ENVIRONMENTAL STATUS AND ISSUES OF PUTTLAM LAGOON A CASE STUDY IN SIX COASTAL VILLAGES

PROTECTING DUGONGS
CONSERVING SEAGRASS
CHANGE FOR COMMUNITIES

The Mohamed bin Zayed SPECIES CONSERVATION FUND

Prepared by Dr. Lalith Ekanayake for Sri Lanka Turtle Conservation Project
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CONTENTS

LIST OF FIGURES

ACRONYMS & ABBREVIATIONS

CBO	:	Community Based Organization
CRMP	:	Coastal Resources Management project
DL	:	Dry zone lowlands
DCS	:	Department of Census and Statistics
DS	:	Divisional Secretariat
DSD	:	Divisional Secretariat Division
GEF	:	Global Environmental Facility
GN	:	Grama Niladhari Divisions
IDP	:	Internally Displaced People
IUCN	:	International Union for Conservation of Nature
MbZSCF	:	Mohamed bin Zayed Species Conservation Fund
SLTCP	:	Sri Lanka Turtle Conservation Project
TV	:	Television
UNEP	:	United Nations Environment Program

Environmental status and issues of Puttlam lagoon – A case study in six coastal villages.

1. Introduction to Puttlam lagoon environment

General geography and climate

Puttlam lagoon is located in the northwestern coast of Sri Lanka in the Puttlam district of North Western Province. Puttalam lagoon and Dutch, along with Portugal bay form the largest brackish water body in Sri Lanka. Total water surface is approximately 32,700 ha. Although widely referred to as a lagoon, the Puttalam lagoon is technically a barrier-built estuary (Dayaratne et al 1997). The northern end of Puttalam lagoon opens to the sea. Its southern end is connected to the northern end of Mundal lake by the Dutch canal, which carries brackish water. The entire Puttalam lagoon system is very shallow, with depths of no more than 1-2 m, except in the deep channels within the Puttalam lagoon, where depths of 4-5 m have been recorded (Dayaratne et al, 1997). The water is of normal oceanic salinity in the north, whilst high evaporation makes it generally hypersaline in the south. Three river basins, Mee Oya, Kala Oya and the very small Moongil Ara discharge into the Puttalam lagoon. Their catchment areas are: Kala Oya 2772 sq km, Mee Oya 1516 sq km and Moongil ara 44 sq km. Kala Oya discharges the highest quantity of water (587 Cu M x 106) followed by Mee Oya (387 Cu M x 106) and Moongil ara (587 Cu M x 106). Two ground water basins, Vanathaviluwa and Madurankuliya are also located close to the Puttalam lagoon system (Dayaratne et al 1997). A number of small low islands exist in Puttalam lagoon and Dutch bay and they have evolved due to sediment and sand transport under the influence of currents, tides and winds. The land is low laying flat area meeting the sea with very low gradient expanse of marine habitats. Steep rocky areas or hills are almost absent. Most of the land cover is of anthropogenic origin while near natural vegetation systems are fragmented and patchy.

The area lies in the dry zone part of Sri Lanka. The annual temperature ranges between 30.4^{0}C to 33.6^{0}C and characterized by seasonal rainfall during monsoon periods. Average annual rainfall ranges between 1000mm - 1100 mm and it is seasonal, characteristic with two dry seasons, i.e. January - March and July to September. Hence, the terrestrial flora has characteristic of arid zone botanical elements. Maximum. Rainfall is in the period November - December, by inter-monsoon convectional rains. A semi-diurnal tidal pattern occurs in the lagoon (estuary). The average tidal range is about 25 cm (Ekanayake et al, 1995) and the maximum tidal range recorded is 79 cm (Perera & Siriwardena, 1982). The tidal pattern in Puttalam lagoon does not occur in rhythm with that of the Indian Ocean to which it is connected through Dutch bay at the northern end. Monsoon winds play a significant role in tidal movement in this shallow lagoon where the mean depth is approximately 5 m. Tidal range is highest during the northeast monsoon and it is lowest during the southwest monsoon (Perera & Siriwardena, 1982).Surface water salinities vary between 0.00 ppt (at Kala Oya estuary) and 55.0 ppt. Residence time of Puttalam lagoon is approximately 50 days (Arulananthan et al, 1995).

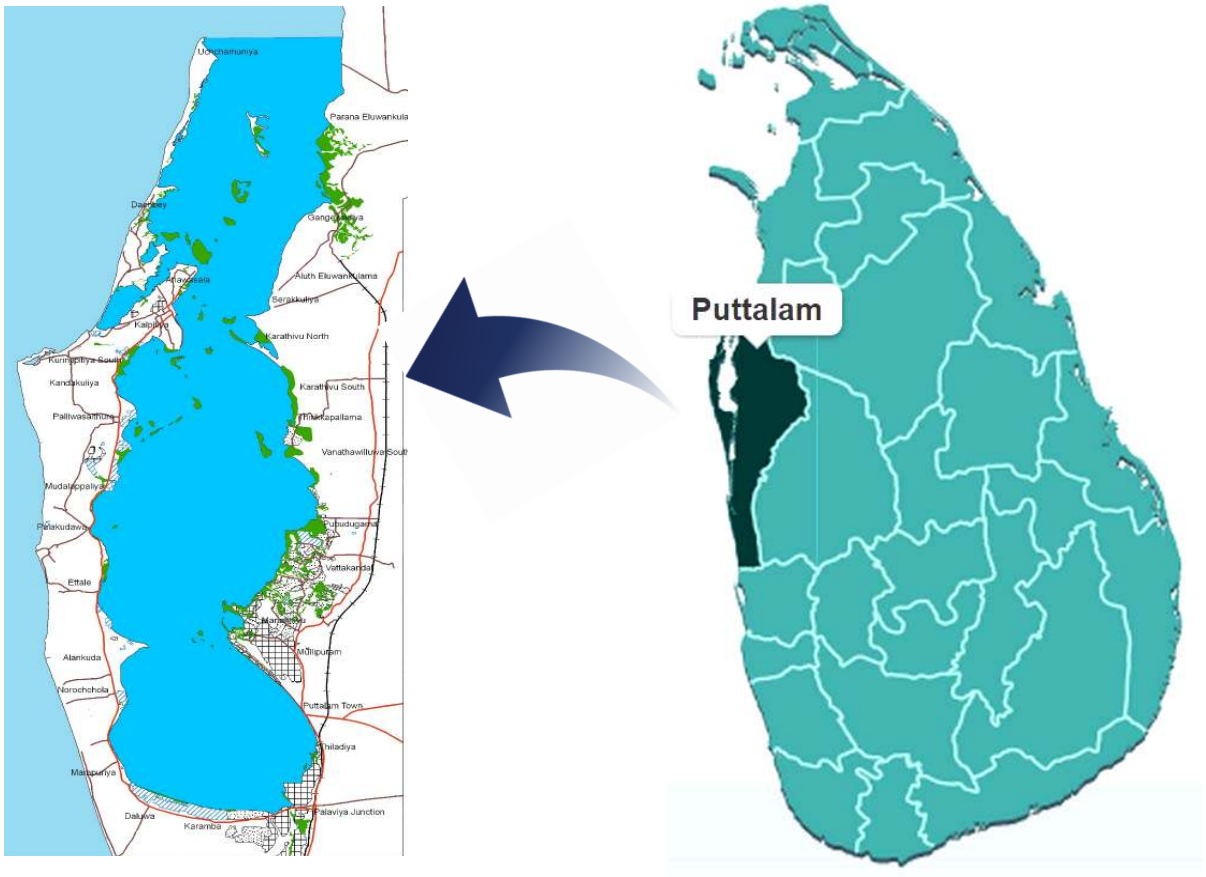

Figure 1: Map of Puttlam lagoon.

Socio economic setting

Puttalam is the largest town in Puttalam District, North Western Province, Sri Lanka. It is the administrative capital of the Puttalam District and governed by an Urban Council. Situated 130 kilometres (81 mi) north of Colombo, the capital of Sri Lanka and 95 kilometres (59 mi) north of Negombo. Puttalam is known for energy production, salt, coconut production and fishing. It has one of the largest lagoons in the country. The history of Puttalam dates back to the arrival of Prince Vijaya, nearly 2,500 years ago, when his vessel washed ashore to "Thambapani" which is located north side of Puttalam lagoon. The name "Puttalam" may be a modification of the Tamil word Uppuththalam, Uppu means salt and Thalam means salt production zone, which evolved into the name Puttalam. Urban areas of Puttalam are dominated by Muslims(95%) while Buddhists and Christians are residing outside the town. Hindus are minority. All religious places are available in the town as well as outside the town. Puttalam has 3 main highways that connect it to major cities in the country. A3 which connects Puttalam with Colombo via Negombo. A10 which connects Puttalam with Kandy via Kurunegala. A12 which connects Puttalam with Trincomalee via Anuradhapura. Puttalam situated at the center of the Coconut Triangle, Puttalam is the second largest Coconut producer of the country with Muslim Moors dominating this production process. Its key economic highlights are as follows.

-Puttalam is also the second largest salt producer in the country.

-Puttalam hosts one of the largest cement factories in the country: Holcim Cement factory.

-Puttalam is also famous for Shrimp farming and Agriculture.

-Puttalam is now the first place in Sri Lanka to host a Crab farm and hatchery run by a Singapore-based company. (https://en.wikipedia.org/wiki/Puttalam;Accessed 14/02/2016)

Figure 2: Highly urbanized Puttlam town area.

A brief on the overall project.

This environmental study is a supportive activity of the larger project titled The GEF Dugong and Seagrass Conservation Project (Full Title: "Enhancing The Conservation Effectiveness of Seagrass Ecosystems Supporting Globally Significant Populations of Dugongs Across the Indian and Pacific Ocean Basins"). This GEF Project is executed by The Mohamed bin Zayed Species Conservation Fund (MbZSCF) and implemented by the United Nations Environment Program (UNEP) with financing from the Global Environmental Facility (GEF). It has the goal of improving the conservation status of dugongs and their seagrass habitats across the Indian and Pacific Ocean basins and project activities will span over four years from January 2015 to December 2018.

Dugongs are vulnerable to extinction because they are killed directly or indirectly by human-related activities, which include fishing, coastal development and hunting. The seagrasses on which they depend are thought to be one of the most threatened ecosystems on Earth. Protection of the dugong as an icon or flagship species will have a wider conservation impact by addressing seagrass ecosystem conservation as well as the socio-economic needs of communities dependent on these ecosystems. This Project will be achieved through 40 individual projects in collaboration with more than 30 project partners in eight countries; Indonesia, Madagascar, Malaysia, Mozambique, Solomon Islands, Sri Lanka, Timor Leste and Vanuatu. This project focuses on building the capacity of stakeholders at local-community, national, regional and global levels to protect dugongs and their seagrass habitats.

The focus area

Six coastal villages were selected to conduct the socio-economic assessment and later the sites have been ear marked for implementing small-scale development interventions of the project. The localities include Anawasala, Pallivasathurei, Serakkuliya, Soththupitiya, Thikkapallama and Kandakuliya, around Putlam lagoon. Location details of different project sites (villages) are as follows (see the map below).

2. Objectives

- To prepare the environmental baseline with particular reference to fauna and flora in and around six selected villages around Puttlam lagoon. The localities included Anawasala, Pallivasathurei, Serakkuliya, Soththupitiya, Thikkapallama and Kandakuliya, around Putlam lagoon. Location details of different project sites (villages) are given in Figure xx.

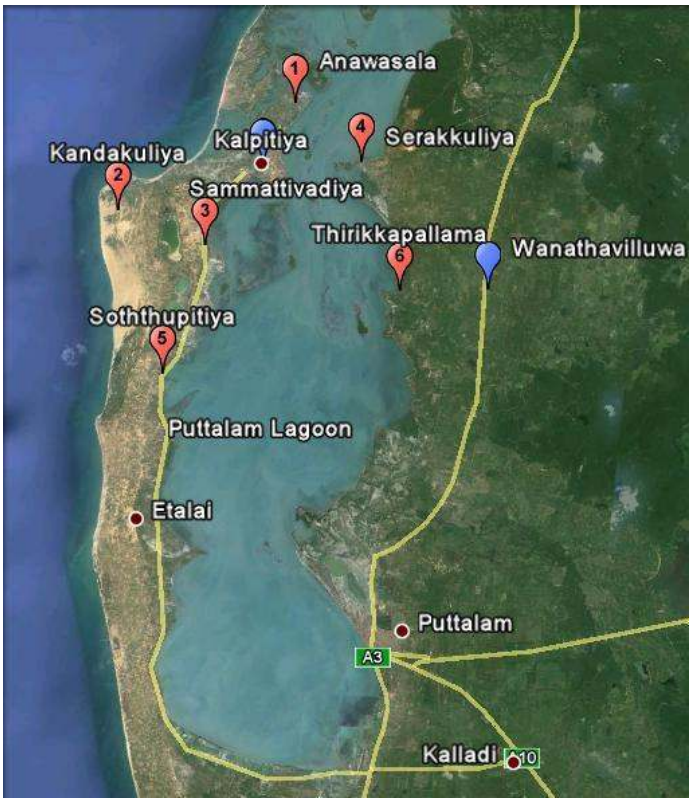

Figure 3: Map of study sites

- To document the current status of environmental degradation in those sites as baseline conditions.

3. Methodology

Initially a reconnaissance survey was carried out to understand the present situation of the area. The initial visits made it possible for;
(a) Familiarization of the territory and environmental situation using pertinent references viz; road maps, aerial photographs, geological and geographical maps, previous knowledge of the flora, fauna, climate data etc.
(b) Compilation of literature review pertinent to the area.
(c) Ground survey of the territory and vegetation. For this much of the area that was approachable was traversed to:

a. familiarize with the territory and accessibilities.
b. get the knowledge of flora in general and its status.
c. collect plant materials representing in the area in order to identify and verify for the preparation of floristic inventory.
d. acquaint with the local people whose help and understanding of their home territory was extremely useful in order to do an effective work in a strange region.

The detail survey was planned according to the ground situation examined.

Field sampling techniques - Documentation of general biodiversity

During this rapid assessment event, Visual Encounter Survey (VES) method was used to document general flora (flowering plants) and fauna (mammals, birds, reptiles, fish, amphibians, butterflies and dragonflies) in different seasons in different ecosystems. There are three standard sampling designs for visual encounter surveys: opportunistic or randomized walk, transects, or a quadrate design (Crump and Scott, 1994), and the present survey was carried out through opportunistic or randomized walks in different uniform ecosystems. Visual encounter surveys can determine species richness; be applied in long term monitoring projects; provide information for compilation of a species list; and provide data used to estimate proportion of area surveyed that is occupied by target species.

Photographic records were made to identify less familiar species, and standard taxonomic keys and other scientific literature mentioned in the list of references were used in the process.

Figure 4: Data collection at the field

Literature survey

Amarasinghe (2004) has identified several habitat types in Puttlam lagoon and the surrounding environs. They are;*Terrestrial ecosystems and habitats:* Natural terrestrial ecosystems include dry monsoon forest and dry thorny scrublands, while man influenced terrestrial land-use types include coconut/banana/cashew cultivations, home gardens, and teak plantation forests. A vast extent of dry monsoon forest occurs in the Vanathavilluwa area. Dominant tree species include *Manikara hexandra*, *Drypetes sepiaria*, and *Chloroxylon sweitenia*. These forests harbor a rich animal diversity, including nationally threatened mammalian species such as the Elephant, Sloth Bear, and Leopard.
Wetland Ecosystems and habitats: Natural wetland ecosystems in the Puttalam District include rivers, streams, villus, mangrove, sea grass beds, coral reefs, salt marsh, lagoon and seashore vegetation. Man-influenced wetlands include rice fields, irrigation canals, saltpans and shrimp ponds. Mangrove ecosystems of Puttlam lagoon are proportionately the largest extent of mangrove ecosystems in Puttalam lagoon is located in Kala oya and Mee oya estuaries as well as in the uninhabited islands. Mangals (area covered by mangroves) in Puttalam lagoon show distinct differences with respect to their net above ground primary productivity (NPP) (Amarasinghe & Balasubramaniam, 1992b). Accordingly, mangrove areas in Puttalam lagoon and Dutch bay can broadly be categorized into two groups, i.e. fringing mangles and revering mangles. Fringing mangles occupy the intertidal areas along the coast of the mainland and in the islands while revering mangles exist in the estuaries and along the riverbanks, particularly of Kala Oya and Mee Oya. Fringing mangles predominantly occur in the larger islands in Puttalam lagoon and Dutch bay and in a few locations on the mainland, i.e. Pallivasalthurei, Tannikudah, Kuringipiti, Mandalakudah, Kovilkudah, Keerimundel, Serakkuli and Karathivu areas. Small patches of

over-wash mangals, i.e. fringe mangals located in small islands or patches of mud flats that get completely submerged during every high tide, occur around Kungimathottam. Scrub mangals occur along the mainland shoreline towards more saline upper inter-tidal areas. Scattered and stunted *Avicennia marina* plants are characteristic to these mangals.
Floristic diversity studied by Amarasinghe (1989) shows the presence of *Rhizophora mucronata* and *Avicennia marina* as the major constituent species of the mangals of Puttalam lagoon and Dutch bay. Monospecific stands of *A. marina* is commonplace in Puttalam lagoon and *R. mucronata* dominates the water-front areas of the riverine mangals of Kala Oya. A total of 14 exclusive or true mangrove plant species and 29 species of mangrove-associated species have been reported from Puttalam lagoon and Dutch bay. Among them, *Scyphiphora hydrophyllacee* is a very rare species that occurs only at Etalai, (western shore of Puttalam lagoon), on the entire west coast, where 04 shrubs were found to grow.

True mangrove and mangrove-associated species in Puttalam Lagoon & Dutch bay:

1. *Acanthus ilicifolius*
2. *Aegiceras corniculatum*
3. *Avicennia marina*
4. *Bruguiera cyllindrica*
5. *Bruguiera gymnorhiza*
6. *Ceriops tagal*
7. *Cynometra iripa*
8. *Excoecaria agallocha*
9. *Lumnitzera racemosa*
10. *Rhizophora apiculata*
11. *Rhizophora mucronata*
12. *Scyphiphora hydrophyllacea*
13. *Sonneratia alba*
14. *Xylocarpus granatum*

Mangrove associated species are:

1. *Acrostichum aureum*
2. *Ardisia eliptica*
3. *Calophyllum inophyllum*
4. *Cassia auriculata*
5. *Cerbera manghas*
6. *Cissus quadrangularis*
7. *Clerodendron inerme*
8. *Cordia subcordata*
9. Cryptolepis buchanania
10. *Derris uliginosa*
11. *Flagellaria indica*
12. *Gyrocarpus sp.*
13. *Hibiscus tiliaceus*
14. *Indigofera sp.*
15. *Ipomoea maritime*
16. *Pemphis acidula*
17. *Phoenix sp*.
18. *Premna integrifolia*
19. *Salicornia brachiata*
20. *Salvadora persica*
21. *Sesuvium portulacastrum*

22. *Sueda maritime*
23. *Sueda monoica*
24. *Sueda nudiflora*
25. *Syzygium cumini*
26. *Tamarix gallica*
27. *Thespesia populnea*
28. *Typha sp.*
29. *Vitis carnosa*

Animals in mangroves play an important role in ecological dynamics of Mangroves. Apart from the fish and crustaceans, a diverse benthic fauna is associated with the mangrove areas. Molluscs form a dominant faunal group in the mangals. In certain mangals, such as in Erumathivu island, *Terebralia palustris* dominates the waterfront areas and it plays a significant role in litter degradation. Among the crab species in these mangals and sea grass beds, Portunid crabs such as *Uca* sp, *Scylla serrata*, *Portunus pelagicus* and *Macrophthalmus* sp. are common. *Neosermatium malabaricum*, and *Chiromantes* sp are the frequently occurring Grapsid crabs in these coastal ecosystems. Besides, the mud lobster, *Thalassina anomala* is also present in the mangrove areas and their mounds alter the hydrology within the mangals. The mangals serve as important feeding and roosting sites for several species of aquatic birds, such as herons, egrets, king fishers and waders. The marsh crocodile (*Crocodilus palustris*) – a nationally threatened species, occurs along the Kala-oya mangrove stretch (Kanakaratne et al, 1983, Amarasinghe & Perera, 1995).

Salt marshes and sea grass beds of Puttalam lagoon and Dutch bay provide feeding grounds for avifauna, especially for migratory waders. Salt marshes are closely associated with the mangals in this dry climatic region. Extreme soil salinities that prevail in these inter-tidal soils have given rise to vegetation consisting of salt-tolerant herbaceous plants (halophytes). Five species of salt marsh plants have been recorded from the study area, namely, *Arthrochnemum indicum*, *Sueda maritime*, *S. monoica*, *S. nudiflora* and *Salicornia brachiata* . Besides, an algal mat called “lab lab”, dominated by nitrogen fixing filamentous cynobacteria such as *Lyngbia* sp. exists on the soil surface. During high tide, when the marsh gets inundated, these algal mats start floating and during day- time due to their photosynthesis, these marsh waters become oxygen- rich. Salt marshes with algae form the habitat for the juveniles of a number of fish and shellfish, particularly *Chanos chanos* (milk fish), fry of which are collected in large numbers for pond aquaculture. Dwarf *Avicennia marina* is found to grow in salt marshes near Kalpitiya. Either extremely high soil salinities prevailed at the time of colonization or cattle and goat grazing or both together would have given rise to the establishment and maintenance of dwarf *Avicennia marina* (Amarasinghe & Perera, 1995).

Sea grass ecosystems are recognized as nursery grounds and habitats of a large number of marine aquatic organisms, including the threatened marine mammal, Dugong (*Dugong dugong*). Sea grass beds in Mannar bay, Portugal and Dutch bay have been reported to provide habitats for the latter species (Colin & Bertram, 1970). Eight species, belonging to 6 genera of sea grasses have been identified in Puttalam lagoon (Jayasuriya, 1991). Viz. *Enhalus acaroids*, *Thalassia hemprichii*, *Halodule uninervis*, *Siringodium isoetifolium*, *Cymodocea rotundata*, *Cymodocea serrulata*, *Halophila ovalis*, *Halophila decipiens*. Besides sea grasses provide substrata for epiphytes, which have been widely evident as food for most of the juveniles that inhabit the sea grass beds. *Gracilaria edulis* is an economically important epiphyte that occurs in Puttalam lagoon. The major Gracilaria beds are found in the sea grass beds near Udayarpidi island.

Coral reef ecosystems are also an integral part of the SAM area. The Bar Reef Marine Sanctuary is located in the southern Gulf of Mannar northwest of the Kalpitiya Peninsular. The Sanctuary covers an area of 307 km with the nearest coral patches lying approximately 2 km from the shore (Ohman et al. 1998, Ohman et al. 1997). The reef is affected by rough sea conditions during the southwest monsoon.

During the months of November, December and January northeasterly winds bring in turbid water from several river outlets as well as the Puttalam Lagoon (Ohman et al. 1993). The Gulf of Mannar has some of the most extensive coral reef formations in Sri Lanka. In addition to Bar Reef there exist several other reef formations to the south off Kandakuliya and northwards towards Mannar, including the reefs off Silavaturai. Combined with other marine ecosystems such as estuaries, lagoons, salt marshes, sea grass beds and mangroves, this area could be considered one of the most productive and biologically diverse coastal habitats in Sri Lanka. Although declared a Marine Sanctuary in 1992 management of the reef is virtually non-existent. For most part, Bar Reef has remained relatively undisturbed owing to its remoteness. Civil unrest in nearby areas and restrictions on fishing imposed by the Sri Lanka Navy for security reasons has also limited human impacts on the Bar Reef. This Bar Reef Marine Sanctuary is considered an offshore patch reef and consists of 2 distinct habitat types. These are the shallow coral reef and the deeper sandstone reef. The coral reef is situated from the surface to a depth of around 10 m while the sandstone reef is located deeper than 18m. The coral reef area is composed mainly of branching and tabulate corals although fairly large coral domes are found at around 10m depths. The deeper reefs are mainly sandstone substrate with corals growing on it. It is characterized by rocks, small hills and flat plateau like structures with holes and crevices (Ohman et al. 1997). Prior to coral bleaching live coral cover was nearly 80% (Ohman et al. 1993) with *Acropora* spp. accounting for nearly 90% of all corals. The shallow coral reef habitats of Bar Reef were composed mainly of branching and tabulate *Acropora* and foliaceous *Echinopora*. However most of these corals died due to coral bleaching in 1998. Bar Reef was severely affected by coral bleaching in 1998 resulting in nearly 100% mortality of corals up to a depth of around 10m. Corals beyond 10m depths were also bleached but most of them recovered later. However there have been strong signs of recovery since 1998. Many small colonies of branching Pocillopora and Acropora as well as tabulate Acropora have been recorded in 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 Podabacea being the most common types (Rajasuriya et al. 2002). Ohman et al. (1997) recorded 135 species of reef fish belonging to 19 families in the Bar Reef. However this did not included cryptic and nocturnal species and hence does not reflect the true diversity of fish species for this reef. Bar Reef also has one of the highest diversities of Butterfly fish (Chaetodontidae) in Sri Lanka with over 30 species. Butterfly fishes are an indicator of reef health with both species diversity and numbers being higher on healthy coral reefs (Ohman et al 1998). Damselfishes (Pomacentridae) are one of the most dominant fish groups with *Chromis* spp., *Stegastes* spp. and *Dascyllus* spp. being the most common. Surgeonfish's (Acanthuridae) and Parrotfish's (Scaridae) are also common. *Pseudanthias* spp. (Serranidae) was one of the most abundant fishes in the sandstone habitats (Ohman etal. 1997). Since coral bleaching however, the number of Butterfly fish has decreased dramatically due to the lack of live corals on which many of them feed. Major piscivores such as Groupers (Serranidae), Barracudas (Spyraenidae) and Jacks (Carangidae) are common. In addition, Black-tip Reef Sharks (*Carcharhinus melanopterus*) and White-tip Reef Sharks (*Triaenodon obesus*) are also frequently encountered. Whale sharks (*Rhyncodon typus*), dolphins and sea turtles are also found in the area (Ohman et al. 1993). Major invertebrates include numerous species of mollusks including the commercially exploited Conch shells. Sea Cucumbers, Starfish and Spiny Lobsters are also abundant. Despite the affects of coral bleaching Bar Reef remains one of the most biologically diverse coral reefs in Sri Lanka. It has also shown strong signs of natural recovery from coral bleaching compared to many other reefs in the country. Ohman et al. (1993) estimated that nearly 50% of fish species caught in Sri Lanka were directly dependent on the reef ecosystem for their survival. Therefore, reef habitats such as Bar Reef are extremely important for the sustainability of marine fisheries in Sri Lanka. It is important not only due to its natural value but also as a valuable resource to coastal communities in the area.

4. Results and discussion

4.1 Major ecosystem types and their plants and animals in and around selected coastal villages.

The major ecosystem types in the area can be classified as follows.

a. Open water zone and sub tidal ecosystems: Lagoon and ocean open water body, Coral reefs and sea grass beds.

b. Tidal ecosystems: Mangroves, mud flats, seashore and salt marsh.

c. Terrestrial ecosystems: Grasslands, Scrublands, Palmyrha woodlands, coconut plantations and Home gardens.

Detail documentation of species were done in those ecosystem types except for coral reefs – which was explained using past studies. Fishing related species and other common species were recorded in open water body of lagoon and ocean. As shown in below following major ecosystem types were encountered in the project area and their leading plants and animal species are given in annex 1 & 2. Descriptive accounts of respective ecosystem types are as follows.

4.1.1 Open lagoon / ocean

The open lagoon/oceans or pelagic ecosystems are the areas away from the coastal boundaries and above the seabed. It is a highly heterogeneous and dynamic habitat. Physical processes control the biological activities. The upper zone or photic zone is well illuminated, so plants can photosynthesize. The water is nutrient – rich, because of the river inflows and closed environment of lagoon. The sparse plants that live here are entirely planktonic. The habitat sustains highly important marine fish species that support local livelihoods of traditional fishing community of the area.

The lagoon is a shallow body of water separated from sea by a narrow connection with the sea. The lagoon form along coastal plains - flat or gently sloping landscape, and visibly there is small tidal change. The lagoon has mostly brackish water, a mix of saltwater from the sea and freshwater from rain run-off. The area is rich in biodiversity - wetland birds and fish are easily observed in lagoon ecosystem. Its salinity varies with seasons. During the rainy season, when rain run-off accumulates, the salinity becomes lower. During the dry season, when run off slows and seawater seeps in, lagoon becomes more brackish. The lagoon ecosystem is highly productive area for the local fishing community.

Figure 5: The vast stretch of open lagoon

4.1.2 Coral reefs

Coral reefs ecosystems were not studied in the present biodiversity survey, but their occurrence in the area have been recorded by previous investigators (Rajasuriya and Amarasinghe, 1997). Coral reefs are composed of calcium carbonate, or limestone, derived from the water by the reef organisms: The reef's structure is formed from coral polyps, that live in colonies; when coral polyps die, they leave behind a hard, stony, branching structure made of limestone. Most of these structures, the underlying foundation of the reef, is dead, made up of layer upon layer of coral skeletons. Since the sea is warm, clear and shallow, corals are rich in life. Although present study did not focus on coral reefs, some studies done by Rajasuriya and Amarasinghe (1997) have located two small coral reefs areas, a fringing coral reef at the Kandakuliya point and off- shore coral reef at a distance of about 1.5km from the coast. Fringing reefs are reefs that form along a coastline. They grow on the continental shelf in shallow water. Also, a reef at Talawila, approximately 300m from the shore.

Conservation values: The coral provides shelter for many animals in this complex habitat, including sponges, nudibranchs, fish (like Blacktip Reef Sharks, groupers, clown fish, eels, parrotfish, snapper, and scorpion fish), jellyfish, anemones, sea stars (including the destructive Crown of Thorns), crustaceans (like crabs, shrimp, and lobsters), turtles, sea snakes, snails, and mollusks (like octopuses, nautilus, and clams). Birds also feast on coral reef animals.

Threats: Major threats to coral reefs are water pollution (from sewage and agricultural runoff), dredging off the coast, careless collecting of coral specimens, and sedimentation (when silt or sand from construction or mining projects muddies the waters of a reef and kills coral, which needs light to live).

Figure 6: Coral reef

4.1.3 Sea grass beds

They are a benthic community dominated by grass-like marine plants, usually growing on shallow, sandy or muddy bottoms of sea. These marine plants have the same basic structure as terrestrial plants. They have tiny flowers and strap-like or oval leaves. They form under water 'grasslands' in estuaries and shallow coastal waters. Most closely related to lilies, they are quite different from seaweeds, which are algae. To grow, seagrasses need nutrients, often obtained from nearby mangroves, and good light, which means clear water. They cannot grow easily where they dry out at low tide. They therefore thrive in shallow coastal waters where there is shelter (such as a sand bar) from drying winds and from wave action and strong currents which could create turbulent muddy water. Seagrasses are well adapted to

their marine habitat. The roots of seagrasses serve to anchor the plants, and are not necessary for water intake. They share the task of nutrient collection with the leaves which can absorb food and water directly from the surrounding water.

Conservation values: Seagrass beds are believed to rival rice paddies in their photosynthetic productivity (the amount of the sun's energy they convert to plant sugars) and are very important as nurseries and habitat for many commercially important species of fish and prawns. Also, they are an essential part of the marine environment. Not only do the plants stabilize sand and mud banks (keeping water clear) but they form the basis of a complex ecosystem supporting forms of life from dugong to plankton. Seagrasses are central to a web of life. Only a few animals — dugong, green turtles, sea urchins and some fish — have the ability to digest cellulose and feed directly on the leaves themselves. However, their usefulness does not end there. The leaves support an array of attached seaweeds and tiny filter-feeding animals like bryozoans, sponges, and hydroids as well as the eggs of ascidians (sea squirts) and molluscs. These provide food for small fish which feed the larger fish. While living seagrasses might not be a popular item on the menu, dead seagrasses are a sought-after delicacy, forming the basis of lengthy food chains. Detritus from bacterial decomposition of dead seagrass plants provides food for worms, sea cucumbers, crabs and filter feeders such as anemones and ascidians. Further decomposition releases nutrients (nitrogen, phosphorus) which, dissolved in water, are re-used by seagrasses and phyto (plant) plankton. Plankton, both plant and animal, is a food source for juvenile prawns and fish, as well as other filter feeders. Changes may led to severe losses in the fisheries of the area. (http://www.epa.qld.gov.au/nature_conservation/habitats/marine_habitats/seagrass/).

Threats: Generally, sea grass beds found in locations where human presence is frequent are under stress due to physical damage from fishing gear, sewage discharges, dredging and filling releasing polluted water into the sea, oil spills and changes in light transmission due to turbidity. Perhaps, their occurrence and vigor can be viewed as an indicator of human impact.

Figure 7: Some seagrass in Puttlam area

4.1.4 Mudflats

Mudflats are sedimentary intertidal 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. They commonly appear in the natural sequence of habitats between subtidal areas and terrestrial inland vegetation. In many places they have been much reduced by land encroachment and land development. Several species of plants, mainly washed over sea grasses and algae were, recorded as common species.
Conservation values: Mudflats, like other intertidal areas, dissipate wave energy minimizing the impacts on salt marshes and flooding low-lying lands. The mud surface also seem to play an important role in nutrient budget of coastal system. As indicated by abundant bird life, mudflats are characterized by high biological productivity and abundance of organisms, but low in plant species diversity. They provide feeding and resting areas for internationally important migrant birds, and are also important nursery areas for fish.

Threats: Land claim, for prawn culture, social infrastructure are the main threats. Loss of mudflats reduces estuary productivity and may influence other estuary habitats such as saltmarsh. Discharges from agriculture, settlements, including polluted storm-water run-off, can create abiotic areas or produce algal mats which may affect invertebrate communities. They can also remove embedded fauna and destabilizing sediments thus making them liable to erode.

Physical damage due to trampling and dredging for prawn culture have an important effect on sediment biota and on sediment supply and transport.

The introduction of new or non-native species, for example, craw can reduce the naturally mudflat dependent species. In future, higher sea level and increased storm frequency, resulting from climate change, may further affect the sedimentation patterns of mudflats and estuaries.

Figure 8: Mudflats

4.1.5 Mangroves

Mangroves are salt-tolerant woody plant assemblages located along sheltered lagoons and estuaries. Well developed mangroves usually reach up to 6m-10m and some species like *Rhisophora mucronata* and *Sonneratia alba* may grow beyond that height. In mature stands the stratification is limited almost to a single layer of true mangrove tree species forming a dense canopy; e.g *Rhisophora mucronata*, *Avicennia marina*, *Aegiceras corniculata* and *Ceriops tagal*. They have developed charasteristic structural features of mangrove flora adapted to live under extreme edaphic conditions; shallow water, thick mud,

water logged saline soil, loose soil, heavy clays containing a large amount of organic matter, daily fluctuation of salinity etc. In order to overcome the difficulties encountered in this habitat the plants have developed various anatomical and physiological features such as stilt roots, prop roots or knee roots for anchorage e.g *Bruguiera cylindrica*, pneumatophores (breathing roots) for respiration e.g. *Sonneratia alba*, succulent leaves for storage of water e.g. *Excoecaria agallocha* removal of extra salts by leaves e.g. *Rhizophora mucronata*, shiny leaves for light reflection e.g. *Lumnitzera racemosa*. vivipory mode for seed germination e.g. *Rhizophora mucronata* and *Ceriops tagal*. In addition to true Mangrove stands, certain patches, Mangrove mixed communities, are mixed with back mangrove species. E.g. *Excoecaria agallocha* and *Lumnitzera racemosa*.

In the project area several sub types of Mangroves, based mainly on floristic, could be found.

1. *Rhizophora mucronata* dominated stands.
2. *Avicina marina* dominated stands.
3. *Ceriops tagal* dominated stands.
4. Mixed stands.

Conservation values: Ecological values of mangroves are many and varied - Help in soil formation by trapping debris, stabilize loose soil and detritus, act as a filter for land runoffs, prevent sea erosion and protect the hinterland from tidal surges, cyclonic impacts, provide appropriate ecosystem conditions and refuge for fish, marine invertebrates, mollusk and birds. The products and services provided by mangroves are indispensible for socio economic sustainability of the area- provide various economically valuable plant materials needed for the community. e.g. fire wood, light timber, Mas Athu for prawn fishery and bark tannin (young *Acrostichum aureum* leaves). Fishery industry is highly dependent on the ecosystem condition of mangroves.

Threats: Clearing by local people, timber harvesting, physical damage due to fishing gear, oil spills from boats, prawn culture, accumulation of polythene and other solid waste are the main threats to these valuable mangrove systems.

Figure 9: Mangroves

4.1.6 Seashore habitats

Sandy beaches although appear barren, many animals and plants species can be located if observed carefully. Beach sediments are continually flushed by sea water, which carries oxygen and bits of animal and plant debris into the pore spaces between the sand grains. This action creates an ideal environment for microscopic organisms. This sandy areas are also occupied by burrowing animals such as crab and worms. These animals bury themselves in the sand to avoid detection by predators and to escape the strong wave action. In places where sand bars have formed parallel to wave action, many species of birds can be seen perching on sand in search of food e.g. crabs, prawns and shrimps. A unique assemblage of diverse plant species can be found sand dunes of the sea shore habitats. Sand dunes are developed as a result of continuous sand accretion around certain creepers, shrubs or trees growing as clumps on the coast. Usually, 2m-4m hills or ridges of sand are piled up by wind along the sea coast. The dunes usually occur as parallel rows with increasing size, height, stability and complexity from the sea shore to the inland. A series of plant assemblages representing different phases of dune succession can be observed. Young mobile dunes are frequented by herbaceous species (up to 25cm) such as *Cyperus bulbosus*, *Ipomoea pes-caprae*, *Hydrophylax maritima* and *Spinifex littoreus*. Those young hummocks on the bare coast are the initiators of the sand dune system and appear as a poor vegetation carpet on the sandy surface. The sand dune development accompanies considerable edaphic changes as a consequence of colonization and sequential stabilization of assemblages of plants. Young hummocks are highly unstable owing to wind induced and wave induced erosion, but they provide some degree of shelter and protection, which help building up of the dune. The accumulation of organic debris and humus increase the water holding capacity and improve the soil fertility, favoring further luxuriant growth of the vegetation cover. The more stabilized older dunes occurring away from the sea are characterized by a more complex woody vegetation e.g. *Scavola taccada*, *Clerodendrum inerme*, *Erythroxylum monogynum, Pempis pisudula, Thespesia populnea, Pisonia grandis, Cassine glauca, Maytenus emarginata, Limonia acidissima, Azima tetracantha, Salvadora persica.*

The physical appearance and floristic composition depend on the extent and steepness of the shore and the degree of ground stability. The vegetation is located in the zone beyond the direct impact of waves and tides and supports a carpet of densely growing creepers (0.5m) and small shrubs(1m) which help consolidation of surface soil by restricting wind induced erosion and by providing resistance to removal of sand by occasional sea water. The commonest species which predominates the carpet is *Spinifex littoreous* (Maha rawana revula), *Scavola taccada*, *Ipomoea pes-caprae*, Launaea *sarmentosa*, *Cyperus bulbosus* and *Hydrophylax maritima*. This plant cover can minimize the wind impact considerably. Often, pure populations of *Spinifex littoreous* provides shelter to the highly unstable sea shore exposed to heavy blowing. Occasionally are other creepers which occur as sporadic individuals in between *Spinifex littoreous* clumps. Towards the leeward side a mixed assemblage of low shrubs and some hardy herbaceous species occur. The common species include *Cyperus* spp., *Eragrostis spp*., *Hydrophylax maritima*, *Pempis asiudula*, *Erythroxylum monogynum*, *Bauhinia racemosa* (Maila) and *Capparis* spp. All these are characterized by stunted habit, a feature attributed to the impact of strong wind action, salt spray and insulation.

In places where sand accumulation is not very significant and relatively steeper experiencing frequent salt water spray (beach front) from wave action, a particular set of plant species can be observed. Such beach front communities consist of species such as *Scaevola taccada*.

Conservation values: Sand of the seashore can effectively dissipate wave energy minimizing the impacts on inland areas. In places where sand bars are formed several species of birds can be seen as their favourite feeding site. Sand dunes are ecologically precious and indispensable, for they provide protection to the coast and facilitate its development and expansion. Along with some other maritime unique natural ecosystems, sand dune vegetation also fast disappearing elsewhere in the country. Their role is incomparable and indispensable, for no other natural ecosystem can be expected to perform the

same. Scientifically, they are one of the least studied ecosystems in Sri Lanka. Ecological dynamics and floristic trends are little understood. When located in the vicinity of human settlements, illegal clearing and trampling have caused serious destruction to the natural ecology of these vegetation.

The carpet of creepers consolidates the surface soil and enriches it with humus and nutrients from decomposing organic debris, which are plentiful beneath the *Spinifex littoreous* shoots in particular.

Threats: Digging of sandy areas by people in search of water e.g Plalliyawatta.

Figure 10: Beach environment

4.1.7 Salt Marsh

Salt marsh is an intertidal plant community complex dominated by herbs (up to 0.5m) and low growing shrubs (0.75m). There is a clear structural distinction between saltmarsh and mangroves - which is an intertidal community dominated by trees. The sites become extremely dry during the prolonged dry period (April-August) and consequently excessive evaporation intensifies salinity. Often crystallized free salt can be seen. *Arthrochnemum indicum*, *Salicornia brachiata* and *Suaeda maritima* populations occur covering the bare ground. They are perennial herbs with prostrate and upright shoots. Usually, the ground is 75% bare soil and species like *Cynodon dactylon* and *Cyperus* spp. occurs intermixed.

Environmentally extreme conditions such as dry atmospheric condition, soil salinity, desiccating salt spray, perennially high temperature, excessive evaporation do not attract other plant species to such locations. Under that situation the saltmarh community is the last natural option that provides a protective ground cover to these specific locations. Well developed salt marsh communities are becoming rare in the country due to various impacts. Comparatively they are also one of the least studied community in the country.

Conservation values: They provide nursing habitat and breeding grounds several faunal species. Many fish and shellfish depend on them for living and breeding. Physically mangroves can contribute to protect

shore line from flood and Storm by shielding coastal areas and are important shoreline stabilizers due to their wave dampening effect. Well established herbaceous communities are also highly effective against erosion. Also, one can clearly see the ground evidence for run off filtering properties of salt marsh vegetation. Furthermore, recreation associated with salt marshes provide humans unique opportunities-walking and educational outdoor laboratories.

Threats and their locations: Filling of salt marshes - filling in a salt marsh can eliminate a marsh all together, or lead to changes in elevation that prevent the ebb and flow of tides on the marsh surface, consequently inhibiting the growth of specially adapted salt marsh plants. Even small changes in elevation can drastically affect the drainage of water and allow growth of invasive plants such as *Opuntia dellinii*. Structures such as dikes, roads with inappropriately sized drainage pipes, inadequately sized culverts and pipes can frequently cause a number of problems in salt marshes. Restriction of tidal flow results in a direct reduction in estuarine habitat area. Lowering of salinity, caused by the reduction of tidal input, 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 specie in the marsh changing the entire habitat.

Pollution from surrounding settlements, including polluted runoff from roads, fertilized landscapes, and failing septic systems can change the vegetation in the salt marsh. Increased nutrient-rich runoff usually promote invasive plant cover.

Figure 11: Salt marshes

4.1.8 Grasslands

Grasslands are characterized as patches of lands dominated by grasses of varying heights (5cm-25cm). These occur as intermittent patches of the terrestrial landscape. The structure and floristic composition of the grassland system is highly influenced by grazing pressure, trampling, salinity and drought.

The chief species of grasslands are *Cynodon dactylon*, *Cyperus rotundus*, *Panicum repens*, and *Eragrostis* spp. However, the site specific moisture levels decide the species dominance and composition.

Conservation values: Grasslands are indispensable with regard to the role played in sustaining the cattle population in the area. Many graminivorous birds can be seen feeding in grasslands. Similar to other open vegetation types, grasslands act as ground stabilizer - the vegetation cover and the root mat are highly effective against erosion. Also, effective in filtering run off. Recreations associated with grasslands provide people unique opportunities- walking and educational outdoor laboratories.

Threats: Regeneration of grasslands is also at stake due to the damage caused by the livestock, and in many places the bare ground is expanding.

Figure 12: Coastal grasslands

4.1.9 Scrublands

Thorn scrubs are characterized by three distinct aerial strata occupying ecologically indispensible niches. The upper most tree layer (5m-8m) is composed of scattered trees / treelets such as *Limonia acidissima* (Divul), *Cassia auriculata* (Ranawara), *Bauhinia racemosa* (Maila), *Salvadora persica* (Maliththan) *Azadirachta indica* (Kohomba), *Flueggea leucopyros* (Andara). The effects of strong desiccating winds are evident in the stunted growth habit and heavily wind cut crowns of above species. Climbers like *Cissus quadrangularis* (Heeressa) and *Jasminum* spp. (Walpichcha) are commonly found associated with thorn scrubs. Below the scattered tree layer shrubby plants like *Toddalia asiatica* (Kudumiris), *Dichrostachys cinerea* (Andara), *Carissa spinarum* (Karamba), *Catunaregam spinosa*, *Flueggea leucopyrus* (Katupila), *Randia* spp., *Ziziphus* spp.(Eraminiya) and *Capparis* spp. occur as dominants.

Underneath the woody strata is a ground herbaceous layer (up to 75cm) consisting of plants like *Commelina* ssp., *Barleria prionitis*, *Crinum latifolium*, *Heliotropium indicum*, *Cyanotis* sp., *Crotalaria* ssp., *Sida acuta*, *Sida cordifolia*, *Urena lobata* and *Hemidesmus indicus*.

Conservation values: Dense structure of vegetation is an excellent cover against erosion or 'desertification' caused by strong winds prevailing in the area. Thorn scrubs can trap finer particles of soil and sand blown away from the seaward open habitats and build up the soil layer. The seed bank therein helps to promote the habitat into late successional systems like thorn forests.

In view of the services to arid zone fauna the thorn scrubs are indispensable. The habitat is a complex system providing animals with opportunities for feeding, breeding and hiding.

Threats: Presently many sites of scrublands are modified and rendered inferior due to invasion of *Eupatorium odoratum*, *Opuntia dilenii*, *Lantana camara*.

Figure 13: Coastal scrubland plants

4.1.10 Palmyrah woodlands

The arid climatic affinities in the area has enabled successful spread of Palmyra in some vegetation pockets. Palmyrha (*Borassus flabellifer*) tree is a robust, 25m-40 m tall, solitary dioecious palm. It has a massive stem which is straight, up to 1 m in diameter at base, conical up to about 4 m high, thereafter cylindrical and 40-50 cm in diameter. Stem is covered by leaf bases when young and many animal species find a safe abode there, especially bats and reptiles.

Conservation values: All parts of the Palmyra are useful to the community. The seedlings (underground and tuber-like) are sometimes grown for use as a starchy vegetable, and eaten boiled or raw. The growing point of the palm is also edible. The tender mesocarp of fruits is cooked as a curry. The ripe fruit has a yellow edible pulp with a distinctive smell. The young endosperm of the seeds is also eaten fresh or in syrup. The fibers of young leaves can be woven into delicate patterns. Petioles often can be split into fiber, to be used for weaving and mat making. The wood and leaves are also used as fuel. Some traditional medicinal uses are known for all parts of the palm. The lowest 10 m of the trunk of mature trees has hard and strong wood. The leaves are used as thatch and are said to last several years. They are also used for baskets and mats. Leaves are used as boundary or barrier or support- petioles are often used as poles for fencing. Toddy palms very often provide shelter to many animals (birds, bats, rats, squirrels, mongooses, monkeys) and plants (orchids, ferns and other epiphytes). Thick stands of Palmyra are good wind breaks.
Threats: Land clearance for various infrastructure is a current threat.

Figure 14: Palmyra woodlands

4.1.11 Coconut plantations

Coconut plantations are widespread in the area and is one of the main source of income generation. Traditional tall coconut varieties are commonly cultivated in the area. Usually they can grow up to a height of 24-30 m; dwarf selections also exist but not common. The trees are planted at spacing of about 7 x 7 m-10 x 10 m, resulting in about 48 to 70 trees per acre. Ground vegetation is mainly grass sustaining the livestock farming.

Conservation values: Economically and ecologically coconut is highly valued plant, especially in coastal areas. Some of the uses are; it is a valuable source of food, oil, fiber, fuel wood, timber, charcoal, thatching material, sap etc. Many utensils and handicrafts are made from coconut tree. Also it is a good soil improver- burnt husks form a useful sort of potash that is used to fertilize the trees. The husks also make valuable mulch for moisture conservation in the dry season and help to suppress weeds. It has therefore been intercropped with cereals (cassava, sweet potatoes and yams) or fruits (bananas, passion fruit, pineapples and ground nuts). Fibrous root system has good soil binding properties and minimizing erosion. Many pollinator insects depend on coconut flowers.

Threats: Removal of coconut trees can be seen as a minor threat due to expansion of housing and infra structures.

Figure 15: Coconut plantations associated with home gardens.

4.1.12 Home gardens

Home gardens are the vegetation type found immediately around homesteads and are results of long-term human adaptations. Occurrence of tree dominated multipurpose vegetation communities arranged at different vertical levels is visible in these home gardens. Well developed multi-storey home gardens are located in certain locations. Generally, a canopy (20m-35m), sub-canopy (10m) and shrub/herb layer (2m) could be recognized. Often the structure is fast changing in time and space due to agricultural practices such as weeding, pruning, fencing, digging etc. Exotic and agricultural crop species are found in this habitat. Common tree species include Coconut, Teak, Mango and Wood apple. Coconut is dominated in almost all the home gardens.

Home gardens are important faunal habitat providing animals with feeding and nesting sites and also provides people with fruits, nuts, yams, flowers, vegetables, medicines, firewood, timber etc. throughout the year. This helps to reduce the pressure on natural forests, especially Mangroves.

Conservation values: Home garden as a closed canopy vegetation system in this arid area is a valuable land cover for conservation of soil, fauna and ground vegetation. It sets the right conditions for diverse livelihoods; mainly animal husbandry (goat, cattle and poultry) and coconut based income generation activities.

Threats: Most fisherman lack interest in planting trees in their home gardens. Most plants remain due to ' let it grow' attitude by people and little after care tasks are performed.

Figure 16: A home garden

4.2 Highlights on lagoon ecosystem based fishery sector

The livelihoods of communities in the selected localities are primarily related to fishery industry. Fishing in the lagoon remains as open access and the fishery are comprises of an artisanal fishery, modern fishery and destructive fishery. The following main fishing gear and methods are currently used by local fisherman.

Trammel net (Disco net)
Stake net (Kattu dela)
Cast net (Visi dela)
Push net (Thallu dela)
Drive-in-net (Gok ran dela)
Trap net (Kudu dela)
Brush pile (Mas athu)
Lagoon seine (Gawana dela)
Kadippu dela
Cover pot (Karakgediya)
Rod & line /hand line
Crab net
Dip net
Katta
Fish kraal (Ja kottu)
Kotu dela
Scoop net (Athanguwa)
Manda
Mada mirikeema
Crab traps (Kakulu thattiya)
Haras dela
Kemana
Iratta

The fishing industry of the lagoon is a massive process concerned with harvesting, culturing, processing, preserving, storing, transporting, marketing or selling fish or fish products. The commercial activities are aimed at the delivery of fish and other seafood products for people in the surrounding urban areas as well as those in distant places like Colombo and Kandy. Some products, especially prawns and crabs, are directed for exporting. As far as fishery operations are concerned, there are two fishery operational sectors; commercial sector and subsistence sector. The commercial sector comprises enterprises and individuals associated with lagoon catch or aquaculture resources and the various transformations of those resources into products for sale. It is also referred to as the "seafood industry" and linked with big companies in Colombo. The subsistence sector comprises individual level small scale enterprises that sustain some families in day to day basis - for family consumption as well as for local level selling of fish. The commercial sector of the fishing industry is a massive operation that comprises the following chain.

-Commercial fishing and fish farming which produce the fish
-Fish processing which produce the fish products
-Marketing of the fish products

Fishery products -fresh, dried and frozen forms are available for consumers.

Figure 17: Highly valued commercial fishery resources

Figure 18: Production of dry fish

Figure 19: A business center for fishery products

4.3 Major causes of degradation of lagoon environment

4.3.1 Overfishing

Locations: The problem is serious at Kandakuliya and Soththupitiya areas while it is happening at moderate levels at Serakkuliya. The rest of the sites; Anawasala and Pallivasathurei have little or no issue of overfishing.

Causes and impacts: As elsewhere in fishing villages in Sri Lanka, there are community recognized zones in the lagoon water body where access to fishing in those zones are allocated only for different village groups. This is a mutually understood community practice that has been there since ancient times. Such community practices support sustainability of fishing harvest through exploitation by limited number of fishermen. However, since late some fishermen have totally neglected those social norms and carry out fishing in wherever they want in the lagoon system. Use of harmful fishing methods by those fishermen further aggravated the problem. This has led to the problem of overfishing. As commonly known, overfishing occurs when more fish are caught than the population can replace through natural reproduction. Gathering as many fish as possible may seem like a profitable practice, but overfishing has serious consequences. The results not only affect the balance of life in the lagoon, but also the social and economic well-being of the coastal communities who depend on fish for their way of life. Hundreds of people around Puttlam lagoon rely on fish for protein, and fishing is the principal livelihood for those. Earlier people living around Puttlam lagoon considered as a limitless bounty of fish supply. However, increasing fishing efforts over the last 10 years as well as unsustainable fishing practices are pushing many fish stocks to the point of collapse. Another important factor that exerted much pressure on fish population is the relaxation of restrictions on fishing after end of the 30 year civil war. During that unrest, no fishing were allowed in the lagoon during night time, and from 2009 May onwards no more war time fishing restrictions were implemented. This is well expressed by older fishermen generation, and post war period is marked by a boom in fishing in the lagoon. At the moment, more than 75 percent of the lagoon's fisheries have been pushed to or beyond their biological limits and are in need of strict management plans to restore them. Several important commercial fish populations have declined to the point where their survival as a species is threatened. Target fishing of top predators is changing marine communities, which lead to an abundance of smaller marine species. As per discussions, many fishers are aware of the need to safeguard fish populations and the lagoon environment, however illegal fishing and other regulatory problems still exist.

4.3.2 Destructive fishing techniques

Locations: Use of illegal and destructive fishing gear is very common at Pallivasathurei, Kandakuliya and Soththupitiya. Some recent incidence at Kandkuliya include killing of dolphins. At Sothhupiya regular use of Thangus nets was observed and few months ago Navy arrested those law breakers. They were produced to the court and duly fined. However, the problem itself has not stopped at Sotthupitiya area for the reason that fishermen from far and away are visiting the area and carry out illegal practices unhindered. The problem is at very low level in sites such as Serakkuliya and Thikkapallama,

Causes and impacts: Another area of concern is the widespread use of damaging and illegal fishing techniques. The case in point is the push nets, sine nets etc. which can cause serious damage on the marine environment especially on non-target organisms, such as the indiscriminate catch of juvenile fishes. The by-catch of juveniles and trash fish, once seen as unwanted and a waste of valuable resources, has caused negative effect on the fishery resources. Although such catch may present low economic value to fishers, it can comprise high value species in the future, if these are allowed to survive and grow to commercial size. To ensure the sustainability of the resource, avoiding such kind of catch should be a priority. Over the last few years fisheries development agencies have been actively engaged in the development and promotion of responsible fishing technologies and practices, that have the potential to significantly reduce such “by-catch”. Removal of non-target species or group of species severely affect multiple trophic levels that sustain the entire fishery system. Physical impacts to lagoon bottom environment due to destructive fishing techniques further affect nursery grounds of fish and prawns. Such impacts are exacerbated when combined with other stressors such as climate change and land-based sources of pollution.

Figure 20: Traditionally used destructive illegal fishing gears

4.3.3 Marine debris & shoreline trash

Locations: There is already an increasing trend of accumulation of solid waste in beach areas and near shore waters at Soththupitiya and Kandakuliya. The problem is less severe in other sites.

Causes and impacts: Marine debris and shoreline trash include large numbers of plastic bags, as well as metal cans, fishing equipment, glass bottles, shoes, tires, plastic/polymer based solid waste material that enters the lagoon environment from fishing activities as well as domestic waste. Debris is found around almost every where of the surrounding fringe of the lagoon and also below water as well. But their abundance varies depending of relative human presence, wave pattern and natural barriers. Marine solid waste is a pollution problem that impacts human health and safety, endangers marine and coastal habitats. Many people assume that if trash exists in the lagoon, it must be that the fishing industries are to blame. But in fact, careful observation shows that significant volume of trash are from land-based sources; like litter - from households, motorists, beach visitors, garbage such as ill-fitting trash can lids, etc. Such debris affect the marine and coastal environment in variety of ways.

Entanglement: Common items like fishing line, strapping bands and rings can hamper the mobility of marine animals and cause injury. Once entangled, animals have trouble eating, breathing or swimming, all of which can have fatal results. Plastics do not biodegrade and may continue to trap and kill animals year after year.

Ingestion: Birds, fish and mammals can mistake plastic for food. Debris may cause choking and injuries, and with plastic filling their stomachs, animals may have a false feeling of being full and may die of starvation. Sea turtles mistake plastic bags for jellyfish, one of their favorite foods. Ingestion of debris has been documented for many cetacean species. Disruption of habitat: When debris are accumulated, the natural features required for marine and coastal fauna and flora get affected. Floating marine debris can provide a new and increased method of transport for species across vast distances, which may cause trouble for biodiversity if the introduced species prove to be invasive.

Problems to people: Marine debris can present a danger to human health. Nails, glass, and syringes on the beach can cause physical harm to beach users. Additionally, trash in our waterways increases the amount of pathogens and chemicals, impacting water quality. Sometimes, in fish species commonly eaten by people contain anthropogenic debris in their digestive tracts. Plastic debris can concentrate and transport chemical pollutants into the marine food web, and potentially to human diets. Moreover, marine debris is a hazard to livelihoods. Fishing line and nets can entangle propellers, causing damage to boats. Unsightly trash on beaches detracts from tourism.

Figure 21: Various types of debris

4.3.4 Constructions and reclamation

Locations: At Soththupitiya some illegal infrastructure development activities are going on using reclaimed lands from the lagoon. In all other sites, such coastal constructions and reclamation activities are at a low level but likely to expand in future.

Causes and impacts: Coastal construction involves the removal or placement of deposits and the building of structures in or near lagoon waters for a variety of purposes; land reclamation, coastal roads/causeways, housing, resorts, small industries etc. This includes the dredging and filling (land reclamation) of lagoon waters or the erection of structures for the purposes of increasing inhabitable land area, construction of transportation facilities or protection of shorelines prone to erosion.

Both the direct and indirect effects of coastal constructions have been severe on coastal and marine living resources. Any construction that modifies the shoreline will invariably change currents, wave action, tidal fluctuations, and the transport of sediments along the coast. Fill or land reclamation activities result in the permanent loss of some lagoon habitats while excavation and dredging will permanently alter habitats and displace native ecosystems such as mangroves, seagrasses, and beaches. Coastal construction that restricts the circulation of coastal water bodies can also degrade water quality and coastal ecosystems. The use of some forms of dredging equipments can generate large amounts of sediments that can be transported well beyond the immediate vicinity of the construction activity and bury or smother bottom dwelling marine life and chase fish away. Removal of vegetation from adjacent land areas can mangroves and other native coastal habitats and promote soil erosion and sedimentation. Reclamation causes serious and permanent damage to coastal ecosystems. The loss of coastal fringe and impacts from dredging of fill material permanently destroy valuable coastal habitats.

As this activity normally takes place along the coast it mainly influences coastal and near shore marine habitats, e.g. sandbanks, mudflats, salt marshes, mangroves and other halophytic habitats; as well as species occurring in these habitats, e.g. wading birds, prawns and lagoon fishes. Marine habitats are permanently lost where land is reclaimed from the lagoon. Knowledge on the overall pressures and impacts of land reclamation activities on marine ecosystems in the Puttlam lagoon is still very limited and no comprehensive reports are available on the environmental effects of land reclamations n other coastal areas. Most land reclamation activities are carried out for expansion of residenses and tourist infrastructure. Impacts of dumping of concrete rubble and other urban waste for land reclamation activities may bring serious problems such as;

<u>Possible chemical disturbances due to soluble substances.</u>

- habitat alterations due to a change in sediment structure (i.e. grain-size). For example, complexity and community structures would change due to the deposition of fine grained sediment on coarser grained natural sediment (and possibly vice versa);
- burial and smothering of the benthic community caused by enhanced sedimentation due to the disposal of sediment;
- local and temporal repeated change in the suspension of sediments, causing increased turbidity. High turbidity results in low levels of transmitted light and can negatively affect the functioning of light-dependent organisms such as phytoplankton and visual predators, e.g. fish and fish-eating birds.
- possible increase in suspended particulate matter concentrations as large amounts of sediments are brought into suspension. This can cause a regression of sea grass meadows. This may impact on seagrass dependent marine fauna in an area extending to long distances.

Figure 22: An illegal construction and land filling

4.3.5 Discharge of household sewage and agro chemicals

Locations: Apparently, the fecal pollution is significant at Soththupitiya since some households lack toilets. Chena cultivation applying agro chemical was noted at Tirikkapallma. In overall the entire peripheral belt of the lagoon is consisting of chemical heavy agricultural lands.

Causes and impacts: People who live around the lagoon are involved with various land based activities that tend to degrade the lagoon water. Some examples include soil erosion due to minor agricultural activities, use of agro chemicals/ fertilizer and household pesticides, fecal pollution caused by households with out toilet facilities and flow of domestic sewage. Addition of such substances to the lagoon can have negative environmental effects, such as destruction of lagoon ecosystem that support various fish and marine mammals. When concentrated in small, confined, and overcrowded areas, pollution pose greater threats to human health. Perhaps, sewage is the largest source of environmental contamination, and discharges have increased dramatically in the past three decades as per village elders. Bathing in or ingesting sewage-contaminated water can cause infections and transmit diseases, particularly among children. Chemicals and heavy metals found in pesticide runoff also damage human and marine health. These toxins can kill or contaminate marine life. People who eat seafood from polluted areas or who swim in contaminated waters are vulnerable to gastric and other infections.

4.3.6 Aquaculture structures

Locations: Aquaculture structures can be located in all sites except at Kandakuliya. They may be non-functional, partly functional or fully functional structures, but different degrees of impacts are there.

Causes and impacts: Impacts on the natural marine system can potentially occur in any of the areas in which prawn aquaculture activities occur. Locations presently utilized for aquaculture in this region are patchy and widely separated. Current management techniques require reasonably sheltered, shallow waters with good nutrient supply and moderate to high current flows. However, this industry is developing

and expanding into new types of environments as techniques are developed and market demands increase.

Some of the environmental issues associated with prawn culture are as follows.

Accumulation of waste: Prawn tanks produce solid waste, mainly consisting of faeces. This particulate matter settles near a tank farm in higher concentrations than would occur naturally. Prawn farming can therefore result in the build-up of organic matter in the lagoon surrounding, with impacts on sediment quality predominantly arising from deposition of these solid wastes. The extent of the impact depends on the nature of the waste and the extent of the accumulation, which in turn is influenced by the location of the farm and farm management practices. In an organically enriched environment in which accumulation of wastes exceeds the rate at which the organic matters are broken down, impacts can occur. These impacts include the smothering of light-dependant plants (e.g. seagrasses) and impacts associated with increased activity of benthic fauna and microorganisms that consume the excess organic matter. This increased activity of microorganisms can lead to a depleted oxygen supply in bottom water.

Nutrients: Prawns are farmed using techniques that keep on adding nutrients to prawn tanks. Generally, such additions seep into surrounding areas and disturb the natural balance, hence altering the habitat parameters of nearby areas.

Impacts associated with farming structures: Prawn farming structures such as tanks may alter the hydrodynamics of an area, though such changes have been rarely documented. Sediment accretion and compaction may also result from heavy machinery use in prawn growing areas. In addition, shading by farm infrastructure, and farm activities such as vehicular traffic may have a detrimental impact on some species.

Figure 23: Aquaculture tanks

4.3.7 Ad hoc landing sites

Locations: In the entire waters edge of the lagoon area there are many ad hoc landing sites disturbing the coastal margin.

Causes and impacts: Presence of several unplanned fish landing sites is causing some disturbance to the lagoon environment.

- Propellers may disturb the lagoon water or bottom directly, or indirectly through the wash or turbulence they produce, especially in shallow water. This may affect water clarity by increasing the amount of sediment particles in the water.

-Waves created by fishing vessels may contribute to shoreline erosion, which can cloud the water.

- Shoreline erosion due to mechanical damage from fishing gear and increased human presence. Uncontrolled foot paths used by fishermen disturb the coastal habitats.
- Fishing vessels may impact mangroves and salt marshes either directly, through contact with the propeller and boat hull, or indirectly through turbidity and wave damage. Propellers can chop off plant shoots and uproot whole plants if operated in shallow water. Sometimes, boats may transport non-native species, such as xx, from one area to another.

Figure 24: Ad hoc landing sites for fishermen

4.3.8 Threat to protected marine animals

Locations: As per local informants, fisherman from Soththupitiya and Kandakuliya areas are involved in illegal catching of protected marine animals. In other sites, such activities are occasional.

Causes and impacts: Three marine species, namely sea turtles, Dugong and Dolphins, have been under anthropogenic threats in Puttlam lagoon area and the surrounding sea. The causes are of several kinds.
Illegal hunting: This has been the single most important factor since several decades ago.

Fisheries: Attempts have been made in recent years to reduce the incidental take (i.e., by-catch) of marine mammals by fisheries authorities though relatively high numbers of, for example, dolphins, dugong and turtles are still killed each year. Entanglement in discarded fishing gear also continues to be a problem, notably for the threatened sea turtles Olive ridley. Declines in forage fish because of commercial fishing is a prime suspect, either as cause or contributor, in the decline populations of threatened animals.
Environmental pollution: Pesticides and industrial chemicals and by-products are considered to be having some impact on at least some species and populations.
Other impacts: There are other impacts and factors that have particular relevance for specific species and regions. Boat strikes are an important obstacle.

Figure 25: Turtles, Dugong and Dolphins – protected but constantly under threat.

Overall Summary

Puttlam lagoon (33,000 ha) is located in the northwestern coast of Sri Lanka. Studies have concluded that fishing activities and other natural resource use in the marine system are no longer sustainable.

Therefore, in order to address some selected marine and coastal issues, a project is being implemented with the financial support from GEF, and its focus is conservation of dugongs and seagrass habitats that are under anthropogenic pressure. This environmental study is a supportive activity of the afore said larger project. The main objective was to document the baseline biological environmental situation of the area with particular reference to the localities; Anawasala, Pallivasathurei, Serakkuliya, Soththupitiya, Thikkapallama and Kandakuliya, around Putlam lagoon. Rapid assessment approaches were used in the study. During the survey, following major ecosystem types were identified and described in detail.

a. Open water zone and sub tidal ecosystems: Lagoon and ocean open water body, Coral reefs and sea grass beds.

b. Tidal ecosystems: Mangroves, mud flats, seashore and salt marsh.

c. Terrestrial ecosystems: Grasslands, Scrublands, Palmyrha woodlands, coconut plantations and Home gardens.

Major causes of degradation of lagoon environment was explored and documented in connection with those localities and respective ecosystem types. Significant factors behind environmental degradation of coastal and marine habitats included; overfishing, destructive fishing techniques, accumulation of marine debris & shoreline trash, illegal coastal constructions and reclamation, discharge of household sewage and agro chemicals, introduction of aquaculture structures, use of ad hoc landing sites and human impacts on protected marine animals. As far as considered the environmental destructive activities Kandakuliya and Soththupitiya localities and communities pose a serious threat to the coastal and marine environment in overall assessment.

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Annex- I List of Flora recorded in and around Puttlam lagoon

Species Name	NCS	Main sites					Additional Sites		
		Soththupitiya (080 82 49N 079 43 667E)	**Palliwasathurei** (08 10 948N 079 44 745E)	**Anawasala** (08 15549N 079 45 987E)	**Thirikkapallama** (08 10 970N 079 49 452E)	**Serakkuliya** (08 10 863N 079 49 119E)	**SLBC site** (075 58 623N 079 48 989E)	**Sethapola** (075 88 46N 079 46 750E)	**Pubudugama** (08 08 018N 079 50 105E)
Avicennia marina	LC			+	+	+			+
Avicennia officinalis	NT	+		+		+	+	+	+
Bruguiera cylindrica	EN	+	+			+			
Excoecaria agallocha	LC	+	+	+	+	+	+	+	+
Lumnitzera racemosa	NT	+		+	+	+	+		+
Pemphis acidula	NT		+			+	+		
Rhizophora mucronata	LC	+	+		+	+	+	+	+
Scyphiphora hydrophyllacea	VU								+
Sonneratia alba	EN	+					+		
Salicornia brachiata	NT		+						
Suaeda maritima	NT		+	+					
Suaeda monoica	NT		+				+	+	+
Suaeda vermiculata	NT		+						
Abutilon indicum	LC							+	
Acacia mangium								+	
Acacia eburnea	LC	+	+				+	+	+
Acrostichum aureum	LC				+	+			
Asparagus sp.						+			
Atylosia scarabaeoides	LC		+					+	+
Azadirachta indica		+	+			+		+	+
Cardiospermum halicacabum	LC		+						
Calotropis gigantea	LC	+		+				+	
Cassia auriculata			+					+	+
Catharanthus roseus			+						
Cereus peruvianus						+			

Cissus quadrangularis	LC							+	
Clerodendrum inerme	LC			+				+	
Coccinia grandis	LC	+	+			+			
Cocos nucifera			+		+			+	
Crotalaria verrucosa	LC								+
Croton bonplandianus								+	
Cuscuta chinensis	LC							+	+
Euphorbia tirucalli			+					+	
Ficus heterophylla	VU	+							
Flueggea leucopyrus	LC					+		+	+
Hewittia sublobata	LC							+	
Hydrophylax maritima	LC		+	+		+			
Ipomoea marginata	LC		+		+				+
Jatropha gossipifolia		+							
Lantana camara			+			+		+	+
Launaea sarmentosa	LC			+					
Leucaena leucocephala		+						+	
Sesbania bispinosa	LC	+							
Sesuvium portulacastrum	NT							+	+
Spermacoce hispida	LC		+	+				+	+
Syzygium cumini	LC	+							
Tecoma stans					+				
Tephrosia purpurea	LC	+		+		+	+	+	
Terminalia catappa							+	+	
Thespesia populnea	LC	+		+	+		+	+	
Trema orientalis	LC	+							
Tridax procumbens		+		+	+			+	
Leucas zeylanica	LC		+	+			+	+	
Momordica charantia	LC							+	+
Morinda citrifolia	LC							+	
Moringa oleifera								+	

Parkinsonia aculeata								+	
Panicum maximum								+	
Passiflora sp.						+			
Phoenix pusilla	LC		+	+	+			+	+
Premna obtusifolia	LC					+			+
Caesalpinia bonduc	LC							+	
Azima tetracantha	LC					+			+
Salvadora persica	NT		+	+		+			
Scaevola taccada	LC								
Senna sp.			+	+				+	
Solanum trilobatum	LC							+	
Stachytarpheta sp.		+	+		+			+	
Sida acuta	LC	+	+	+		+	+	+	
Xanthium indicum	LC				+		+	+	+
Vernonia cinerea	LC		+	+		+	+		
Mimosa pudica		+		+			+	+	
Dichrostachys cinerea	LC	+					+	+	+
Vigna marina		+		+		+		+	
Wedelia trilobata					+			+	
Ziziphus mauritiana	LC		+						
Maduruthala			+			+	+	+	+
Borassus flabellifer			+			+		+	

Annex- II List of Fauna recorded in and around Puttlam lagoon

Species Name	English Name	NCS	Main sites					Additional Sites		
			Soththupitiya (080 82 49N 079 43 667E)	**Palliwasathurei** (08 10 948N 079 44 745E)	**Anawasala** (08 15549N 079 45 987E)	**Thirikkapallam** (08 10 970N 079 49 452E)	**Serakkuliya** (08 10 863N 079 49 119E)	**SLBC** (075 58 623N 079 48 989E)	**Sethapola** (075 88 46N 079 46 750E)	**Pubudugama** (08 08 018N 079 50 105E)
LANDSNAILS										
Camaenidae										
Trachia vittata		CR		+						
Bradybaenidae				+						
Bradybaena similaris	Asian Tramp Snail	NE								
DRAGONFLIES										
Libellulidae										
Orthetrum sabina	Green Skimmer	LC					+		+	
Acisoma panorpoides	Asian Pintail	LC	+							
Brachythemis contaminata	Asian Groundling	LC				+	+	+	+	+
Neurothemis tullia	Pied Parasol	LC					+			
Rhyothemis variegata	variegated Flutterer	LC	+			+	+	+	+	+
Papilionidae										
Pachliopta hector	Crimson Rose	LC		+		+		+	+	+
Papilio demoleus	Lime Butterfly	LC		+		+	+	+		
Papilio polytes	Common Mormon	LC							+	
Pieridae										
Appias albina	Common Albatross	LC				+			+	
Catopsilia pomona	Lemon Emigrant	LC		+		+	+	+	+	+
Catopsilia pyranthe	Mottled Emigrant	LC		+	+				+	
Colotis amata	Small Salmon Arab	LC		+			+			
Delias eucharis	Jezebel	LC		+		+			+	+
Eurema blanda	Three-spot Grass Yellow	LC		+						
Eurema hecabe	Common Grass Yellow	LC				+	+	+	+	+
Leptosia nina	Psyche	LC	+		+		+		+	

Nymphalidae										
Danaus chrysippus	Plain Tiger	LC		+	+	+		+	+	+
Danaus genutia	Common Tiger	LC			+					
Elymnias hypermnestra	Common Palmfly	LC	+							
Euploea core	Common Crow	LC				+	+		+	
Junonia atlites	Grey Pansy	LC		+	+			+	+	
Mycalesis perseus	Common Bushbrown	LC		+			+		+	
Neptis hylas	Common Sailor	LC							+	
Parantica aglea	Glassy Tiger	LC							+	
Tirumala limniace	Blue Tiger	LC		+						
Ypthima ceylonica	White Four-ring	LC	+			+	+	+	+	
Lycaenidae					+					
Catochrysops strabo	Forget-me-not	LC				+		+	+	
Chilades putli	Grass Jewel	LC		+						
Jamides celeno	Common Cerulean	LC			+				+	+
Zizeeria karsandra	Dark Grass Blue	LC		+				+	+	+
Zizina otis	Lesser Grass Blue	LC		+						
REPTILES										
Agamidae										
Calotes calotes	Green garden lizard	LC							+	
Calotes versicolor	Common garden lizard	LC	+			+			+	
Sitana devakai	Devaka's Fan-throated lizard					+				
Gekkonidae										
Hemidactylus frenatus	Common house-gecko	LC					+			
BIRDS										
Sternidae				+						
Chlidonias hybrida	Whiskered tern					+	+			+
Charadriidae										
Vanellus indicus	Red-Wattled Lapwing	LC	+	+						
Ramphastidae										
Megalaima zeylanica	Brown-headed Barbet	LC							+	
Meropidae										

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Merops orientalis	Green Bee-eater	LC			+	+	+		+	
Merops philippinus	Blue tailed Bee-eater								+	
Apodidae										
Collocalia unicolor	Indian Swiftlet	LC		+	+					+
Columbidae										
Streptopelia chinensis	Spotted Dove	LC	+	+	+	+	+		+	+
Accipitridae										
Haliastur indus	Brahminy Kite	LC		+			+		+	+
Phalacrocoracidae										
Phalacrocorax niger	Little Cormorant	LC						+	+	
Ardeidae					+					
Ardea cinerea	Grey Heron	LC			+	+	+			
Ardeola grayii	Indian Pond Heron	LC							+	
Bubulcus ibis	Cattle Egret	LC				+			+	
Butorides striata	Striated Heron	LC	+	+	+					
Casmerodius albus	Great Egret	LC	+			+	+			
Egretta garzetta	Little Egret	LC		+	+	+	+	+	+	+
Mesophoyx intermedia	Intermediate Egret	LC				+	+		+	
Corvidae										
Corvus splendens	House Crow	LC	+	+	+	+	+	+	+	+
Artamidae										
Artamus fuscus	Ashy Woodswallow	LC		+						
Sturnidae						+				
Acridotheres tristis	Common Myna	LC							+	
Apodidae			+							
Cypsiurus balasiensis	Asian Palm-swift	LC	+	+	+	+	+		+	
Hirundinidae										
Hirundo rustica	Barn Swallow	LC							+	
Pycnonotidae										
Pycnonotus cafer	Red-vented Bulbul	LC	+		+		+	+	+	
Cisticolidae										
Prinia inornata	Plain Prinia	LC		+	+	+		+	+	
Prinia sylvatica	Jungle Prinia	LC				+			+	
Sylviidae										
Orthotomus sutorius	Common Tailorbird	LC	+	+		+			+	+

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Dicaeidae										
Dicaeum erythrorhynchos	Pale-billed Flowerpecker	LC		+	+	+	+		+	
Nectariniidae										
Nectarina zeylonica	Purple-rumped Sunbird	LC		+					+	
MAMMALS										
Bovidae									+	
Bos taurus	Domestic Cattle								+	
Canidae										
Canis familiaris	Domestic dog		+			+			+	
Cercopithecidae										
Macaca sinica	Sri Lanka toque monkey	LC								
Felidae										
Felis cattus	Domestic cat								+	
Hystricidae										
Herpestes edwardsii	Grey mongoose								+	