheries Inspector areas of Puttalam
(Source: Department of Fisheries, Puttalam, 2011)



The estimated annual yield for crab (from crab pots) is 28,000 kg per year worth 2 million rupees (~18,100 USD) (Department of Fisheries, Puttalam, 2011).

The estimated annual yield for shrimp, mullet, catfish, as well as crabs is 90,000 kg per year worth 17 million rupees (about 154,500 USD) (Department of Fisheries, Puttalam, 2011).

According to Dayaratne *et.al* (1997), the maximum sustainable yield[55] (MSY) for Puttalam lagoon fishery is estimated at 5,536 MT. Its maximum economic yield[56] (MEY) has been calculated as 4,945 MT with a value equivalent to LKR 133 million (approximately 1.2 million USD). ADB and IUCN (2003) report that although the fishery in Puttalam Lagoon appears to be well within the estimated MSY, it may have already reached the MEY, therefore, close monitoring is advised to ensure sustainability of the fishery.

Estimates for 2009 and 2010 from the Puttalam Department of Fisheries show that annual fish production for lagoon fisheries was already 1.2 times and 1.5 MSY respectively (See Table 35; Dayaratne et al., 1997).

In addition, many reports indicate the use of harmful fishing gear that harvest juveniles (IUCN and ADB, 2003; Dayaratne et al., 1997; Long et al., 2010). This means that stock replacement could well be retarded. Use of illegal gear that damages coral reefs, demersal and benthic is 'rampant . . . due to lack of enforcement of the fisheries regulations' (Tamlander and Rajasuriya, 2008).

Illegal fishing gear is not the only issue affecting the Lagoon. The issues for Lagoon fisheries are manifold and include habitat destruction and habitat degradation – such as pollution and worsening siltation – already critical issues. (See Chapter 8 for more details.)

Apart from capture fisheries, aquaculture is also popular in the Puttalam Lagoon area.

[55] 'Theoretically, the largest yield (or catch) that can be taken from a species' stock over an indefinite period. Fundamental to the notion of sustainable harvest, the concept of MSY aims to maintain the population size at the point of maximum growth rate by harvesting the individuals that would normally be added to the population, allowing the population to continue to be productive indefinitely' (http://en.wikipedia.org/wiki/Maximum_sustainable_yield).

[56] 'MEY is defined as the total amount of profit that could be earned from a fishery if it were owned by an individual. An open entry policy usually results in so many fisher entering the fishery that profit higher than opportunity cost is zero. Economists have long argued that a fishery that maximizes its economic potential also usually will satisfy its conservation objectives. This scenario is encapsulated in the concept of maximum economic yield (MEY), a long-run equilibrium concept that refers to the level of output and the corresponding level of effort that maximize the expected economic profits in a fishery. In most cases, this scenario results in yields and effort levels that are less than at maximum sustainable yield (MSY) and in stock biomass levels greater than at MSY' (http://en.wikipedia.org/wiki/Maximum_sustainable_yield).

Aquaculture (Shrimp farming)

Commercial shrimp farming in the northwest coast of Sri Lanka – particularly in the Puttalam Lagoon – took off the ground in the 1980s with another developmental spurt in the 1990s. According to estimates in 2006, there were about 1,434 shrimp farms, with a total area of 4,539 ha in the region of which more than 90% was located around the Puttalam Lagoon. Weragodatenna (2010) estimated in 2009 that there are 1,817 ha of shrimp farms in the Lagoon area, of which 1,167 ha (64%) were not in in operation. Shrimp farming in Sri Lanka has been affected by repeated disease outbreaks, uncontrolled expansion exceeding carrying capacity, and deterioration of water quality (Siriwardena, 2001).

Shrimp farming provides casual employment.

The CEA (1994) reported that areas along the Dutch canal, the Mi Oya delta and Mundel Lake were converted to shrimp farms. According to 1992 North Western Province figures, the land allocation for aquaculture development in the province was 1,072 ha, but only 100 ha (9.7%) was developed or was still in production (CEA 1994). Jayasinghe (2010) estimated that the area allocated for shrimp farms was 2534.5 ha; of this, 1003.2 ha were operational and 1531.7 were abandoned. Data extracted from GIS ground-truthed data are contrasted with the data from two decades ago in the Table 36 below.

Table 36. Changes in the extent of land allocated for shrimp farming in Puttalam Lagoon area

(Source CEA, 1994; Weragodatenna, 2010)

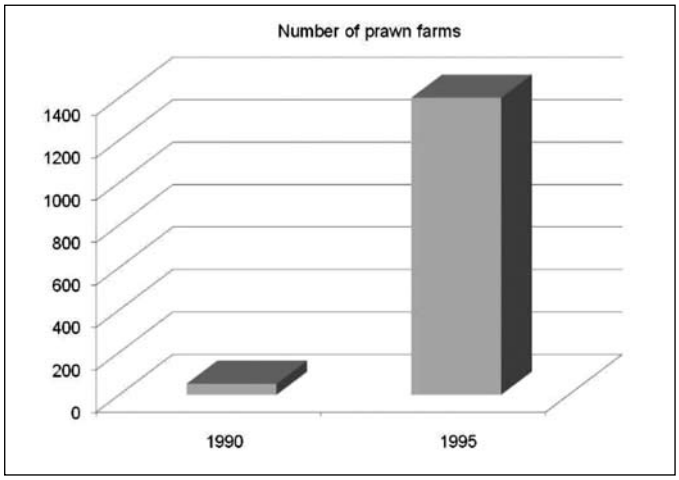
	CEA (1994)		Weragodatenna (2010)	
	Total land allocated (ha)	Abandoned	Total land allocated (ha)	Abandoned
Vanathavillu	142	117.86 (83%)	78.73	259 (76.69%)
Puttalam	100	90 (90%)	9.75	641 (98.5%)
Kalpitiya	40	40 (100%)	563.66	267.667 (32.2%)

Based on the information collected and secondary sources, in 2003, 140 shrimp farms were found in Puttalam, Kalpitiya and Vanathavillu DS divisions (ADB and IUCN, 2003). Jayasinghe (2010) estimated that there was a total of 814 farms in the area, of which 524 were operational, representing a five-fold increase. Weragodatenna (2010) mapped the extent of land under active shrimp farming and found it to be 650 ha.

For projects greater than 4 ha of land, approval is granted by a national level Scoping Committee chaired by the Secretary of the Ministry of Fisheries and Aquatic Resources, and including committee members representing CEA, CCD, NARA, the Irrigation Department, the Land Commissioner's Department, the Survey Department, the North Western Provincial Council and the District Fisheries Extension Officer (DFEO). For projects less than 4 ha of land, approval is granted by the Scoping Committee of the North Western Provincial Council, chaired by the Provincial Secretary of Fisheries, and including committee members representing CEA, NARA and the Irrigation Department.

Some 900 shrimp farms mushroomed in the region, but only about 50% were legal and only a few had carried out the environmental impact assessment required by the law (Fernando, 2010), so half of these shrimps farms were unauthorised and unregulated. This spurt of growth occurred in the 1990s, as shown below.

Figure 67. Growth of shrimp farms in the Puttalam District
(Source: Fernando,2010)



According to the National Aquaculture and Development Authority (NAQDA) (2006), there are about 1,434 shrimp farms with a total extent of 4,539 ha in the region, of which, more than 90% are located around the Lagoon.

Using Google Earth imagery in 2009, Weragodatenna (2010) estimated that the total area of shrimp farms in the Puttalam Lagoon area in 2009 was 1,817 ha, of which 1,167 ha (64%) were unproductive, abandoned farms.

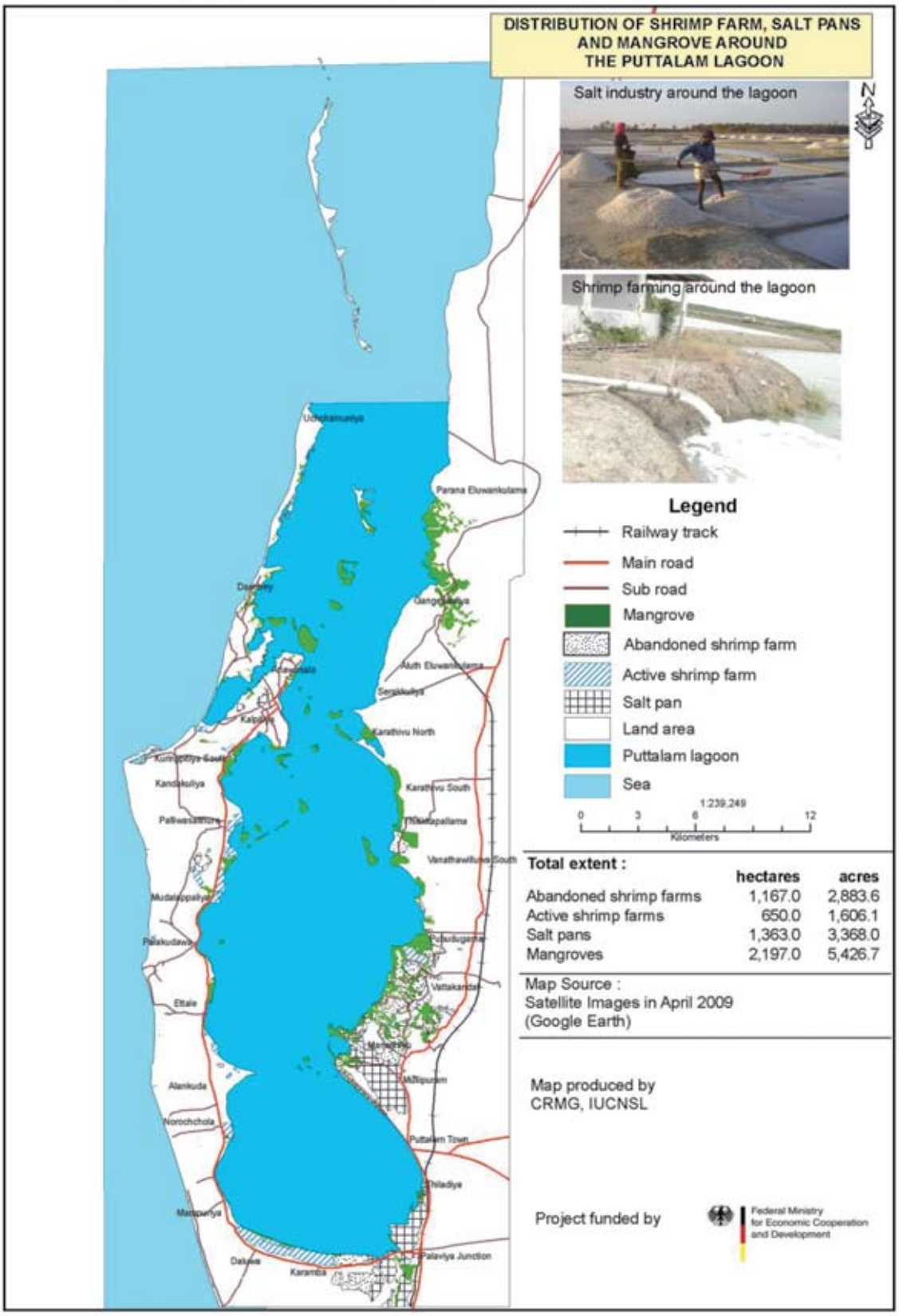
The shrimp that is cultured is *Penaeus monodon*[57], which are reared in earthen ponds.

These shrimp farms provide casual employment to people of the area.

Figure 68. Paddle wheel aeration in a shrimp farm
(© Dilup Chandranimal)

[57] Sri Lanka has thus far deliberately not imported white leg shrimp culture. It is one of very few Asian countries which has not done so.

Figure 69. Distribution of shrimp farms and salterns around the Puttalam Lagoon area
(Source: Weragodatenna, 2010)



Chapter 8. Other livelihoods

Agriculture

Agriculture is the second most important economic activity of the district, with 29.3% of the population engaged in it. Coconut, paddy, cashew, vegetable crops, and fruit crops are the main crops cultivated around the Lagoon area. About 22% of the land area of the DS divisions of Kalpitiya, Puttalam, Mundel and Vanathavillu are used for coconut and other crops (Dayaratne et al., 1997). In the Kalpitiya area, coconut plantations and vegetable crops are the predominant agricultural activities, because of the sandy regosols soil type. Cashew and coconut cultivation can be seen close to the Lagoon and paddy cultivation, while slash and burn cultivation is more prominent in the interior in the Vanathavillu DSD.

Table 37. Cultivated area in the divisional secretariat divisions of the Puttalam Lagoon area
(Source: Census and Statistics Division, Puttalam, 2009; information is unavailable for Kalpitiya)

Divisional Secretariat Division	Cultivated Area (ha)	
	***Maha* Season (the wet season)**	***Yala* Season (the dry season)**
Vanathavillu	348.45	331.5
Puttalam	248.68	309.4
Mundel	607.33	458.2
Kalpitiya	-	-

Low lying areas of the Mundel and Vanathavillu DSD are used for paddy cultivation in both the wet and dry seasons (Dayaratne et al., 1997).

In the past 20-30 years, the cultivation of vegetables in Kalpitiya has taken prominence. Red onions, chillies, potatoes, gherkins, okra and gourds are cultivated and find a ready market in Colombo, given the easy transport access. Dayaratne et al. (1997) reported 2,593 ha and 460 ha of onions and respectively were under cultivation in Kalpitiya.

The distribution and area of fruit cultivation is presented in Table 38 below. Of all fruit crops, coconut is the most extensively cultivated and is found along the coastal belt.

Table 38. Distribution and extent of fruit crops cultivated in the Puttalam Lagoon area
(Source: Census and Statistics Division, Puttalam, 2009)

Divisional Secretariat Division	Cultivated Area (ha)								
	Coconut	Cashew	Betel	Mango	Orange	Lemon	Banana	Papaw	Pineapple
Vanathavillu	1,238.5	4,063.0		12.5	9.0	4.9	64.0	10.3	
Puttalam	3,630.2	120.5	0.8	61.7	15.3	8.9	60.3	7.7	1.2
Mundel	7,235.5	68.4		29.1	16.3	6.6	41.3	18.4	0.8
Kalpitiya	5,635.7	-		1.5	0.2	1.8	20.6	33.0	-

A new market centre had to be established at Nuraicholai in Kalpitiya to accommodate the volume of vegetables produced (Fernando, 2010).

Small scale home gardens are quite common in the area. Within a five kilometre radius of the Lagoon, there are 5,195.8 ha of home gardens. There are a number of garden types and scales including commercial, and subsistence home gardens growing vegetable, and medicinal and herbal plants (Ranasinghe, 2010).

Figure 70. Intensive onion cultivation with irrigation in Kalpitiya
(Naalin Perera © IUCN)

Animal Husbandry

In addition to the fishing and agriculture, animal husbandry plays an important livelihood role in the area. It is practised by both fishers and farmers to provide supplemental income. The most widespread animal husbandry activity in the area is backyard rearing of poultry. Goat rearing is also common, as goats need less fodder than cattle.

Table 39. Animal husbandry in the Puttalam Lagoon area in 2008
(Source: Census and Statistics Division, Puttalam, 2009)

Divisional Secretariat Division	Animal						Daily Production		
	Milk Cows	Buffalos	Goats	Pigs	Poultry	Ducks	Milk (litre)	Curd	Eggs
Vanathavillu	5,144	492	3,209	544	50,662	25	729	273	5,185
Puttalam	1,724	77	1,598	803	10,927	277	778	106	2,647
Mundel	6,669	416	2,011	2,029	40,455	125	1,382	50	12,537
Kalpitiya	3,391	63	3,629	1,353	14,489	50	114	-	5,426

Figure 71. Poultry farming in Seguwantivu
(© Sriyanie Miththapala)

IUCN and ADB (2003) report that that most of the land used previously for grazing cattle has now been converted into salt pans and shrimp farms and hence, there is little large animal husbandry in the area at present.

Salt Production

At present there are 1,363 ha of salterns in the Puttalam Lagoon area (Weragodatenna, 2010; See Figure 69). During the 1990's, there was only one saltern close to Puttalam town, but currently there are many large-scale salterns in the area. Like shrimp farming, salterns provide casual employment. A family engaged in the industry can earn LKR 3,000-5,000 (~26.4-44 USD) per month from a 0.135 ha salt pan (Fernando, 2010).

In 1997, Dayaratne et al. reported that over 7,000 people were employed during the salt harvesting season, and that another 300 more were engaged to pack the salt.

Figure 72. Workers in a saltern in the Lagoon area
(© Dilup Chandranimal)

Other Industries

Cement Industry

Holcim Lanka Limited operates a cement manufacturing plant in the Puttalam district. This plant was established in 1967 as a government plant and but was sold in 1996 to the Holcim Group. This plant has over 650 staff, an installed capacity of 560,000 tons annually and produces approximately 520,000 tons of cement annually.

The quarry from which the limestone is extracted is located about 20 km distant from the factory. Limestone is extracted by blasting and the use of heavy earth-moving equipment. The company owns a dedicated railway line that transports limestone from the quarry to the plant.

Nuraicholai Coal Power Plant

A thermal coal-fired power plant, with infrastructure for 900 MW has been constructed in Narakaliya, 2 km from the coastal Nuraiocholai village, in the Kalpitiya peninsula. The plant which has a total allocated area of 250 ha, is currently operating at 300 MW of electricity.

The power plant was constructed to meet shortfalls of electricity generation from hydropower, outside the monsoon season.

To date the coal power plant has provided less employment opportunities to the area and the country than its designed capacity. The Nuraiocholai power plant is reported to employ 200 Ceylon Electricity Board personnel and 30 staff from a Chinese contractor (Anon. person. comm.).

Wind Power Plants

The Sri Lankan Board of Investment approved grants of up to 68 million USD to four companies for two wind farms in Puttalam.

Two joint venture companies have been formed: Seguwantivu Wind Power (Pvt.) Ltd and Vidatamuani Wind Power (Pvt.) Ltd with the Akbar Group, Hirdramani, E-bug Computers and Star Packaging as shareholders. These wind farms are expected to generate 10 MW of electricity, and are being sited in Mampuri and Mullipurama. The generated power will be transmitted to the national grid via a transmission line connecting to the Puttalam Grid Sub-station at Kalladi.

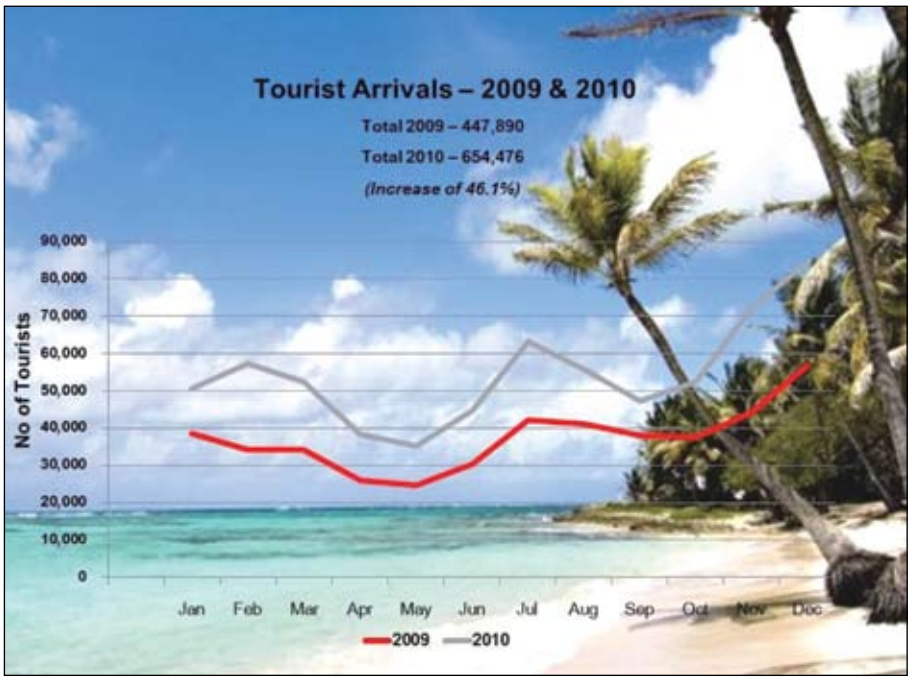
Another plant is proposed at Uppudaluwa, Kalpitiya.

Five hectares have been allocated per 20 MW, and it is expected that 10 people will be given employed per 10 MW of electricity generated (Chamila Jayasekera, person. comm.).

Tourism

For decades during the civil war, the tourist industry struggled. However, since the civil war in Sri Lanka ended, there has been a robust growth in the number of tourists: from 447,890 in 2008 and 438,475 in 2009, the number for 2010 increased dramatically to 654,476 (i.e., a 46% increase).

Figure 73. Tourist arrivals to Sri Lanka 2009 and 2010
(Source: S. Miththapala, person. comm.)



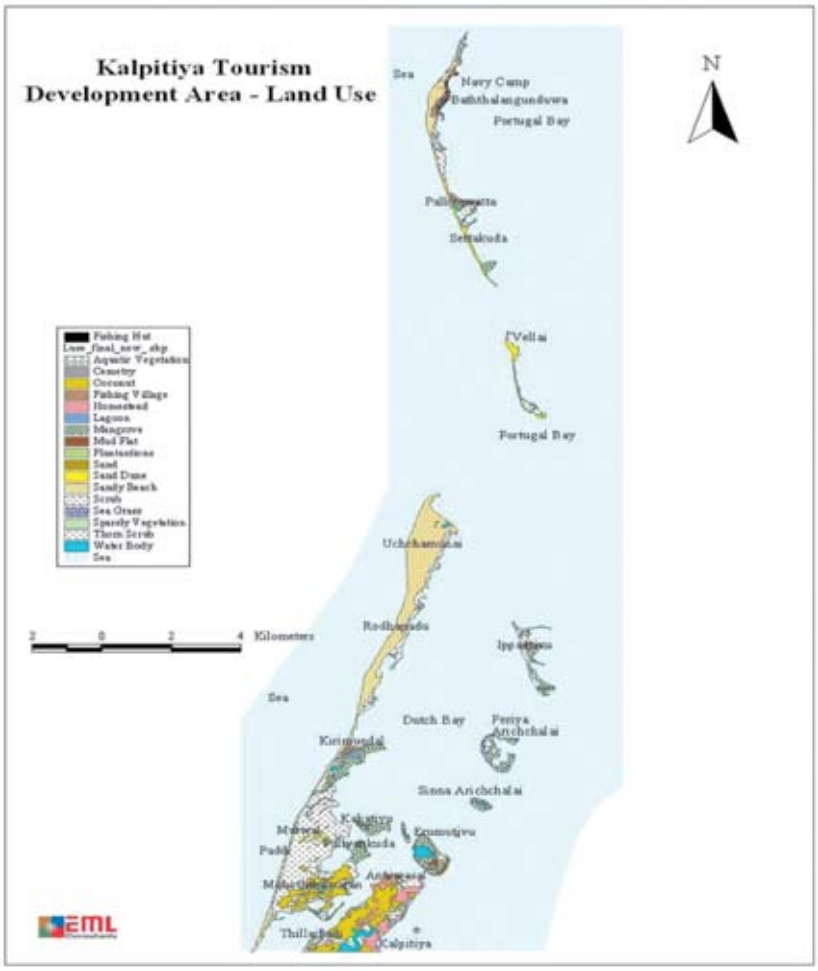
Kalpitiya has been identified by the tourism sector as one of several new areas that will 'mobilise the development of a strategic tourism development zone' (Tourism Private Sector, 2010). It is a mere two hours' drive from the capital with easily accessible beaches, and a range of terrestrial and coastal natural habitats. Five thousand new rooms are planned in Kalpitiya. Large-scale resort developments, designed with environmentally-sound and sustainable practices (for example, self-contained sewerage disposal facilities with recycling of water, solar lighting for resort public areas, no-build green belts within resorts), are planned (Tourism Private Sector, 2010).

The Kalpitiya Dutch Bay Resort Development Project has commenced under the auspices of the Sri Lanka Tourism Development Authority (http://www.sltda.gov.lk/kalpitiya).

This development will create significant employment opportunities. It is estimated that 25,000 jobs will be created and there also will be indirect employment for another 10,000 people.

Currently, seasonal dolphin watching from the Kalpitiya peninsula is popular.

Figure 74. Proposed Kalpitiya tourist development area
(Source: EML, 2008)



Other small-scale industries

A considerable number of SMEs (small-scale industries/enterprises) are found in the area.

Table 40. Small-scale industries in the area
(Source: Census and Statistics Division, Puttalam, 2009)

Divisional Secretariat Division	Small-scale Industries								
	Shops	Food Processing	Garments	Timber and Furniture	Paper Production and Printing	Chemical Mineral, Rubber and Plastic	Non Metal	Metal Equipment	Other
Vanathavillu	12	8	-	-	-	-	-	-	-
Puttalam	1,682	127	16	115	25	26	10	25	134
Mundel	571	-	19	14	1	3	4	3	48
Kalpitiya	423	4	1	12	-	-	-	-	-

Chapter 9. The main issues and threats affecting the Puttalam Lagoon

There are many issues and threats affecting the Puttalam Lagoon. They are presented below, grouped under main topics. (Most of this chapter is extracted directly from IUCN 2010c.)

Direct Threats

Habitat destruction

Habitat destruction is by far the biggest threat affecting the Lagoon Area.

Destruction of Mangroves

Vast areas of mangroves and salt marsh habitats continue to be cleared for unplanned development activities such as salterns, shrimp farms, coconut cultivation and temporary human settlements.

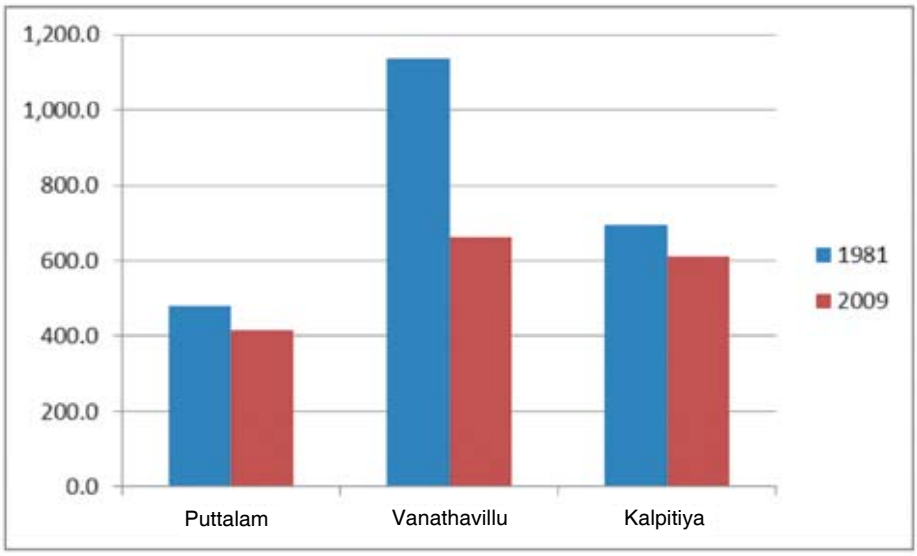
Figure 75. Destruction of mangroves near Anakutti
(© Sriyanie Miththapala)

Mangroves serve as nurseries for commercially important aquatic species including fish and shrimps. Removal of mangroves destroys these nurseries, resulting in decreased harvest.

According to data from the Census and Statistics Division, Puttalam (2010) in 1981, there was a total of 2,309.8 ha in the Puttalam, Vanathavillu and Kalpitiya DS divisions. By 2009, the extent had shrunk to 1,691.7 ha, representing a loss, between 1981 and 2009, of 618.2 ha or 26.8%.

Figure 76. Extent of mangrove destruction in divisional secretariat divisions

(Source: Census and Statistics Division, Puttalam, 2009)



Once mangroves are cleared, the coast is made vulnerable to erosion, while coral reefs and seagrass meadows become vulnerable to sedimentation. The land that is adapted to the ebb and flow of the tide is now flooded permanently, and this damages the soil.

Perhaps most importantly for the life of the Lagoon, mangroves balance freshwater inflow into the Lagoon. The salinity of the brackish water of the Lagoon is maintained by the mangroves that fringe the Lagoon. When these mangroves are destroyed, the influx of freshwater changes, and species composition in the Lagoon will change, affecting both commercial and subsistence fish harvests.

Mangroves are cleared for commercial shrimp farming. At present, it has been estimated that approximately as much as 75% of shrimp farms are not in operation. Repeated disease outbreaks, uncontrolled expansion exceeding carrying capacity, and deterioration of water quality have affected shrimp farming in Sri Lanka (Siriwardena, 2001). Out of existing the shrimp farms in Puttalam Lagoon area, the majority are small-scale, illegal farms, 60% of which are less than 0.8ha (Pathirana et al., 2008).

Mangrove clearance for shrimp farming is heavy in Anaikutti, Kuringipitti, Seguwantivu and Thirikapallama (Dilhari Weragodatenna, person. comm).

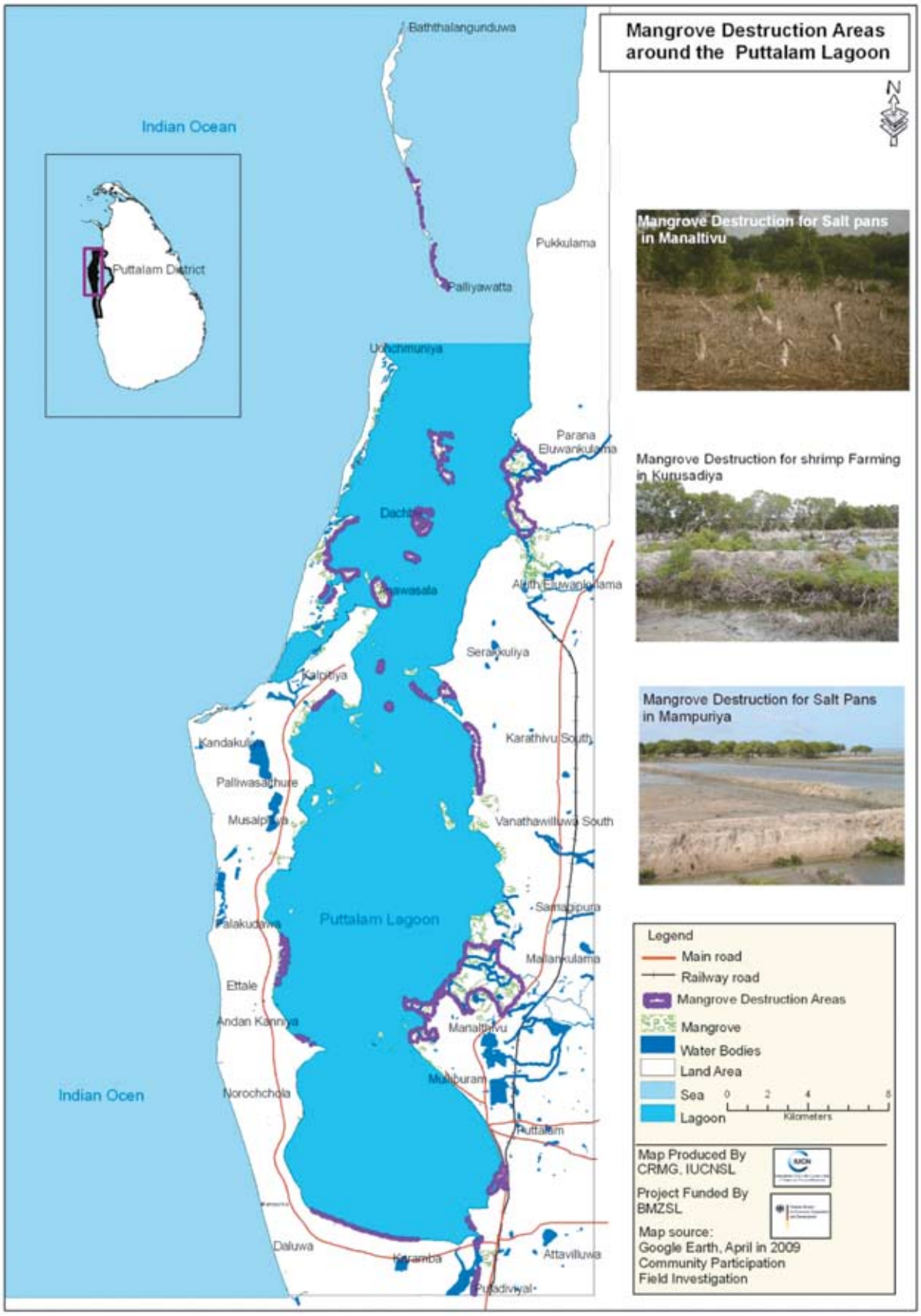
Although the rapid expansion of shrimp farms has now decreased, the expansion of salterns has increased. Mangroves are now clear-felled for the establishment of salterns.

Heavy clearance of mangroves for salterns has been observed in Anaikutti, Kalladi, Seguwantivu and Serakkuliya ((Dilhari Weragodatenna, person. comm.).

Figure 77. Clear-felling mangroves in the Puttalam Lagoon area
(© Dilup Chandranimal)

Destruction of mangroves is heavy on the eastern coast of the Lagoon in Anaikutti, Kalladi, Kuringipitti, Seguwantivu, Thirikapallama and Manalthivu, and heaviest in Anaikutti (Fernando, 2010; Dilhari Weragodatenna, person. comm.). (See Figure 76.)

Figure 78. Mangrove destruction around the Lagoon
(Source: Weragodatenna, 2010)



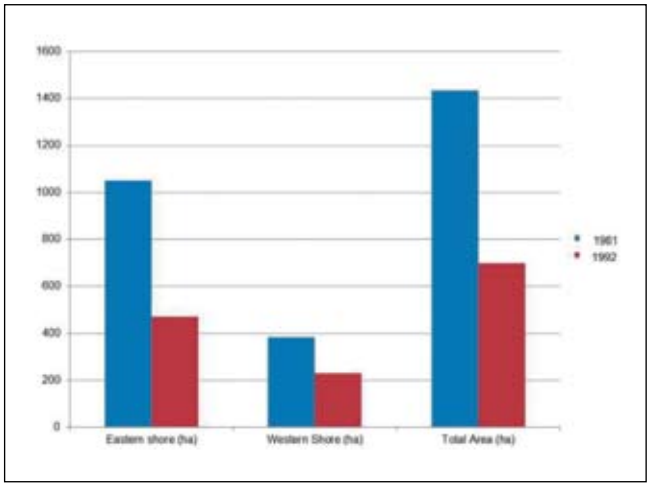
Destruction of Salt Marshes

Salt marsh habitats are cleared for unplanned development activities, such as for shrimp farming and saltern expansion.

Salt marsh habitats are also reclaimed for agricultural expansion. This has led to the degradation of the remaining salt marshes, as a consequence of the interruption of daily flooding by brackish water, which is essential to maintain these habitats. Restriction of the diurnal tidal flow results in a reduction in salinity, which can cause major changes in the composition of salt marsh vegetation, wetland chemistry and other wetland processes. A common symptom of lowered salinity is the invasion of weedy species (IUCN, 2010).

Figure 79. Extent of salt marsh destruction in Puttalam Lagoon 1980-1992

(Source: Pathirana et al., 2008)



Salt marsh habitats are also reclaimed for housing (IUCN, 2010). Illegal encroachment – both by internally displaced persons and residents – is also affecting habitats, contributing to their degradation (Ranasinghe, 2010).

Sometimes, infrastructure and housing is built both illegally, but also far too close to the water line, which worsens beach erosion and also makes the areas extremely vulnerable to extreme weather events.

Figure 80. Illegal construction far too close to the water line

(© IUCN)

Destruction of Mudflats

Mudflats are also affected by habitat degradation. (See the following section.)

Destruction of Barrier Beaches, Spits and Sand Dunes

The area from Puttalam town to Eluvankulam is now becoming more populated and land is being converted more and more for human settlements and agriculture. Many locals are selling their properties at high prices to large-scale investors and are settling on government or reserved land around the Lagoon.

In comparison to other tourism destinations the Kalpitiya peninsula and its islands do not have the required basic infrastructure facilities for tourism. There will be a huge demand created for improved infrastructure, services, communications and safety, as tourism expands. This will increase income and the social status of communities and could serve to provide protection for natural habitats, which tourists will want to visit.

The corollary of this argument is that once investors move in to develop the area, there is an imminent threat of user conflicts, large-scale habitat destruction to accommodate tourists, over-exploitation of natural resources and lack of attention to the visitor carrying capacity for these habitats. Experiences in Hikkaduwa (in the southwest) and Arugam Bay (in the east) have shown that user conflicts and damage to the environment can ensue when short-term gains are prioritised before long-term sustainability.

Sand dunes and beach vegetation are being levelled and cleared for the construction of tourism infrastructure. This is on-going in Kalpitiya (Sanjeewa Lellwala, person. comm.).

It is ironic that the advent of peace in the island is posing so many threats to the natural environment in the Puttalam Lagoon area.

Destruction of Seagrass meadows

Seagrass meadows are affected by habitat degradation and the use of illegal fishing gear. (See later sections on habitat degradation and over-exploitation for details.)

Destruction of Coraf Reefs

Coral reefs were affected by coral bleaching in 1998 and the Indian Ocean tsunami of 2004 (Tamlander and Rajasuriya, 2008). These rich habitats are also seriously affected by habitat degradation and the use of illegal fishing gear. (See later sections on habitat degradation and over-exploitation for details.)

Destruction of Tropical Mixed Evergreen Forests

Quarrying for limestone denudes habitats. In Arawakkalu, limestone quarrying has devastated large tracts of tropical dry mixed evergreen forests.

On the eastern side of the Lagoon, tropical mixed evergreen forests have been clear-felled for the cultivation of coconut (seen in Kalladi), and other crops (Sanjeewa Lellwala, person. comm.).

Figure 81. Coconut cultivation on the eastern shore of Puttalam Lagoon
(© Sriyanie Miththapala)

Destruction of Tropical Thorn forests

Tropical thorn forests are being reclaimed for shrimp farming and saltern expansion. On the eastern shore of the Lagoon, these habitats are being clear-felled for cultivation of coconut (seen in Kalladi), and other crops (Sanjeewa Lellwala, person. comm.).

Habitat degradation

Apart from the threat of habitat destruction from various human activities, the Lagoon and its surrounds are under considerable threat from habitat degradation.

The Puttalam Lagoon is hyper-saline at the south, and it is predicted that this hyper-salinity will spread; causing considerable changes in the fish communities of the Lagoon, and ultimately affecting livelihoods.

Mundel Lake has already become hyper-saline and nearly fishless as evidenced by the reduction in the number of boats in the lake from 1997 to 2011 (Table 29). The southern part of the Lagoon is hyper-saline – around 45-50 ppt[58], in comparison to sea water which is 30 ppt (NARA, 1995). The average annual salinity level of the Puttalam Lagoon has increased by 25 % (36.4 ppt to 46 ppt) within the last thirty years (Arulanathan, 1992).

Seagrass meadows and coral reefs are particularly under threat from various sources of chemical pollution and sedimentation.

Seagrasses and coral reefs are particularly susceptible to pollution. Runoff from inland waters, carrying high levels of nitrogen and phosphorus from fertilisers, and nimal and domestic waste, increases the mineral content of coastal waters, which can result in massive algal blooms. Dense algae populations make the water green and prevent light and oxygen from reaching the waters below the surface. The ecosystem balance is destroyed by this process - which is called eutrophication. When algal blooms suddenly die off, oxygen deficits which kill fish can occur as the algae decomposes. Seagrass meadows and coral reefs are extremely susceptible to eutrophication (http://www.sms.si.edu/IRLspec/Seagrass_Habitat.htm).

Another major and common threat to seagrass meadows and coral reefs is the deterioration of water clarity through sediment loading. Because both seagrass meadows and zooxanthellae symbiont on corals are dependent on sunlight for photosynthesis, water clarity and quality are important for the health of this ecosystem. When there is excessive sedimentation and the turbidity of the water increases, then seagrass meadows are affected. When there is too much sediment, seagrasses can become smothered (Short & Short, 1984).

[58] Parts per thousand.

Habitat degradation through pollution from effluent discharge from shrimp farms

The productivity of the Lagoon is being choked slowly by pollution that originates from shrimp farms and agricultural cultivation.

In addition to destroying natural habitats, shrimp farms discharge polluting effluents, rich in both nutrients and sediments, into the environment. Shrimp farms take in water from, and discharge effluents to, the same water source. In order to grow as much shrimp as possible, shrimp farmers add artificial feeds with chemical additives (including chlorine) and insecticides (such as malathion and parathion – which persist in the environment), as well as antibiotics to prevent shrimp disease. Most shrimp farms have no effective effluent treatment procedures and discharge their usually untreated effluent into surrounding land and/or downstream waterways. This negatively impacts on water quality and aquatic life, upon which many poorer households in particular, depend for wild fish catch, nutrition and income.

Shrimp farms release effluents with high suspended solids (200-600 mg/l) and high BOD[59] levels (60-180 mg/l) (Dayaratne et al., 1997). Suspended solids in water can obstruct respiration of aquatic organisms and smother eggs of aquatic fish species. In addition, suspended solids become deposited as silt and heavy siltation has already been observed in the Dutch Canal. Apart from turbidity, high sulphide, nitrite and ammonia levels have been recorded.

Table 41. Pond water quality analysis
(Source: Senerath, 1998)

	units	Farm 1	Farm 2	Farm 3	Acceptable range
Turbidity	Nephelometric Turbidity Units	16-36	-	-	0-150
Total suspended solids	mg/L	**30-59**	**34-75**	-	2-14
Dissolved oxygen	mg/L	5.7-10.5	-	5.9-6.3	3-12
Salinity	ppt	11-28	-	-	10-35
pH		8.2-8.6	-	-	7.5-8.7
Nitrate	mg/L	-	0.43-0.69	0.03-0.36	0-200
Nitrite	mg/L	0.01-0.17	**0.03-0.47**	0.005-0.014	<0.25
NH_4	mg/L	-	**0.25-0.62**	0.05-0.058	<0.25
H_2S	mg/L	0.17-0.19	**0.28-0.80**	-	<0.25
PO_4	mg/L	-	**0.36-0.72**	0.017-0.031	-
BOD_5	mg/L	5.2-**14.6**	**-**	3.9-4.3	<10

Acid sulphate and potentially acidic sulphate soils have been recorded in and around the southern part of the Puttalam Lagoon, in Vanathavillu and in Seguwantivu in particular. Potentially acidic sulphate soils contain pyrites (iron sulphide) in deep layers which are exposed during pond construction. These pyrites oxidize on exposure to air, and form hydroxides on the gills of fish and crustaceans, causing harm to their respiration (IUCN and CEA, 1996).

The concentration of dissolved iron, aluminium and manganese is very high in the water as a result of pond construction. These levels are unfavourable to aquatic organisms.

A survey carried out by ADB and NARA in 1995 revealed that Dolomite, lime, tea seed cake and chlorine were used during culture by aquaculture farms, and these negatively impact on water quality of the area. In particular, these compounds increase pH, and eliminate fish predators, upsetting the natural balance of the lagoon ecosystem.

[59] Biological Oxygen Demand

In concert, these effluents have increased the pH of the water. The pH values were acidic (4.8-6) in 1983, and in 1994, had increased to 8-8.8 (basic). Many surveys carried out during this same period have revealed that there has been a gradual increase of ammonia concentration in coastal areas around the Puttalam Lagoon, particularly in the southern part, making the water basic. This increase in ammonia is a direct result of activities of shrimp farms.

Scientists believe that these high levels of nutrients are the cause of eutrophication resulting in substantial fish deaths in the Dutch Canal (Corea et al., 1995 in litt. Dayaratne et al., 1997). Part of the Mi Oya Lagoon is covered by algal blooms during the dry seasons. All the canals drain to the Lagoon are becoming eutrophic, overly-nitrified, and de-oxygenated.

Seagrass meadows and coral reefs are particularly susceptible to pollution (See box above). There are likely to be species also that cannot tolerate changes in environmental quality, and in the long term, this will result in decreased fish production.

Habitat degradation through pollution from chemical discharge from cultivated areas

The Lagoon is fed by three rivers: Kala Oya, Mi Oya and Moongil Ara. Land around these fresh water sources has been cultivated and intensive crop cultivation such as paddy, coconut, vegetables and fruit can be seen in these regions, as well as around the Lagoon. Agro-chemicals and chemical fertilisers are heavily used to produce high crop yields. The chemicals, nutrients and soil from the agricultural fields wash into the Lagoon, poisoning the water and causing sedimentation.

Studies have shown that there is a high level of nitrate pollution in the ground water of Kalpitiya. In the 225 drinking wells tested, they found 31% of the wells had nitrate concentrations between 50-100 mg per litre and in 17.4% of the wells, very high concentrations of nitrates ranging from 101-300 mg per litre. Examination of the cultivated vegetables showed that they too contained high concentrations of nitrates ranging from 2.79-3.25 g per kilogram. The high concentrations of nitrates can result in the development of toxic Methemoglobinaemia[60] in human beings (Fernando, 2010).

Chemical pollution of the Lagoon can be observed around Thirikkapallama (Dilhari Weragodatenna, personal communication).

Chemical pollution adversely affects mudflats, in turn, degrading the winter feeding grounds of many migrant birds.

Seagrasses and coral reefs are negatively impacted and damaged through chemical pollution, as are fish and shellfish species, although there are no detailed data on such species.

Habitat degradation and pollution from Coal Power Plant water discharge

There are serious concerns that hot water discharged from the coal power plant will damage and destroy marine organisms. However no data is currently available to assess the likely impacts.

[60] This is a disorder characterised by the presence of a higher than normal level of methemoglobin in the blood. Methemoglobin is a form of hemoglobin that does not bind oxygen. When its concentration is elevated in red blood cells, tissues are deprived of oxygen.

Habitat degradation through solid waste pollution

Solid waste pollution is another unsightly and unhealthy issue affecting the Lagoon area. The municipalities of Puttalam, Kalpitiya and Karativu collect garbage daily, but dump the waste in open areas around the Lagoon. For example, there is a small settlement called Thora Adi Odai three kilometres north of Kalpitiya town that is currently covered fully with garbage (Fernando, 2010). In addition, damaged fishing nets, old boats, plastic and non-biodegradable waste have also been dumped near the Lagoon, posing both environmental and health hazards (Ranasinghe, 2010). In fact, plastic bags stuck on the pencil roots of *Avicennia marina* are a common sight *en route* to Kalpitiya.

The canals in and around Puttalam town were clogged with sludge and solid waste debris, until the IUCN under the aegis of the BMZ project, undertook to have the main canal cleaned.

Figure 82. Irresponsible solid waste disposal dumping near the Lagoon
(Dilhari Weragodatenna © IUCN)

Habitat degradation resulting from erosion and sedimentation of the Puttalam Lagoon

Satellite images and community consultations have revealed that some areas of the Lagoon are diminishing as a result of sedimentation. (See Figure 36.) This phenomenon could be as a result of natural changes or because of human-induced changes. The following map shows clearly that the area near the Lagoon mouth has potential for sedimentation. This has serious implications for the long-term viability of the Lagoon. If the mouth closes, then commercially important species that move between the sea and the Lagoon for breeding/feeding will be prevented from doing so, and their reproductive success will decrease. In addition, the salinity within the Lagoon will change and the species composition of both flora and fauna of the Lagoon will also be affected (IUCN, 2010).

Erosion is common adjacent to shrimp farms, as a result of the practices (that bring water in and out of ponds) employed by shrimp farmers (Sanjeewa Lellwala, person. comm.). Sites at Kalpitiya, Kusalpitiya, Ettalai, Seguwantivu and Vanathavillu have high sedimentation. Most of the aquaculture ponds around the Lagoon do not have a proper dike gradient to minimise erosion. Ponds dikes are not maintained or repaired regularly. Erosion of dikes contributes to the siltation of mangrove areas, seagrass meadows and other habitats, negatively impacting on the nursery grounds of brackish water finfish and shellfish.

When shrimp culture ponds are cleaned, the effluent is released into adjacent areas without proper treatment. These sediments have gradually drained into the Lagoon system. Cultivated areas are also vulnerable to soil erosion, because farmers to not practise soil conservation methods (Ranasinghe, 2010).

It is feared the extensive water usage from the Coal Power Plant may also cause coastal erosion and instability of the area.

All natural habitats will be affected, if the water-land boundaries of the Lagoon change as a result of land accretion.

Deterioration of the aesthetic quality of the environment is another consequence of habitat degradation.

Habitat degradation from air pollution

According to the published data and information, the emission levels of the area are 1,750 tons/year for NO_x, 7,650 tons/year for SO_2 and 85,000 tons/year for particulate matter. Although the Holcim cement factory emits more than 90% of sulphur dioxide and particulate matter and almost 80 % of nitrogen, recent studies show that air pollution levels are well below the national standard level beyond 5 km radius from the plant (SO_2=74 µg/m^3; NO_2=85 µg/m^3; SPM=189 µg/m^3; CO=3.6 µg/m^3) (EML, 2008).

There are however great concerns about the Coal Power Plant: environmentalists warn that emissions of sulphur dioxide could contribute to the formation of acid rain which will harm local agriculture; and emissions of carbon dioxide and carbon monoxide will contribute to global warming; coal dust from the station may also cause respiratory diseases to residents living in the vicinity.

Over-exploitation of natural resources

Over-exploitation of fisheries resources

Harvest data are available for the Lagoon: the fisheries catch for the Lagoon for 2010 is 8,512 metric tonnes and the entire catch for the District (marine, coastal and lagoon) is estimated to be 20,010 metric tonnes for 2009 (Department of Fisheries, Puttalam, 2010, Statistical Abstract, 2010).

Lagoon fisheries are already at 1.5 times MSY. (See the section on Fish Production.)

Sanders and Jayasinghe (2009 in litt. CENARA 2010) assessing trawl data between October 2008 and October 2009, state that the shrimp stocks in the Lagoon and associated coastal area are exploited heavily and have been for several years. Because it is reported that the level of exploitation has been more or less constant, the authors assumes that the fishery is ‘at or around’ the MSY point (Sanders and Jayasinghe, 2009 in litt. CENARA 2010). The mean catch per effort for shrimp over the 12 months from October 2008 was 15.79 kg/haul with the total biomass about 3.64 tonnes (Sanders and Jayasinghe, 2009 in litt. CENARA 2010). CENARA (2010) notes that there is over-fishing by an increased number of trawlers.

Data for ornamental species reveals a decline in abundance (Figure 59) and the sea cucumber fishery has been deemed unsustainable (Long et al., 2010). Data are urgently needed for other harvested species.

It is clearly evident that fishing practices are not being monitored nor regulated sufficiently. The increase in the number of fishers in the Lagoon (through natural population increase and migration) has added further pressure on the limited fisheries resources.

Fishing times, durations, seasons and species fished are not regulated. This means that the life cycles of certain species may not be completed before they are harvested again.

Further, many different types of illegal fishing gear are used in the Lagoon. These gears are illegal because they damage the environment or increase unsustainable harvest e.g. by the taking of juvenile fish. Common illegal nets include drag nets; trammel nets (*yaka dela*), push nets, and pull nets, *sangili* nets, purse seine nets, moxy nets and *thungus* nets. Drag nets, push nets and pull nets damage demersal and benthic organisms; while moxy nets damage coral reefs. *Sangili* nets, purse seine nets and *thungus* nets are all small-meshed, and catch not only target species, but catch juveniles as well.

Push nets are common in Kuringipitti (IUCN, 2008); *thungus* nets in Kalladi and Tillamotai; trammel and drags nets are used all around the Lagoon (Dilhari Weragodatenna, personal communication).

Some illegal fishing gear damage seagrasses and coral reefs.

The Department of Fisheries is currently focusing on reducing the use of illegal nets in the Lagoon.

Figure 83. Illegal push net used for Lagoon fishing
(© Dilup Chandranimal)

Figure 84. Fisher with an illegal thungus net in Sothupitiya
(© Sriyanie Miththapala)

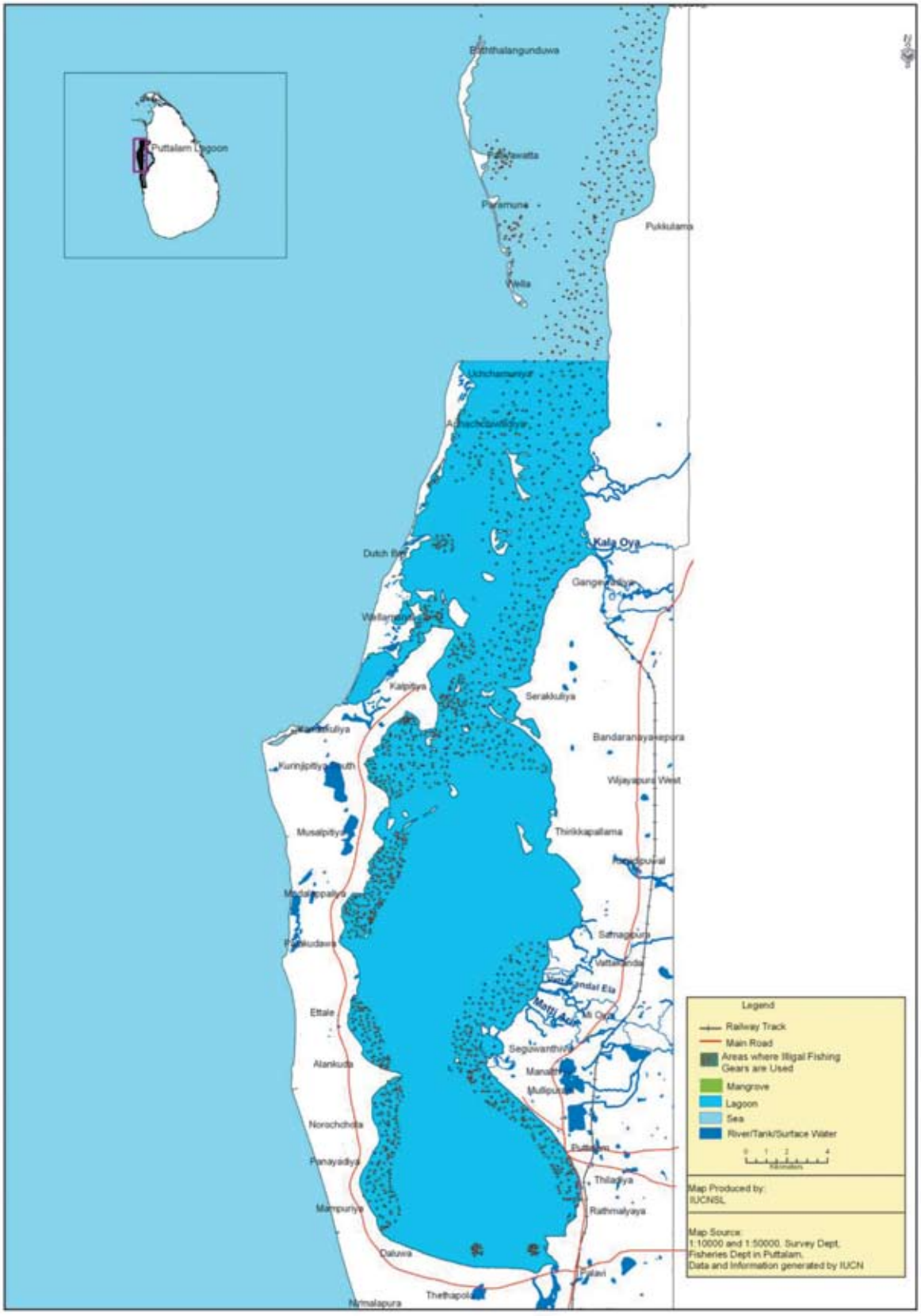
Over-exploitation through waste by-catch

Another form of over-exploitation is waste from by-catch. Many lagoon fishers target specific species, such as shrimps. When they catch juvenile sizes of other commercially valuable species (such as under-sized mud crabs), they discard these on the shore while the species are still alive, instead of releasing them back into the Lagoon.

According to information gathered by villagers and observations made on discarded specimens, a significant number of sea snakes, turtles and dolphins that visit the coastal waters of this area are killed each year as by-catch in fishing gear (IUCN, 2010).

Figure 85. Discarded catch – including under-sized Mud and Blue Sea Crabs – in Gangewadiya
(© Sriyanie Miththapala)

Figure 86. Prevalence of the use of illegal fishing gear
(Source: Weragodatenna, 2010)



Increasing trends in exploitation of medicinal and ornamental species

Of the species caught for medicinal and ornamental purposes, sea-horses and molluscs are now exported commercially. Research is currently on-going to estimate the extent of this exploitation (IUCN, 2010).

Indications of poaching

Eighteen turtle carapaces were found during a six-month ecological assessment of the area, indicating that poaching of sea turtles is currently occurring in the Kalpitiya peninsula and the islands (IUCN, 2010).

Figure 87. Turtle carapace found in the Kalpitiya peninsula
(Naalin Perera © IUCN)

Over-exploitation of natural water sources

Apart from the destruction of natural habitats, chemical pollution of the Lagoon and erosion of adjacent areas, shrimp farming threatens the water resources of the area.

Aeration of ponds, increases evaporation and requires large quantities of water to top up pond water levels, which is extracted from the Lagoon.

Further, when pond water becomes too contaminated with chemicals and antibiotics, shrimp farmers sometimes tap into ground water sources to obtain fresh water. This has very severe negative consequences as it draws down aquifers and can result in saline intrusion.

'In an unconfined coastal aquifer, freshwater typically sits on top of a layer of brackish or saline water; moving inland the boundary between these layers gets progressively deeper. This fresh groundwater has a variety of competing uses: water for drinking, cooking or bathing in coastal villages; supports deeper rooted trees; water for irrigation or, mixed with saltwater, for replenishing shrimp ponds. Unfortunately, if extraction rates of freshwater exceed recharge in an unconfined aquifer, saltwater can intrude. At the coast, where the freshwater layer is thinnest, the aquifer is particularly vulnerable.'

Aeron-Thomas, undated.

In Chilaw, it is reported that freshwater had to be delivered to villagers in coastal areas by bowsers because of contamination of the aquifer by shrimp farms (Aeron-Thomas, undated).

Given that the Lagoon lies in the dry zone, where it is hot and dry most of the time, farmers also use water intensively. It has been reported that ground water is over-used for vegetable cultivation in Kalpitiya (Fernando, 2010).

Over-extraction of water damages sand dunes and beaches.

Fresh water sources are likely to be stressed further by the intense tourism focus in Kalpitiya, unless controls are established.

Figure 88. Water being pumped from the Lagoon to top up shrimp pond water levels
(© Dilup Chandranimal)

Invasive alien species

Invasive Alien Species are introduced species that do not stay confined to the area into which they were introduced, which compete vigorously with native species, become established in natural ecosystems, threaten native species and have the potential to eradicate them. When they displace native species and disrupt ecosystem interactions, they damage ecosystem services and can cause severe economic damage (IUCN, 2000).

At present many scrublands have been modified as a result of invasion of *Chromolaena odoratum*, Prickly Pear (*Opuntia stricta) Lantana camara* and Mesquite (*Prosopis juliflora)*. Although this spread is not currently extensive, it is likely to become a major ecological issue, if proper management measures are not taken to control, eradicate or manage these species.

Salvinia, Water Lettuce (*Pistia)* and *Typha* are known aquatic invasives that are found in the Lagoon.

Invasive alien species are serious threats in any habitat.

Climate change

Recent studies indicate Kalpitiya and Mundel, both in the Puttalam District, show high levels of vulnerability due to climate change. It is known that sea level rise will affect water tables. This will have worse impacts in regosoils. Much of the Kalpitiya peninsula comprises

regosols. The likely sea water intrusion into freshwater aquifers will have profound impacts on agriculture (Punyawardana 2007 in Athulathmudali et al., 2010).

Annual mean air temperature anomalies have shown significant increasing trends during the recent decades in Sri Lanka (Survey Dept. 2007). The rate of increase of mean air temperature for the 1961-1990 period is of the order of 0.016^0C per year (Survey Dept., 2007). Annual mean maximum air temperatures have shown increasing trends at almost all stations with the maximum rate of increase about 0.021^0C per year in Puttalam.

Rainfall patterns are also changing as a consequence of climate change (Survey Dept., 2007). Increase or decreases in rainfall quantities and patterns across the Puttalam area will alter the salinity of the Lagoon, and will have far-reaching consequences for aquatic food webs.

Damage to the aesthetic beauty of the area

The intense thrust for development and investment in the Puttalam Lagoon area is changing the scenic beauty of the area. Wind farms, salterns, the coal power plant and shrimp farms have all altered the scenic vista of the area.

Indirect threats

Underlying the above mentioned direct threats to the Lagoon, there are also indirect drivers of biodiversity loss that include demographic, economic and socio-political issues (Millennium Ecosystem Assessment, 2005).

Socio-economic and demographic issues

Poverty and unemployment are high in the Lagoon area. It was estimated that 16,864 households in Puttalam, 36,197 in Kalpitiya and 6,373 in Vanathavillu respectively live below the poverty line[61] (Department of Census and Statistics, 2009). The unemployment rate in the Puttalam district is 15.2% (Department of Census and Statistics, 2008). Based on the Millennium Development Goals (MDG) indicators for 2008, 48.8% of the population consumed less than the minimum level of dietary energy consumption in 2006/07 (Department of Census and Statistics, 2008 – MDG).

According to the Internal Displacement Monitoring Centre, there are approximately 66,200 internally displaced persons in Puttalam Lagoon area, accounting for almost 10% of the total population of the District (www.internal-displacement.org/). Even though these people have been settled in the region for over a decade, they are still considered migrants and most still live in temporary settlements. The inequity of the government support given to these communities, causes conflict between them and resident communities.

However, many of these migrants are now moving back to the North and East, and these socio-economic issues may change in the near future.

There are also other residents who, for quick cash, have sold their land, and now live illegally on state land, sometimes on flood plains and eroded areas, which leave them vulnerable to the elements.

Lack of land tenure is therefore a major issue in the Lagoon area.

Among the Lagoon communities, many – such as the communities who live on the islands, the community at Gangewadiya and Seguwantivu – are marginalised by either distance

[61] The official poverty line at the national level for September 2011 is approximately Rupees 3,249 (30.7 USD) (minimum expenditure per person per month to fulfill basic needs) (Department of Census and Statistics, 2009).

(Gangewadiya and the island communities) or by ethnicity (Seguwantivu). The community in Gangewadiya lives in abject poverty, without basic needs such as water, health, sanitation facilities, electricity, transport etc.

Some communities – such as those living near the mouth of the Mi-Oya exist on insecure and illegal livelihoods, for example, by making and selling *kasippu*[62].

Lack of employment opportunities, child labour, child trafficking, poor participation of women in community development, marginalisation of some communities and disabled persons as well as a limited awareness about environmental and conservation issues are some of the serious social issues facing the Puttalam District (Ranasinghe, 2010).

Socio-political issues

Poor management mechanisms and approaches

Major impediments to conservation of the Lagoon and its surroundings are the complexities of jurisdictions and mandates of the institutions operating in the Lagoon area. No less than 15 national laws, overlaid with a constitutional amendment that devolves power to the provinces, are operational in this area. Each of these laws confers a different government organisation with a different – sometimes conflicting – mandate. This leaves implementing field officers unsure of their roles and responsibilities.

There is jurisdictional and functional overlap among some of these laws. For example, there are jurisdictional overlaps among the Coast Conservation Act, the Mines and Minerals Act, and the Urban Authority Law, causing delays in decision-making and incurring costs in terms of resources and time. Mangroves are protected under the Forest Ordinance, and by the Forest Department, but they are found in the coastal zone, which is under the jurisdiction of the Coast Conservation Department.

Although there are some management tools for locally-driven resource management – such as Fisheries Management Authorities under the Fisheries act – none of these laws empower or even include communities of the Puttalam Lagoon, with the result that they feel no ownership in the management of the Lagoon. Ultimately it is the communities who live in a particular landscape, who value it most and will invest the most effort, to conserve its services.

There is also inadequate integrated (cross-sectoral) planning and this leads to a lack of holistic management. Even though various coordinating bodies have been established and are mediated by the District Secretary, the approach still remains piecemeal. For example, lagoon management is often seen to be the responsibility of the Department of Fisheries, although there are a suite of players who must be involved. The tourism sector appears to be operating in isolation of any of the natural resource-based institutions (IUCN 2010b).

[62] Moonshine.

Key players of the Lagoon area
(not in order of immediate relevance)

- Civil Society
- Coast Conservation Department
- Communities
- District Secretariat
- Fisheries Ministry
- Forest Department
- Land use Planning
- National Water Supply and Drainage Board
- Northwestern Environmental Authority
- Private Sector
- Road Development Authority
- Tourism Authority
- Urban Development Authority
- Water Resources Board
- Wildlife Department

Currently, information is scattered and there are no mechanisms for sharing available information, with the result that decisions are not always made on the best available knowledge (IUCN, 2010b).

Institutional, policy and legal issues

The lack of an over-arching, integrated policy for the Lagoon is hampering conservation and sustainable management of natural resources. Lagoon management is seen as the responsibility of the Department of Fisheries and therefore, the policy focus is extremely narrow. A paradigm shift to an integrated policy is needed urgently.

A second lacuna in existing Lagoon policies is the lack of recognition of local communities as partners in conservation and sustainable management. Without this recognition, there can be no ownership. Without local ownership, conservation fails.

Although there are a suite of laws that govern the conservation of natural resources in the Lagoon area, enforcement of these laws is weak, as exemplified by the open and common use in the Lagoon of illegal fishing nets and gears.

Among institutions, there is a lack of capacity and resources for management. For example, mangrove forest areas in the Lagoon surrounds have not been demarcated because of the lack of both staff and funds. The fisheries district office has 17 staff members who have to cover 38 *Grama Niladhari* divisions, extending over large areas.

In addition, legal complexities and conflicts, as described in Chapter 5, further complicate enforcement.

Shown below is a timeline that reveals changes in activities in the Lagoon and its surrounds and the consequential impacts.

Figure 89. Changes in activities over time and consequences for the Puttalam Lagoon area
(Source: Kapila Gunarathne, person.comm.)

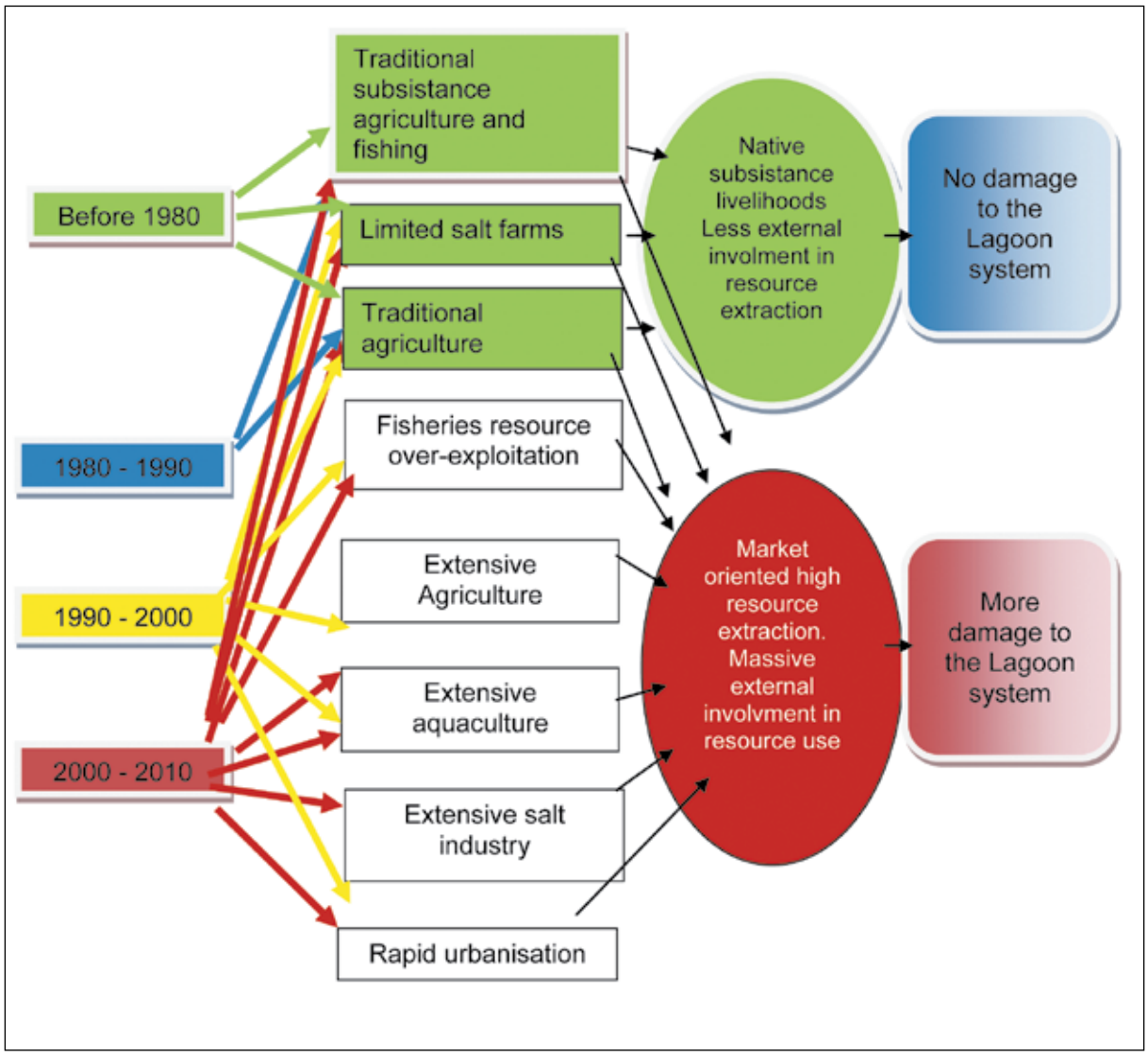


Figure 90. Impact of anthropogenic activities on the Lagoon area
(Source: Kapila Gunarathne, person.comm.)

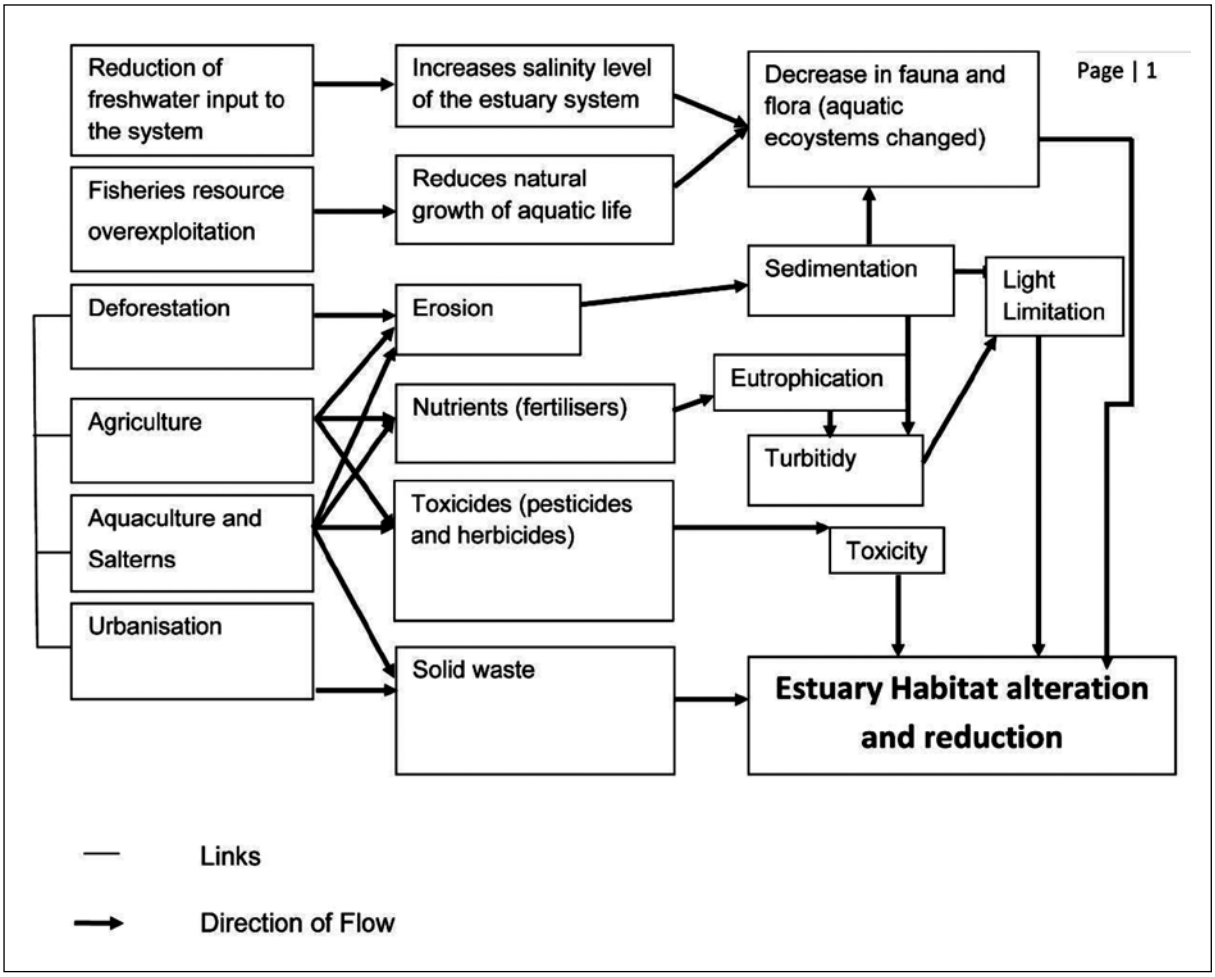
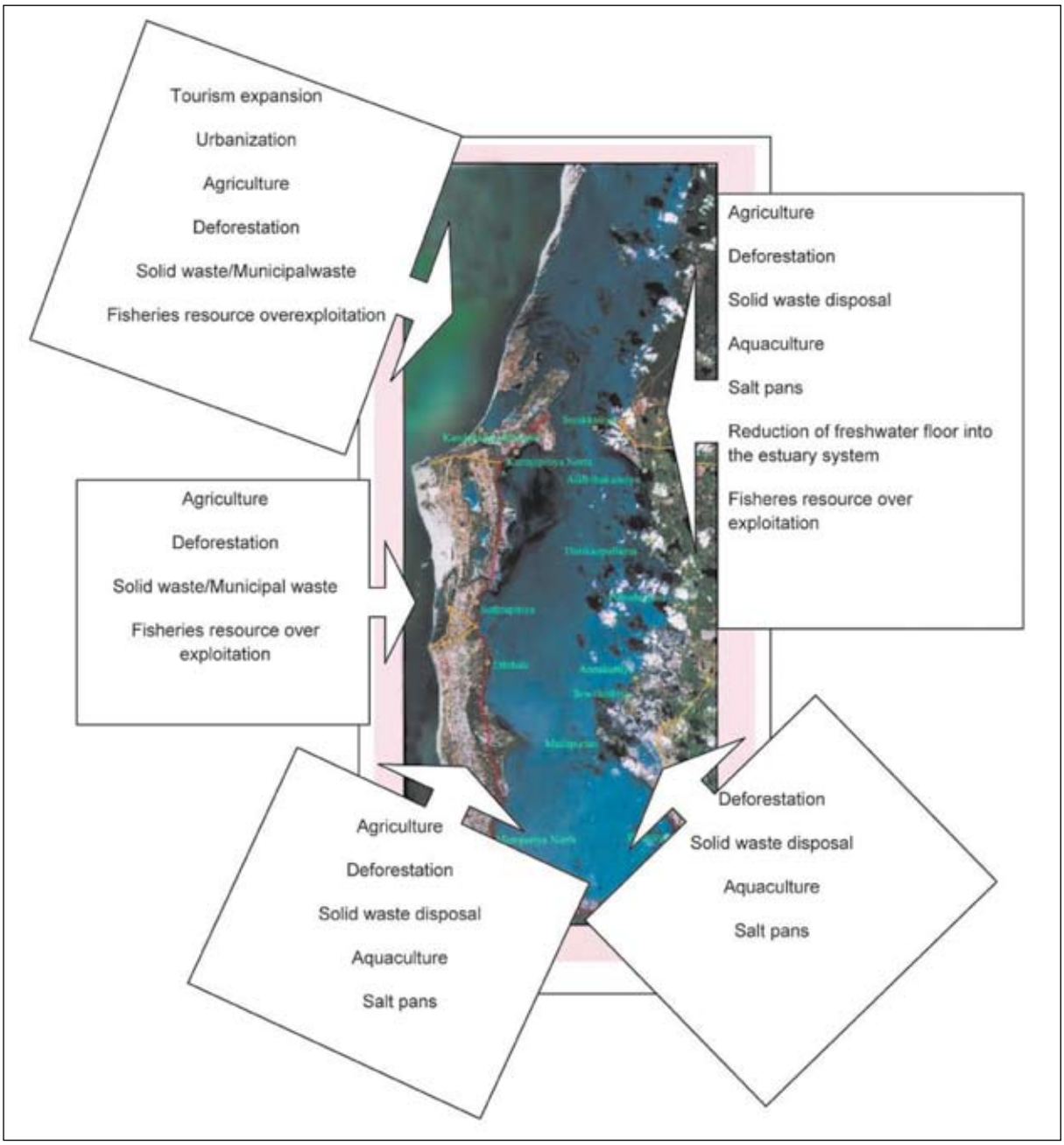


Figure 91. Spatial distribution of anthropogenic threats around the Puttalam Lagoon
(Source: Kapila Gunarathne, person.com • m.)



Chapter 10. Strategic actions for the Puttalam Lagoon – recommendations for the way forward

A range of strategic actions – from conservation and management; restoration; institutional strengthening; strengthening alternate livelihoods and knowledge creation, education and awareness – are proposed for the Puttalam Lagoon. These actions will address the threats described under Chapter 8, but are not necessarily sequential. (This chapter is extracted directly from IUCN, 2010c.)

Development of a Fisheries Management plan for the Lagoon

Currently, under the CENARA[63] project of NARA, fisheries management plans are being prepared for export species such as shrimp and chank. However, a more holistic view that recognises that fisheries cannot be managed in isolation and must be integrated into development planning and into local/ district, provincial and national policies is urgently needed.

As a part of the BMZ project, IUCN Sri Lanka commissioned a fisheries management Strategy for the Lagoon. The Strategy has identified habitat destruction, pollution and non-compliance of laws as major issues affecting the Lagoon (Fernando, 2010).

Further information gathering and validation, *inter alia* regarding, catch data per species per season, catch per unit effort, catch per boat, is required for the formulation of a lagoon fisheries management plan. These data are being obtained currently only for export-oriented species (Long et al., 2010).

Once data are collected, they need to be correlated with land use changes – such the changes in the extent of natural habitats (mangroves, salt marshes, mudflats, seagrass meadows, tropical mixed evergreen forests etc.); the expansion of shrimp farms and salterns; as well as changes in fresh water regimes.

The fisheries management plan must also resolve conflicting regulations and strengthen enforcement. It will have to ensure that destructive fishing practices are eradicated from the Lagoon surrounds and that over-exploitation of resources is prevented, through species, size, spatial and temporal restrictions, that can be formulated based on data obtained as described in the previous paragraph.

The fisheries management plan should also assess the current levels of by-catch and the harvesting of ornamental and medicinal species and formulate strategies for reducing and managing both.

The strategy also identified the lack of community participation in the decision-making process as a major issue of concern (Fernando, 2010). The development of a fisheries management plan for the Lagoon must necessarily occur through a process of consultation with and consensus of the government sector, the private sector and the concerned Lagoon communities. The plan must be the ultimate outcome of agreements about fisheries management issues and the regulatory and non-regulatory means of managing these.

Promotion of mechanisms to enhance active participatory stakeholder engagement in resource use management decisions

This will require the formalisation of an administrative body to implement the newly declared fisheries management area (the Lagoon water body at high tide). The mobilisation of this body

[63] Capacity Enhancement of NARA.

will directly engage community groups in the decision-making, planning and implementation of activities related to lagoon management.

The BMZ project established a District Level Coordination Committee (DLCC) comprising representatives from several community-based organisations, as well as officers from different government agencies. In doing so, they have been successful in creating awareness that the Puttalam Lagoon needs conservation and management throughout its entirety. The establishment of this participatory mechanism was unique because such a cross-sectoral committee which includes communities has not existed before. The DLCC can be transformed from a project management body to a Lagoon Resource Management body and its mandate changed from a coordinating mechanism for the BMZ to a governing body for Lagoon management.

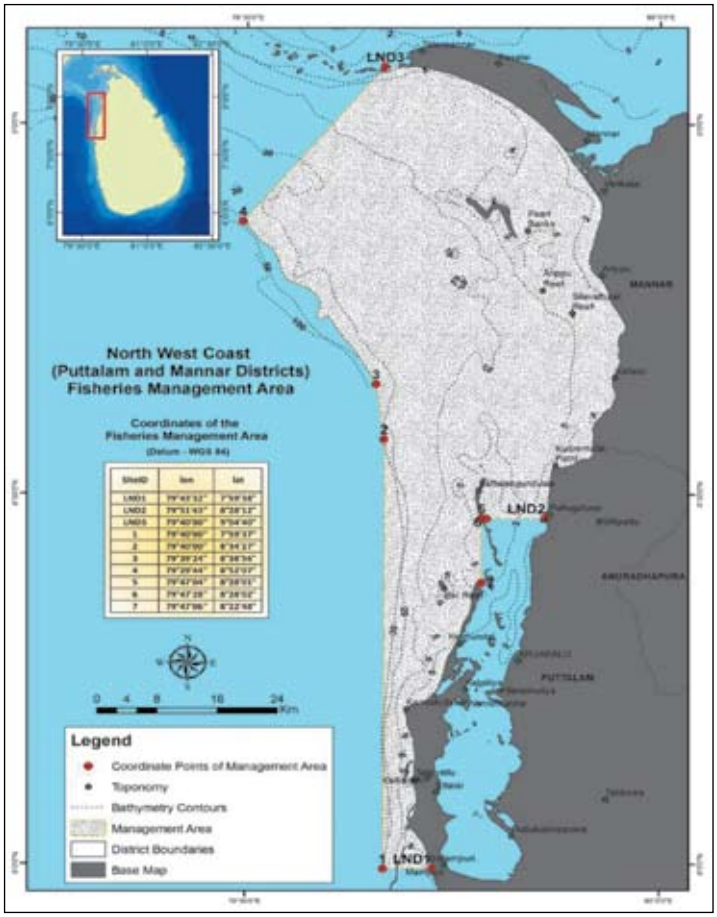
Formulating regulations about the newly designated Puttalam Lagoon as a Fisheries Management Area

Under the Fisheries and Aquatic Resources Act, No.2 of 1996, the Minister of Fisheries and Aquatic Resources has the powers to designate prescribed areas of Sri Lanka Waters or land adjacent thereto or both, as fisheries management areas for the purposes of the Fisheries Act. The North West Coast (Puttalam and Mannar Districts) Fisheries Management Area (NWCFMA) has been designated under this provision (CENARA, 2010).

However, the regulations about what can and cannot be done in a fisheries management area, what it means to fishers and other stakeholders, have yet to be gazetted. This must be rectified.

Figure 92. The North West Coast Fisheries Management Area

(Source: CENARA 2010)



Ensuring habitat protection

The Puttalam Lagoon has a range of ecosystems – both coastal and terrestrial – which contribute services to human well-being in the District. (See Chapter 4.) Degradation or destruction of these habitats will adversely affect ecosystem services, and in turn, human well-being. Therefore, it is essential that these natural habitats are afforded a greater level of protection, through the declaration of protected areas, with a suitable level of protection. (See Chapter 4.)

An ecological assessment carried out in the Lagoon area by IUCN under the aegis of the BMZ project identified ecologically important areas not only where threatened species are found, but also areas which provide valuable ecosystem services to humans. Because much of the natural area around the Lagoon has been severely degraded and destroyed as a result of human-induced activities, it is critical that these ecologically important areas are conserved in their current state and if possible regenerated, in order to maintain their services and in turn, to sustain the Lagoon and its resources.

Critical habitats for conservation

This assessment identified critical areas for conservation, as shown in the map that follows. (See Figure 94.) These are described below.

On the eastern coast of the Lagoon:

The Kala Oya delta

The largest and one of the most undisturbed mangrove habitats in Sri Lanka – which covers over 560 ha – is associated with Kala Oya, which abuts Wilpattu National Park. A striking ecological feature of the mangroves of Kala Oya is the zonation, which extends gradually to the natural dry zone forest areas of Wilpattu. Protection of the land area from erosion, flood regulation and provision of breeding grounds and shelter for commercially important fin fish and shellfish are the main services provided by the mangrove habitats of Gangewadiya.

The mangroves of Tirikkapallama

A healthy mangrove stand exists in the Thirikapallama, covering over 240 ha. The total extent of the mangroves in Thirikapallama includes the mangroves in Kodapitiya Island. Here, the mangroves are inter-spaced uniquely with open grasslands. A healthy population of the Critically Endangered Black mangrove (*Scyphiphora hydrophyllacea*) is found among the mangroves of Thirikapallama. As the Lagoon is the only location where this rare mangrove species is found on the entire western and southern coasts of Sri Lanka, conservation measures are essential to protect this mangrove habitat.

The mangroves of Pubudugama

Adjacent to the Mi Oya Lagoon, this area has a large and diverse mangrove habitat, as well as an extensive mudflat. Coastal tropical thorn forests are also important habitat types in this area. The Forest Department has declared the southern part of the Pubudugama site as a conservation forest area. As most of the mangroves are disappearing from the Mi Oya area, it is vital to protect the existing mangroves in the area.

The Mi Oya delta: Anaikutti and Seguwantivu

The Mi Oya delta is critical to the Lagoon area as it provides the major freshwater inflow to the Lagoon. Maintenance of healthy natural systems at this site is vital to maintain the

brackish water quality of the Lagoon, which, in turn, is essential for fish production. This area harbours a rich mangrove community with some rare and Critically Endangered species, such as *Cynometra iripa*. A considerable area of healthy mangrove communities is found at this site, despite expansion of salterns and shrimp farming. The mangroves of this area should be conserved in order to protect the Mi Oya delta, in turn to ensure the freshwater input to the Lagoon.

On the western side of the Lagoon:

The mangroves of Ettalai

Ettalai has a large area of mangroves and the rare and Critically Endangered *Scyphiphora hydrophyllacea* is found here. This area should be conserved.

The islands of the Lagoon area

All the islands in the Lagoon contain pristine mangrove species assemblages that merge with other habitats, such as salt marshes. These island habitats are under severe pressure from investors who wish to develop these areas as tourist destinations. The unique beauty of the islands, with their varied natural habitats that harbour many species of interesting animals and plants, must be conserved. An ideal way of achieving this would be through community-based ecotourism, to facilitate maintenance of the ecological integrity of the islands.

The mangroves and maritime grasslands of Keerimundel

The coastal ecosystems in Keerimundel area contains a unique assemblage of habitats with extensive maritime grasslands, gentle sand dunes in the broad sand bar and coastal scrub mixed with Palmyrah trees. A narrow stretch of mangrove habitat that extends towards the Dutch Bay can also be found in the Keerimundel area. The mangroves are visited by a diverse community of migratory birds (all of the above, IUCN, 2010).

Figure 93. The Critically Endangered Black Mangrove (*Scyphiphora hydrophyllacea*)
(Naalin Perera © IUCN)

Figure 94. Ecologically important areas for conservation in Puttalam Lagoon
(Source: Weragodatenna, 2010)

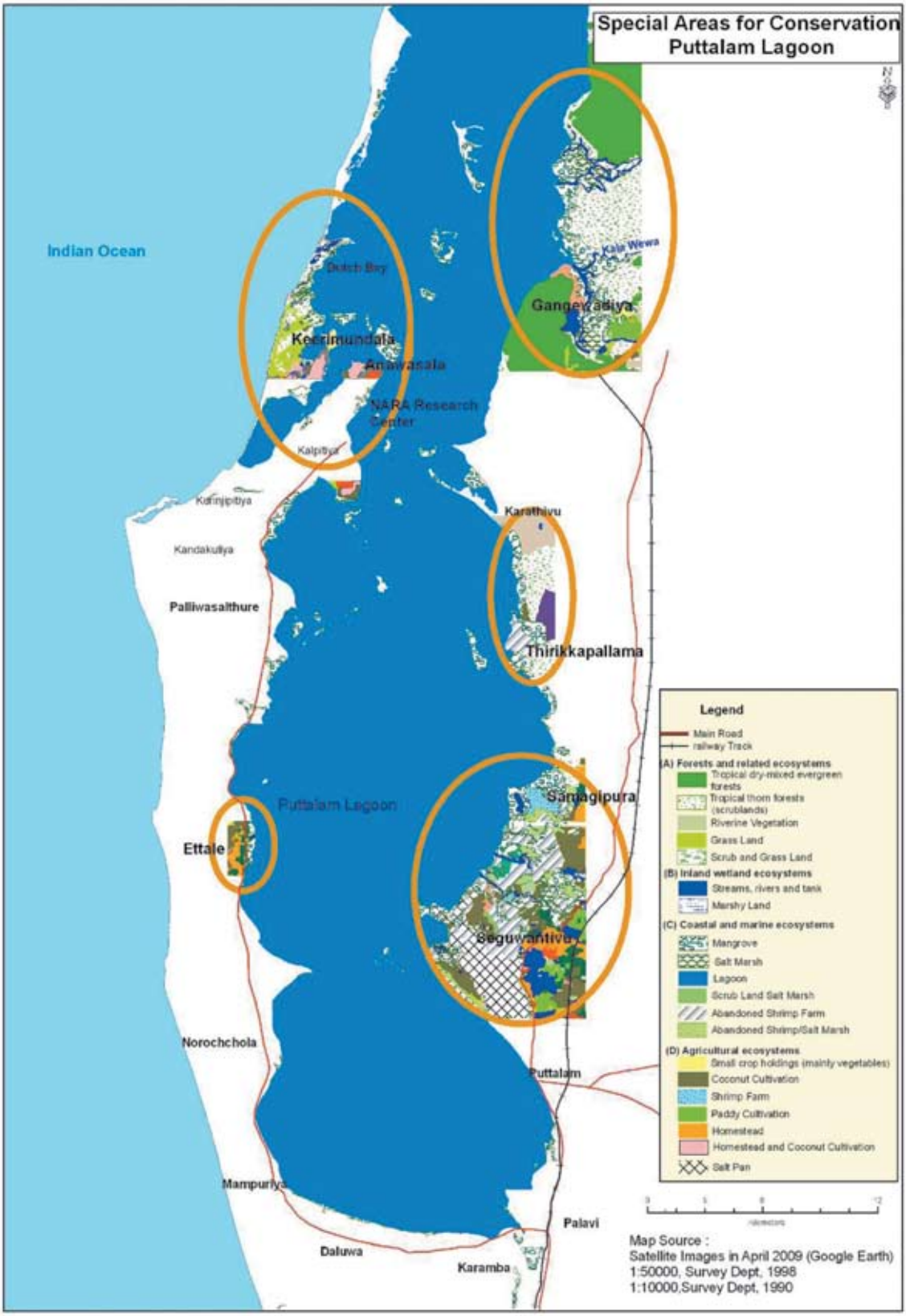
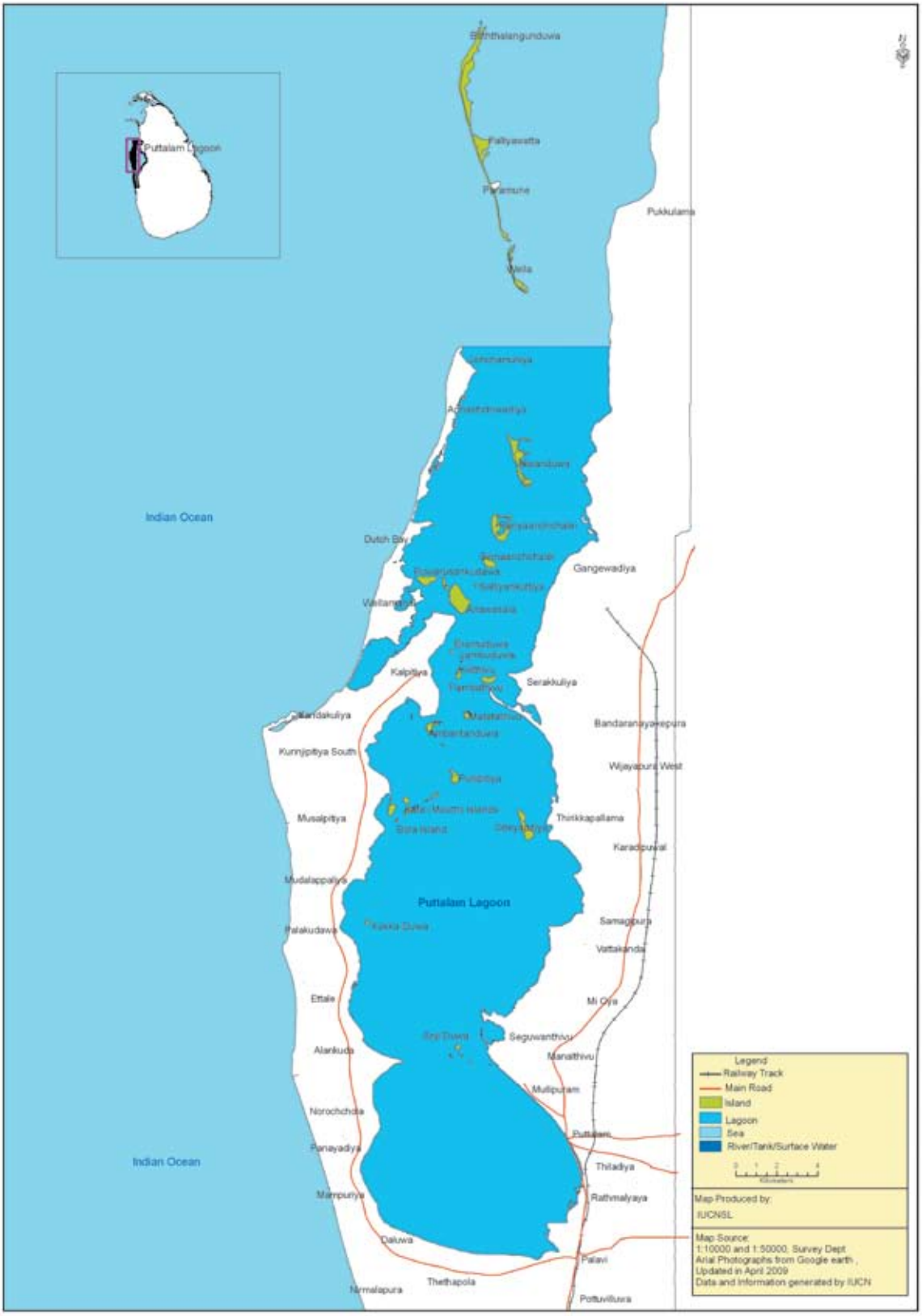


Figure 95. Islands of the Puttalam Lagoon area
(Source: Weragodatenna, 2010)



Regulation and strict control of development activities – such as aquaculture, agriculture and salt production – that destroy and degrade natural ecosystems

Currently, it is estimated that 50% of the existing shrimp farms in the region were not subject to the required environmental impact assessment process, and land had been acquired illegally. The rapid expansion of salterns also raises similar concerns of legality and whether due environmental process was followed.

Regulation of the expansion of these activities – in extent and location, as well as establishing and implementing strict controls for the processing of effluents and waste – is essential.

Ensuring prevention of coastal erosion and sedimentation control

Erosion adjacent to shrimp farms and cultivation will be addressed when land zoning is carried out and development activities are regulated or controlled.

However, activities upstream in the Mi Oya and Kala Oya will have profound effects downstream of these rivers. Earthworks and sand mining can have severe effects on the stability of river banks. Mangrove clearance along the banks of these rivers can also not only destabilise the banks, but also change freshwater inflow into the Lagoon, resulting in overwhelming changes.

Managing activities upstream of these rivers is therefore crucial to the sustainable management of the Lagoon area.

Development of a Water Conservation and Management Strategy for the Puttalam Lagoon area

The mis-use and over-use of water is a critical issue in the Lagoon area which must be addressed. The district lies in the dry zone of the country where rainfall is sharply seasonal with a distinct dry season of three to four months. Because of this, fresh water is a scarce resource that needs to be managed carefully.

Ground water is being over-used and in some areas, contaminated.

Establishing a solid and effluent waste management plan for the Lagoon area

Chemical and solid waste pollution are destroying life in the Lagoon. Urgent action is needed to manage both chemical and solid waste.

Under the aegis of the BMZ project, a solid waste collection centre has been established in Kalpitiya and is expected to process three tons of solid waste per day. This initiative needs to be expanded to cover the entire Lagoon area.

A plan for solid waste management needs to include:

- Creation of awareness among communities on the benefits of responsible waste disposal, and increased recycling and re-using of materials;
- Establishment and locations of waste collection centres;
- Separation into recyclable and non-recyclable waste; and,
- Processing plants.

Management of effluents is also needed urgently. Existing regulations and laws that require treatment of waste effluents and processing must be implemented.

Influence dialogue on the development of a sustainable tourism development plan

Tourism can place heavy, additional stresses on an already seriously over-stretched environment by its greater consumption, waste production and pollution. Lack of water, waste and pollution are already serious problems in the Lagoon area.

The tourism industry generally over-uses water resources for hotels, swimming pools, golf courses and personal use by tourists. Water consumption in hotels is usually 300-400 litres per guest per night (Srilal Miththapala, person. comm.). Extrapolating for 500 rooms at 50% occupancy for the year (the current rate), the average current stay per guest (eight days), and average guest ratio 1:1.8 (Srilal Miththapala, person. comm.), an estimated 11,086,875-14,782,500 litres of additional fresh water will be needed in the Kalpitiya district for guests alone. Hotel staff needs, pool requirements and landscaping will add to these quantities.

In order that this additional water is not extracted at the expense of communities in the Lagoon area, a tourism plan for the area must necessarily explore desalinisation of seawater, waste water management (for gardens) and rainwater harvesting (for use in toilets) as methods for implementation.

Approximately 3.7 kg of waste is generated per guest per night (Hasantha Lokugamage, personal communication). This translates to 136,738 kg waste per year under the same conditions as above. The tourism plan must include responsible solid waste management practices (that reduce, recycle and reuse waste) in these resorts. Waste generated form resorts and hotels must not add to the solid waste in the area.

Hotels also tend to use heavy doses of pesticides and fertilisers for their gardens and lawns. Again, the tourism plan must propose organic gardening and environmentally-friendly landscaping for implementation by hoteliers.

The Kalpitiya area is already a favourite spot for dolphin watching. Dolphin and whale watching is a lucrative business in many parts of the world, and Sri Lanka has great potential to become a whale and dolphin watching hotspot, because of the abundance and diversity of cetaceans in coastal waters, and the ease with which they can be observed (Anouk Illangakoon, person. comm.). Yet, responsible eco-tourism is not practised by all boat operators, with the result that the welfare of these marine mammals is not considered and the safety of the tourists is not observed (Anouk Illangakoon, person. comm.). A checklist has been prepared for use in the southern part of the island and some operators in Kalpitiya have been given some training in use of these guidelines, but these best practices need to be formalised and incorporated into a tourism plan.

The development of tourism in a given area can lead to social problems, when local communities are excluded from that development. When jobs in both the service and support sectors are given to non-locals, and products are purchased from out of town, then local communities begin to feel displaced, local livelihoods suffer and community resentment against a hotel can build.

To this end, contributions to community development and improving economic linkages with local livelihoods are essential. One tool for linking local livelihoods is nature-based tourism. Given the range of pristine habitats in some of the islands and other areas of the Lagoon, community-based nature tourism is a good option for inclusion into a tourism plan. Nature-based tourism protects natural resources, while providing jobs and increasing local revenues.

However, in order to ensure sustainability, thorough training – linking the well-being of ecosystems and the well-being of humans – should be given to the communities to ensure that

over-visitation does not become an issue. To this end, best practice guidelines for responsible nature-based tourism should be developed.

Institutional strengthening

There is a lack of capacity for management: a dearth of adequate skills, as well as human resources. This necessarily hampers implementation.

Under the aegis of the BMZ project, IUCN worked in the Lagoon area with government officials to strengthen conservation and management. IUCN trained land use department staff in GIS allowing them to map inter alia, land use, state and private land. They also supported the Fisheries and Forest Departments by giving equipment (boats and motor cycles to the former) and assisting in demarcating mangroves (with the latter).

Institutional strengthening needs to be widened to encompass other key players in the Lagoon area – such as, *inter alia*, the Urban Development Authority, the Department of Wildlife Conservation, the Coast Conservation Department, the Tourism Authority and the Road Development Authority. **All key players in Lagoon area must come to view the Lagoon as a landscape of inter-connected and inter-related ecosystems, whose well-being directly affects the well-being of humans.** It is also important that these departments and their staff are also made aware that upstream activities have significant downstream effects on river mouths and the Lagoon.

Strengthening alternate livelihoods

Under the BMZ project, some alternate livelihoods were introduced among some communities in the Lagoon area. These were home gardening with drip-irrigated systems, poultry farming at the homestead level and the provision of sewing machines to women. In Sothupitiya and Thillamotei, women earn 3,000-4,000 rupees a month from sewing. This is an income they did not have earlier. Poultry farming in Kalkuda and home gardening in Thirikapallama, yield a clear profit of 10,000 rupees a month per household (Miththapala, in preparation).

Given that the pressure on the Lagoon has increased dramatically over the last few decades with migration and population increases, alternate livelihoods (that ease this pressure and also supplement fishers' income during months when fishing is not possible) are urgently needed in the area. Supporting the livelihood initiatives taken under the BMZ project, increasing and strengthening the range of activities will be necessary.

Ecological restoration

Restoration of degraded habitats must be integral to the management of the Lagoon.

Analysed spatial data using GIS has been used to produce up-to-date ground-truthed maps of the Lagoon area (Weragodatenna, 2010). One of these maps showed the considerable extent of abandoned shrimp farms. (See Figure 69.)

These abandoned shrimp farm areas can be restored effectively through community participatory ecological restoration of natural habitats, such as mangroves and salt marshes. It is important that scientifically-based ecological restoration is carried out (for example, through judicious cutting of channels, and selection of suitable mixed species for mangrove restoration) to ensure firstly that the replanting is successful. Secondly, that an assemblage of suitable species is planted, not monocultures. A recent ecological assessment of the area has shown which species are dominant in different natural habitats and this knowledge can be used in restoration programmes (IUCN, 2010). An initial site for such restoration is Thirikapallama,

because a healthy mangrove source is located adjoining abandoned shrimp farms (IUCN, 2010).

It is essential that this restoration is made possible through legal provision of land. When the Sri Lanka BMZ team commenced work in the Puttalam Lagoon, they began working closely with the North Western Provincial Environmental Authority, who identified restoration of shrimp farms to original habitats, as a priority issue and requested IUCN's help. Despite enthusiasm from the Government Agent of the Puttalam District and support from the Director of the North Western Province Environmental Authority, nothing could be done till government land, on long lease to shrimp farmers, was released back to the government. When this release could not be achieved through regular means, the Director of the North Western Province Environmental Authority took legal action, ending in the Supreme Court. In late 2008, the Supreme Court ruled against the shrimp farmers, ordering the Divisional Secretary of Vanathavillu to release two hectares of land in the Vanathavillu area to the North Western Provincial Environmental Authority, for the specific purpose of allowing IUCN (named in the judgement) to carry out restoration of the area. The land has still not been released.

Identifying ownership of land and releasing abandoned shrimp farms for ecological restoration should be made a priority action.

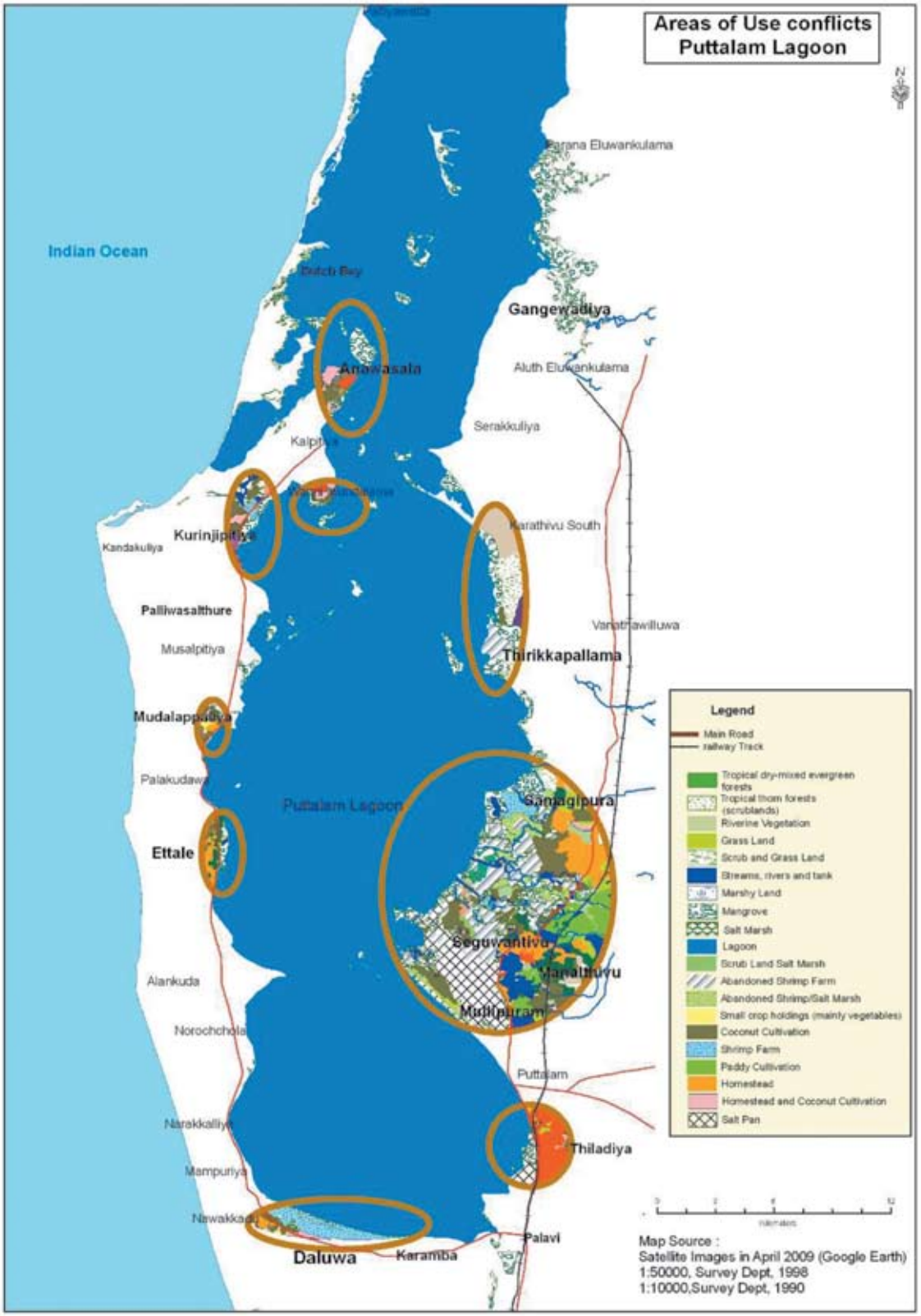
Development of Special Area Management for use-conflict areas

GIS mapping of the Lagoon area highlighted use conflicts in certain areas. For example, the Mi-Oya delta, identified as being ecologically critical for the inflow of fresh water into the Lagoon, was also shown to be an area of high-use conflict (Figure 96).

These areas will need special management to accommodate land use needs, yet protect natural habitats in the area vital for the health of the Lagoon.

Since the 1990s, nine Special Area Management (SAM) sites have been operational around the coast, managed under the aegis of the Coast Conservation Department. Special Area Management uses local and geographically specific planning and active stakeholder participation in order to plan for optimal sustainable use of natural resources, ensure economic well-being as well as ecological integrity, and to practise sound natural resource management. Benefits gained from the SAM process include zoning of sites to maximise ecological protection, yet allowing sustainable use, poverty alleviation by provision of facilities for the enhancement of livelihoods, social upliftment through various community-based training programmes and improvement of water quality and waste management. Puttalam has been previously proposed as a SAM site, but has not yet been declared as such (Nissanka Perera, person. comm.).

Figure 96. Areas showing use conflicts
(Source: Weragodatenna, 2010)



Development of an integrated Land and Lagoon use management strategy (Integrated Resource Management Strategy) for the Puttalam Lagoon area

The Lagoon and its surrounding areas must be seen as a landscape of inter-connected and inter-dependent ecosystems, that are impacted by actions both within and without the landscape, and which needs a central, holistic approach of integrated coastal management, recognising that spatial, temporal, sectoral, political and institutional integration are all essential for success. Until this paradigm shift is made, conservation will not be successful, nor will long term sustainability of the Lagoon be assured.

To this end, a spatial planning process is needed that that will lead to the development of an integrated land and sea use plan (zonation plan). Recommendations listed above – each dealing with a specific topic or theme – should feed into the development of such a plan. For example, declaration of protected areas under the zonation plan will allow for zoning of areas where visitation is prohibited, or use is regulated through permits; declaration of special area management (SAM) sites will allow zoning of other areas which will be governed by SAM regulations under the Coast Conservation Act of 1981.

Similar zonation for the Lagoon and coastal areas should be developed.

Knowledge creation, education and awareness

The Millennium Ecosystem Assessment examined how ecosystem well-being affects ecosystem services. It used a framework that clearly linked ecosystem well-being to human well-being, and showed explicitly that humans are integral parts of ecosystems.

Human well-being and economic development are dependent on the health, well-being and productive potential of the Lagoon and its environs. In short, in order to achieve human well-being, it is essential that there is also ecosystem well-being.

This is the link that underpins sustainability of livelihoods and of development. Yet this link is rarely elucidated in awareness programmes and in environmental education. To a politician, eager for votes, protection of the Critically Endangered Black Mangrove (*Scyphiphora hydrophyllacea*) would probably mean nothing, yet showing a link between degradation of mangrove and reduction in fish production would be much more meaningful.

The Millennium Ecosystem Framework needs to be used extensively to create awareness about the importance of the Lagoon to human well-being among communities, government officers, non-governmental organisations and the private sector.

Sustainable financing for the conservation and management of the Puttalam Lagoon area

The decrease in government financing and international donor funding for natural resource management has prompted the need for the development of additional sustainable financing mechanisms for the long term conservation and management of the Puttalam Lagoon area.

A sustainable financing and benefit sharing strategy provides economic incentives, increases the cost effectiveness of lagoon management, supports compatible enterprise development to provide alternative income to local communities and generates incentives and resources for conservation of the Lagoon.

Sustainable financing and benefit sharing link management actions for ecosystem services to outcomes in terms of delivery for ecosystem services. If a sustainable financing and benefit-sharing mechanism is properly instituted and adequate funding is allocated, stakeholders will

be able to generate enough revenue to finance a number of long-term sustainable development initiatives.

Out of all the activities that were supported by the project, firstly, there is a need to set realistic short, medium and long-term investment priorities based on community preferences, government priorities and donor interest. The short-term objective should be to raise adequate finances to establish a governing body for management as described earlier in this chapter, and to continue some of the existing project initiatives.

The medium term and long-term objective ahould be to provide strategies to raise funds from local, national and international sources to implement this current conservation framework. This fund can be named and spent on activities that support the framework, up-scaling the quality of conservation activities and the conservation movement in the management area; alternative livelihoods, basic facilities and infrastructure development for Lagoon fisher communities; strengthening community-based enterprises, building the capacity of fisher communities, education and awareness raising programmes on sustainable resource use and conservation; empowerment of community organisations and strengthening of NGOs and CBOs in the management area.

A redistributive and benefit sharing system must be put in place to ensure that pro-poor conservation in the project areas is funded and addresses poverty and unsustainable resource use, equity issues and behavioural changes of the resource dependent communities. A pre-requisite to establishing such a benefit sharing mechanism is the identification of the needs and niches for benefits sharing and institutional arrangements to share the actual benefits among the stakeholders. In order to implement a benefits sharing mechanism, there is a need to identify a) What benefits are generated locally, nationally and internationally from the lagoon ecosystems; and, b) What the institutional arrangements are available to share the benefits among the stakeholders.

At present there are a number organisations working in the area including government agencies, NGOs and the private sector; and who have committed to invest financial resources for lagoon resources management activities. There is vast potential to increase the self-generated financial resources from the economic and livelihood activities which are being implemented in the Lagoon and surrounding eco-systems. The Fisheries Corporative Societies (FCS) can play a major role in resource management and in generating financial resources and sharing the benefits generated from the project activities as well as natural resources. Building the capacity of the FCS on fund raising and management, needs and opportunities for benefit sharing and undertaking conservation management activities is a must. In the long run the governing body can undertake sustainable financing, as well as implementation of conservation and management activities with the support of FCS (quoted directly from Ranasinghe, 2010).

A detailed sustainable financing strategy for the Lagoon area was developed under the aegis of the BMZ project and is available at http://cmsdata.iucn.org/downloads/sustainable_financing_and_benefit_sharing_strategy_for_conservation_and_management_of.pdf

Implementation of existing laws and policies

Focus on the Puttalam Lagoon is not new. Since 1962, numerous agencies and scholars have been involved in studying this system (Alwis et al., 1992; Amarasinghe, 1988; Amarasinghe and Perera, 1995; Arulananthan et al, 1995; Corea et al., 1995; Dayaratne et al., 1995 and 1997; Gunaratne et al., 1995; Jayasuriya, 1985 and 1991; Jayawardena and Dayaratne, 1995; Suraweera and Jayawickrama, 1989; Wijeratne et al., 1995). Many of the recommendations made in their studies are repeated in this chapter, indicating that although issues that damage the Lagoon have been identified for decades, actions to resolve them have not been implemented. This is a general malaise that grips the entire country.

It is essential therefore, that existing laws and policies are implemented.

Conclusion

Strategic interventions must be formulated and implemented now, as a matter of urgency, before Puttalam Lagoon, like Mundel Lake before it, becomes virtually fishless and unproductive, and before thousands of people are left without the means for living.

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Annex I. Check list of plant species recorded in Puttalam Lagoon Area

Abbreviations:

S-Sinhalese Name, T-Tamil Name, E-English Name

Endemic Species are in bold font

Exotic Species are marked as *

IAS - Invasive Alien Species,

M- Mangrove, MA-Mangrove Associate, SG-Seagrass, SM-Salt marshes

CR-Critically Endangered, EN-Endangered, VU-Vulnerable

Uses (M-Medicinal Plant, F-Food plant)

No	Family	Species	Local name	Uses
Lower Plants				
1	Azollaceae	*Azolla pinnata*		
2	Marsileaceae	*Marsilea minuta*	Dwarf waterclover(E)	
3	Pteridaceae	*Acrostichum aureum*[MA]	Karan-koku(S)	M,F
4	Salviniaceae	*Salvinia molesta**[IAS]	Salvinia(S)	
Flowering Plants				
No	**Family**	**Species**	**Local name**	**Uses**
1	Acanthaceae	*Acanthus ilicifolius*[MA]	Ikili(S) Sea Holly(E)	M
2	Acanthaceae	*Asystasia gangetica*	Puruk(S) Peypatchotti(T) Chinese Violet(E)	M
3	Acanthaceae	*Barleria prionitis*	Katu-karandu(S) Varamulle(T) Yellow Hedge Barleria(E)	M
4	Acanthaceae	*Blepharis maderaspatensis*	Samadana(S) Creeping Blepharis(E)	
5	Acanthaceae	*Elytraria acaulis*		M
6	Acanthaceae	*Hygrophila ringens*	Nil-puruk(S)	
7	Acanthaceae	*Hygrophila schulli*	Neeramulliya, Katu-ikiliya(S) Niramulli(T) Marsh Barbel(E)	M,F
8	Acanthaceae	*Justicia adhathoda*	Adhatoda, Agal Adara(S) Adhatodai(T) Malabar Nut(E)	M
9	Acanthaceae	*Justicia betonica*	Sudu-puruk(S) White Shrimp Plant(E)	M
10	Acanthaceae	*Justicia procumbens*	Mayani(S) Ottu-pillu(T) Common Small Justicia(E)	M
11	Acanthaceae	*Stenosiphonium cordifolium*[VU]	Bu-nelu(S) Nelu(T)	
12	Aizoaceae	*Sesuvium protulacastrum* [SM]	Maha-sarana(S) Vankiruvilai(T) Seaside Purslane(E)	
13	Aizoaceae	*Trianthema decandra*	Maha-sarana(S) Charania(T)	M
14	Aizoaceae	*Trianthema protulacastrum*	Heen-sarana(S) Trianthema(E)	M,F
15	Alliaceae	*Allium cepa* *	Lunu(S)	M,F
16	Aloaceae	*Aloe vera**	Komarika(S) Kattalai(T)	M,F
17	Amaranthaceae	*Achyranthes aspera*	Gas-karal-heba(S) Nayururi(T) Pickly Chaff-flower(E)	M,F
18	Amaranthaceae	*Aerva lanata*	Pol-pala(S) Kanpuli(T) Eerva(E)	M,F
19	Amaranthaceae	*Alternanthera sessilis*	Mukunu-wenna(S) Ponankani(T) Sessile Joyweed(E)	M,F
20	Amaranthaceae	*Amaranthus lividus* *	Thampala(S)	F

21	Amaranthaceae	*Amaranthus spinosus*	Katu-tampala(S) Mudkirai(T) Spiny Amaranth(E)	M,F
22	Amaranthaceae	*Amaranthus viridis*	Kura-thampala(S) Araikkirai(T) Slender Amaranth(E)	M,F
23	Amaranthaceae	*Celosia argentea*	Kiri-handa(S) Silver Spiked Cockscomb(E)	F
24	Amaranthaceae	*Gomphrena celosioides* *	Prostrate Globe Amaranth(E)	
25	Amaranthaceae	*Nothosaerva brachiata*	Tampala(S) Chirupilai(T)	F
26	Amaryllidaceae	*Crinum defixum*	Heen-tolabo(S)	M
27	Amaryllidaceae	*Crinum latifolium*	Goda Manel(S) Pink-striped Trumpetn Lily(E)	M
28	Anacardiaceae	*Anacardium occidentale* *	Caju(S) Montin-kai(T) Cashew Nut(E)	M,F
29	Anacardiaceae	*Lannea coromandelica*	Hik(S)Odi(T)	M
30	Anacardiaceae	*Mangifera indica* *	Amba(S) Ma,Manga(T) Mango(E)	M,F
31	Anacardiaceae	*Spondias pinnata*	Amberella(S) Ampallai(T) Hog Plum(E)	M,F
32	Annonaceae	*Annona glabra** [IAS]	Wel-atta(S)	F
33	Annonaceae	*Annona muricata* *	Katu-anoda(S) Sitha(T) Soursop(E)	M,F
34	Annonaceae	*Polyalthia korinti*	Ul-kenda, Mi-wenna(S) Uluvintai(T)	
35	Annonaceae	*Polyalthia longifolia*	I-petta(S) Assathi(T)	M
36	Apiaceae	*Centella asiatica*	Gotukola(S) Vallarai(T) Indian Pennywort(E)	M,F
37	Apocynaceae	*Carissa grandiflora* *	Damson(S) Damson(T) Natal Plum(E)	F
38	Apocynaceae	*Carissa spinarum*	Heen-karamba(S) Chiru-kula(T)	M,F
39	Apocynaceae	*Catharanthus roseus* *	Mini-mal(S) Pattippu(T) Madagascar Periwinkle(E)	M
40	Apocynaceae	*Ichnocarpus frutescens*	Gerandi-wel(S)	M
41	Apocynaceae	*Nerium oleander* *	Kaneru(S) Alari(T) Oleander(E)	M
42	Apocynaceae	*Plumeria obtusa* *	Araliya(S) Temple Tree (E)	M
43	Apocynaceae	*Plumeria rubra* *	Araliya(S) Temple Tree, Frangipani(E)	M
44	Apocynaceae	*Tabernaemontana divaricata* *	Wathu-sudda(S) Nandi-battai(T) Grape Jasmine(E)	
45	Apocynaceae	*Thevetia peruviana* *	Kaneru(S) Yellow Oleander(E)	
46	Aponogetonaceae	*Aponogeton natans*	Kekatiya(S) Koddi(T)	F
47	Araceae	*Pistia stratiotes* * [IAS]	Diya-gowa, Diya-paradel(S) Water Lettuce(E)	M
48	Arecaceae	*Borassus flabellifer* *	Tal(S)Panai(T) Palmyrah(E)	M,F
49	Arecaceae	*Calamus rivalis* [VU]	Ela-wewel(S)	
50	Arecaceae	*Cocos nucifera*	Pol,Thambili(S) Thengai(T) Coconut,King coconut (E)	M,F
51	Arecaceae	*Phoenix dactylifera* *	Rata-indi(S) Perichchambalam(T) Date Palm(E)	F
52	Arecaceae	*Phoenix pusilla* [MA]	Indi(S)Inchu(T)	M,F
53	Aristolochiaceae	*Aristolochia indica*	Sapsanda(S) Isuru(T) Indian Birthwort(E)	M
54	Asclepiadaceae	*Calotropis gigantea*	Wara(S) Errukalai(T) Giant Milkweed(E)	M
55	Asclepiadaceae	*Leptadenia reticulata*	Pala(T)	M
56	Asclepiadaceae	*Oxystelma esculentum*	Usepale(S) Kulappulai(T)	M
57	Asclepiadaceae	*Pentatropis capensis*		
58	Asclepiadaceae	*Pergularia daemia*	Mada-hangu(S) Uttamakam(T)	M
59	Asclepiadaceae	*Sarcostemma brunonianum*	Muwa-kiriya(S)	M
60	Asclepiadaceae	*Secamone emetica*		M
61	Asclepiadaceae	*Tylophora indica*	Mundu-Bin-Nuga(S) Nancharapanchan(T) Wild Ipecacuanha(E)	M

62	Asclepiadaceae	*Tylophora tenuissima*		
63	Asclepiadaceae	*Wattakaka volubilis*	Anguna(S)Kodi-palai(T)	F
64	Asperagaceae	*Asparagus racemosus*	Hatawariya(S)Chattavari(T)	M,F
65	Asteraceae	*Acanthospermum hispidum* *	Katu-nerenchi(S) Bristly Stabur(E)	
66	Asteraceae	*Blumea obliqua*	Muda-mahana(S) Nara-karamba(T)	
67	Asteraceae	*Chromolaena odorata* *IAS	Podisingnomaran(S) Devil Weed(E)	M
68	Asteraceae	*Eclipta prostrata*	Kikirindi(S)Kaikechi(T) Marsh Daisy(E)	M
69	Asteraceae	*Emilia sonchifolia*	Kadupara(S)	M
70	Asteraceae	*Launaea sarmentosa*		M
71	Asteraceae	*Mikania cordata* *IAS	Loka-palu(S) Tuni-kodi(T) Mile-a-minute(E)	M
72	Asteraceae	*Sphaeranthus africanus*	Vel-mudda(S) African globethistle(E)	M
73	Asteraceae	*Tridax procumbens* *	Kurunegala Daisy(E) Wasu sudu(S)	
74	Asteraceae	*Vernonia cinerea*	Monarakudumbiya(S) Chitiviyarchenkalainir(T)	M,F
75	Asteraceae	*Vernonia zeylanica*	Pupula(S)Kuppailay(T)	M
76	Asteraceae	*Xanthium indicum* *IAS	Uru kossa(S) Rough Cocklebur(E)	M
77	Avicenniaceae	*Avicennia marina* M	Manda(S) Kanna(T) Gray Mangrove(E)	
78	Avicenniaceae	*Avicennia officinalis* M	Manda(S) Kanna(T) White Mangrove(E)	M
79	Basellaceae	*Basella alba*	Nivithi(S) Pasalai(T) Malabar Spinach(E)	M,F
80	Bignoniaceae	*Dolichandrone spathacea* MA	Diya-danga(S) Vil-padri(T) Mangrove Turmpet Tree(E)	M
81	Bignoniaceae	*Stereospermum colais*	Dunu-madala(S) Padri(T)	
82	Bignoniaceae	*Tecoma stans* *	Kalani-tissa(S) Yellow Elder(E)	
83	Bombacaceae	*Ceiba pentandra*	Pulun-imbul(S) Silk cotton Tree(E)	M
84	Boraginaceae	*Carmona retusa*	Heen-tambala(S) Pakkuvetti(T)	M
85	Boraginaceae	*Coldenia procumbens*	Chirupaddi(S)	
86	Boraginaceae	*Cordia curassavica* *		
87	Boraginaceae	*Cordia dichotoma*	Lolu(S)Naruvilli(T)	M,F
88	Boraginaceae	*Cordia sinensis*		
89	Boraginaceae	*Cordia subcordata*		
90	Boraginaceae	*Heliotropium indicum*	Et-honda,Dimi-biya(S) Tedkodukku(T) Indian Turnsole(E)	M
91	Boraginaceae	*Trichodesma zeylanicum*	Camel Bush(E)	M
92	Cactaceae	*Cereus peruvianus*		
93	Cactaceae	*Opuntia cochenillifera*	Velvet Opuntia(E)	
94	Cactaceae	*Opuntia* sp.		F
95	Cactaceae	*Trichocereus pachanoi*		
96	Capparaceae	*Cadaba fruticosa*	Vili(T)	
97	Capparaceae	*Cadaba trifoliata*	Oothi-perali(T)	M
98	Capparaceae	*Capparis rotundifolia*	Karunchurai(T)	
99	Capparaceae	*Capparis sepiaria*	Hora-balal Wel(S) Karuchurai(T)	
100	Capparaceae	*Capparis* sp.		
101	Capparaceae	*Capparis zeylanica*	Sudu-welangiriya(S) Vennachchi(T) Ceylon Caper(E)	M
102	Capparaceae	*Crateva adansonii*	Lunu-warana(S) Navala(T)	M
103	Caricaceae	*Carica papaya* *	Gas-labu, Papol(S) Pappali(T) Pawpaw(E)	M,F
104	Caryophyllaceae	*Polycarpaea corymbosa*	Old Man's Cap(E)	M
105	Casuarinaceae	*Casuarina equisetifolia* *	Kasa(S) Chavakku(T) Whistling Pine(E)	

106	Celastraceae	*Cassine glauca*	Neralu(S) Perunpiyari(T)	
107	Celastraceae	*Maytenus emarginata*		
108	Celastraceae	*Pleurostylia opposita*	Panakka(S) Chiru Piyari(T)	
109	Chenopodiaceae	*Atriplex repens* [SM]	Elichchevi(T)	F
110	Chenopodiaceae	*Halosarcia indica* [SM]	Kotanai(T)	M
111	Chenopodiaceae	*Salicornia brachiata* [SM]		M
112	Chenopodiaceae	*Suaeda maritima* [SM,MA]	Umari(T)	F
113	Chenopodiaceae	*Suaeda monoica* [SM]		M
114	Chenopodiaceae	*Suaeda vermiculata*[SM]	Umari(T) Wormleaf Saltwort(E)	
115	Clusiaceae	*Calophyllum inophyllum* [MA]	Domba(S) Dommakottai(T) Alexandrian Laurel(E)	M
116	Colchicaceae	*Gloriosa superba*	Niyangala(S) Kartikai(T)	M
117	Combretaceae	*Lumnitzera racemosa* [M]	Beriya(S) Tipparuthin(T) Black Mangrove(E)	M
118	Combretaceae	*Terminalia arjuna*	Kumbuk(S) Marutu(T)	M
119	Combretaceae	*Terminalia bellirica*	Bulu(S) Ahdan-koddai(T) Myrabalans(E)	M
120	Combretaceae	*Terminalia catappa* *	Kottamba(S) Country Almond(E)	M,F
121	Commelinaceae	*Commelina diffusa*	Gira-pala(S)	M,F
122	Commelinaceae	*Cyanotis obtusa*		
123	Commelinaceae	*Murdannia spirata*		
124	Connaraceae	*Connarus monocarpus*	Radaliya(S) Chettupulukodi(T)	M
125	Convolvulaceae	*Cuscuta chinensis*	Aga-mula-neti-wel(S) Dodder(E)	M
126	Convolvulaceae	*Evolvulus alsinoides*	Visnu-kranti(S) Vichnu-kiranti(T)	M
127	Convolvulaceae	*Evolvulus nummularius* *		
128	Convolvulaceae	*Ipomoea aquatica*	Kankun(S) Water Spinach(E)	M,F
129	Convolvulaceae	*Ipomoea batatas* *	Batala(S) Vel-kelengu(T) Sweet Potatao(E)	F
130	Convolvulaceae	*Ipomoea obscura*	Tel-kola(S) Lesser Glory(E)	M
131	Convolvulaceae	*Ipomoea pes-caprae*	Mudu-bin-thamburu(S) Adapukodi(T) Goat's Foot Glory(E)	M
132	Convolvulaceae	*Ipomoea sepiaria*	Rasa-tel-kola(S) Tali(T)	
133	Convolvulaceae	*Ipomoea violacea*		
134	Convolvulaceae	*Merremia tridentata*	Heen-madu(S) Mudiyakuntal(T) African Morningvine(E)	M
135	Crassulaceae	*Kalanchoe pinnata**	Akkapana(S)	M,F
136	Cucurbitaceae	*Cucumis melo*	Heen kekiri(S) Metukku(T)	M,F
137	Cucurbitaceae	*Benincasa hispida*	Alupuhul(S) Puchini(T) Ash Pumpkin(E)	M,F
138	Cucurbitaceae	*Coccinia grandis*	Kowakka(S) Kovvai(T) Ivy Gourd(E)	M,F
139	Cucurbitaceae	*Cucumis sativus*	Pipinha(S) Cucumber(E)	M,F
140	Cucurbitaceae	*Cucurbita maxima* *	Wattakka(S) Pumpkin Gourd(E)	M
141	Cucurbitaceae	*Gymnopetalum scabrum*		
142	Cucurbitaceae	*Lagenaria siceraria* *	Diya-labu(S) Churai(T) Bottle Gourd(E)	M,F
143	Cucurbitaceae	*Luffa acutangula* *	Vetakolu(S) Peypichukka(T)	M,F
144	Cucurbitaceae	*Luffa cylindrica* *	Niyan Vetakolu(S)Pikku(T)	M,F
145	Cucurbitaceae	*Momordica charantia*	Batu-karavila(S) Pakal(T) Bitter Gourd(E)	M,F
146	Cucurbitaceae	*Momordica dioica*	Thumba-karavila(S) Tumpai(T)	M,F
147	Cucurbitaceae	*Mukia maderaspatana*	Gon-kekiri(S) Mochumochukkai(T) Rough Bryony(E)	
148	Cucurbitaceae	*Trichosanthes anguina* *	Pathola(S) Podivilangi(T) Snake Gourd(E)	M,F
149	Cymodoceaceae	*Cymadocea rotundata* [SG]		

150	Cymodoceaceae	*Cymadocea serrulata* [SG]		
151	Cymodoceaceae	*Halodule uninervis* [SG]	Narrowleaf Seagrass(E)	
152	Cymodoceaceae	*Syringodium isoetifolium* [SG]		
153	Cyperaceae	*Bulbostylis barbata*	Uru-hiri(S)	
154	Cyperaceae	*Cyperus arenarius*	Mudu-kalanduru(S)	
155	Cyperaceae	*Cyperus corymbosus*	Gal-ehi(S)	
156	Cyperaceae	*Cyperus javanicus*	Ramba(S)Irampai(T)	
157	Cyperaceae	*Cyperus pilosus*		
158	Cyperaceae	*Cyperus rotundus*	Kalanduru(S)Korai(T)	M
159	Cyperaceae	*Cyperus stoloniferus*		M
160	Cyperaceae	*Eleocharis actangula*		
161	Cyperaceae	*Eleocharis dulcis*	Boru-pan(S)	
162	Cyperaceae	*Fimbristylis cymosa*		
163	Cyperaceae	*Fimbristylis dichotoma*		
164	Cyperaceae	*Fimbristylis ferruginea*		
165	Cyperaceae	*Fimbristylis miliacea*	Mudu-hal-pan(S)	
166	Cyperaceae	*Fuirena ciliaris*		
167	Cyperaceae	*Pycreus polystachyos*		
168	Cyperaceae	*Pycreus pumilus*	Go-hiri(S)	
169	Cyperaceae	*Schoenoplectus supinus*		
170	Dioscoreaceae	*Dioscorea oppositifolia*	Hiritala(S)	M,F
171	Dioscoreaceae	*Dioscorea tomentosa*	Uyala(S)	
172	Dracaenaceae	*Sansevieria zeylanica*	Niyanda(S) Maral(T) Bow-string Hemp(E)	M
173	Ebenaceae	*Diospyros ebenum* [EN]	Kalu-wara(S) Karunkali(T) Ebony(E)	M
174	Ebenaceae	*Diospyros malabarica*	Thimbiri(S) Panichchai(T) Gaud Persimmon(E)	M
175	Ebenaceae	*Diospyros montana*	Katukanni(T)	
176	Ebenaceae	*Diospyros ovalifolia*	Kunumella(S) Vedukkanari(T)	
177	Ebenaceae	*Maba buxifolia*	Jabara(S)	F
178	Erythroxylaceae	*Erythroxylum monogynum*	Devadaram(S) Chemanatti(T)	M
179	Euphorbiaceae	*Acalypha indica*	Kuppameniya(S) Kuppameni(T) Indian Copperleaf(E)	M,F
180	Euphorbiaceae	*Acalypha lanceolata*	Nettle-leaf Acalypha(E)	M,F
181	Euphorbiaceae	*Breynia retusa*	Wa(S)	M
182	Euphorbiaceae	*Croton aromaticus*	Wel-keppitiya(S) Teppaddi(T)	M
183	Euphorbiaceae	*Croton bonplandianus* *	Mal-miris(S) Kolinge(E)	
184	Euphorbiaceae	*Croton hirtus**	Gan-veda, Val-tippili(S)	
185	Euphorbiaceae	*Croton laccifer*	Gas-keppetiya(S) Teppaddi(T)	M
186	Euphorbiaceae	*Croton officinalis*		
187	Euphorbiaceae	*Drypetes sepiaria*	Wira(S)Virai(T)	M,F
188	Euphorbiaceae	*Euphorbia hirta*	Bu-dada-kiriya(S)Palavi(T) Common Spurge(E)	M
189	Euphorbiaceae	*Euphorbia indica*	Ela-dada-kiriya(S) Hypericum leaf Spurge(E)	M
190	Euphorbiaceae	*Euphorbia rosea*	Mudu-dada-kiriya(S)	M
191	Euphorbiaceae	*Euphorbia thymifolia*	Bin-dada-kiriya(S) Chittirapalavi(T) Thyme-leaf Spurge(E)	M
192	Euphorbiaceae	*Euphorbia tirucalli*	Nawa-handi(S) Kalli(T) Milk Hedge(E)	M
193	Euphorbiaceae	*Excoecaria agallocha* [M]	Tela-kiriya (S)Tilai(T) Blind-your-eye Toe (E)	M

194	Euphorbiaceae	*Flueggea leucopyrus*	Hen-katu-pila(S) Mudpulanti(T)	
195	Euphorbiaceae	*Jatropha curcas**	Rata Endaru(S) Kaddamanakku(T) Physic Nut(E)	M
196	Euphorbiaceae	*Jatropha gossypifolia**	Bellyache Bush(E)	M
197	Euphorbiaceae	*Mallotus eriocarpus*	Vel-keppetiya(S) Maratini(T)	
198	Euphorbiaceae	*Manihot esculenta**	Maiokka,Manyokka(S) Cassava,Manioc(E)	F
199	Euphorbiaceae	*Manihot glaziovii**	Gas-manyokka(S)Ceara Rubber(E)	
200	Euphorbiaceae	*Mischodon zeylanicus*	Tammanna(S) Tampanai(T)	
201	Euphorbiaceae	*Phyllanthus acidus**	Japan nelli(S)	F
202	Euphorbiaceae	*Phyllanthus amarus*	Pita-wakka(S) Kikaunelli(T) Carry Me Seed(E)	M
203	Euphorbiaceae	*Phyllanthus maderaspatensis*		M
204	Euphorbiaceae	*Phyllanthus polyphyllus*	Kuratiya(S)	
205	Euphorbiaceae	*Phyllanthus reticulatus*	Wel-kayila(S) Mipullanti(T)	M
206	Euphorbiaceae	*Phyllanthus urinaria*	Rat-pita-wakka(S) Kilkaynelli(T)	M
207	Euphorbiaceae	*Ricinus communis*	Endaru(S) Chittamanakku(T) Castor Oil Plant(E)	M,F
208	Euphorbiaceae	*Sapium insigne*	Tel-kaduru(S) Tilai(T)	M
209	Euphorbiaceae	*Sauropus bacciformis*	Bin-delung, et-pitawakka(S)	
210	Euphorbiaceae	*Tragia* sp.	Wel-kahambiliya(S)	M
211	Fabaceae	*Abrus precatorius*	Olinda(S) Kundu-mani(T) Crab's eyes(E)	M
212	Fabaceae	*Acacia auriculiformis **	Earleaf Acacia(E)	
213	Fabaceae	*Acacia eburnea*	Kukul-katu(S) Kaludai(T) Cockspur Thorn(E)	
214	Fabaceae	*Acacia nilotica **	Karuvel(T)	
215	Fabaceae	*Acacia pennata*	Goda-hinguru(S)	
216	Fabaceae	*Adenanthera pavonina*	Madatiya(T) Anaikuntumani(T) Red Sandalwood(E)	M,F
217	Fabaceae	*Aeschynomene indica*	Diya-siyambala(S) Indian Jointvetch(E)	
218	Fabaceae	*Aeschynomene villosa**	Diyasiyambala(S) Thrnless Mimosa(E)	
219	Fabaceae	*Albizia amara*	Thuringi(T)	M
220	Fabaceae	*Alysicarpus vaginalis*	Aswenna(S Kuthiraivali(T) Alice Clover(E)	M
221	Fabaceae	*Arachis hypogaea**	Ratakaju(S) Nella-kadalai(T) Earth Nut, Pea-nut(E)	F
222	Fabaceae	*Atylosia scarabaeoides*	Wal-kollu(S)	
223	Fabaceae	*Bauhinia racemosa*	Maila(S)Atti(T)	M
224	Fabaceae	*Bauhinia tomentosa*	Kaha-pethan(S) Tiruvathi(T) Bell-bauhinia(E)	M,F
225	Fabaceae	*Caesalpinia bonduc*[MA]	Kumburu-wel(S) Punaikkaichchi(T) Grey Nicker(E)	M
226	Fabaceae	*Caesalpinia crista*	Diya-wawuletiya(S) Woodgossip Caesalpinia(E)	
227	Fabaceae	*Caesalpinia pulcherrima**	Monara-mal(S) Peacock Flower(E)	
228	Fabaceae	*Canavalia cathartica*	Wild Bean(E)	
229	Fabaceae	*Cassia alata**	Rata-tora(S) Candle Bush(E)	M,F
230	Fabaceae	*Senna auriculata*	Rana-wara (S) Avarai(T)Matara Tea(E)	M,F
231	Fabaceae	*Cassia fistula**	Ehela(S)Kavani(T) Indian Laburnum(E)	M,F
232	Fabaceae	*Cassia occidentalis*	Peni-tora(S) Ponnantakarai(S) Coffee-senna(E)	M,F
233	Fabaceae	*Cassia tora*	Peti-tora(S) Vaddutakarai(T) Pot Cassia(E)	M,F
234	Fabaceae	*Clitoria ternatea*	Katarodu-wel(S) Karuttappu(T)	M

235	Fabaceae	*Crotalaria hebecarpa*	Bu-gota-kola(S)	
236	Fabaceae	*Crotalaria pallida*	Andanaheriya(S) Smooth Rattle Box(E)	
237	Fabaceae	*Crotalaria verrucosa*	Yak-bariye(S) Kilukiluppai(T) Blue Andana(E)	M
238	Fabaceae	*Cynometra iripa* MA CR	Opulu(S) Attukaddupulli(T)	
239	Fabaceae	*Delonix regia*	Mal-mara(S) Mayaram(T) Flame Tree(E)	
240	Fabaceae	*Derris parviflora*	Sudu-Kala-wel(S)	
241	Fabaceae	*Derris scandens*	Bo-kala-wel(S) Tekil(T Forest Beanstalk(E)	
242	Fabaceae	*Derris trifoliata* MA	Kala-wel(S) Tilankoddi(T)	
243	Fabaceae	*Desmodium heterophyllum*	Maha undu piyali, Et-undupiyali(S) Spanish Clover(E)	M
244	Fabaceae	*Desmodium triflorum*	Heen-undupiyali(S) Narankodi(T) Creeping Tick Threefoil(E)	M
245	Fabaceae	*Dichrostachys cinerea*	Andara(S) Vindattai(T) Sickle Bush(E)	M
246	Fabaceae	*Erythrina variegata*	Erabadu(S) Mullu-murukku(T) Coral Tree(E)	M,F
247	Fabaceae	*Gliricidia sepium*	Watahira, Kona(S) Kona(T) Maxican Lilac(E)	
248	Fabaceae	*Indigofera colutea*		
249	Fabaceae	*Indigofera linnaei*	Bin-avari(S) Cheppunerenchi(T)	
250	Fabaceae	*Indigofera oblongifolia*	Kuttukarasmatti(T)	M
251	Fabaceae	*Indigofera tinctoria*	Nil-awari(S) Nilam(T)Indigo(E)	M
252	Fabaceae	*Leucaena leucocephala* *IAS	Ipil-ipil(S) Tangavai(T) Ipil-ipil(E) Wild Eamarind(E)	
253	Fabaceae	*Mimosa pudica**	Nidi kumba(S)Tottal-vadi(T) Sensitive Plant(E)	M,F
254	Fabaceae	*Parkinsonia aculeata**	Mulvakai(T) Maxican Palo-verde(E)	
255	Fabaceae	*Peltophorum pterocarpum*	Kaha-mara(S) Iya-vakai(T) Yellow Flame(E)	
256	Fabaceae	*Pongamia pinnata*	Magul-karanda(S) Poona(T) Mullikulam Tree(E)	M
257	Fabaceae	*Prosopis juliflora* *IAS	Kalapu-andara(S) Mesquite(E)	F
258	Fabaceae	*Psophocarpus tetragonolobus**	Dara-dambala(S) Winged Bean(E)	F
259	Fabaceae	*Samanea saman**	Mara(S) Rain Tree(E)	
260	Fabaceae	*Sesbania bispinosa*		
261	Fabaceae	*Sesbania grandiflora*	Kathuru-murunga(S) Akatti(T) Agati(E)	M,F
262	Fabaceae	*Tamarindus indica**	Siyambala(S) Puli(T) Indian Date ,Tamarind(E)	M,F
263	Fabaceae	*Tephrosia purpurea*	Gam-pila(S) Kavilai(T) CopmmonTephrosia(E)	M
264	Fabaceae	*Tephrosia villosa*	Bu-pila(S) Hoarypea(E)	M
265	Fabaceae	*Vigna marina*	Karal-li-me(S) Kodippayaru(T) Field Bean(E)	M
266	Fabaceae	*Vigna mungo**	Mun(S) Ulundu(T) Black Gram(E)	M
267	Fabaceae	*Vigna radiata**	Bu-me-mun(S) Chirupparatu(T) Mung Bean(E)	M
268	Fabaceae	*Vigna trilobata*	Munwenna, Bin-me(S) Navippayaru(T)	
269	Fabaceae	*Vigna unguiculata**	Me-karal(S) Kodip-payam(T) Cowpea(E)	
270	Flacourtiaceae	*Flacourtia indica*	Uguressa(S) Katukali(T)	F
271	Flagellariaceae	*Flagellaria indica*	Goyi-wel(S)	M
272	Gentianaceae	*Enicostema axillare*	Vellakuru(T)	M

273	Goodeniaceae	*Scaevola plumieri*	Heen takkada(S)	
274	Goodeniaceae	*Scaevola taccada*	Takkada(S) Half-flower(E)	
275	Hernandiaceae	*Gyrocarpus americanus*	Diya-labu-gas(S) Tanakku(T)	
276	Hippocrateaceae	*Salacia oblonga*	Himbutu(S) Chundan(T)	M,F
277	Hippocrateaceae	*Salacia reticulata*	Kotala Himbutu(S)	M
278	Hydrocharitaceae	*Enhalus acoroides* SG	Waattala(S)	F
279	Hydrocharitaceae	*Halophila ovalis* SG		
280	Hydrocharitaceae	*Halophila decipiens* SG		
281	Hydrocharitaceae	*Thalassia hemprichii* SG	Chatelai(T)	
282	Lamiaceae	*Hyptis suaveolens**		
283	Lamiaceae	*Leonotis nepetiifolia*	Maha-yak-wanassa(S) Kasitumpai(T)	M
284	Lamiaceae	*Leucas zeylanica*	Gata-tumba(S) Mudi-tumpai(T)	M,F
285	Lamiaceae	*Ocimum americanum*	Heen-tala(S) Kanchankorai(T) Hoary Basil(E)	M
286	Lamiaceae	*Ocimum tenuiflorum*	Maduru-tala(S) Sacred Basil(E)	M
287	Lamiaceae	*Platostoma menthoides*		
288	Lecythidaceae	*Berringtonia acutangula*	Ela-midella(S) Adampu(T)	M
289	Linaceae	*Hugonia mystax*	Bu-getiya(S) Motirakanni(T)	M
290	Loganiaceae	*Spigelia anthelmia**	Wormbush(E)	
291	Loganiaceae	*Strychnos benthamii*		
292	Loganiaceae	*Strychnos nux-vomica*	Goda-kaduru(S) Eddi(T) Nux Vomica(E)	M
293	Loganiaceae	*Strychnos potatorum*	Ingini(S) Tetta(T) Clearing Nut(E)	M
294	Loranthaceae	*Taxillus cuneatus* VU		
295	Loranthaceae	*Dendrophthoe falcata*	Pilila(S)	M
296	Loranthaceae	*Dendrophthoe ligulata* VU		
297	Lythraceae	*Lawsonia inermis*	Maruthondi(T) Mignonette Tree(E)	
298	Lythraceae	*Pemphis acidula* MA	Mudu-wara(S) Kiri-maram(S)	
299	Malvaceae	*Abelmoschus esculentus**	Bandakka(S) Vandakkay(T) Lady's Fingers(E)	F
300	Malvaceae	*Abelmoschus* sp.		
301	Malvaceae	*Abutilon hirtum*	Vaddatutti(T)	M
302	Malvaceae	*Abutilon indicum*	Anoda(S) Peruntulli(T)	M
303	Malvaceae	*Gossypium arboreum**	Kapu(S) Cotton(E)	M
304	Malvaceae	*Hibiscus eriocarpus*	Kapukinissa(S) Parutti(T)	
305	Malvaceae	*Hibiscus micranthus*	Bebila(S) Perumaddi(T)	M
306	Malvaceae	*Hibiscus rosa-sinensis**	Sapaththu mal,Wada(S) Shoeflower(E)	M
307	Malvaceae	*Hibiscus tiliaceus* MA	Beli-patta(S) Artia, Nir-paratthi(T)	M
308	Malvaceae	*Hibiscus vitifolius*	Maha-epala(S) Vaddattutti(T) Tropical Rose-mallw(E)	M
309	Malvaceae	*Pavonia odorata*		M
310	Malvaceae	*Sida acuta*	Gas-bevila(S) Vaddatiruppi(T) Common Sida(E)	M
311	Malvaceae	*Sida cordata*	Bevila(S) Palampadu(T)Heartleaf Fanpetals(E)	
312	Malvaceae	*Sida cordifolia*	Wal-bevila(S) Chevakanpudu(T)	M
313	Malvaceae	*Sida mysorensis*	Siriwadi-bavila(S)	M
314	Malvaceae	*Thespesia populnea* MA	Suriya(S) Kavarachu, Puvarachu(T) Tulip Tree(E)	M
315	Martyniaceae	*Martynia annua**	Naga Darani(S) Naga-tail(T) Tiger's Claws(E)	

316	Melastomataceae	*Memecylon capitellatum*	Weli-kaha(S)Katti-kaya(T)	M
317	Melastomataceae	*Memecylon umbellatum*	Kora-kaha(S) Kaya(T) Blue mist(E)	M
318	Meliaceae	*Azadirachta indica*	Kohomba(S) Vembu(T) Neem(E)	M
319	Meliaceae	*Cipadessa baccifera*	Hal-bembiya(S) Pulippan-cheddi(T)	
320	Meliaceae	*Melia azedarach*	Kiri-kohomba(S)Malvi-vembu(T) Bead Tree(E)	M
321	Meliaceae	*Walsura trifoliolata*	Kirikon(S) Chadavakku(T)	M
322	Meliaceae	*Xylocarpus granatum* [M]	Mutti-kadol(S) Kandal Anga(T)	M
323	Meliaceae	*Xylocarpus rumphii* [MA]	Mudu Delum, Koon-talan(S)	M
324	Menispermaceae	*Cissampelos pareira*	Diya-mitta(S) Appatta(T) Abuta(E)	M
325	Menispermaceae	*Tinospora cordifolia*	Rasa-kinda(S) Chintil(T)	M
326	Menyanthaceae	*Nymphoides hydrophylla*	Heen-ambala, Heen-olu(S)	
327	Molluginaceae	*Glinus oppositifolia*	Henn-ala(S) Kachchantirai(T)	M,F
328	Molluginaceae	*Mollugo cerviana*	Udetta(S) Pat-padakam(T) Threadstem Carpet Weed(E)	M
329	Molluginaceae	*Mollugo pentaphylla*	Mollugo(E)	M,F
330	Moraceae	*Artocarpus heterophyllus*	Kos(S) Pila(T) Jak(E)	M,F
331	Moraceae	*Ficus amplissima*	Ela-nuga(S) Kalatti(T)	
332	Moraceae	*Ficus benghalensis*	Maha-nuga(S) Arla(T) Banyan(E)	M
333	Moraceae	*Ficus hispida*	Kota-dimbula(S)	M
334	Moraceae	*Ficus mollis*	Wal-aralu(S)	
335	Moraceae	*Ficus racemosa*	Attikka(S) Atti(T)	M,F
336	Moraceae	*Ficus religiosa*	Bo(S) Arachu(T) Bo-Tree(E)	M
337	Moraceae	*Streblus asper*	Gata-netul(S) Patpirai(T) Crooked Rough-bush(E)	M
338	Moringaceae	*Moringa oleifera* *	Murunga(S) Murungamaram(T) Horse Radish Tree(E)	M,F
339	Musaceae	*Musa x.paradisiaca**	Kesel(S) Valippalam(T) Banana(E)	M,F
340	Myrsinaceae	*Aegiceras corniculata* [M]	Avari-Kadol, Heen-kadol(S) Vitlikanna(T) River Mangrove(E)	
341	Myrtaceae	*Eucalyptus* sp.*		
342	Myrtaceae	*Psidium guajava**	Pera(S) Guava(E)	M,F
343	Myrtaceae	*Syzygium cumini*	Madan, Maha-dan(S) Naval,Perunaval(T) Java Plum(E)	M,F
344	Najadaceae	*Najas minor*		
345	Nelumbonaceae	*Nelumbo nucifera*	Nelum(S) Tamarai(T) Lotus(E)	M,F
346	Nyctaginaceae	*Boerhavia diffusa*	Pita-sudu-pala(S) Karichcharanai(T)	M,F
347	Nyctaginaceae	*Bougainvillea spectabilis**	Boganvilla(E)	
348	Nyctaginaceae	*Pisonia grandis*	Wathabanga, Lechchakotta(S) Chandi(T) Lettuce Tree(E)	M,F
349	Nymphaeaceae	*Nymphaea nouchali*	Manel(S) Common Water Lily(E)	M,F
350	Ochnaceae	*Ochna jabotapita*	Mal-kera(S) Chilanti(T)	M
351	Oleaceae	*Jasminum angustifolium*	Wal-pichcha(S) Wild Jasmine(E)	M
352	Oleaceae	*Jasminum auriculatum*		
353	Oleaceae	*Jasminum grandiflorum**	Saman-pichcha(S)	M
354	Oleaceae	*Jasminum rottlerianum*		
355	Onagraceae	*Ludwigia adscendens*	Beru-diyanilla(S) Creeping Water Primrose(E)	
356	Onagraceae	*Ludwigia perennis*		
357	Orchidaceae	*Vanda tessellata* [VU]	Rassana(S) Anuradhapura Orchid(E)	M

358	Oxalidaceae	*Biophytum nervifolium*	Gas-nidikumba(S)	M
359	Oxalidaceae	*Oxalia barrelieri**	Barrelier's Woodsorrel(E)	
360	Pandanaceae	*Pandanus odoratissimus* [MA]	Mudu-keyiya(S) Talai(T) Screw Pine(E)	
361	Passifloraceae	*Passiflora edulis**	Wal-dodan(S) Passion Fruit Vine(E)	F
362	Passifloraceae	*Passiflora foetida**	Delbatu(S) Kodimathulai(T) Common Passion Flower(E)	
363	Pedaliaceae	*Pedalium murex*	Et-nerenchi(S) Anai-nerinchi(T) Common Pedalium(E)	M
364	Pedaliaceae	*Sasamum indicum**	Tel-tala(S) Ella(T) Gingelly(E)	M,F
365	Pedaliaceae	*Sesamum radiatum*		
366	Periplocaceae	*Cryptostegia grandiflora**	Rubber Vine(E)	
367	Periplocaceae	*Hemidesmus indicus*	Heen-Iramusu(S) Nannari(T) Indian Sarssaparilla(E)	M,F
368	Plumbaginaceae	*Plumbago zeylanica*	Ela-netul(S) Ceylon Leadwort(E)	M
369	Poaceae	*Alloteropsis cimicina*	Budeni-tana(S) Unni-pul(T)	
370	Poaceae	*Aristida setacea*	Et-tuttiri(S)	
371	Poaceae	*Bambusa bambos*	Kaha-una(S) Mungil(T) Spiny Bamboo(E)	M,F
372	Poaceae	*Chloris barbata*	Mayuru-tana(S) Kandai-pul(T)	
373	Poaceae	*Chrysopogon aciculatus*	Tuttiri(S) Ottu-pul(T) Love Grass(E)	M
374	Poaceae	*Cynodon dactylon*	Ruha(S) Arugam-pillu(T) Bermuda Grass(E)	M
375	Poaceae	*Dactyloctenium aegyptium*	Bela-thana, Putu-tana(S)	M
376	Poaceae	*Echinochloa colona*	Gira-tana(S) Adipul(T)	F
377	Poaceae	*Eleusine indica*	Bela-tana(S)	
378	Poaceae	*Eragrostis ciliaris*		
379	Poaceae	*Eragrostis viscosa*		
380	Poaceae	*Heteropogon contortus*	I-tana(S)	M
381	Poaceae	*Hygroryza aristata*	Go-jabba, Beru-tana(S)	M
382	Poaceae	*Imperata cylindrica* *[IAS]	Iluk(S) Varli-pillu(T)	M
383	Poaceae	*Ischaemum ciliare*	Rat-tana(S)	
384	Poaceae	*Leptochloa neesii*		
385	Poaceae	*Oryza sativa*	Wi(S) Paddy(E)	M,F
386	Poaceae	*Panicum repens*	Etora(S) Inji-pul(T)	M
387	Poaceae	*Panicum sumatrense**	Heen-meneri(S) Shamai(T)	
388	Poaceae	*Panium maximum* *[IAS]	Rata-tana(S) Guinea Grass(E)	
389	Poaceae	*Paspalum distichum*		
390	Poaceae	*Saccharum officinarum**	Uk(S) Karumbu(T) Sugar-cane(E)	M,F
391	Poaceae	*Setaria barbata*		
392	Poaceae	*Spinifex littoreus*	Maha-ravana-ravula(S) Ravanan-meesai(T)	
393	Poaceae	*Sporobolus virginicus*	Mudu-etora(S)	
394	Poaceae	*Zea mays**	Bada-iringu(S) Makka-cholam(T) Maize(E)	F
395	Poaceae	*Zoysia matrella*		
396	Polygalaceae	*Polygala chinensis*	Cinese Milkwort(E)	M
397	Polygonaceae	*Persicaria attenuata*	Sudu-kimbul-wenna(S) Water martweed(E)	
398	Pontederiaceae	*Eichhornia crassipes* *[IAS]	Japan-jabara(S) Water Hyacinth(E)	
399	Pontederiaceae	*Monochoria vaginalis*	Diya-habarala(S) Pickerel Weed(E)	M,F
400	Portulacaceae	*Portulaca oleracea*	Genda-kola(S) Sun-plant(E)Pulikkirai(T)	M
401	Portulacaceae	*Portulaca quadrifida*	Heen-genda-kola(S) Chiken Weed(E)	M,F
402	Potamogetonaceae	*Potamogeton* sp. [SG]		

403	Potamogetonaceae	*Ruppia maritima* [SG]		
404	Punicaceae	*Punica granatum**	Delum(S) Madalai(T) Pomergranate(E)	M,F
405	Rhamnaceae	*Colubrina asiatica*	Tel-hiriya(S) Mayirmanikkam(T)	M
406	Rhamnaceae	*Scutia myrtina*	Tudari(T)	
407	Rhamnaceae	*Ziziphus mauritiana*	Debera,Masan(S) Ilantai(T) Indian Jujube(E)	M
408	Rhamnaceae	*Ziziphus oenoplia*	Heen-eraminiya(S) Churai(E)	M
409	Rhamnaceae	*Ziziphus xylopyrus*	Kakuru ,Masan(S) Nari-ilantai(T)	
410	Rhizophoraceae	*Bruguiera cylindrica* [M]	Mal-kadol(S)	
411	Rhizophoraceae	*Bruguiera gymnorhiza* [M]	Mal-kadol(S) Mangrove(E)	
412	Rhizophoraceae	*Ceriops tagal* [M]	Pun-kanda(S) Chiru-kanal(T)	
413	Rhizophoraceae	*Rhizophora apiculata* [M]	Maha-Kadol(S) Kandal(T)	
414	Rhizophoraceae	*Rhizophora mucronata* [M]	Maha-kadol(S) Kandal(T) Asiatic Mangrove(E)	
415	Rubiaceae	*Benkara malabarica*	Pudan(S)	
416	Rubiaceae	*Canthium coromandelicum*	Kara(S) Karai(T) Spring Randia(E)	
417	Rubiaceae	*Cantunaregam spinosa*	Kukuruman(S) Karai(T) False Guava(E)	
418	Rubiaceae	*Hydrophylax maritima*	Mudu-geta-kola(S) East Indian Water Bluet(E)	
419	Rubiaceae	*Ixora coccinea*	Ratambala(S) Vedchi(T) Jungle Flame(E)	M
420	Rubiaceae	*Ixora pavetta*	Maha-ratambala(S) Kanmuttankirai(T) Torch Tree(E)	
421	Rubiaceae	*Mitragyna parvifolia*	Halamba(S)	
422	Rubiaceae	*Morinda citrifolia*	Ahu(S) Manchavanna(T) Great Morinda(E)	M
423	Rubiaceae	*Morinda coreia*	Ahu(S) Manchavanna(T)	
424	Rubiaceae	*Nauclea orientalis*	Bakmi(S) Atuvangi(T)	M,F
425	Rubiaceae	*Oldenlandia biflora*	Thirapala(S)	M
426	Rubiaceae	*Oldenlandia herbacea*		M
427	Rubiaceae	*Oldenlandia umbellata*	Saya(S) Chaya(T) Chay-root(E)	M
428	Rubiaceae	*Pavetta indica*	Pavatta(S) Pavddai(T)	M
429	Rubiaceae	*Psydrax dicoccos*	Panakarawa(S) Vatchikuran(T) Ceylon Box Wood(E)	
430	Rubiaceae	*Scyphiphora hydrophyllacea* [MA]*CR*	Kalu-kadol, Keera Kadol(S) Black Mangrove(E)	
431	Rubiaceae	*Spermacoce articularis*		
432	Rubiaceae	*Spermacoce hispida*	Heen-geta-kola(S) Nattaichchuri(T)	
433	Rubiaceae	*Tarenna asiatica*	Tarana(S) Karanai(T)	M
434	Rutaceae	*Aegle marmelos**	Beli(S) Vilvam(T) Bael Fruit(E)	M,F
435	Rutaceae	*Atalantia ceylanica*	Yakinaran(S) Pey-kuruntu(T)	M
436	Rutaceae	*Atalantia racemosa*		
437	Rutaceae	*Chloroxylon swietenia*	Buruta(S) Muritai(T) Satinwood(E)	M
438	Rutaceae	*Citrus aurantifolia**	Dehi(S) Desi-kai(T)True Lime(E)	M
439	Rutaceae	*Citrus aurantium**	Ambul Dodan(S) Narankai(T) Sour Orange(E)	M,F
440	Rutaceae	*Citrus limon**	Lemon(E)	F
441	Rutaceae	*Citrus sinensis**	Peni Dodan(S) Sweet Orange(E)	F
442	Rutaceae	*Clausena indica*	Migon-karapincha(S) Pannai(T)	M
443	Rutaceae	*Glycosmis mauritiana*	Dodan-pana(S) Kulapannai(T)	
444	Rutaceae	*Limonia acidissima*	Divul (S) Mayaladikkuruntu, Vilatti(T) Wood-apple(E)	F

445	Rutaceae	*Murraya koenigii*	Karapincha(S) Karivempu(T) Curry-leaf(E)	M,F
446	Rutaceae	*Murraya paniculata*	Etteriya(S) Orange Jassamine(E)	
447	Rutaceae	*Paramignya monophylla*	Wellangiriya(S)	
448	Rutaceae	*Toddalia asiatica*	Kudu-miris(S) Kandai(T)	M
449	Salvadoraceae	*Azima tetracantha*	Ichanku(T) Needle Bush(E)	M
450	Salvadoraceae	*Salvadora persica*	Malithtan(S) Uvay(T)	M
451	Santalaceae	*Santalum album**	Sudu-handun(S) Sandal Maram(T) Sandalwood(E)	M
452	Sapindaceae	*Allophylus cobbe*	Kobbe(S) Amarai(T)	M
453	Sapindaceae	*Cardiospermum halicacabum*	Wal-penela(S) Ballon Vine(E)	M,F
454	Sapindaceae	*Dodonaea viscosa*	Eta-werella(S) Virali(T)	M
455	Sapindaceae	*Filicium decipiens*	Pehimbiya(S) Chitteraivempu(T)	
456	Sapindaceae	*Lepisanthes tetraphylla*	Dambu(S) Nekota(T)	
457	Sapindaceae	*Schleichera oleosa*	Kon(S)Kula(T) Ceylon Oak(E)	M,F
458	Sapotaceae	*Madhuca longifolia*	Mi(S)Illupai(T) Mousey Mi(E)	M,F
459	Sapotaceae	*Manilkara hexandra*	Palu(S)Palai(T)	M,F
460	Scorophulariaceae	*Bacopa monnieri*	Lunu-wila(S) Water Hyssop(E)	M,F
461	Scorophulariaceae	*Centranthera indica*	Dutu-satutu(S)	M
462	Scorophulariaceae	*Dopatrium nudicaule*	Bin-sawan(S) Horsefly's Eye(E)	
463	Scorophulariaceae	*Lindernia crustacea*		
464	Scorophulariaceae	*Lindernia pusilla*		
465	Scorophulariaceae	*Lindernia rotundifolia*		
466	Scorophulariaceae	*Scoparia dulcis**	Wal-kottamalli(S) Sweet Broom Weed(E)	M,F
467	Solanaceae	*Capsicum annuum **	Miris(E) Chilli(E)	M,F
468	Solanaceae	*Capsicum frutescens **	Kochi(S) Bird Pepper(E)	F
469	Solanaceae	*Datura metel*	Attana(S) Venumattai(T) Devil's Trumpet(E)	M
470	Solanaceae	*Lycopersicon esculentum**	Takkali(S) Tomato(E)	F
471	Solanaceae	*Physalia angulata**	Cutleaf Groundcherry(E)	
472	Solanaceae	*Solanum macrocarpon**	Wam-batu(S)	F
473	Solanaceae	*Solanum melongena**	Thalana-batu/Ela-batu(S) Vaddu(T) Egg Plant(E)	M,F
474	Solanaceae	*Solanum torvum*	Gona-batu(S)Turkey Berry(E)	F
475	Solanaceae	*Solanum trilobatum*	Wel-tibbatu(S) Tuttuvalai(T)	M,F
476	Solanaceae	*Solanum virginianum*	Katu-wel-batu(S) Kandan-kattai(T)	M
477	Sonneratiaceae	*Sonneratia alba* [M]	Sudu-Kirala(S) Kinnai(T)	
478	Sterculiaceae	*Heritiera littoralis* [M]	Attoona(S) Chonmuntiri(T) Boat-shaped Mangrove (E)	
479	Sterculiaceae	*Melochia corchorifolia*	Gal-kura(S) Chcolaleweed(E)	
480	Sterculiaceae	*Pterospermum suberifolium*	Velang(S)Taddaemarum(T) Fishing Rod Tree(E)	
481	Sterculiaceae	*Waltheria indica*	Punnikki(T) Sleepy Morning(E)	
482	Tamaricaceae	*Tamarix indica* [MA]	Karai(T) Tamarisk(E)	
483	Tiliaceae	*Berrya cordifolia*	Hal-milla(S) Chvandalai(T) Trincomalee Wood(E)	
484	Tiliaceae	*Grewia carpinifolia*		
485	Tiliaceae	*Grewia helicterifolia*	Bora-damaniya(S) Taviddai(T)	
486	Tiliaceae	*Grewia orientalis*	Wel-mediya(S) Taviddai(T)	F
487	Tiliaceae	*Muntingia calabura**	Jam(S) Jam Tree(E)	
488	Turneraceae	*Turnera ulmifolia**	Twelve o'clock Flower(E)	
489	Typhaceae	*Typha angustifolia* [*IAS]	Hambu pan(S) Cat-tail(E)	

490	Ulmaceae	*Trema orientalis*	Gadumba(S) Charcoal Tree(E)	
491	Verbenaceae	*Clerodendrum inerme* [MA]	Bu-renda(S) Dangamkuppi(T) Common Hedge Bower(E)	M
492	Verbenaceae	*Clerodendrum phlomidis*	Gas Pinna(S) Talu-dala(T)	
493	Verbenaceae	*Gmelina asiatica*	Heen-Demata (S) Kumil(T) Asiatic Beechberry(E)	M
494	Verbenaceae	*Lantana camara* [*IAS]	Hinguru, Ganda-pana(S) Wild Sage, Prickly Lantana(E)	M,F
495	Verbenaceae	*Phyla nodiflora*	Hiramana-datta(S) Podutalai(T) Button weed(E)	M
496	Verbenaceae	*Premna latifolia* [MA]	Dangra-seya, Maha-midi(S) Pachumullai(T)	M
497	Verbenaceae	*Premna obtusifolia*	Maha-midi(S) Erumaimulla(T) Headache tree(E)	
498	Verbenaceae	*Premna tomentosa*	Boo-seru(S) Kolkutti(T)	M
499	Verbenaceae	*Stachytapheta jamaicensis**	Balu-nakuta(S) Nay-uranchi(T)	
500	Verbenaceae	*Tectona grandis**	Thekka(S) Tekku(T) Teak(E)	M
501	Verbenaceae	*Vitex leucoxylon*	Nabadde(S) Kaddu-nochchi(T)	M
502	Verbenaceae	*Vitex negundo*	Nika(S) Nochchi(T) Chaste Tree(E)	M
503	Vitaceae	*Cayratia pedata*	Gerandi-dul-wel(S) Kattuppirandai(T)	M
504	Vitaceae	*Cissus quadrangularis*	Hiressa(S) Arugani(T) Grape(E)	M
505	Vitaceae	*Cissus vitiginea*	Wal-niviti(S) Kaddumuntiri(T)	
506	Vitaceae	*Vitis vinifera**	Midi(S) Graps(E)	M,F
507	Zygophyllaceae	*Tribulus cistoides**		
508	Zygophyllaceae	*Tribulus terrestris*	Sembu Nerenchi(S) Chiru-nerenchi(T) Puncture Plant(E)	M

Total number of species=512; Number of native species = 406; Number of Exotic species = 106; Number of endemic species =9; Number of IAS = 13; number of families = 114

Number of threatened species = 8
Number of species used for food = 123; number of species used for medicinal purposes=278

Invasive Alien Species(IAS)=13
Family=114

Annex II. Abundance of plant species in different habitats of the Puttalam Lagoon Area

Abundance of different species in tropical dry mixed evergreen forests habitat

Herbs					
Stenosiphonium cordifolium	40%	cover			
Small shrubs					
*	1	Individuals			
Azima tetracantha	1	Individuals			
Mischodon zeylanicus	6	Individuals			
	Basal area* (BA) cm^2	% BA	Density	% Density	CVI
Small trees					
Capparis rotundifolia	17.90	0.41	1.00	3.13	3.53
Maba buxifolia	25.22	0.58	1.00	3.13	3.70
Diospyros ovalifolia	25.78	0.59	1.00	3.13	3.72
Grewia carpinifolia	76.77	1.76	1.00	3.13	4.88
Tarenna asiatica	89.34	2.05	3.00	9.38	11.42
Hibiscus eriocarpus	155.93	3.57	3.00	9.38	12.95
Mischodon zeylanicus	410.98	9.41	12.00	37.50	46.91
Manilkara hexandra	3564.60	81.63	10.00	31.25	112.88

* Basal area is the cross sectional area of a tree or shrub measured at breast height. This is a measure of dominance of a species in an area.

Abundance of different species in tropical thorn forests habitat

Herbs					
Cover Percentage					
Aerva lanata	0.66	% cover			
Tylophora tenuissima	0.66	% cover			
Stenosiphonium cordifolium	3.29	% cover			
Indigofera tinctoria	6.58	% cover			
Sporobolus virginicus	19.74	% cover			
Eragrostis viscosa	26.32	% cover			
Cynodon dactylon	42.76	% cover			
Large Shrubs					
Catunaregam spinosa		1	Individual		
Euphorbia tirucalli		1	Individual		
Excoecaria agallocha		1	Individual		
Gmelina asiatica		1	Individual		
Pemphis acidula		1	Individual		
Manilkara hexandra		2	Individuals		

Dodonaea viscosa		3	Individuals		
Senna auriculata		4	Individuals		
Salvadora persica		4	Individuals		
Azima tetracantha		6	Individuals		
Dichrostachys cinerea		9	Individuals		
Phoenix pusilla		12	Individuals		
Small trees	Basal area cm^2	%BA	Density	% Density	CVI
Salvadora persica	31.82	1.37	1.00	7.14	8.51
Phoenix pusilla	853.62	36.71	2.00	14.29	51.00
Euphorbia tirucalli	1439.94	61.93	11.00	78.57	140.50

Abundance of different species in mangrove habitats

Herbs	**% Cover**
Fimbristylis cymosa	0.04
Thespesia populnea	0.04
Aegiceras corniculata	0.21
Oldenlandia umbellata	0.21
Cyperus rotundus	0.21
Fimbristylis dichotoma	0.21
Fimbristylis ferruginea	0.21
Salvadora persica	0.21
Eragrostis viscosa	0.41
Sporobolus virginicus	0.41
Cyperus stoloniferus	0.62
Cyperus rotundus	0.62
Eragrostis ciliaris	0.83
Aristida setacea	0.83
Phoenix pusilla	0.83
Scyphiphora hydrophyllacea	0.83
Sporobolus sp.	1.03
Rhizophora mucronata	1.07
Azima tetracantha	1.44
Suaeda monoica	1.44
Sporobolus virginicus	1.86
Cyperus javanicus	2.06
Lumnitzera racemosa	2.31
*Eleusine indica**	2.48
Panicum repens	2.48
Hyptis suaveolens	2.48
Salicornia brachiata	2.48
Eragrostis sp.	3.30
Fimbristylis sp.	3.30
Bruguiera cylindrica	4.74

Cynodon dactylon	5.78
Sesuvium portulacastrum	6.23
Ceriops tagal	7.43
Avicennia marina	20.71
Suaeda maritima	20.71

Small shrubs	**Density**
Azima tetracantha	1
Bruguiera cylindrica	1
Senna auriculata	1
Ceriops tagal	1
Clerodendrum inerme	1
Lantana camara	1
Rhizophora apiculata	1
Scyphiphora hydrophyllacea	1
Sonneratia alba	1
Thespesia populnea	1
Unknown sp.	1
Xylocarpus granatum	1
Phoenix pusilla	3
Aegiceras corniculata	4
Excoecaria agallocha	4
Fimbristylis sp. 8	4
Stenosiphonium cordifolium	4
Suaeda monoica	5
Suaeda maritima	6
Avicennia marina	9
Lumnitzera racemosa	14
Eragrostis sp. 3	16
Rhizophora mucronata	20
Acacia nilotica	42

Large shrubs	**Density**
Senna auriculata	1
Clerodendrum inerme	1
Phoenix pusilla	1
Thespesia populnea	1
Ipomoea violacea	2
Suaeda monoica	2
Salvadora persica	3
Sonneratia alba	4
Lumnitzera racemosa	14
Excoecaria agallocha	15
Scyphiphora hydrophyllacea	26
Ceriops tagal	39
Rhizophora mucronata	46

Small trees	Basal area (BA)	%BA	Density	% Den	CVI
Phoenix pusilla	9.63	0.01	1.00	0.16	0.16
Acacia nilotica	22.99	0.02	1.00	0.16	0.17
Leucaena leucocephala	25.78	0.02	1.00	0.16	0.18
Salvadora persica	35.08	0.03	1.00	0.16	0.18
Xylocarpus rumphii	94.43	0.08	1.00	0.16	0.23
Cocos nucifera	336.12	0.27	1.00	0.16	0.42
Xylocarpus granatum	685.84	0.55	1.00	0.16	0.70
Aegiceras corniculata	141.37	0.11	5.00	0.78	0.89
Scyphiphora hydrophyllacea	173.51	0.14	8.00	1.25	1.38
Cynometra iripa	173.51	0.14	7.00	1.09	1.23
Ceriops tagal	618.85	0.49	11.00	1.71	2.21
Thespesia populnea	128.24	0.10	6.00	0.93	1.04
Bruguiera cylindrica	1107.40	0.88	12.00	1.87	2.75
Lumnitzera racemosa	1712.97	1.37	65.00	10.12	11.49
Sonneratia alba	1707.88	1.36	20.00	3.12	4.48
Rhizophora mucronata	1692.28	1.35	73.00	11.37	12.72
Excoecaria agallocha	2693.66	2.15	152.00	23.68	25.82
Avicennia marina	2688.57	2.14	276.00	42.99	45.14

Large trees	Basal area (BA)	%BA	Density	% Den	CVI
Tamarix indica	35.08	0.05	1.00	0.53	0.59
Derris trifoliata	53.78	0.08	1.00	0.53	0.62
Avicennia officinalis	378.76	0.59	1.00	0.53	1.12
Lumnitzera racemosa	561.34	0.87	1.00	0.53	1.40
Manilkara hexandra	217.82	0.34	3.00	1.60	1.94
Ziziphus oenoplia	523.31	0.81	3.00	1.60	2.41
Phoenix pusilla	516.87	0.80	2.00	1.07	1.87
Thespesia populnea	365.16	0.56	2.00	1.07	1.63
Avicennia marina	88.70	0.14	4.00	2.14	2.28
Cynometra iripa	60.86	0.09	13.00	6.95	7.05
Sonneratia alba	49.40	0.08	8.00	4.28	4.35
Rhizophora mucronata	30.71	0.05	31.00	16.58	16.62
Excoecaria agallocha	1020.79	1.58	117.00	62.57	64.14

Abundance of different species in Salt marsh habitats

Herbs	Cover Percentage (%)
Bulbostylis densa	0.04
Salvadora persica	0.04
Setaria sp. 1	0.04
Enicostima exillare	0.21
Eragrostis unioloides	0.21
Rhizophora mucronata	0.21
Unknown sp. 7	0.21
Eragrostis sp. 3	0.41
Fimbristylis sp. 6	0.41
Atriplex repens	0.62
Ipomoea violacea	0.62
Lumnitzera racemosa	0.62
Avicennia marina	0.90
Fimbristylis sp. 4	1.03
Cynodon dactylon	1.44
Eragrostis viscosa	1.89
Sporobolus virginicus	2.88
Suaeda vermiculata	3.29
Halosarcia indica	3.50
Salicornia brachiata	13.36
Sesuvium portulacastrum	20.81
Suaeda maritima	47.29

Small shrubs	**Cover Percentage (%)**
Tylophora tenuissima	0.29
Suaeda maritima	1.45
Avicennia marina	2.89
Azima tetracantha	4.34
Rhizophora mucronata	7.23
Salicornia brachiata	11.56
Suaeda monoica	72.25

Abundance of different species in sand dunes and beaches (including seashore vegetation)

Herbs	Cover Percentage
Eragrostis sp.12	0.02
Lumnitzera racemosa	0.02
Evolvulus alsinoides	0.04
Leucas zeylanica	0.04
Launaea sarmentosa	0.05

Vigna sp.	0.07
Coccinia grandis	0.11
Maba buxifolia	0.11
Salvadora persica	0.11
Alysicarpus vaginalis	0.12
Senna auriculata	0.12
Chrysopogon zeylanica	0.12
Panicum sp.	0.12
Pentatropis capensis	0.12
Phoenix pusilla	0.12
Phyllanthus maderaspatensis	0.12
Xanthium indicum	0.12
Centranthera indica	0.16
Oldenlandia umbellata	0.18
Cyperus stoloniferus	0.18
Cyperus sp. 4	0.18
Desmodium triflorum	0.18
Chloris barbata	0.18
Spermacoce hispida	0.18
Avicennia marina	0.23
Excoecaria agallocha	0.23
Polygala chinensis	0.23
Setaria sp. 1	0.23
Tylophora tenuissima	0.23
Oldenlandia umbellata	0.35
Croton bonplandianus	0.36
Justicia procumbens	0.36
Murdannia spirata	0.36
Cyperus sp. 3	0.37
Enicostima axillare	0.37
Suaeda maritima	0.44
Luffa nudiflora	0.64
Fimbristylis sp. 3	0.69
Fimbristylis sp. 5	0.71
Fimbrytylis sp. 2	0.89
Cyperus stoloniferus	0.89
Catunaregam spinosa	1.07
Justicia procumbens	1.07
Hydrophylax maritima	1.07
Cyperus sp. 1	1.39
Aristida setacea	1.39
Vernonia zeylanica	1.42
Eragrostis sp. 2	1.45
Fimbristylis sp. 1	1.50
Sesuvium portulacastrum	1.59

Thespesia populnea	1.62
Dichrostachys cinerea	1.64
Fimbristylis sp. 6	1.73
Fimbristylis sp. 4	1.73
Ipomoea pes-caprae	1.80
Eragrostis sp. 3	1.94
Salicornia brachiata	1.96
Spinifex littoreus	1.99
Ocimum tenuiflorum	2.00
Bacopa monnieri	2.16
Sporobolus virginicus	2.49
Asystasia gangetica	2.56
Panicum repens	3.02
Scaevola plumier	3.35
Eragrostis viscosa	3.70
Azima tetracantha	4.26
Imperata cylindrica	4.95
Cyperus rotundus	6.63
Sporobolus virginicus	9.03
Cynodon dactylon	19.25

Small shrubs	Cover Percentage
Capparis zeylanica	0.19
Scaevola plumieri	0.19
Salvadora persica	0.39
Acacia nilotica	0.97
Clerodendrum inerme	0.97
Hibiscus micranthus	0.97
Opuntia sp.	0.97
Lumnitzera racemosa	1.55
Senna auriculata	2.90
Crinum defixum	2.90
Catunaregam spinosa	3.87
Thespesia populnea	3.87
Excoecaria agallocha	4.84
Dodonaea viscosa	5.80
Cissus vitiginea	5.80
Scaevola taccada	18.38
Spinifex littoreus	22.24
Phoenix pusilla	23.21

Large shrubs	Cover Percentage
Acrostichum aureum	0.16
Calophyllum inophyllum	0.16
Derris trifoliata	0.16
Grewia carpinifolia	0.16
Ziziphus mauritiana	0.16
Lumnitzera racemosa	0.32
Ipomoea violacea	0.48
Dodonaea viscosa	0.80
Euphorbia tirucalli	0.80
Flueggea leucopyrus	0.80
Maba buxifolia	0.80
Maytenus emarginata	0.80
Sida mysorensis	0.80
Suaeda monoica	0.80
Carissa spinarum	1.60
Clerodendrum inerme	1.60
Benkara malabarica	1.90
Cordia sp.	2.08
Lantana camara	3.21
Prosopis juliflora	4.81
Azadirachta indica	5.48
Atalantia ceylanica	7.21
Scaevola taccada	7.21
Leucas zeylanica	8.20
Premna latifolia	9.62
Phoenix pusilla	10.42
Spinifex littoreus	12.82
Calotropis gigantea	14.32
Salvadora persica	19.13
Excoecaria agallocha	19.69
Senna auriculata	20.40
Dichrostachys cinerea	36.49
Borassus flabellifer	57.85

Small trees	Basal Area (BA)	% BA	Density	% Den	CVI
Strychnos nux-vomica	181.23	2.58	1.00	4.35	6.92
Coccinia grandis	268.97	3.82	1.00	4.35	8.17
Phoenix pusilla	321.40	4.57	2.00	8.70	13.27
Excoecaria agallocha	277.25	3.94	2.00	8.70	12.64
Salvadora persica	389.58	5.54	4.00	17.39	22.93
Acacia nilotica	379.95	5.40	5.00	21.74	27.14
Thespesia populnea	332.54	4.73	5.00	21.74	26.47
Borassus flabellifer	286.40	4.07	3.00	13.04	17.12

Abundance of different species in seagrass meadows

Sea grasses	Cover Percentage
Thalassia hemprichii	8.86
Enhalus acoroides	11.39
Halophila ovalis	12.66
Cymodocea rotundata	27.85
Halodule uninervis	29.11

Abundance of different species in coconut plantations.

Herbs	Cover Percentage
Catunaregam spinosa	0.41
Croton bonplandianus	2.03
Setaria sp.	2.03
Sida cordifolia	2.03
Cyperus rotundus	4.07
Oldenlandia sp.	4.07
Hyptis suaveolens	6.10
Catharanthus roseus	10.16
Leucas zeylanica	18.29
Fimbristylis sp. 6	20.33
Indigofera tinctoria	30.49

Small shrubs	% cover
Typha angustifolia	50
Fimbrytylis sp. 1	10
Eragrostis japonica	10
Premna obtusifolia	30

Large shrubs	Density
Borassus flabellifer	1
Azadirachta indica	1

Large trees	Basal area (BA)	%BA	Density	% Density	CVI
Phyllanthus acidus	25.78	0.08	1.00	1.56	1.64
Azadirachta indica	86.63	0.27	1.00	1.56	1.83
Cocos nucifera	32549.80	99.66	62.00	96.88	196.53

Abundance of different species in homegardens.

Large trees	Basal area (BA)	%BA	Density	% Density	CVI
Pongamia pinnata	49.72	3.54	1.00	12.50	16.04
Borassus flabellifer	161.10	11.47	1.00	12.50	23.97
Cocos nucifera	1193.32	84.99	6.00	75.00	159.99

Annex III: Checklist of animal species recorded in the Puttalam Lagoon area

BrR: Breeding Resident
M: Migrant
SU: Status Unknown
CR: Critically Enangered
EN: Endanagered
VU: Vulnerable
GTR: Globally threatened

Checklist of Butterflies of Puttalam Lagoon area

	Scientific Name	English Name	Status	Threatened status
Family - Papilionidae				
1	*Troides darsius*	Common birdwing	**Endemic**	
2	*Pachliopta hector*	Crimson rose	Indigenous	
3	*Pachliopta aristolochiae*	Common rose	Indigenous	
4	*Papilio crino*	Banded peacock	Indigenous	
5	*Papilio demoleus*	Lime butterfly	Indigenous	
6	*Papilio polytes*	Common mormon	Indigenous	
7	*Papilio polymnestor*	Blue mormon	Indigenous	
8	*Graphium agamemnon*	Green jay / Tailed jay	Indigenous	
Family - Pieridae				
9	*Leptosia nina*	Psyche	Indigenous	
10	*Delias eucharis*	Jezebel	Indigenous	
11	*Belenois aurota*	Pioneer	Indigenous	
12	*Cepora nerissa*	Common gull	Indigenous	
13	*Appias libythea*	Striped albatross	Indigenous	
14	*Appias paulina*	Lesser albatross	Indigenous	
15	*Ixias marianne*	White orange tip	Indigenous	
16	*Ixias pyrene*	Yellow orange tip	Indigenous	
17	*Hebomoia glaucippe*	Great orange tip	Indigenous	
18	*Catopsilia pyranthe*	Mottled emigrant	Indigenous	
19	*Catopsilia pomona*	Lemon emigrant	Indigenous	
20	*Pareronia ceylanica*	Dark wanderer	Indigenous	
21	*Colotis amata*	Small salmon arab	Indigenous	
22	*Colotis fausta*	Large salmon arab	Indigenous	VU
23	*Colotis etrida*	Little orange tip	Indigenous	
24	*Eurema hecabe*	Common grass yellow	Indigenous	
Family - Nymphalidae				
25	*Tirumala limniace*	Blue tiger	Indigenous	
26	*Tirumala septentrionis*	Dark blue tiger	Indigenous	

27	*Parantica aglea*	Glassy tiger	Indigenous	
28	*Danaus chrysippus*	Plain tiger	Indigenous	
29	*Danaus genutia*	Common tiger	Indigenous	
30	*Euploea core*	Common crow	Indigenous	
31	*Euploea klugii*	Brown king crow	Indigenous	
32	*Ariadne ariadne*	Angled castor	Indigenous	
33	*Byblia ilithyia*	Joker	Indigenous	
34	*Phalantha phalantha*	Leopard	Indigenous	
35	*Junonia lemonias*	Lemon pansy	Indigenous	
36	*Junonia orithya*	Blue pansy	Indigenous	EN
37	*Junonia atlites*	Grey pansy	Indigenous	
38	*Junonia iphita*	Chocolate soldier	Indigenous	
39	*Junonia almana*	Peacock pansy	Indigenous	
40	*Hypolimnas bolina*	Great eggfly	Indigenous	
41	*Hypolimnas misippus*	Danaid eggfly	Indigenous	
42	*Neptis jumbah*	Chestnut-streaked sailor	Indigenous	
43	*Euthalia aconthea*	Baron	Indigenous	
44	*Acraea violae*	Tawny costor	Indigenous	
45	*Melanitis phedima*	Dark evening brown	Indigenous	
46	*Ypthima ceylonica*	White four-ring	Indigenous	
47	*Elymnias hypermnestra*	Common palmfly	Indigenous	
Family - Lycaenidae				
48	*Arhopala amantes*	Large oakblue	Indigenous	
49	*Azanus jesous*	African babul blue	Indigenous	
50	*Azanus ubaldus*	Bright babul blue	Indigenous	CR
51	*Castalius rosimon*	Common pierrot	Indigenous	
52	*Catochrysops strabo*	Forger-me-not	Indigenous	
53	*Chilades lajus*	Lime blue	Indigenous	
54	*Chilades pandava*	Plains cupid	Indigenous	
55	*Chilades parrhasius*	Small cupid	Indigenous	VU
56	*Curetis thetis*	Indian sunbeam	Indigenous	
57	*Euchrysops cnejus*	Gram blue	Indigenous	
58	*Everes lacturnus*	Indian cupid	Indigenous	
59	*Freyeria trochilus*	Grass jewel	Indigenous	
60	*Jamides bochus*	Dark cerulean	Indigenous	
61	*Jamides celeno*	Common cerulean	Indigenous	
62	*Lampides boeticus*	Pea blue	Indigenous	
63	*Rathinda amor*	Monkey-puzzle	Indigenous	
64	*Spalgis epeus*	Apefly	Indigenous	
65	*Spindasis ictis*	Ceylon silverline	Indigenous	
66	*Spindasis vulcanus*	Common silverline	Indigenous	
67	*Syntarucus plinius*	Zebra blue	Indigenous	
68	*Tajuria cippus*	Peacock royal	Indigenous	
69	*Talicada nyseus*	Red pierrot	Indigenous	

70	*Virachola isocrates*	Common guava blue	Indigenous	
71	*Zesius chrysomallus*	Redspot	Indigenous	
72	*Zizeeria karsandra*	Dark grass blue	Indigenous	
73	*Zizina otis*	Lesser grass blue	Indigenous	
74	*Zizula hylax*	Tiny grass blue	Indigenous	
Family - Hesperiidae				
75	*Caprona ransonnettii*	Golden angle	Indigenous	
76	*Hasora taminatus*	White banded awl	Indigenous	
77	*Pelopidas* sp.	Branded swift sp.	Indigenous	
78	*Spalia galba*	Indian skipper	Indigenous	
79	*Suastus gremius*	Indian palm bob	Indigenous	
80	*Taractrocera maevius*	Common grass dart	Indigenous	
81	*Telicota colon*	Pale palmdart	Indigenous	

Checklist of fishes of Puttalam Lagoon area

No.	Family	Species	Common name
1	Hemiscyllidae	*Chiloscyllium griseum*	Grey bamboo shark
2	Carcharhinidae	*Carcharhinus* sp.	Shark species
3	Myliobatidae	*Aetobatus narinari*	Spotted egle ray
4		*Rhinoptera javanica*	Javanese cownose ray
5	Dasyatididae	*Himantura* sp.	Stingray species
6	Ariidae	*Arius* sp.	Sea catfish species
7	Belonidae	*Strongylura strongylura*	Spottail needlefish
8	Centropomidae	*Lates calcarifer*	Sea bass
9	Chanidae	*Chanos chanos*	Milkfish
10	Charangidae	*Alectis ciliaris*	African pompano
11		*Caranx sexfasiatus*	Bigeye travally
12		*Caranx* sp.	Travally species
13		*Crangoides* sp.	Travally species
14		*Scomberoides* sp.	Queenfish species
15	Cichlidae	*Oreochromis mossambicus*	Tilapia
16		*Etroplus suratensis*	Pearl spot
17	Clupeidae	*Nematalosa nasus*	Bloch’s gizzard shad
18		*Amblygaster clupeoides*	Bleeker’s smoothbelly sardinella
19		*Sardinella gibbosa*	Goldstripe sardinella
20		*Sardinella* sp.	
21	Drepanidae	*Drepane punctata*	Spotted sicklefish
22	Engraulidae	*Thryssa hamiltoni*	Hamilton’s thryssa
23		*Thryssa* sp.	
24		*Stolephorus indicus*	Indian anchovy
25		*Stolephorus* sp.	
26	Gerridae	*Gerres abbreviatus*	Deepbody silverbiddy
27	Gobiidae	*Glossogobius giuris*	Bar eyed goby

28		Goby sp. 1	
29		Goby sp. 2	
30		Goby sp. 3	
31	Hemiramphidae	*Hemiramphus* sp.	Half beak
32	Hippocamphidae	*Hippocampus* sp.	Sea horse sp.
33	Leiognathidae	*Leiognathus equulus*	Common ponyfish
34		*Leiognathus berbis*	Berber ponyfish
35		*Gazza minuta*	Toothpony
36	Lutjanidae	*Lutjanus argentimaculatus*	Mangrove red snapper
37		*Lutjanus ehrenbergii*	Ehrenberg's snapper
38	Monodactylidae	*Monodactylus* sp.	Moony species
39	Mullidae	*Parupeneus indicus*	Indian goatfish
40	Muraenidae	*Uropterygius marmoratus*	Marbled moray
41	Oryziidae	*Onjzias cf. dancena*	Blue eye
42	Scatophagidae	*Scatophagus argus*	Spotted scat
43	Siganidae	*Siganus javus*	Streaked spinefoot
44		*Siganus lineatus*	Goldlined spinefoot
45	Sillaginidae	*Sillago sihama*	Silver sillago
46	Soleidae	*Solea elongata*	Elongate sole
47		*Zebrias* sp.	Zebra sole species
48	Sphyraenidae	*Sphyraena barracuda*	Great barracuda
49	Stromateidae	*Pampus chinensis*	Chinese silver pompret
50	Terapontidae	*Terapon jarbua*	Jarbua terapon
51		*Terapon puta*	Smallscaled terapon
52	Triacanthidae	*Triacanthus biaculeatus*	Shortnosed tripodfish
53	Anguillidae	*Anguilla bicolor*	Shortfin eel
54	Bagridae	*Mystus gulio*	Long-whiskered catfish
55	Aplocheilidae	*Aplocheilus parvus*	Dwarf panchax

Checklist of Amphibians of the Puttalam Lagoon area

Family	Species	Common Name
Bufonidae		
1	*Duttaphrynus melanostictus*	Common house toad
2	*Duttaphrynus atukoralei*	Atukorale's dwarf toad
Dicroglossinae		
3	*Euphlyctis cyanophlyctis*	Skipper frog
4	*Euphlyctis hexadactylus*	Sixtoe green frog
5	*Sphaerotheca rolandae*	Marbled sand frog
6	*Fejervarya shyadrensis*	Common paddy field frog
7	*Hoplobarachus crassus*	Jerdon's bull frog
Rhacophoridae		
8	*Polypedates maculatus*	Chunam tree frog

Checklist of Reptiles of Puttalam Lagoon area

	Scientific Name	English Name	Status	Threatened status
Crocodylidae				
1	*Crocodylus palustris*	Marsh crocodile	Indigenous	VU
Bataguridae				
2	*Melanochelys trijuga*	Parker's black turtle	Indigenous	
Cheloniidae				
3	*Chelonia mydas*	Green turtle	Indigenous	GTR
4	*Lepidochelys olivacea*	Olive ridley sea turtle	Indigenous	GTR
Testudinidae				
5	*Geochelone elegans*	Indian star tortoise	Indigenous	VU
Trionychidae				
6	*Lissemys punctata*	Flapshell turtle	Indigenous	
Chameleonidae				
7	*Chamaeleo zeylanicus*	Sri Lankan chameleon	Indigenous	NT
Agamidae				
8	*Calotes calotes*	Green garden lizard	Indigenous	
9	*Calotes versicolor*	Common garden lizard	Indigenous	
10	*Sitana ponticeriana*	Fanthroat lizard	Indigenous	
Gekkonidae				
11	*Hemidactylus parvimaculatus*	Spotted housegecko	Indigenous	
12	*Hemidactylus frenatus*	Common house-gecko	Indigenous	
13	*Hemidactylus leschenaultii*	Bark gecko	Indigenous	
14	*Geckoella yakhuna*	Blotch bowfinger gecko	Endemic	
Scincidae				
15	*Lygosoma punctatus*	Dotted skink	Indigenous	
16	*Eutropis carinata*	Common skink	Indigenous	
17	*Eutropis macularia*	Bronzegreen little skink	Indigenous	
18	*Eutropis tammanna*	Tmmanna skink	Endemic	
19	*Nessia hickanala*	Sharkhead snakeskink	Endemic	CR
Varanidae				
20	*Varanus bengalensis*	Land monitor	Indigenous	
21	*Varanus salvator*	Water monitor	Indigenous	
Acrochordidae				
22	*Acrochordus granulatus*	Wart snake	Indigenous	EN
Boidae				
23	*Python molurus*	Indian python	Indigenous	
Colubridae				
24	*Ahaetulla nasuta*	Green vine snake	Indigenous	
25	*Boiga beddomei*	Beddoms cat snake	Indigenous	DD
26	*Cerberus rynchops*	Dog-faced watersnake	Indigenous	VU

27	*Chrysopelea taprobanica*	Striped flyingsnake	Endemic	VU
28	*Coeloganthus helena*	Trinket snake	Indigenous	
29	*Dendrelaphis tristis*	Common bronze back	Indigenous	
30	*Ptyas mucosa*	Rat snake	Indigenous	
31	*Xenochrophis* cf. *piscator*	Checkered keelback	Endemic	
Hydrophidae				
32	*Enhydrina schistosa*	Hook nose sea snake	Indigenous	
33	*Thalassophina viperina*	Schmidt's sea snake	Indigenous	
Elapidae				
34	*Calliophis melanurus*	Sri Lanka coral snake	Indigenous	
35	*Naja naja*	Indian cobra	Indigenous	
Viperidae				
36	*Daboia russelii*	Russell's viper	Indigenous	
37	*Hypnale hypnale*	Merrem's hump-nosed viper	Indigenous	

Checklist of Birds of Puttalam Lagoon area

	Scientific Name	**English Name**	**Status**	**Threatened status**
Phasianidae				
1	*Francolinus pondicerianus*	Grey francolin	BrR	
2	*Pavo cristatus*	Indian peafowl	BrR	
Turnicidae				
3	*Turnix suscitator*	Barred buttonquail	BrR	
Picidae				
4	*Dinopium bengalense*	Black-rumped flameback	BrR	
5	*Chrysocolaptes festivus*	White-naped woodpecker	BrR	VU
Ramphastidae				
6	*Megalaima zeylanica*	Brown-headed barbet	BrR	
7	*Megalaima haemacephala*	Coppersmith barbet	BrR	
Coraciidae				
8	*Coracias benghalensis*	Indian roller	BrR	
Alcedinidae				
9	*Alcedo atthis*	Common kingfisher	BrR	
10	*Pelargopsis capensis*	Stork-billed kingfisher	BrR	
11	*Halcyon smyrnensis*	White-throated kingfisher	BrR	
12	*Ceryle rudis*	Pied kingfisher	BrR	
Meropidae				
13	*Merops philippinus*	Blue-tailed bee-eater	M	

14	*Merops orientalis*	Little green bee-eater	BrR	
Cuculidae				
15	*Eudynamys scolopaceus*	Asian koel	BrR	
16	*Phaenicophaeus viridirostris*	Blue-faced malkoha	BrR	
17	*Clamator jacobinus*	Pied cuckoo	BrR	
18	*Phaenicophaeus leschenaultii*	Sirkeer malkoha	BrR	
19	*Centropus sinensis*	Greater coucal	BrR	
Psittacidae				
20	*Psittacula krameri*	Rose-ringed parakeet	BrR	
Apodidae				
21	*Cypsiurus balasiensis*	Asian palm swift	BrR	
Hemiprocnidae				
22	*Hemiprocne coronata*	Crested treeswift	BrR	
Caprimulgidae				
23	*Caprimulgus asiaticus*	Indian nightjar	BrR	
Columbidae				
24	*Treron pompadora*	Pompadour green pigeon	BrR	
25	*Columba livia*	Rock pigeon	BrR	
26	*Stigmatopelia chinensis*	Spotted dove	BrR	
Rallidae				
27	*Amaurornis phoenicurus*	White-breasted waterhen	BrR	
Scolopacidae				
28	*Tringa nebularia*	Common greenshank	M	
29	*Tringa totanus*	Common redshank	M	
30	*Actitis hypoleucos*	Common sandpiper	M	
31	*Calidris ferruginea*	Curlew sandpiper	M	
32	*Numenius arquata*	Eurasian curlew	M	
33	*Tringa ochropus*	Green sandpiper	M	
34	*Calidris minuta*	Little stint	M	
35	*Arenaria interpres*	Ruddy turnstone	M	
36	*Calidris alba*	Sanderling	M	
37	*Xenus cinereus*	Terek sandpiper	M	
38	*Numenius phaeopus*	Whimbrel	M	
Recurvirostridae				
39	*Himantopus himantopus*	Black-winged stilt	BrR	
Haematopodidae				
40	*Haematopus ostralegus*	Eurasian oystercatcher	M	
Charadriidae				
41	*Charadrius leschenaultii*	Greater sand plover	M	
42	*Pluvialis squatarola*	Grey plover	M	
43	*Charadrius alexandrinus*	Kentish plover	M	
44	*Charadrius mongolus*	Lesser sand plover	M	
45	*Vanellus indicus*	Red-wattled lapwing	BrR	

Laridae				
46	*Sterna caspia*	Caspian tern	BrR/M	
47	*Sterna hirundo*	Common tern	M/BrR	
48	*Sterna nilotica*	Gull-billed tern	BrR/M	
49	*Sterna albifrons*	Little tern	BrR	
50	*Chlidonias hybrida*	Whiskered tern	M	
Accipitridae				
51	*Haliastur indus*	Brahminy kite	BrR	
52	*Spilornis cheela*	Crested serpent-eagle	BrR	
53	*Accipiter badius*	Shikra	BrR	
54	*Haliaeetus leucogaster*	White-bellied sea-eagle	BrR	
Phalacrocoracidae				
55	*Phalacrocorax niger*	Little cormorant	BrR	
56	*Phalacrocorax fuscicollis*	Indian cormorant	BrR	
Ardeidae				
57	*Casmerodius albus*	Great egret	BrR	
58	*Ardea cinerea*	Grey heron	BrR	
59	*Ardeola grayii*	Indian pond heron	BrR	
60	*Mesophoyx intermedia*	Intermediate egret	BrR	
61	*Egretta garzetta*	Little egret	BrR	
62	*Ardea purpurea*	Purple heron	BrR	
63	*Butorides striata*	Striated heron	BrR	
64	*Egretta gularis*	Western reef egret	M	
Threskiornithidae				
65	*Platalea leucorodia*	Eurasian spoonbill	BrR	
Fregatidae				
66	*Fregata ariel*	Lesser frigatebird	SU	
Artamidae				
67	*Artamus fuscus*	Ashy woodswallow	BrR	
Oriolidae				
68	*Oriolus xanthornus*	Black-hooded oriole	BrR	
Aegithinidae				
69	*Aegithina tiphia*	Common iora	BrR	
Corvidae				
70	*Corvus splendens*	House crow	BrR	
71	*Corvus levaillantii*	Jungle crow	BrR	
Dicruridae				
72	*Dicrurus caerulescens*	White-bellied drongo	BrR	
Muscicapidae				
73	*Saxicoloides fulicatus*	Indian robin	BrR	
74	*Copsychus saularis*	Oriental magpie robin	BrR	
Sturnidae				
75	*Acridotheres tristis*	Common myna	BrR	
Hirundinidae				
76	*Cecropis daurica*	Red-rumped swallow	BrR	

Pycnonotidae				
77	*Pycnonotus cafer*	Red-vented bulbul	BrR	
78	*Pycnonotus luteolus*	White-browed bulbul	BrR	
Timaliidae				
79	*Turdoides affinis*	Yellow-billed babbler	BrR	
Sylviidae				
80	*Orthotomus sutorius*	Common tailorbird	BrR	
Cisticolidae				
81	*Prinia socialis*	Ashy prinia	BrR	
82	*Prinia inornata*	Plain prinia	BrR	
83	*Cisticola juncidis*	Zitting cisticola	BrR	
Alaudidae				
84	*Mirafra affinis*	Jerdon's bushlark	BrR	
Nectariniidae				
85	*Nectarinia lotenia*	Long-billed sunbird	BrR	
86	*Nectarinia asiatica*	Purple sunbird	BrR	
87	*Nectarinia zeylonica*	Purple-rumped sunbird	BrR	
Motacillidae				
88	*Anthus rufulus*	Paddyfield pipit	BrR	
Dicaeidae				
89	*Dicaeum erythrorhynchos*	Pale-billed flowerpecker	BrR	

Checklist of Mammals of Puttalam Lagoon area

	Scientific Name	English Name	Status	Threatened status
Family - Hipposideridae				
1	*Hipposideros ater*	Bicolored leaf-nosed bat	Indigenous	
2	*Hipposideros speoris*	Schneider's leaf-nosed bat	Indigenous	
Family - Pteropodidae				
3	*Cynopterus sphinx*	Short-nosed fruit bat	Indigenous	
4	*Pteropus giganteus*	Flying fox	Indigenous	
Family - Vespertillionidae				
5	*Kerivoula picta*	Painted bat	Indigenous	EN
6	*Pipistrellus coromandra*	Indian pipistrel	Indigenous	
Family - Elephantidae				
7	*Elephas maximus*	Asian elephant	Indigenous	VU
Family - Cercopithecidae				
8	*Macaca sinica*	Sri Lanka toque monkey	**Endemic**	
9	*Semnopithecus priam*	Grey langur	Indigenous	
Family - Lorisidae				
10	*Loris lydekkerianus*	Grey slender loris	Indigenous	
Family - Canidae				
11	*Canis aureus*	Jackal	Indigenous	
12	*Canis familiaris*	Domestic dog	Domestic	

Family - Felidae				
13	*Felis chaus*	Jungle cat	Indigenous	VU
14	*Felis catus*	Domestic cat	Domestic	
15	*Prionailurus viverrinus*	Fishing cat	Indigenous	VU
Family - Herpestidae				
16	*Herpestes brachyurus*	Brown mongoose	Indigenous	
17	*Herpestes edwardsii*	Grey mongoose	Indigenous	
18	*Herpestes smithii*	Black-tipped or Ruddy mongoose	Indigenous	
Family - Mustelidae				
19	*Lutra lutra*	Otter	Indigenous	VU
Family - Bovidae				
20	*Bubalus bubalis*	Domestic water buffalo	Domestic	
21	*Bos indicus*	Domestic hump-backed cattle	Domestic	
22	*Capra hircus*	Domestic goat	Domestic	
Family - Suidae				
23	*Sus scrofa*	Wild boar	Indigenous	
24	*Sus domesticus*	Domestic pig	Domestic	
Family - Tragulidae				
25	*Moschiola meminna*	Sri Lanka mouse-deer	**Endemic**	
Family - Equidae				
26	*Equus asinus*	Donkey	Feral	
27	*Equus caballus*	Mannar ponies / Delft ponies / Horse	Feral	
Family - Hystricidae				
28	*Hystrix indica*	Procupine	Indigenous	
Family - Muridae				
29	*Bandicota indica*	Malabar bandicoot	Indigenous	
30	*Mus booduga*	Field mouse	Indigenous	
31	*Rattus rattus*	Common rat	Indigenous	
32	*Vandeleuria oleracea*	Long-tailed tree mouse	Indigenous	
33	*Tatera indica*	Antelope rat	Indigenous	
Family - Sciuridae				
34	*Funambulus palmarum*	Palm squirrel	Indigenous	
35	*Ratufa macroura*	Giant squirrel	Indigenous	VU
Family - Leporidae				
36	*Lepus nigricollis*	Black-naped hare	Indigenous	
Family - Delphinidae				
37	*Sousa chinensis*	Indo-pacific hump-back Dolphin	Marine	
Family - Dugongidae				
38	*Dugong dugon*	Common Dugong/ Sea cow	Marine	GTR