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MANGROVES IN LAGOON ECOSYSTEMS: A NEGLECTED HABITAT IN SRI LANKA

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ABSTRACT - Mangroves are limited to the coastal ecosystem and are associated with lagoons and estuaries due to high salinity, low oxygen levels, high light intensity, strong winds and periodic inundation by tidal water. Many lagoons, out of 82 lagoons in Sri Lanka, mangroves play an important role on microscopic and mesoscopic fauna and also for coastal inhabitants in the country. The micro relief of the mangrove habitats produces food and shelter, and provides nursery grounds for the birds, fish, reptiles and other crustaceans. Further, they help to preserve the balance of nature.

Different research groups *viz.*, individual scientists and institutional researches provide different figures on the extension of mangrove vegetation in Sri Lanka. However, there is no conformity on total figure. In this study, we try to calculate the exact extent of mangrove vegetation in 82 lagoons with their availability and identified threats. Mangroves in the lagoons of Sri Lanka have been damaged by anthropogenic activities and have also been degraded by (a) changes in freshwater run-off, salinity regime and tidal flow patterns; (b) excessive siltation and discharge of toxic substances; and (c) flowing of polluted water into lagoons, lakes, estuaries and tidal creeks. The depletion and degradation of mangroves have directly and indirectly influence the livelihood of the people, economy of the country and survival of the wildlife. Therefore, an increased public awareness is of utmost importance to promote management and conservation of mangrove habitats for posterity in Sri Lanka.

KEY WORDS : Mangrove ecosystem, Lagoons, Tidal water, Overexploitation, Coastal inhabitants, Degradation, Public awareness.

INTRODUCTION

The mangrove ecosystem is commonly understood to be made up of a collection of woody and shrub plant species. These plants grow in shallow and muddy salt water or brackish waters, such as those along quiet shorelines, lagoons or in estuaries of anaerobic soils found in the intertidal zone, and show their greatest extent and diversity on tropical coasts, especially in Sri Lanka (Figure 1), and in some subtropical areas, where they rapidly form mangrove swamps.

Geomorphologically, a mangrove swamp covers by trees or shrubs that have the common trait of growing in shallow and muddy salt or brackish waters, and are a common name applied to a number of flowering plants that are members of several different families. Mangrove swamps provide excellent nesting and feeding grounds and constitute a reservoir and a refuge for a variety of marine and brackish fish, invertebrates, and birds (Hamilton and Snedakar, 1984; Cox and Liaison, 1999, Bird 2008). Mangroves are often referred to as mangrove forest, coastal woodland, mangal and tidal forest. Like the tropical forests, mangroves play an important role in the economy of tropical people for thousands of years.

Mangroves provide food and shelter for a large and varied group of fishes and shellfish. The leaf detritus (fallen and decaying leaves)

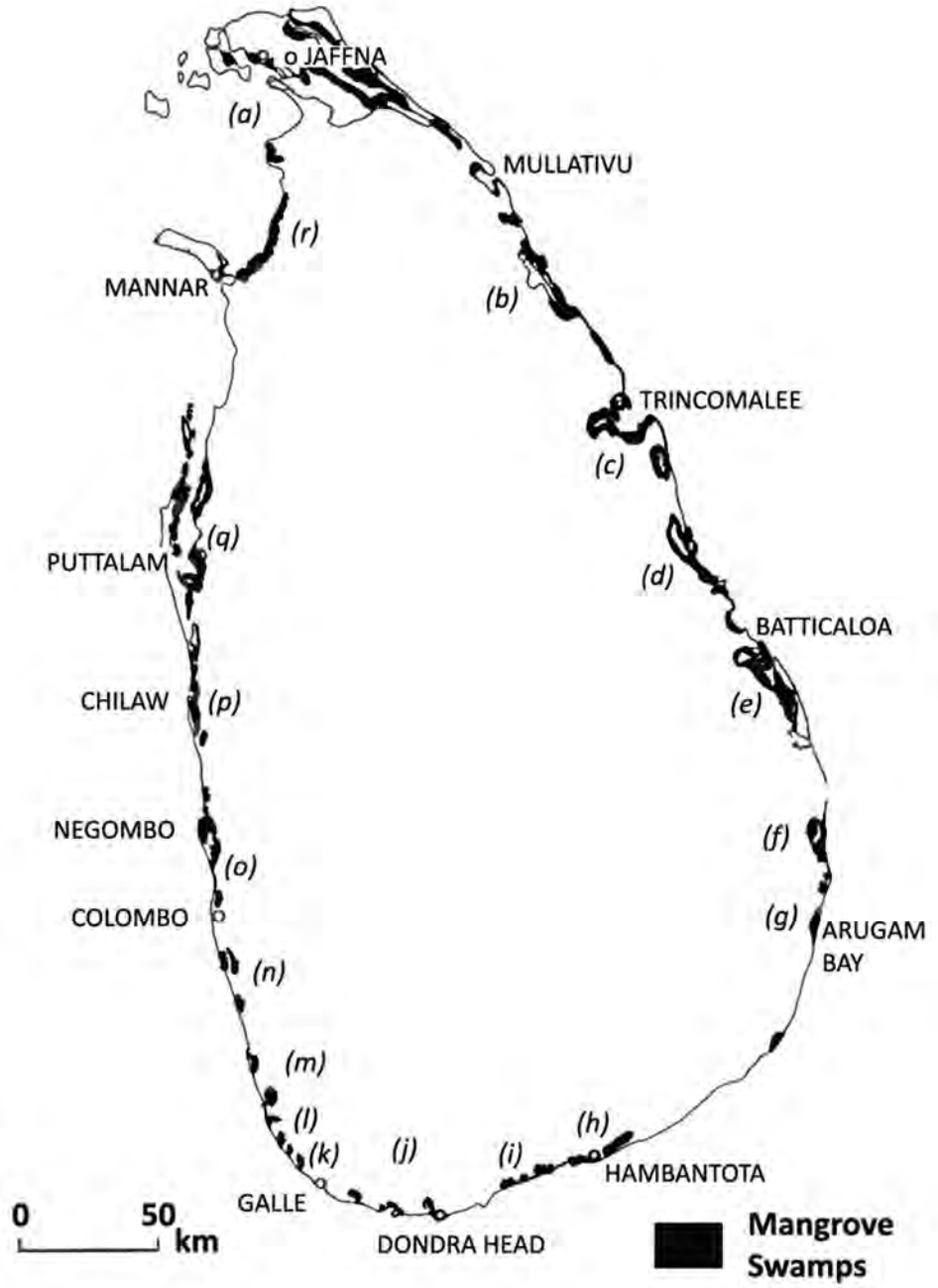

FIGURE 1: Distribution of mangrove swamps in Sri Lanka: (a) Jaffna Lagoon, Thondamanaru and Chundikulam Lagoon complex, (b) Nayaru and Kokkilai Lagoon complex, (c) Trincomalle, Uppaveli and Kodiyar complex, (d) Ullakali Lagoon, (e) Upparu Lagoon, (f) Kalmunai complex and Batticaloa complex, (g) Periya Lagoon, (h) Potuvil area, (i) Walawe Ganga estuary, (j) Nilwala Ganga, Polwatta Ganga and Tudawe Ganga complex, (k) Gin Ganga estuary, (l) Madampe Lake and Madu Ganga complex, (m) Bentota Ganga estuary, (n) Bolgoda Lake and Weras Ganga complex, (o) Kelani Ganga estuary and Muthurajawela area, Pamunugama area and Negombo Lagoon complex, (p) Chilaw Lake, Deduru Oya estuary and Mundal Lake areas, (q) Puttalam Lagoon, Portugal Bay complex (eastern coast of Kalpitiya Peninsula and Kala Oya complex, and (r) Vankalai complex.

provides the base of the major mangrove community food chain. The aerial roots provide shelter for many species of commercial fish and shellfish (Table 7), particularly in their juvenile and most predators prone stages. The trees and shrubs provide protection from storm surges and high winds associated with tropical storms such as typhoons, cyclones or tsunamis. This ecosystem serves as protection against soil erosion. Soil erosion and sedimentation causes in the ocean are the number one cause of coral reef degradation. Similarly, they serve as land builder through soil accretion. Sediment from the land collects among the dense roots building up the land and trap coastal pollutants, which may otherwise severely damage adjacent marine ecosystems. Beside these, mangroves serve as a wildlife sanctuary, offer aesthetic, educational and scientific values.

Mangrove habitats with its variety of sub-habitats are a source of forest products such as food and beverages, timber, firewood, tannin, wax, honey etc., and provide suitable environmental conditions for aquaculture and opportunities for tourism. However, when compared to their role in countries such as Brazil, Australia, Indonesia, Malaysia, India and Philippines, it appears that mangroves have not played as significant a role in the national economy of Sri Lanka.

PREVIOUS STUDIES

There are no records of the exact extent of mangrove swamps in Sri Lanka. According to the CCD report (1986) about 12190 hectares of mangrove swamps occur mainly around lagoons, lakes and in the river estuaries as fringes and patches. Revised CZMP (1997) reports that this amount has reduced up to 8000. However, NARA (1997) indicates that in Sri Lanka, there are 158,016 ha of the brackish water area and out of this 18489 ha covered by mangroves. Twenty-nine species of mangroves have been identified in Sri Lanka, and some of these have adapted themselves to regional variations of edaphic and climatic conditions (Katupotha, 1995). Priyadarshani et al (2008) mention that there are twenty three true mangrove species of trees and shrubs have been recorded in Sri Lanka, the common species being *Rhizophora mucronata, Avicennia marina, Excoecaria agallocha, Acanthus ilicifolius, Lumnitzera racemosa, Sonneratia caseolaris, Bruguiera gymnorhiza* and *Aegiceras corniculatum*. Further, they reported that the mangrove forests is estimated as only 8700 ha.

Studies have attempted to describe the interrelationship of mangrove communities in terms of a relatively simple zonation with particular species characterizing zones in a unidirectional sequence normal to the water's edge, ecological characteristics as well as their economic significance and human interference on them. Tansely and Fritsch (1905) described the zonation, habitat and the characteristics of true mangrove and semi-mangrove species of Sri Lanka. Even at the beginning of the 20th century, they reported the effect of human interference on the mangrove forests of Sri Lanka.

The physiographic distribution and ecological conditions of the mangroves have described by Arulchelvam (1968) and Swan (1982). Pinto's (1984) study indicates the significance of the mangrove environment for crab population in the Negombo Lagoon on the western coast. Furthermore, Pinto (1986) provides a detailed account on the morphology of several mangrove species, emphasizing their different characteristics and the behavior of the portunid and ocypodid crabs, grapsid crabs, mud lobsters, prawns and molluscs. An ESCAP report formulated (1985) a Coastal Management Environmental Plan for the western coast of Sri Lanka emphasizing on the role of mangroves. Furthermore, Silva and Balasubramaniam (1984) deal with the types of mangroves on the west coast of Sri Lanka, their ecological zonation and the effect of man’s interference with them. This research, twenty five years before, has emphasized that urgent conservation measures were required to save the mangrove ecosystem in Sri Lanka. Besides, in 1986, Silva and Silva have described the ecological characteristics of the mangrove fauna in the west coast of Sri Lanka.

Palihawadana (1987) explains the survival

and growth of Rhizophora mucronata and Ceriops tagal seeding under different environmental conditions. This study reveals the distribution, zonation, taxonomy, physiology, ecology, productivity and uses of family Rhizophoraceae in Sri Lanka. Therefore, Coastal Zone Management Plan of CCD (1990) emphasizes the extent, nature and significance, uses, management issues, objectives and policies on mangroves. Amarasinghe and Balasubramanium (1992a & b) classified the mangrove stands in Puttalam Lagoon and Ducth Bay (western coastal zone) broadly into two groups: (a) estuarine, and (b) island/mainland fringe. Structural diversity of six mangrove stands of these two types was studied in terms of floristic composition, density, basal area, mean, stand diameter, tree light, standing aboveground biomass and leaf-area index. Furthermore, the same authors (1992b) examined the net primary productivity of two mangrove forest stands (estuarine and island fringing) in Dutch Bay. All these reports reveal that during the last two decades, only a limited research had been conducted on the different aspects pertaining to the mangroves.

The mangroves support the depending communities by providing finfish and shellfish, fuel wood and building materials, dyes for coloration of fishing nets and fruit juice, which have pragmatic values (Costa and Wijeyaratne 1994; Jayatissa *et al*. 2002a; Gunawardena and Rowan 2005). In addition, to their cultural values, recreation and tourism importance, they also show an array of mitigation and adaptations to climate change. Mangroves are also excellent environs for aesthetic enjoyment and creative productions such as films, tele-cinema, paintings, songs which have tacit values. Today protection of mangrove worldwide is based almost entirely on their purported importance to fisheries and a number of rare and endangered species (Alongi 2002). In Sri Lanka, because of the inter-tidal swath is narrower than the other parts of the Indo-Malay region, on account of the small tidal amplitude, mangrove show ribbon or patchy development instead of occurring in extensive swampy forests (Swan 1982). Distribution patterns of mangroves and their diversity in Sri Lanka are fairly understood (Aruchelvam 1968; Jayasuriya 1991b; Amarasinghe 1997a, b; Jayewardene *et al*. 1999; Jayatissa *et al*. 2002a, b; Dahdouh-Guebas *et al*. 2005; Jayakody *et al*. 2008; NECDEPP 2010c).

Above all studies coexist with other ecosystems with least human interference under certain circumstances lagoons in Sri Lanka undergo natural evolution. Mathematical models can be derived to predict physical, chemical and biological attributes in such cases. Apparently, a majority of scientific studies on coastal lagoons in Sri Lanka has been focused on fringe mangroves whereas least emphasis has been laid on salt marsh vegetation (Table 1).

Bathymetry and hydrography are known for fourteen lagoons while fish fauna or fish productions of nine lagoons have been studied. Only the Negombo Lagoon on the west coast, Rekawa Lagoon the south coast and Chilaw and Puttalam lagoons and Mundel Lake, located on the northwest coast have been subjected to a fair number of studies including mangrove habitats leaving huge lacunae of science-based knowledge on the entire lagoon ecosystem of the island (Silva *et al*, 2013).

PURPOSE AND SIGNIFICANCE

Ecological conditions and multiple uses of mangroves in coastal lagoons at the National Level have been neglected. Causes of mangrove destruction in Sri Lanka are overexploitation by traditional users than commercial users. Destructive action resulting from activities generally unrelated use of mangroves is commercial timber harvesting; conversion of mangrove areas for aquaculture, especially for prawn farms, agriculture, saltpans and urban development.

The applications of insecticides and herbicides at agroecological zones have caused damage to mangrove habitats. These problems and degradation which clearly threaten mangrove ecosystems have not been taken into consideration in the above mentioned studies. This paper envisages revealing different uses, the behavior of the fauna and flora of mangrove

TABLE 1: Scientific studies conducted on coastal lagoons in Sri Lanka.

Number of studies	BM	HG	NT	PL	PP	BT	FS	SH	SG	MG	SM	AF
North coastal lagoons	3	1	0	0	0	0	1	1	0	9	0	1
Northeast coastal lagoons	1	1	0	0	0	0	0	0	0	4	0	0
East coastal lagoons	0	1	1	1	1	0	1	1	0	1	0	0
Southeast coastal lagoons	1	1	0	0	0	0	1	0	0	9	0	0
South coastal lagoons	2	2	1	1	1	0	1	1	1	1	0	2
Southwest coastal lagoons	2	2	1	0	0	0	0	0	0	2	0	1
West coastal lagoons	2	3	1	2	1	1	2	2	1	2	0	2
Northwest costal lagoons	3	3	1	2	2	1	3	3	1	3	1	1
Total	**14**	**14**	**5**	**6**	**5**	**2**	**9**	**8**	**3**	**31**	**1**	**6**

Source: Silva *et al*, 2013. Note: BM=bathymetry, HG=hydrography, NT=nutrient, PL=plankton, BT=primary production, BT=benthos, FS=fish, SF=shellfish (SF), SG=seagrasses, MG=mangroves, SM=salt marshes, AF=avifauna.

habitats, human impact and degradation. For this purpose, field observations, formal and informal discussions with the inhabitants and officials were carried out within the period between 1993 and 1998 infrequently. The reconnaissance phase of the study was useful to highlight the nature of the environmental problems and the degradation of mangrove species. Both published and unpublished data have also been mentioned where relevant in the study.

STUDY AREA

The island of Sri Lanka has a 1,338 km long coastline and identified 82 lagoons with a 2,791 km lagoon shoreline which skirts 1,520 km^2 of brackish water mass (Table 2, Figure 1). The lagoon shoreline is more than twofold compared to its Indian Ocean intact coastline (Silva *et al*, 2013). Evidently, origins of coastal lagoons in Sri Lanka are related to mid-Holocene and late Holocene fluctuations. These fluctuations have been summarized by Katupotha (1995) who recognized five stages in the late Pleistocene and Holocene events. All these events are evidently related to origin, formation and evolution of lagoons on Sri Lanka (Silva *et al*, 2013).

Mangroves in most of the lagoons are highly productive, but extremely vulnerable habitats confined to intertidal zones of coastal environments including specially lagoons. They have special adaptations to harsh environmental conditions and mangrove habitats are considered as biodiversity hotspots (Kumara *et al*. 2010).

Coastal lowlands in the island extend from MSL to about +5.0m high elevation. These lowlands are narrow on the southwestern and southern coasts, but gradually widens towards the north from the Kelani Ganga Estuary (west) and Kubukkan Oya Estuary (east), and consisted of a series of small sized beach ridges and barrier islands, buried corals, emerged coral reef patches and beach-rock shoals. Most of these landforms indicate that the sea-level changes had occurred during the post-glacial transgression (Katupotha, 1988a; 1988b; 1988c; Katupotha and Fujiwara, 1988). Low hills and ridges in southwestern and southern areas have

TABLE 2: Length of coastline, lagoon area, perimeter and number of lagoons on each coastal sector

Coast	Coastline (km)	Lagoon area (km^2)	Lagoon perimeter (km)	Number of lagoons
North	403	804	1221	17
Northeast	294	182	411	04
East	89	44	174	14
Southeast	105	29	149	16
South	117	23	109	10
Southwest	101	20	166	09
West	98	46	151	03
Northwest	131	372	410	09
∑	**1,338**	**1,520**	**2,791**	**82**

Source: Silva *et al*, 2013.

been formed of weathered bedrock which are sometimes capped by lateritic soils, while other areas covered by terrestrial deposits as well as windblown sand. Head-land-bay beaches are the most significant feature along the western, southern and eastern coasts that have a close relationship with the regional geological structure while straight coastlines with zeta-form beaches are a significant feature of the west coast. These characteristics are clearly influenced for the present configuration of the island, and the existence of mangrove vegetation in the country.

The tidal range of Sri Lanka is small, ranging from mean low water spring at -37 cm to mean high water spring at +40 cm in relation to the mean sea level (data based on Colombo datum, Tide Tables vol. 2, Pacific and Indian Oceans 1987). The level of the tides has an obvious influence on the extension of tidal flats, which have been formed by soft mud and clay. This in turn has influenced the extent of mangroves. But in high wave energy along the exposed shoreline mangroves do not occur successfully, although they grow on inter-tidal flats and protected by sand dunes. Similar conditions have been reported from other humid areas of tropical countries. The mangrove fringes as well as patches, where developed along the sea coast, lagoon and estuaries have been protected by sand spits, beaches and beach ridges of headland-bay-beaches. Such formations have developed as a result of a lowering of sealevels in the Late Holocene period (Katupotha, 1988a & 1988b).

Soil is one of the most important components in mangrove ecosystem (Wada, 1984). The oxidation-reduction rate of the soil is closely related to relief. Mangrove species prefer the soil quality, which have been modified by tidal, and salinity of the water. Several families such as (Rhizophoraceae) which grow near the water assist in preventing soil being washed by trapping soil between the proper root system and help in building up the shore. People have grown mangroves, especially west and northwest coasts, to protect their lands from erosion because they are a cheap, safe and easy method of protecting lands.

A dry climate prevails and the average annual rainfall is distinct with two dry seasons in the Dry Zone, while the Wet Zone receives annual rainfall as high as 2,500 mm. The precipitation and the marine processes mainly waves and tides, are strongly governed by the monsoons. The differences of freshwater runoff by annual precipitation, tidal flow patterns and the rate of surface salinity have caused the spatial distribution of several mangrove species and their faunal habitats. The surface salinities of the Kala Oya estuary vary from 0.00 ppt to 45.00 ppt (Amarasinghe and Balasubramanium,

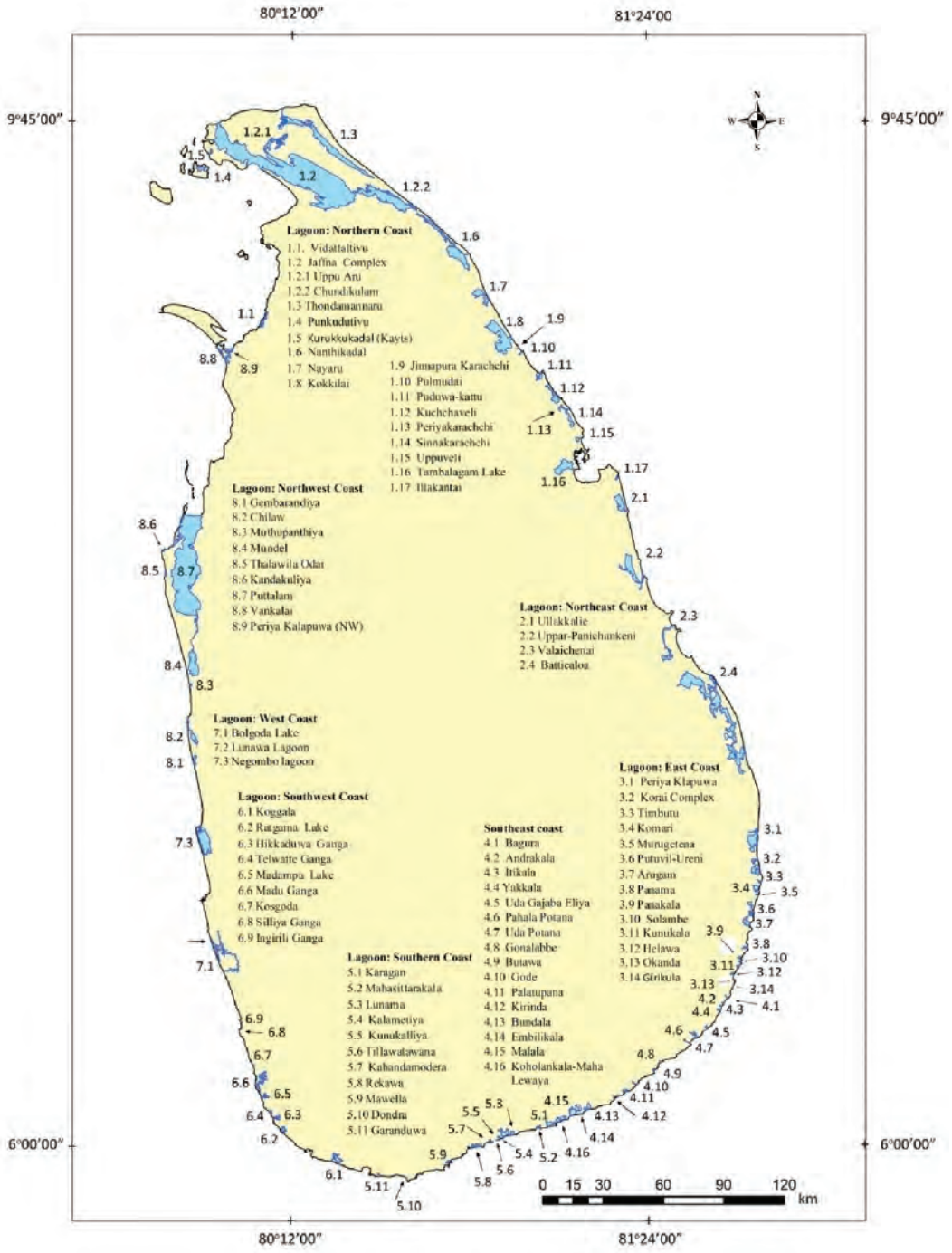

FIGURE 2: Distribution of coastal lagoons in Sri Lanka (Silva *et al*, 2013).

1992a). Although more freshwater runoff of Wet Zone rivers reduce the salinity content in the estuaries than the Kala Oya estuary. Arudpragasam and Jayasinghe (1980) have shown that in the Moratuwa Panadura estuary on the west coast a clear pattern of distribution and seasonal change of the salinity is determined mainly by rainfall and wind pattern. Accordingly, in the Moratuwa Panadura estuary and adjoining lake systems of the Bolgoda area range between 1.0-2.0 ppt and 30.00 ppt.

RESULT AND DISCUSSION

There are twenty nine species of mangroves identified as fringes and patches from the lagoon ecosystems, which fall into seventeen families (Table 3). The distribution, density and identified threats in fringe mangroves vegitation in lagoons of Sri Lanka. (Appendix 1).

Knox and Miyabara (1984) and IIRR (1992) summarized the common uses (Table 4) and multiple uses of the mangroves from the Indonesian and Philippine experiences. Accordingly, mangroves:

TABLE 3: Fringe mangrove species in the lagoons located in different coasts.

True mangrove species	North	NE	East	SE	South	SW	West	NW
Acanthus ilicifoliu **(Acanthaceae)**		x	x	x				
Acrostichum aureum **(Pteridaceae)**		x			x			
Acrostichum speciosum **(Pteridaceae)**					x	x	x	
Aegiceras corniculatum **(Myrsinaceae (or Primulaceae)**		x	x	x	x		x	
Avicennia alba **(Acanthaceae)**							x	
Avicennia marina **(Acanthaceae)**	x	x	x	x			x	x
Avicennia **(Acanthaceae)**		x	x	x	x		x	x
Bruguiera cylindrical **(Rhizophoraceae)**				x				x
Bruguiera gymnorrhiza **(Rhizophoraceae)**		x	x	x	x	x	x	x
Bruguiera sexangula **(Rhizophoraceae)**				x	x	x	x	
Cerbera manghas **(Apocynaceae)**		x	x	x				
Ceriops decandra **(Rhizophoraceae)**		x	x					
Ceriops tagal **(Malpighiales)**		x		x	x		x	x

True mangrove species	North	NE	East	SE	South	SW	West	NW
Dolichandrone spathacea **(Bignoniaceae)**		x						
Excoecaria agallocha **(Euphorbiaceae)**		x	x	x	x	x	x	x
Heritiera littoralis **(Sterculaceae)**			x	x	x		x	x
Hibiscus littoralis **(Malvaceae)**		x	x	x				
Lumnitzera littorea **(Combretaceae)**						x	x	
Lumnitzera racemosa **(Combretaceae)**	x	x	x	x	x		x	x
Morinda citrifolia **(Rubiaceae)**					x	x	x	
Nypa fruticans **(Arecaceae)**					x	x	x	
Pandanus tectorius **(Pandanaceae)**	x	x	x	x	x	x	x	x
Pemphis acidula **(Lythraceae)**	x							x
Rhizophora apiculata **(Rhizophoraceae)**		x	x	x		x	x	x
Rhizophora mucronata **(Rhizophoraceae)**	x						x	x
Sonneratia alba **(Lythraceae)**							x	x
Sonneratia caseolaris **(Lythraceae)**	x	x	x	x	x	x	x	x
Sonneratia ovalis **(Sonneratiaceae)**			x					
Xylocarpus granatum **(Meliaceae)**						x	x	
29 Species	**6**	**16**	**15**	**16**	**14**	**11**	**20**	**14**

Source: Field Observations and Silva *et al*, 2013.

(a) Provide food and shelter for a large and varied group of fishes and shellfish. The leaf detritus (fallen and decaying leaves) provides the base of the major mangrove community food chain. The aerial roots provide shelter for many species of commercial fish and shellfish, particularly in their juvenile and most predators prone stages.

(b) Provide protection from storm surges and high winds associated with tropical typhoons. This is important in a country that is hit by an average of 20 typhoons a year.
(c) Provide the bulk of primary production in lagoons and estuaries.
(d) Serve as protection against soil erosion. Soil erosion and sedimentation causes in the ocean are the number one cause of coral reef degradation.
(e) Serve as a land builder through soil accretion. Sediment from the land collects among the dense roots building up the land and minimize the coast erosion
(f) Traps and buffer adjacent estuarine areas against the large changes in up-streams input of nutrients and wastes.
(g) Trap coastal pollutants, which may otherwise severely damage adjacent marine ecosystems.
(h) Buffer adjacent flood plains from the damage caused by severe storms, and they reduce the maintenance cost of habours and navigation channels by trapping silt.
(i) Play an important role as nursery areas for the larva and juvenile stages of many coastal fish and invertebrates including commercial species especially for crustaceans. They may be important in maintaining and controlling the normal cycles of nitrogen and sulphur.
(j) Serve as a wildlife sanctuary.
(k) Offer aesthetic, educational and scientific values

The above mentioned uses indicate that the mangrove can play an important role, but it appears that in Sri Lanka they have been a largely neglected and destroyed the resources.
For many years the inhabitants of the coastal zones have lived close to the mangroves and derived many benefits from the aquatic as well as the terrestrial components of the mangrove species. By this means they obtained food and beverages, firewood, timber for construction of houses, household items (mats and baskets) and fishing boats, agricultural manure, animal feed and medicine (Table 4). There are many species of mangrove fauna than flora both in numbers and in diversity. There are eighteen species of birds associated with mangrove habitats shown in Table 5. Several species of birds, both indigenous and seasonal migrants who come in the winter from the Northern Hemisphere are the mangroves and associated environs (Henry, 1978; de Silva & de Silva, 1986). The species and their living habits of the birds differ on sub-habitats of the ecosystem.

Mangrove biotopes indicate that there exist a fairly large number of snails, crabs, fishes and molluscs, which feed directly on the fresh leaves or litter of mangroves (Tables 6). The most common fish species in lagoons/estuarine mangrove ecosystems in both dry and wet zones are bring a considerable amount of foreign exchange to the country. Table 7 indicates that abundant macroscopic mangrove animals such as crabs (Potunidae, Ocypodiae and Graspsidae families), mud lobsters, prawns, mollusks as well as oysters in Sri Lanka. All these animals were common in mangrove areas and associated mud flats of the Kalpitiya Peninsula, Negombo Lagoon as well as other southwestern and southern lagoons. Besides, these faunal species toads and tree frogs, reptiles (water and land snakes, python), lizards, crocodiles, terrapin, jackal and jungle cat (carnivorous), rats, wild-pigs etc. are common in mangrove areas (de Silva and de Silva, 1986).

The area under mangrove cover in Sri Lanka was fairly large during the early nineteenth century. Decreasing trend in mangrove cover in the country has started over the last 2-3 decades. Most of the tree species had been cleared for commercial timber harvesting (construction of human settlements and tourist resorts), conversion of mangrove areas for aquaculture (e.g., fish, shrimp, prawns), agriculture and salt pans, and for mining/mineral extraction (mining of buried corals).

Mangrove ecosystems of the western and northwestern coasts have been cleared for construction of hundreds of prawn farm ponds, especially from Puttalam lagoon to Chilaw Lake (Katupotha 2012). EFL (1994) reveals

TABLE 4: Uses of mangrove species in Sri Lankan view

SPECIES	USES
Acanthus illicifolius	Fruit pulp used as a blood purifier and dressing for boils and snake bites; leaf preparation as reliable of rheumatism; leaf juice as preserver; leaves can be used to feed the goats.
Acrosticbun aureun	Litter for cattle and roof thatching; tender leaves as vegetables.
Aegiceras corniculatum	Firewood; bark as poison; manure.
Avicinnia spp.	Leaves use for agricultural manure; firewood. *A. marina*: tender leaves as vegetable; support for bee colonies. *A.officinalis*: charcoal. Avicinnia branches are preferred for brush piles; wood for home construction.
Bruguira spp.	*B. cylindrica*: firewood and timber. *B. gymnorhiza* and *B. sexangula*: timber, fishing stakes, firewood, charcoal, telegraph poles, tannin; radiles as vegetables; eye medicine from fruits; scent from pneumatophorres; condiment from bark; adhesive from bark; fruit chewed as betel.
Cerbera manghas	Rubbing with fruit to ease rheumatism; seed contains a medicina oil; bark and sap contain a purgative; making masks.
Ceriops tagal	Firewood, tannin. Bark decoction used to stop hemorrhage. Adhesive and net protection from bark; batic and mat making.
Clerondendrun inerme	Firewood.
Derris scandens	Weakfish poison.
Dolichandrous spatbacea	Firewood.
Excoecaria agallocha	Paper pulp; sap and wood purgative; sap yields fish poison; match wood; boxes.
Heritiera littoralis	
Hibiscus tiliaceus	Barks used for rope making.
Lumnitzera racemosa	Files; poor firewood; decoction of leaves used for thrush, tool handles.
Morinda citrifolia	Firewood.
Nypa fructicans	Leaves for thatch and mats; young leaves for cigaret wrapping, sap for sugar, alcohol and vinegar.
Pandonus tectories	Leaves are used for making mats.
Rhizophora spp.	*R. apiculata*: tanin. *R. mucronata*: bark use for hematoma, diarrhoea, dysentery, leprosy; root bark and fruit sap as mosquito repellent; wine from fruit; honey from nectar; timber for firewood and home construction
Scaevola sericea	Use as a traditional medicine
Sonneratia spp.	*S. apelata*, *S. alba* and *S. caseolaris*: poor timber and firewood. Pneumatophores of Sonneratia are porous, and use as bottle

SPECIES	USES
	stoppers and fishing floats; leaves for cattle food; S. caseolaris: fruit eaten and preparation for a beverage. Sap as skin cosmetics; leaves can be fed to goats; produce good pulp.
Xylocarpus spp.	There are two species: *X. granatum* and *X. molluccensis*. They use for timber, firewood, furniture; tannin; oil from seed for illuminant and hair; bark used for medicine; pencils; roots and natural carvings; dye for clothes.

Source: Hamilton and Snedaka, 1984; Pinto, 1984 and Field Observations.

that at prawn farm sites, in and around, the mangrove species cleared and ploughed thoroughly and allowed drying up. By this mechanical activity the mangrove ecosystem and the natural buffer zone completely destroy. Beside these, pollutants such as fungistatic paints, pesticides (organic and inorganic), food remnants and faecal wastes add from prawn farm environments in mangrove areas. These materials add or remove infrequently or frequently and during the seasonal floods causing damage and degrade the indigenous fauna and flora associated with mangrove ecosystems.

During the past forty year period (from 1970 to 2000) mangroves have removed for mining of buried corals and shells for the production of lime in the southwestern and southern coastal areas, mainly at Ambalangoda, Akurala, Hikkaduwa, Habaraduwa, Mihiripenna, Walpola, Madihe and Rekawa areas resulted polluted stagnant water ponds. Clearance of mangrove species for reclamation lands for human settlements and agriculture is visible in Kalpitiya Penisula, between Puttalam Lagoon-Chilaw Lake and Negombo lagoon, Moratuwa and Panadura estuary, Bolgoda lakes, Ratgama lake, islands of Madu Ganga (river), Koggala, Polwatumodara, Mawella and Rekawa lagoons. Cutting of mangroves for wood in house construction, fishing crafts, as fuel for kilns were common in the Rekawa and Mawella lagoons. Likewise, a considerable amount of mangrove vegetation removed for construction of Hambantota habour and other rapid development activities. Similarly mangroves have removed from Koholankala to Platupana particularly for construction of salt fans. Also, mangrove fringes and patches in lagoons to northwards from Periya Kalapuwa (East Coast) up to Jaffna Peninsula also have been cleared for cultivation of paddies and coconuts as well as urbanization and industrialization (Table 4).

The discharge of toxic substances from factories and the waste products such as sawdust and coir dust from saw mills and coir factories to lagoons and estuaries are some of the major hazards faced by mangrove species, especially in Moratuwa Panadura estuary, Lunawa lagoon, Bolgoda Lakes and Ratgama Lake along the western and southwestern areas. All solid and liquid wastes are literally dumping into the mangrove habitats from the tourist resorts and the industrial sites Kalpitiya Peninsula to Maha Lewaya (Hambantota). All these pollution poses a problem to human health through the construction of bacteria and human disease pathogen such as typhoid viruses by filter-feeding bivalves. Discharge of waste material affects mangroves indirectly by causing siltation and thus restricting the free flow of water, which is necessary for the proper growth of mangroves and existence of wildlife.

The introduction of substances directly and indirectly into the coastal habitat by man results in such deleterious aspects as harm to mesocopic and microscopic flora and fauna, hazards to human health, hindrance to marine activities etc. Mangroves are particularly susceptible to pollution. Since they thrive in estuarine areas that are the ultimate link for agricultural, domestic and industrial effluents, they are especially at risk (Konx and Miyabara 1984, Katupotha 2012).

TABLE 5: Common birds of mangrove environments in Sri Lanka

SPECIES	FAVOURED HABITATS
Acrodotheres tristis	Mangroves and swampy environments
Amauronnis phoenicurus	Swampy environments
A. fuscus fuscus	Swampy environments
Ardea cinerea	Brackish lagoons and river estuaries
A. purpurea manilensis	Mangrove linked lagoons
Ardea alba	Lagoon shores
Ardoeta graii	Lagoon shores
Butorides striatu javanicus	Water's edge of mangroves
Caprimulgus asiaticus	Mangroves and swampy environments
Ceryle rudis lencomelanura	River estuaries
Ceryle badis	Mangroves and swampy environments
Chalcophaps indicarobinsoni	Mangroves and swampy environments
Copsychus saularis	Mangroves and swampy environments
Crovus macrorhynchas	Mangroves and swampy environments
Demigratta asha	Tidal creeks, brackish lagoons, mangrove swamps
Eudynamys scolopacea	Mangroves and swampy environments
Egaetta alba modesta	Shore of lagoons
E. garzetta grazetta	Lagoons tidal mud flats
Haliacetus leacogaster	Sea beaches, mud flats
Larus brunneicephalus	Lagoons and estuaries
L. fuscus	Coastal lagoons
Limosa lapponica lapoponica	Lagoons and mud flats
Nycticorax nycticorax nycticorax	Mangrove linked lagoons or estuaries
Oriolus xanthornus	Mangroves and boggy swamps
Pelagopsis carpencis gurial	Mangrove swamps, coastal lagoons
Peisffacula cupatria	Mangroves and swampy environments
Phalaccrocorax niger	Mangroves and boggy swamps
Pholacrocrax fascicollis	Mangroves and boggy swamps
Pholacrocrax niger	Boggy swamps and water bodies
Porzana pussilla pusilla	Boggy swamps
Sterna albifrons sinensis	Sea beaches, dry mud flats
Stena bergi	Sea beaches, dry mud flats
Tringa glareola	Mangroves and boggy swamps

Source: Henry, 1978; Kotagama *et al*, 1986 and Field Observations.

TABLE 6: Common fishes entering lagoons, estuaries, tidal creeks which are associated with mangrove habitats

SPECIES	EXTENT
Eensisus mino	Estuarine and tidal rivers
Ambassis commersoni	Esturaine, ascending rivers
A. urotaenia	Esturaine, entering rivers
Arius caelatus	do
A. dussumieri	Brackish waters, entering rivers
A. jella	Estuaries
A. platystomus	do
A. subrotratus	Estuaries and tidal rivers
A. venosus	do
Arothron stellatus	Coastal lagoons and estuaries
Bagrus thalassinus	Estuaries and tidal rivers
Chaetodon suratensis	Fresh and brackish waters
Cheilodipternus butis	Coastal lagoons and estuaries
Coius chatareus	Fersh and brackish waters of lagoons
Etroplus maculatus	Coastal lagoons and estuaries
Gobius koelreuteri	Estuarine, coming ashore onto mud flats
G. sadanundio	Estuarine waters
Holocentrus surinamensis	coastal waters, entering estuarine and rivers
Lutjanus diacanthus	Coastal waters, entering the tidal waters
L. gymnocephalus	Estuarine, entering fresh waters
Monodactylus argenteus	Coastal waters and estuaries
Mugli macrolepis	do
M. parsia	Entering estuaries
M. strongylocephalus	Inhabitating river mouths and coastal lagoons
M. tade	Entering estuaries and tidal creeks
M. waigiensis	Entering estuaries and lagoons
Muraena brummeri	Inhabits coastal lagoons
Ophisurus cancrivorus	Inhabiting river mouths and coastal
O. rutidodermatoides	do
Osteogeneiosus sthenocephalus	Estuaries and tidal creeks
Perioptalmus	do
Pimelodus sona	do
Plotosus cenius	Entering rivers and brackish waters
Promincrops lanceolatus	Estuaries and lagoons
Scatophagus cergus	Coastal waters and estuaries
Silurus militaris	Esturies and tidal creeks
S. maculatus	do
Sinaera jabua	Coastal waters, estuarine
Sphagebranchus longipinnis	lagoons
Tetroden fluviatilis	Ascending coastal rivers and lagoons
Therapon theraps	Estuaries
Toxotes chatarcus	Estuaries and tidal creeks

Source: Munro, 1955 and Field Observations.

TABLE 7: Abundant macroscopic mangrove fauna in Sri Lanka

Family or Class	Species	Favored Habitats
CRABS		
FAMILY		
Potunidae	*Thalamita crentana*	Resemble the mud crab, but generally it is not sold in the market.
	Portunus pelagieus	Sea crab can be identified by the beautiful colour patterns on itscarapace. It is known as Nepptunus pelegiens.
	Scylla serrata	Deep burrows. Commercially expensive.
Ocypodidae	*Macrophthalmus depressus*	Very fine sand of mud flats adjoining the mangroves
	M. sulcatus	do
	Uca lactea	Upper region with larger sand fractions. Prefer simple
	Uca lactea	Upper region with larger sand fractions. Prefer simple burrows.
	U. dessumieri	Upper regions of mangroves foreshores and unshaded mangrove fringes.
Graspsidae	Neosermatum *malbaricum*	'T' shaped burrows; active in the evening.
	N. smithi	Complex burrows.
	Metapograpsus messor	Boggy soils. Prefer water holes or between mangrove adventions toots.
	Messor spp.	Messor is a species of crab that lives in mangroves
	M. darwinensis	do
	M. bidens	Wet and firm soils. Prefer shallow burrows.
MUD LOBSTERS		
	Thalassina anomala	Burrows and hardly leaves the burrows. Unique to mangrove environment.
	Swimming macrurans	Swim in the lagoon frequent especially for feeding.
PRAWNS		
CLASS		
Penaedae	*Penaeus* spp.	P. indicus is common prawns of lagoons. P. monodon and P. semisuleatus are rare.
	Metapenseus bobsoni	Less saline areas; commercially important.
Caridae:		Various species of Caridians can be seen in the waters around the mangroves.
MOLLUSCS		
	Cassidula musterina	Occurs on the ground and occasionally on the plants.

	Cerithidea cingulata	Abundant on the mud flats adjoining the mangroves
	C. quadrata	Shade of mangroves.
	Faunus ater	Lagoon mud.
	Faunus ater	Lagoon mud
	Galoina coaxans	Lagoon bed
	Littorina scabra	Found on the leaves of mangroves.
	Meretrix casta	Lagoon bed.
	Nerita polita	Attached to the mangrove roots.
	Pleuroploca trapezium	Lagoon bed.
	Telescopium telescopium	Lagoon bed.
OYSTERS		
	Saccostrea spp.	Found on mangrove swamps
	Crassostea spp.	do

Source: Pinto, 1984; 1986 and Field Observations.

Over exploitation that has rapidly destroyed and degradated the mangrove ecosystems are a result of a variety of practices and processes. They can be summarized as follows:

a) Rapid urban development (establishment of Free Trade Zones and townships),
b) Establishment of anchorages and landing of a large number of fishing craft, including Multi-day boats: e.g. Puttalam, Chilaw, Negombo, Baticaloa, Trincomale and Jaffna lagoons,
c) Land reclamation for road construction, settlements and expansion of agriculture,
d) Conversion of marginal mangrove lands into shrimp farm ponds in Gembarandidiya, Chilaw, Muthipanthiya and Puttalam lagoons and Mundal Lake; and in addition into salterns in Puttalam lagoon and Mundal Lake, lagoon areas in southeastern area,
e) Use as municipal solid waste disposal sites,
f) Inflows of inorganic fertilizer, herbicides/weedicides/insecticide runoff from inland agricultural areas (Negombo, Mundal and Puttalam areas; eastern lagoons and Jaffna Lagoon Complex),
(a) Rapid siltation that is often aggravated by coral mining and aquaculture practices,
(b) Industrial pollutants and waste disposal.

Such degradation of the habitat has an adverse impact on the national economy. It has also resulted in the loss of invaluable habitat for a variety of birds, fish and other wildlife species. Therefore, there is a need to create public awareness to protect the mangroves at the regional level as well as at the national level. There is an urgent need to complete an island-wide studies in mangrove taxonomy, production, impact of pollutants, biology of mangroves and identification of socio-economic problems. This can be addressed by the Coast Conservation Department of Sri Lanka, the National Aquatic Resources Agency of Sri Lanka, Central Environmental Authority of Sri Lanka, the National Science Foundation of Sri Lanka and other relevant Institutions, schools and Non-Governnmental Agencies who concern the protection of natural resources. Such activities help to protect mangrove species and to promote associated wildlife. Island-wide quantitative mapping of mangrove areas also help this purpose and it can be completed by using remote sensing techniques.

CONCLUSION

Mangrove ecosystems of the inter-tidal zone in the tropical and sub-tropical areas have multiple uses to human beings and wildlife. Mangroves have scientific, educational and aesthetic and commercial values. They provide good nursery grounds for birds, fish and other crustaceans. Variety of mangrove fauna like crabs, lobsters, prawns and mollusks bring in a considerable amount of foreign exchange. Over the last 4 decades, most of the mangrove species in Sri Lanka have been cleared and water bodies, mainly lagoons reclaimed, and are a rapidly destroyed and degraded the resources. Such destruction is a threat to flora and fauna as well as the livelihood of the people. Thus, it is necessary to manage and conserve the mangrove habitats as a natural heritage to protect the coast from erosion, and to obtain a variety of products from aquatic and terrestrial components. For this purpose, public awareness is needed for the proper use of mangroves.

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Appendix 1. The distribution, density and identified threats of fringe mangrove vegetation in lagoons of Sri Lanka

Lagoon: Northern Coast	**Presence and identified threats**
1.1 Vidattaltivu	A well developed mangrove stretch has been developed along the coastline to inland. It is about 8.0 km long and 320m – 600m wide. Although tidal deposits have encouraged the growth of mangroves, chena cultivation, terrestrial sediments and fishing activities are serious threats to them. A rare mangrove species *Pemphis acidula* has been recorded in this area.
1.2 Jaffna Complex	The lagoon has extensive mudflats, sea grass beds and some fringing mangroves particularly around the lagoon in the south-east. Major species found was *Avicennia marina* while isolated plants of other mangroves such as *Rhizophora mucronata* could be seen around islands. Mangroves have been cut down for security reasons. The densely populated Jaffna lagoon area contains palmyra palms, coconut plantations, and rice paddies. There are numerous fishing villages and some salt pans around the lagoon appear as threats.
1.2.1 Uppu Aru	The lagoon is linked to Jaffna Lagoon by a short channel to the south. The lagoon has extensive mudflats and salt marshes. It is surrounded by mangroves, particularly Avicennia. Brackish water lagoon is surrounded by a densely populated region containing palmyra palms, coconut plantations, grassland, rice paddies and extensive vegetable gardens which pose a threat to mangroves.
1.2.2 Chundikulam	Mangrove swamps and sea grass beds are found in this lagoon. Plantations of *Palmyra* palms and scrub forest are presnt in surrounding areas. Parts of the lagoon are used for aquaculture, and the surrounding mangroves being cleared for this purpose is the main threat.
1.3 Thondamannaru	The lagoon has extensive mudflats, seagrass beds and mangrove swamps, particularly dominated by *Avicennia* sp. The lagoon is surrounded by a densely populated region, containing palmyra palms, coconut plantations, grassland, rice paddies, arid scrubland and open forest. Extraction of timber has caused a marked reduction in mangrove cover. Large areas of the wetland have been reclaimed for agriculture and parts of the lagoon are used for aquaculture, and there is some pollution with pesticides used on the adjacent agricultural land and proposed Salt Water Exclusion Scheme are threats to mangrove vegetation in this lagoon.
1.4 Punkudutivu	No mangrove vegetation.
1.5 Kayts	No mangrove vegetation.

1.6 Nanthikadal	Major mangrove swamps were found in Nanadikadal lagoon periphery and Chalai area which also confronted to clear??? during the civil war. *Rhizophora mucronata* appears as the dominant sp. Conversion of the lagoon to salt pans and aquaculture ponds,and some rice paddies are the threat to mangrove patches.
1.7 Nayaru	Mangroves are present as very few patches and strips, but surrounding lands have been utilized for agriculture.
1.8 Kokkilai	The lagoon has extensive sea grass beds and small areas of mangrove swamp and mudflats. The lagoon is surrounded by cultivated land and scrub, with some patches of open forest. Parts of the lagoon are used for aquaculture, and the adjacent patches of mangroves are being cleared for cultivation.
1.9 Jinnapura Karachchi	Only very few mangrove patches are available. Salt pans and housing schemes surrounding them are the main threat.
1.10 Pulmudai	No mangrove vegetation
1.11 Puduwa-kattu	The lagoon has small areas of mangrove swamp (patches and fringing). Fishing boats (Motor boats), nearby housing schemes and agricultural lands are the main threat.
1.12 Kuchchaveli	Very narrow fringing mangroves are located in this lagoon. Formation of salt pans during the dry season, terrestrial sediments and fresh water inflow during the rainy season are main threats to these mangroves.
1.13Periyakarachchi	No mangroves in this lagoon, and former areas have been encroached by rice paddies, coconut palms, other cultivations and aquaculture activities.
1.14Sinnakarachchi	No mangroves in this lagoon, and former areas have been encroached by rice paddies, coconut palms, other cultivations and aquaculture activities.
1.15Uppuveli	Some mangrove patches are located at the western side of the lagoon. Most of the area has been cleared for agricultural purposes. Landing of fishing craft and housing schemes along the lagoon channel appear as threat to mangroves.
1.16 Tambalagam Lake	Mangroves are present in fringing and estuarine (in stream river mouths) areas. Urban development, security activities and agricultural practices are the main threats to the mangrove vegetation.
1.17 Illakantai	There are small patches of mangrove vegetation in this lagoon. Rice paddies and extension of salt pans appear as threats.
Lagoon: Northeast Coast	**Presence and identified threats**

2.1 Ullakkalie	The lagoon has patches and fringing mangroves???? mangrove swamps. Salt pans, rice paddies and stream sediment during the floods are the main threats.
2.2 Uppar-Panichankeni	The lagoon has well developed patches and fringing mangrove swamps and in some palaces this vegetation has been removed for security purposes. Salt pans, stream sediments and agricultural practices and home gardens in the sand barrier have limited their extent.
2.3 Valaichenai	Well developed mangrove swamps are located in the landward side of this lagoon. Urban development on both sides of the lagoon, aquaculture farms and inflow of flood material during the rainy season are the main threat.
2.4 Batticaloa	Some patches and fringing of mangrove remain in good condition. But surrounding areas are mostly under rice paddies, coconut cultivation and other crops. Housing schemes and urban development are the major threats.
Lagoon: East Coast	**presence and identified threats**
3.1 Periya Klapuwa	Patches and fringing mangroves exist towards the landward side. These have sedimentation from inland streams. Rice paddies, development of settlements at the seaside are major threats
3.2 Korai Complex	Patches and fringing mangroves are present. Rice paddies, coconut cultivation and housing schemes are the major threats.
3.3 Thimbutu	This lagoon has well developed extensive mangrove swamps. Expansion of coconut cultivation reduces the mangrove vegetation of the lagoon edges.
3.4 Komari	Few mangrove patches can see in this lagoon. Rice paddies on the inland side and settlements on the sea side have caused the mangrove vegetation to diminish.
3.5 Murugetena	Only few scatted fringing mangroves are present.
3.6 Putuvil-Ureni	Fringing mangrove vegetation exists in this lagoon. Rice paddies and other agricultural practices and settlements are the main threats.
3.7 Arugam	Well developed mangrove swamps can be seen in the northwestern and southeastern edges of the lagoon. Settlements in the northeastern and southern parts and aquaculture projects are the major threats.
3.8 Panama	This lagoon has well developed fringing mangrove patches. Except boat landing in some places and a few settlements in the southern part, threats are minimized.
3.9 Panakala	No considerable mangroves exist in this lagoon.
3.10 Solambe	Although few patches of mangroves exist, development of salt pans during the dry season has reduced the distribution of mangrove vegetation.

3.11 Kunukala	No considerable mangroves exist in this lagoon.
3.12 Helawa	There are small patches and fringing mangrove vegetation in this lagoon. These have been encroached for coconut cultivation and rice paddies.
3.13 Okanda	Except for a few patches, there is no considerable development in this lagoon.
3.14 Girikula	No considerable mangroves exist in this lagoon.
Lagoon: Southeast Coast	**Presence and identified threats**
4.1 Bagura	Only few patches and fringing pockets are available. There is no human interference due to protection by the Department of Wild Life.
4.2 Andrakala	There is no mangrove vegetation in this lagoon.
4.3 Itikala	There is no mangrove vegetation in this lagoon.
4.4 Yakkala	There is no mangrove vegetation in this lagoon.
4.5 Uda Gajaba Eliya	This lagoon has small fringing mangroves. There is no human interference due to protection by the Department of Wild Life.
4.6 Pahala Potana*	No considerable distribution of mangroves exists in this lagoon, and there is no human interference due to protection by the Department of Wild Life.
4.7 Uda Potana	No considerable distribution of mangroves exists in this lagoon, and there is no human interference due to protection by the Department of Wild Life.
4.8 Gonalabbe	There is no mangrove vegetation in this lagoon.
4.9 Butawa	A permanent brackish lagoon with some mangrove vegetation along its seaward edge.
4.10 Gode	There is no mangrove vegetation in this lagoon.
4.11 Palatupana	No considerable distribution of mangroves exists in this lagoon. The salt industry and chena cultivation have been responsible for the reduction of mangrove vegetation in this lagoon.
4.12 Kirinda	Some mangrove swamps are extant along the lagoon channel, and salt pans and settlements are the major threat to the distribution.
4.13 Bundala	No considerable distribution of mangroves exists in this lagoon. Salt industry and chena cultivation have been responsible for the reduction of mangrove vegetation in this lagoon.
4.14 Embilikala	Mangrove vegetation extends as fringes and swamps in this lagoon. Threats are minimized due to the protection of the area under the Department of Wild Life.
4.15 Malala- Embilikala	Mangrove vegetation exists as fringes and swamps in this lagoon; a few places have been encroached but threats are minimized due to

	the protection of the area under the Department of Wild Life.
4.16 Koholankala-Maha Lewaya	No mangroves are present in this lagoon complex. The principal threat is further development of salt production projects.
Lagoon: Southern Coast	**Presence and identified threats**
5. Karagan	This lagoon has been converted as Hambantota Habour.
5.2 Mahasittarakala	The upper part of the lagoon has small patches of mangroves. Road construction activities and illegal gem mining are the major threats to the mangroves.
5.3 Lunama	Considerable extents of mangrove swamps are located in this lagoon. Rice paddies, other cultivated land, grassland, scrub and coconut plantations in surrounding areas have encroached on the mangroves of the lagoon edge.
5.4 Kalametiya	Well developed and considerable extents of mangrove swamps are located in this lagoon. The area of open water in the lagoons has decreased during the past 3 – 4 decades, mainly because of siltation. An expansion of the mangroves has also occurred at Kalametiya, and this has accelerated the process of siltation. Other threats include disturbance from fishing activities, excavation of mollusc shells for use in lime kilns, reclamation of land for rice cultivation, and pollution with pesticides entering the lagoons in agricultural runoff from the Walawe Development Scheme to the north.
5.5 Kunukalliya	No mangroves exist in this lagoon.It appears as an abandoned lagoon.
5.6 Tillawatawana	No mangroves exist in this lagoon.
5.7 Kahandamodera	Well developed mangrove fringes are located in this lagoon. There are no major threats to the mangroves in this lagoon.
5.8 Rekawa	Very limited mangrove patches and fringes can be seen in this lagoon. Inflow of fresh water during the flood periods, housing schemes and other settlements in the northern side of the lagoon, and illegal tourist structures are the major threats.
5.9 Mawella	Very limited mangrove patches and fringes can be seen in this lagoon. There is no seawater movement due to the low depth and it is located about 800m away from the sea. Housing schemes and other land settlements, unplanned tourist activities and landing of seacraft are the major threats.
5.10 Dondra	Although very narrow fringing mangroves exist at the edge of the lagoon, this area has been encroached by settlers.
5.11 Garanduwa	This lagoon is located in a highly populated area and about 750m inland from the sea. A considerable amount of fringing mangroves is present along the lagoon edge. Housing schemes, homesteads and expansion of coconut cultivation are the major threats to the mangroves.

Lagoon: Southwest Coast	**Presence and identified threats**
6.1 Koggala	Well developed mangrove islets, patches and fringes are found in Koggala Lagoon. Expansion of coconut cultivation and home gardens, Civil Aviation activities and tourism are the main threats to the mangrove development of the lagoon.
6.2 Ratgama Lake	Fringing mangroves exist along the lagoon edge and in tiny islets. Expansion of coconut cultivation and home gardens are the major threats.
6.3 Hikkaduwa Ganga	There is no considerable amount of mangrove distribution in this lagoon. Edge of the lagoon has been used for coconut cultivation, home gardens as well as to construct facilities for tourists.
6.4 Telwatte Ganga	Along the Telwatta Ganga Channel and the lagoon well developed mangrove patches are located. The use of land for coconut cultivation and construction of houses are a major threat.
6.4 Madampa Lake	A considerable extent of mangrove vegetation in this lagoon is located along the edge and on the island. The use of mangrove areas for coconut cultivation and homesteads is the major threat to the expansion of mangrove vegetation.
6.5 Madu Ganga	A considerable extent of mangrove vegetation in this lagoon is located along the edge and in small islands. The expansion of coconut cultivation and house construction and land clearing for cinnamon cultivation have caused the reduction of mangroves in this lagoon.
6.6 Kosgoda	Some fringes along the seaside and a few pockets of mangrove vegetations are located in this lagoon. Due to the scarcity of land for housing and cultivation, the lagoon edge lands have been utilized.
6.7 Silliya Ganga	This small lagoon has few patches of mangroves. Coconut cultivation and home gardens have reached the lagoon edge and appear as a major threat.
6.8 Ingirili Ganga	The fringing mangrove vegetation in this lagoon is gradually reduced due to the land scarcity in the area.
Lagoon: West Coast	**Presence and identified threats**
7.1 Bolgoda Lake	South and North Bolgoda Lakes and the associated channel system have mangrove vegetation to some extent. Land scarcity in the urban area and attraction as a sightseeing area is the major threats. The lagoon system is under considerable threat from the dumping of urban refuse.
7.2 Lunawa Lagoon	There is little development of mangroves in this lagoon.
7.4 Negombo lagoon	The lagoon has extensive mangrove swamps. Mangrove forests are dominated by *Rhizophora* spp, *Bruguiera* spp, *Avicenniamarina* and *Lumnitzera racemosa*. Rice paddies, grassland and coconut plantations in surrounding areas have encroached on the mangrove

	swamps. The clearing of mangroves for housing projects, cutting of mangroves for firewood, and illicit manufacture of liquor are additional threats.
Lagoon: Northwest Coast	**Presence and identified threats**
8.1 Gembarandiya	This lagoon has extensive mangrove swamps. Much of the southern part of the lagoon has been converted to shrimp farm ponds. Construction of tourist hotels, extending coconut cultivation and home gardens are the major threats.
8.2 Chilaw	Chilaw lagoon and the associated channel system have extensive mangrove vegetation. The clearing of mangroves for housing projects, cutting of mangroves for firewood, and illicit manufacture of liquor in mangrove forest areas and converting mangrove swamps for shrimp farm ponds are the major threats. The lagoon mouth at the Deduru Oya estuary is under considerable threat from the dumping of urban refuse.
8.3 Muthupanthiya	Well developed extensive mangrove patches are located in the southern part of this lagoon. All lowlands surrounding the lagoon have been utilized to make shrimp farm ponds.
8.4 Mundel	This lagoon has no extensive mangrove swamps. All surrounding lands (100%) have been converted into shrimp farm ponds. The boundary of the ponds can be considered as co-extensive with the former lagoon boundary, about 30 – 35 years ago. The lagoon and pond areas are surrounded by a region containing rice paddies, coconut plantations and scrubland. The land is used for prawn fishing and rice cultivation.
8.5 Thalawila Odai	This lagoon has small fringing and patches of mangrove vegetation in the seaward side. Coconut cultivation and shrimp farm ponds (sea side) are the main threats.
8.6 Kandakuliya	This is a newly created lagoon (during the past 30 year period). No mangrove vegetation is present.
8.7 Puttalam	The lagoon has extensive mangroves, sea grasses and some salt marshes, The lagoon is surrounded by a region containing coconut trees, open forests, grasslands and scrublands. The southern part of the mangrove land is used for making shrimp farm ponds, salt production, and rice cultivation. Destruction of mangroves for firewood, beams and poles are the major threats.
8.8 Vankalai	Fringing mangroves are the salient feature in this lagoon. Expansion of Vankalai Town and construction of a road network are the main threats to the mangrove vegetation.
8.9 Periya Kalapuwa (NW)	Fringing and patches of mangroves are present as the salient feature in this lagoon. Expansion of rice paddies and construction of a road network are the main threats to mangrove vegetation.

Source: (1). IUCN: 2011. Biodiversity and Socioeconomic Information of Selected Areas of Sri Lankan Side of the Gulf of Mannar, January 2011. (2). Kotagama S.W., Pinto Leonard and Samarakoon L. Jayampathi: Sri Lanka". Wetlands International. http://ramsar.wetlands.org/Portals/15/SriLanka.pdf. (3). National Aquatic Resources Research and Development Agency: 2010. Preliminary report on Coastal and Marine Ecosystems, Fisheries and Aquaculture (Phase 1), Crow Island, Mattakkuliya, Colombo 15, December 2010, (4) Silva, E.I.L., J. Katupotha, O. Amerasinghe, H. Manthrithilake *et al*. Lagoons of Sri Lanka: From the Origins to the Present IWMI 2013; and (5) Field Observations.

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