

THE MANGROVES OF SRI LANKA - AN INITIAL STUDY

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Mangrove forests in Sri Lanka are confined to an extent of around 10,000 hectares mainly around lagoons and in the intertidal zones near the mouths of rivers. In Sri Lanka the tidal variation is only about 1 metre and hence the mangroves only form a thin belt. No detailed island-wide study of the distribution and extent and species composition of the mangroves has been undertaken as yet although for a long time mangroves have supplied Sri Lanka's coastal people living near mangrove areas with their requirements of fuelwood, poles and domestic timber. Mangroves have also yielded tannin extracts and dyes from their barks to meet part of the requirements of the small leather industry in the country. However, some studies on mangroves have been done by the Forest Department, the Universities and the Department of Wild Life Conservation.

The paucity of work on mangroves, and the absence of any definite management plans for such an important forest ecosystem is mainly because of the fact that except for mangrove areas in forest reserves and wild life national parks that abut on the sea coast, mangroves located in other areas of the coast have not been under the charge of any single technical state department. At one time these other areas were controlled by revenue officials of districts and by government agents, and more recently partly by the Department of Coast Conservation, partly by the Urban Development Authority and partly by government agents.

However, with the setting up of a UNESCO sponsored National Mangrove Committee for Sri Lanka, it has been advocated that all mangrove areas be brought under an appropriate form of management and protection. It has also been proposed that scientific research be carried out into the mangrove ecosystem encompassing the disciplines of forestry, fisheries and wildlife. Multiple control over such mangrove areas as in the past is not in the long term interests of the mangrove ecosystem and would not bring benefits to the coastal people living in and around the areas and to the country in general at a sustained level. Even though the extent of mangroves is small and diminishing compared to those of other countries in similar geographical regions, the value of the mangrove ecosystem is immense and should be protected, enriched, regenerated where depleted, and managed to provide sustained benefits to the people. Mangroves provide fuelwood, poles and timber to the coastal poor for their domestic needs. They improve the coastal micro climate, protect the land from erosion and cyclonic conditions, prevent sand dune formation and sedimentation, provide optimum conditions for breeding of fish, prawns, crabs, molluscs, etc., provide nesting places for aquatic birds and is the habitat for a varied fauna. Mangrove plant species and mangrove associate plant species are many forming a unique forest ecosystem.

However with economic development in areas such as the Mahaweli Scheme near estuaries, and

settlement of people in these areas, over cutting of mangroves will take place unless effective measures for protection and conservation are taken. Hence proposals were made in 1983 to make a start in the survey of management, regeneration and research into the mangrove ecosystem in Sri Lanka. These proposals although somewhat ambitious could be implemented by the Forest Department in collaboration with other line agencies and departments that also have an interest in the mangrove areas.

Viewed in the backdrop of this situation for Sri Lanka, the Regional Project RAS/79/002/E/01/13 developed by the UNDP/UNESCO for "Research and Training on Mangrove Ecosystems of Asia and Oceania" was most welcome and was strongly supported by the UNESCO National Committee for Sri Lanka.

Sri Lanka participated in the 1st and 2nd Task Force Meetings of this Regional Project on Research and Training on Mangrove Ecosystems in Asia and Oceania, in 1983 and 1984 and has been fortunate to be a recipient of funds from this project for mangrove development in the country. The funds are provided by UNDP/UNESCO to meet part of the costs of the initial Sri Lanka mangrove study "AN ASSESSMENT OF THE MANGROVE STATUS ALONG THE WEST COAST OF SRI LANKA PHASE I", which has just commenced.

The Forest Department Working Plans and Forest Inventory Branch, NARA the National Aquatic Resources Agency, the Botany Department of the University of Peradeniya, and the Zoology Department of the University of Colombo will cooperate under the guidance of the Sri Lanka NATMANCOM (National Mangrove Committee) to implement this project. The project area of this initial study will cover the west coast of Sri Lanka from Puttalam in the north to the Ginganga in the south.

The main objectives of this initial study are —

- (a) to provide information on the mangrove ecosystem and its structure in the project area,

- (b) to assess the socio-economic influences of mangroves in selected locations in the project area, and
- (c) to start a programme for research, rehabilitation and protection of the mangroves in the project area.

The project covers a one year period and the main activities of this project are —

- (1) Inventory and distribution of existing mangroves in the project area,
- (2) Socio-economic survey of selected locations in the project area, and
- (3) Studies on Mangrove Community Structure and Condition in selected locations in the project area.

Activity (1) is being carried out by the Working Plans and Forest Inventory Branch of the Forest Department, Activity (2) by NARA, and Activity (3) by the Botany Department of the University of Peradeniya, and the Zoology Department of the University of Colombo.

The Forest Department has already commenced a study of the mangrove forests along the country's coast line and mapping them using aerial photographs and landsat imagery. According to Land Use Maps prepared for different districts so far, the extents of mangrove forests in 6 districts are as follows :

1.	Batticaloa District	—	1,520 ha
2.	Amparai District	—	54 ha
3.	Colombo District	—	9 ha
4.	Gampaha District	—	723 ha
5.	Puttalam District	—	2,970 ha
6.	Trincomalee District	—	1,020 ha
Total			— 6,296 ha

Between Gintota and Aluthgama an acreage of 70 ha has been assessed so far, in addition to the above acreage for 6 districts.

On an all island basis, it may be estimated that the extent of mangrove forests is in the region of 10,000 ha.

Twenty three species of mangroves have been recorded for Sri Lanka, both true mangroves, and mangrove associates. Typical genera are mangroves *Rhizophora*, *Avicennia*, *Excoecaria*, *Lumnitzera* and *Aegiceras*, and mangrove associates *Tamarix*, *Acanthus*, *Sphaeranthus* and *Sonneratia*.

A list of species recorded is given below :

1. *Rhizophoraceae*
 1. *Rhizophora apiculata*
 2. *Rhizophora mucronata*
 3. *Bruguiera cylindrica*
 4. *Bruguiera gymnorrhiza*
 5. *Ceriops tagal*
2. *Verbanaceae*
 1. *Avicennia officinalis*
 2. *Avicennia marina*
 3. *Clerodendron inerme*
3. *Sonneratiaceae*
 1. *Sonneratia caseolaris*
4. *Meliaceae*
 1. *Xylocarpus granatum*
 2. *Xylocarpus moluccensis*
5. *Combretaceae*
 1. *Lumnitzera racemosa*
6. *Sterculiaceae*
 1. *Heritiera littoralis*
7. *Euphorbiaceae*
 1. *Excoecaria agallocha*
8. *Apocyanaceae*
 1. *Cerbera manghas*
9. *Myrsinaceae*
 1. *Aegiceras cerniculatus*
10. *Bignoniaceae*
 1. *Delichandrone spathacea*
11. *Palmae*
 1. *Nypa fruticans*
12. *Acanthaceae*
 1. *Acanthus ilicifolius*
13. *Lythraceae*
 1. *Pemphis acidula*
14. *Pteridaceae*
 1. *Acrostichum aureum*
15. *Tamaricaceae*
 1. *Tamarix gallica*
16. *Compositae*
 1. *Sphaeranthus indicus*

The map of Sri Lanka shows locations of the principle mangrove areas in the country.

THE MANGROVE ECOSYSTEM

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During the last few decades, people all over the world have begun to realize that there are many untapped unconventional resources, that could be intelligently exploited. One such natural resource along the coast in the tropics is the mangrove ecosystem.

Although mangroves occur in America, Africa and Australia, they reach the climax in South East Asia. The extent of mangroves in Sri Lanka is comparatively small. It has been estimated to be between 8000 to 10000 acres.³ With the population expansion and industrialization, mangroves have been disappearing fast in Sri Lanka, as in other parts of the world.

Mangrove community or the mangal is a unique ecosystem. It is composed of a terrestrial, marine and a freshwater component. In a sense, this environment reflects the primitive swamp through which animals invaded land. Together with coral reefs and seagrasses, mangrove ecosystem is considered to be one of the most ancient ecosystems of the world.¹⁶ The organisms in the mangrove community have come from the sea, land or rivers, primarily or secondarily.¹⁴

Mangrove flora and fauna

Mangroves interest the naturalist because of the diversity and adaptations of the mangrove organisms. Mangrove plants do not belong to the same family. Originating from different families, they show convergence in adaptations. There are 55 mangroves species in the world⁸ and 28 have been reported for Sri Lanka.¹

Although living in an aquatic environment, they live as if they are faced with xerophytic conditions. The salt water absorbed is desalinated within the plant by secreting salt out of the plant through special glands on the leaves. These glands are found in the leaves of *Avicennia marina* (Manda), *Acanthus ilicifolius* (Mulli) and *Aegiceras corniculatum*. Practically all the mangrove leaves have a thick cuticle for protection and reduction of transpiration.

Since the substrate on which they stand is unsteady they are supported by prop roots as seen in *Rhizophora apiculata* (Kadol) and *Rhizophora mucronata* (Kadol). Mangrove soil is acidic and poor in soil air. Thus mangroves have developed special type of roots to come above the ground in search of air. Pencil like pneumatophores found in *Avicennia* spp. and larger stumpy pneumatophores of *Sonneratia* spp. (Kirila) is one such adaptation. *Bruguiera* spp. (Sirikanda) have developed knee roots. Since the young embryo can be easily destroyed if it falls in to this harsh environment, *Rhizophora* spp., *Bruguiera* spp. and *Ceriops tagal* have developed viviparous seeds. The seed is released from the plant at a fairly matured stage of development and the seedling can be easily fixed in the mud by the spike-like radicle. By this adaptation hazards to the young embryo is evaded.

The mangal shows zonation when the tidal fluctuation is high and when the banks have a low gradient. Zonation in the mangal of Sri Lanka is not spectacular due to the small difference in the tidal fluctuation.²⁰

Mangrove animals also show diversity and adaptation. Annelids, arthropods, molluscs and chordates are the most common visible phyla living in the mangroves.

Marphysa boradellei (Kalandan panuwa) is a common polychaete in the mangroves, whose eggs are protected from the surroundings by an encasing cocoon. In the mangrove islets of Negombo, the polychaete *Branchiocapitella singularis* is common with an annual population fluctuation ranging from 10 — 60 per m² in the surface soil.¹⁸ In spite of the soil water, they migrate upwards during the rainy season.

Although oysters generally live attached to rocks, in the mangroves they are attached to mangrove roots. In the oyster *Crassostrea cucullata* (Kawati) a selection of old *Rhizophora mucronata* roots over the other species has been observed. Twenty four animal species living in association with oysters has been reported.²²

Muddy environment is ideal for the filter feeding bivalves such as *Geloina coaxans* and *Meretrix casta* that live partially buried in the mangrove soil.

Zonation of gastropod molluscs such as *Littorina scabra*, *Cassidula musterina* and *Cerithidea cingulata* reflect their tolerance to temperature and salinity.¹²

Most of the crabs in the mangroves are not edible and belong to Grapsidae and Ocypodidae families. They live in burrows but come out for feeding. The grapsids, *Chiromantes bidens*, *Chiromantes indiarum*, *Chiromantes darwinensis*, *Neoepisesarma versicolor* and *Neosermatium malabaricum* are common in the mangroves of Sri Lanka.¹⁹ *Neosermatium smithii* has adapted a castle-building habit to maintain the conditions of the burrow when the mangroves are flooded during the rainy season. Among the commercially important crabs are *Scylla serrata* (Kalapu kakuluwa) and *Neptunus pelagicus* (Sinakkali). Living in close association with mangrove roots, with climbing habits is the grapsid *Metopograpsus*

messor. Although not popular in Sri Lanka, the grapsid *Varuna litterata* and the portunid *Thalamita* spp. are harvested for consumption in other countries. Xanthid crabs live in association with oysters and are represented by *Baruna socialis* and *Pyseidognathus deianira* in the Negombo Lagoon. *Uca lactea* is the common species of ocypodid, while the other members also occur in the mangroves of Sri Lanka.

Different species of prawns are also found in the mangroves. Tiger prawn, *Penaeus monodon*, *Penaeus indicus* and banana prawn *Penaeus merguensis* are commercially important species. *Acetes erythraeus* (Kunissa) and *Squilla* spp. (Yakissa) also occur in the mangroves close to the sea. The snapping shrimp *Alpheus edwardsi* is generally associated with the oysters or with mangrove roots.

Unique to the mangroves of Asia is the mud-lobster, *Thalassina anomala* that lives in a complex burrow, building mounds in the mangroves. They are active only at night and never leave the burrow.

Amphipods belonging to the genera *Lembos*, *Ceradocus* and isopods of *Cirolana*, *Ligia* and *Cyathura* genera also occur in the mangroves of Negombo.

Among the insects, two species of bees are found to frequent the mangrove plants. *Apis indica* visits the *Avicennia marina* flowers while *Apis florea* frequents *Aegiceras corniculatum* flowers. The common paddy bug *Stenocaris apicalis* and the stung bug *Glaucias dorsalis* are found on a number of species of mangrove plants. But *Oecophylla smaragdina* (Dimiyo) build their nests often on *Sonneratia*, *Avicennia* and *Bruguiera* species.

The mangrove fish community is euryhaline, since the salinity of the mangrove water is subjected to high fluctuations. In the Negombo Lagoon the annual salinity range is from 1 to 36 ppt.¹⁸ In Jaffna Lagoon it ranged from 15

to 50 ppt.⁴ Koddigar Bay, Trincomalee recorded a range of 7 to 34 ppt⁷, and Puttalam Lagoon a range of 20 to 36 ppt.⁸ Whitefield *et al*²⁴ have reported a salinity range of 0.7 to 112 ppt for *Elops machnata* (Mannawa) a species occurring in the mangroves of America, Africa, Asia, and Australia. *Chanos chanos* (Vekkaya) and *Therapon jarbua* (Kili) are also euryhaline with a wide range of 0.7 to 70 ppt. From a single location 128 species of fish have been reported, most of them occurring throughout the year in spite of salinity variations.²¹ One of the most spectacular fish species found in the mangroves is the mud skipper *Periophthalmus* spp. (Diyahuna). Although a fish, it is adapted to a semi-terrestrial life. It can use its fins for skipping on land as well as in swimming.

The birds that frequent the mangroves have various feeding methods. Some are waders like *Ardeola grayi* (Kana koka), *Ardea purpurea* (Karawal koka), *Herodias alba* (Baddadel koka) and *H. intermedia* (Hota kalu koka). Others like *Halcyon smyrnensis* (Pilihuduwa), *Alcedo bengalensis* (Malpilihuduwa) and *Butorides javica* (Kadol koka) wait patiently for the prey while *Cheryl rudis* (Waturanduwa) and *Haliaster indus* (Rajaliya) hover over the mangroves in search of prey. *Totanus stagnatilis* (Kollila), *Totanus glareola* (Sili watuwa), *Actitis hypoleucos* (Sili watuwa) and occasionally stints are found in the mangroves, probing with their bills in the mangrove soil. The members of the above mentioned family, Scolopacinae and Laridae (gulls and terns) are migratory birds and therefore visit the mangroves seasonally. *Phalacrocorax niger* (Diyakawa) that is often found in the fresh-water tanks is also found in the mangroves. Among the birds that utilize the terrestrial component of the mangroves are the Nectariniidae (Sutikka) that come in search of nectar and Meropidae (Ambaya) that come in search of insects.

Although not confined to the mangroves, *Varanus salvator* (Kabaragoya) and *Cerberus rhychops* (Diyabariya) are also found in mangroves, predating on small animals.

The mammals that occur naturally in the mangroves are the rats and bats.

Long-term benefits of the mangrove resource

Mangroves are important because of the major role they play in the ecology of coastlands. Shore communities are one of the highly productive areas of the biosphere with a gross primary production ranging from 10,000 to 25,000 Kcal m⁻²yr⁻¹ compared to less productive deserts, open sea, grasslands and continental shelf waters.¹⁷ Estuaries and reefs are about 10 times more productive than the other coastal zones. It has been estimated that the gross primary productivity in a mangrove community to be 8 g C m⁻² day⁻¹.⁹ In primary productivity, the terrestrial component in the mangroves is as twice as that of the aquatic component.

Litterfall values of 934.4 g m⁻²yr⁻¹ has been reported for the Philippines²¹, 932.2 g m⁻²yr⁻¹ for Thailand² and 967.4 g m⁻²yr⁻¹ for Malaysia.¹⁰ In a *Rhizophora apiculata* stand, Na and Ca in the leaves has been 1.67% and 1.73% respectively, while in the soil their percentages have been 7.78 and 0.04. The average N, P and K in the leaves of the same stand has been 0.89%, 0.10% and 1.01% respectively while in the soil it has been 0.52%, 0.006% and 0.182% indicating a rapid decrease in Phosphorus with decomposition.²³ 50% of the falling leaves decompose within the first month if they fall in the inter-tidal zone and 25% if they fall in the supra tidal-zone.³

Mangroves play an important role in the geomorphology of the coasts. They are said to reclaim land and protect from erosion. Because of their prop roots, they accelerate the process of sedimentation. Solid particles coming down the streams tend to flocculate at the river mouth due to the differences in salinities and densities and get deposited.

Mangroves are the feeding grounds of many marine fish and prawn species. (See Figure 1). Many marine fish breed off shore but their eggs and larvae drift into the mangroves to spend their juvenile stages there. The nutrients released by the decaying leaves enrich the mangrove waters. Nitrates, phosphates and silicates in the waters enhance the growth of algae, which become the food for herbivores. It has been shown that in coastal areas where mangroves occur fish and prawn catch is higher than those areas denuded of mangroves.¹⁵

Since mangrove community is complex and rich in species composition with diverse interspecific interactions, it is a field laboratory to study and test ecological principles. Aside from investigating theoretical hypotheses, it serves as a location for college students to visit and study nature. In certain parts of the world, mangroves are protected for their recreational and aesthetic value.

Short-term benefits of the resource

Although the contribution from the aquatic component to the productivity of the mangrove ecosystem is insignificant, compared to that of the terrestrial component, the economic benefits from the aquatic component is almost twice as that from the terrestrial component.

About 1% of the global fish production comes by way of fishing in the mangroves.¹¹ Aside from fish and highly priced prawns, the cockles such as *Maratrix casta* is harvested from the river bed, and *Geloina coaxans* is gathered from the forest floor for food. While poor fishermen use traditional fishing methods in the mangrove fringed lagoons, enterprising fish farmers have converted mangroves to fish ponds. In using the mangroves for aquaculture or mariculture, care should be exercised so as to leave a mangrove fringe to avoid erosion. In between such ponds, some mangrove areas should be declared as protected areas so that they continue to serve as feeding grounds for juvenile fish.

While culture of *Chanos chanos* (Vekkaya), *Mugil* spp. (Godaya), *Liza* spp. (Godaya) are already practised in the mangroves, the culture of *Siganus* spp. (Orawa), *Epinephalus* spp. (Gal kossa), *Lutjanus* spp. (Thambalaya, Ranna), *Upeneus* spp. (Nagareya) and *Lates calcarifer* (Modha) is still in the experimental stage.

Prawns and crabs are also cultured in fish ponds reclaimed from mangroves. If cage culture is attempted in the mangroves, the adverse effect of destruction of the mangrove plants can be minimised, although feeding fish with artificial food may lead to pollution of the mangroves. Oyster culture on rafts and bamboos is also tried with less adverse effects on the mangrove ecosystem.

The molluscan shells are a source of lime. Aside from oyster shells, cockle shells are also used for lime production. Lime extraction from mangrove molluscs is with no adverse effect on the mangrove ecosystem while lime extraction from corals is hazardous to the coral reef ecosystem.

Mangrove forest is extensively exploited for timber in South East Asia. 40,000 ha Matang mangrove forest in Malaysia is probably the best managed mangrove forest in the world. It has been managed for 60 years at 30 years rotation period with 3 thinnings at 15, 25 and 30 years.¹⁰ Mangrove timber is highly priced for telegraph posts because of its strength. Since they contain a high percentage of tannins, the mangrove timber is naturally protected from insects. Fishermen also use tannins from mangrove plants to dye their nets and sails to give additional durability. Mangrove timber is also used for the production of good quality charcoal.

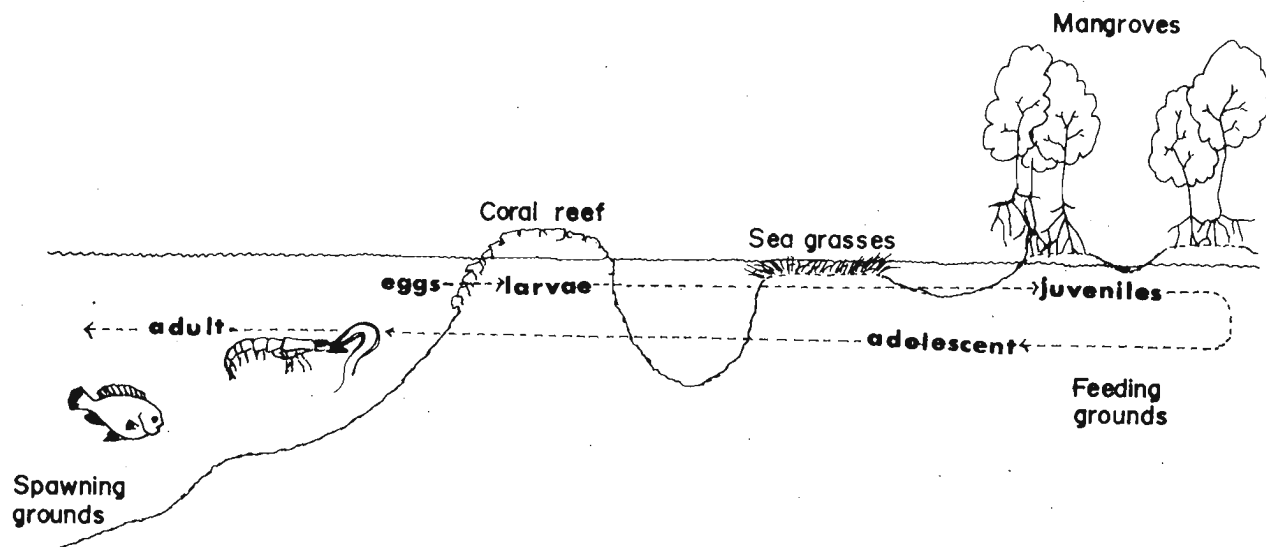
The branches of *Nypa fruticans* (Ginpol) is extensively used in South East Asia for thatching roofs and making other ornamental goods. Its flower is tapped to obtain a type of wine. The fruits of *Sonnarattia caseolaris* (Kirila) can be used to prepare a delicious fruit drink.

Bee-keeping is practised in the mangroves where *Avicennia* spp. is abundant. Even the smell of *Avicennia* spp. flowers is closer to that of honey, thus receiving the name honey mangrove.

Considering all these uses, the effects of one mode of utilization on the other can be categorized as complementary, competitive, mutually exclusive and with no effect.⁵ The uses that have been discussed above fall into complementary, competitive or with no effect categories. The utilization of mangroves for human settlement, road construction, industrial and port development and agriculture excludes the use of a particular mangrove environment for other uses.

Protection of mangroves

Since this vanishing mangrove ecosystem is distributed in a number of countries and benefits a number of persons irrespective of their economic status, the world bodies have taken interest to help the world at large. UNESCO, UNEP, and WWO are some such organizations. They generally work through local agencies such as NARESA and NARA. The countries in the mangrove belt have their National Mangrove Committees. Through all these organizations, research is initiated to bring more information. This information collected by specialists is shared at regional seminars and workshops and is disseminated back to the planners and the public, thus attempting to protect this vanishing natural resource.



Utilization of mangroves as feeding grounds by marine fish and prawn juveniles.

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MANGROVES: A DWINDLING RESOURCE

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What are mangroves ?

Mangroves are the trees and bushes growing between the level of high water of spring tides and level close to, but above mean sea level i.e. the inter-tidal zone. Mangroves dominate the tropical and sub-tropical sheltered coasts and extend into the estuaries of rivers where salt water penetrates. These are the major prominent members of the community which belong permanently to the resource, are generally exclusive to it and lead to its general recognition. Mangrove lands (swamps) are often hot, fetid, mosquito-ridden and almost impenetrable. Consequently, they were held in low regard until recent years. Nevertheless they are unique.

Why are mangroves and mangrove swamps unique ?

Mangroves are unique because they are able to live successfully in the inter-tidal zone where the conditions are not at all favourable for plant growth. These areas subject to inundation by the tides and subsequent exposure. The major problems that they are faced with in this environment are, difficulties in obtaining water and air (to 'breathe'); the key factors that sustain life. Although mangroves are daily flooded with water (but saline), the roots of these plants are unable to take this water in, due to the high salt concentration in this water which prevent water movements into the roots. This condition is

known as 'physiological dryness'. Mangroves are variously adapted to overcome this problem by developing thick outer covers and small leaves, often fleshy, due to storage of water. In addition to the adaptations to conserve water, they have developed various physiological means to exclude the salt taken in along with water. The structures developed as adaptations to obtain atmospheric air, have given the mangroves their characteristic appearance. The 'breathing roots' or the pneumatophores are the remarkable structures developed by *Avicennia* and *Sonneratia* (locally known as Manda and Kirala respectively) to obtain air from the atmosphere. These roots originate from the underground root system and grow out of the ground surface and protrude above the level of tide water, thus providing a continuous air passage to the submerged root system. *Rhizophora*, locally known as Kadol, develop prop roots from the stem, which eventually get attached to the mud, serving a dual purpose by providing air passage and support to the mangrove to withstand the battering by the waves and the wind. 'Knee roots' developed by mangroves such as *Bruguiera* and *Lumnitzera* (the latter is locally known as Beriya) are also effective air passages.

Uniqueness of the mangrove swamps is mostly rendered by their location; margin of the land and the sea. Mangroves attract mammals, reptiles and birds from their landward periphery, in addition to the indigenous swamp animals (fauna), while prawns, crabs and fishes migrate into the swamps with tide. These animals are attracted to these

swamps for the shelter and food. Mangrove swamps are flooded by the rising tide and plant litter and decomposed particles of vegetation (detritus), which is the food base of the food chains in estuarine and coastal waters, are washed into the coastal and sometimes into the offshore areas by the ebb tides and currents. Also, they receive freshwater borne material, which include inorganic nutrients essential for plant life, from landward sources by surface and river runoff. These mangrove swamps therefore, are open ecological systems, interacting with adjoining ecosystems, thus extending their influence far beyond the limits of the inter-tidal zone.

Are the mangroves and the mangroves swamps important ?

The importance of this resource derive both from the products taken directly from them and from amenities provided by it from within and beyond its boundaries.

Products extracted from mangroves range from construction material to alcohol and honey. Firewood, poles and posts for various artisanal fishing techniques and temporary dwellings and tannin are the major products extracted from mangroves in Sri Lanka. Although Sri Lanka's mangroves have not been managed, a limited mangrove area at Negombo lagoon (Munnakkare) has been propagated and managed for their commercial value, by the villagers, for at least, two generations. Livelihood of the majority of these villagers is fishing, either in the lagoon or in the sea. A major fishing technique in the shallow lagoon waters is the 'brush park', a passive fish aggregating device, locally known as 'Mas athu'. These are circular or square in shape and vary in size. 'Mas athu' are effective in attracting fishes and prawns as they provide shelter and food for these commercially important aquatic organisms. Construction is with mangrove poles and mangrove branches are placed vertically or slightly inclined in depths less than 1.5 meters in water. Harvesting is at 10 — 15 day intervals, by surrounding the brush park with a net and collecting the catch with a hand or

scoop net, after removing the twigs and branches from the 'park'. Although a good part of the catch from 'Mas athu' is comprised of juveniles, the monetary gain out of the fishery is noteworthy. Since mangroves provide an ideal source of brush, mangrove cultivation (to be extracted for twigs and branches) has become an integral part of brush park fishery. These cultivated mangroves are harvested also for tannin and small timber.

Propagules (seeds) of mangroves, mainly Kadol, are collected from the wild, mostly by children, at their leisure, and are planted in the mud flats during low tide. Some of these 'mangrove farms' are large as 5 — 7 acres, while some others, the ones that are at their homesteads, are very small; 10 to 15 square meters in area. Most of the homesteads in this area (bordering the lagoon) have such mangrove woodlots at the lagoonward edge, as a barrier for wind, tide and as a mean of stabilising the sediments (mud) in the mud flats, which they finally claim (although illegal) as a part of their homestead. Mangroves (especially, *Rhizophoras*, which possess straight boles) less than 6 meters in height and 3 cm in diameter are not harvested from these woodlots. Selective felling, therefore is the common practice. *Rhizophora*, the dominant mangrove in the wild mangrove swamps in this area as well as in these cultivated woodlots, is grown and harvested for its timber (poles) and the prop roots are used as firewood. *Ceriops*, another mangrove cultivated in these 'farms' is the main tanbark source other than *Rhizophora*. These bushes are harvested mainly for its tannin-rich bark. Stems and branches of *Lumnitzera* (locally known as Beriya), the mangrove that provides most of the twigs and branches for Mas Athu, are harvested periodically leaving the root system and the lower half of the stem to coppice. *Bruguiera* is also grown in these woodlots for poles, posts and tannin.

This generation old cultivation and management practice is a marvellous example for conservation oriented management and utilization of a resource, which could be adopted through community participation in other areas where the mangroves need rehabilitation.

Mangroves are also used as an important fuelwood source by the inhabitants in or more correctly near the mangrove swamps. Uncontrolled exploitation of mangroves as firewood is one among other causative factors for the rapid depletion of mangrove resource of Sri Lanka. Manufacturing charcoal out of mangrove wood, is a well established and a lucrative industry, although not in Sri Lanka, in Thailand, Malaysia, the Philippines and several other South East Asian countries. The standing stock of the Sri Lankan mangrove resource is inadequate to sustain any industry, based on their products. Relatively narrow inter-tidal zone (due to the small inter-tidal range); the mangrove habitat and the destruction of mangroves by human activities, may be the reasons for this.

Nypa palm is another attractive mangrove, which resembles a stemless coconut palm, thrives along rivers which subject to tidal influence. The sap obtained by cutting the stalk of the inflorescence, once fermented, produce alcohol, which could be converted to a transport fuel. The plaited Nypa leaves (fronds) had been the only thatching material available for the mangrove dwellers in most mangrove lands in the South East Asia. Nypa shows a sporadic distribution along the west coast of Sri Lanka.

Currently mangroves in developing countries are being harvested and chipped for paper pulp and particle boards (especially *Excoecaria*, locally known as Thela) on a very large scale by the companies from the developed countries.

Apart from the endless variety of derived products, mangrove swamps supply food for man. Fishes such as mullets, milk fish and prawns from their water ways, crabs, oysters, mussels and cockles from their seaward margin, bird's eggs, honey and edible fruits such as Kirala are some of them.

Among the amenities provided by mangroves, their function as barriers for coastal erosion (a major environmental hazard in Sri Lanka) and wind is remarkable. Unlike the man-made coastal protection barriers, mangroves' ability

to self-repair, even if they are damaged during a severe storm, is incomparable.

Mangrove swamps are the nursery grounds of many kinds of prawns and food fishes. These aquatic animals breed in the sea and the juveniles migrate into the mangrove swamps for food and refuge. Mangroves are very productive. A large part of the materials that they produce by photosynthesis is incorporated into their leaves and stems. Once these leaves detach from the mother tree and fall onto the swamp floor, they decompose by the action of numerous micro-organisms in and on the swamp soil, and end up as protein rich particles, the detritus. These detritus particles are flushed into the coastal and sometimes into the offshore waters where they are taken as food by tiny aquatic animals which form the basic component of the food chains in these waters. These aquatic animals, on which the other commercially important fishes (food fishes) are fed, are being deprived of their food when the mangroves are destroyed, thus affecting valuable fisheries.

The unique flora and fauna of the mangrove swamps, especially the birds, provide valuable opportunities for tourism, as well as for education and research. For instance, Trinidad's Caroni mangrove swamp is a tourist attraction for the great numbers (as many as 20,000 birds) of Scarlet ibis birds inhabiting this swamp.

Mangroves therefore, define an economic resource. This resource has been widely and variously used by coastal people of the tropics for thousands of years. Nevertheless, increased rate and variety of man-induced influences, in the recent years, has become a threat to the existence of mangroves and mangrove lands throughout the tropics. Sri Lanka is not exceptional. Majority of Sri Lanka's mangrove swamps have been converted into other uses such as coconut plantations, human settlements, urban areas and tourist resorts. River damming, also will bring about undesirable changes in the downstream mangrove swamps, by diminishing the the freshwater inflow, hence increased salt concentrations in mangrove soils (deleterious

to mangroves) and decreased nutrient supply.

However, for Sri Lanka, a developing country which experiences rapid population growth with dwindling resources, conservation of mangroves

and mangrove lands may be an unjustifiable luxury. Anyhow, conservation oriented management and utilization of mangroves and mangrove lands are crucial, because of their eminent economic importance.

RESEARCH PLANNING IN MANGROVE ECOSYSTEM – MULTI-DISCIPLINARY RESEARCH MANAGEMENT

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Introduction

Research effort in mangrove ecosystem in Sri Lanka is spread among several individuals who are mostly from the Universities. Research work was largely carried out in the areas of taxonomic studies and general ecological aspects.¹ The distribution patterns of mangrove was studied by several researchers.² Their findings have generated a considerable enthusiasm on the protection and conservation of mangrove in Sri Lanka. Several state agencies such as NARESA, CEA Coast Conservation Department, Forest Department and NARA have shown interest to understand the dynamic of this complex ecosystem.

Previous research has increased the knowledge of the importance of mangroves in the productivity of the coastal ecosystem. Research work carried out in Sri Lanka was not sufficiently strong to look beyond the distribution of mangroves, classification and other taxonomic studies. A very limited knowledge exists on biotic and abiotic parameters which influence the sustenance of the entire ecosystem. Although

previous studies have provided valuable information on some aspects of mangrove flora & fauna in Sri Lanka, there was no concerted effort being made to study the mangrove ecosystem on a systematic basis. Funds have not been allocated sufficiently to conduct research. There are several reasons for this. Such systematic studies involves co-operation of several agencies, commitment of substantial human and financial resources as well as bringing multi-disciplinary research approach to deal with various aspects of mangrove ecosystem.

A firm support to mangrove research other than basic ecological and taxonomic study was given with the inception of the UNESCO programme on mangrove research in the Asia Pacific region. There was also no consistent national programme to support research on mangroves from the national funding agencies. Therefore most of the researchers confined their work to the collection of basic data. A few site specific studies were carried out by enthusiastic researchers (Pinto, 1980). Researchers in universities have made valiant efforts to increase the stock of knowledge of mangrove ecosystem in Sri Lanka with limited

1. See Pinto (1982), Pinto & Wignarajah (1980) for taxonomic and ecological studies.

2. See Aruchelvam (1977) for early estimates and Shagananthan (1980) for recent estimates of mangroves.

resources at their disposal. This however is not a satisfactory approach to study a complex ecosystem such as mangroves. Research has to be oriented towards studying the ecosystem in a systematic manner with available financial and human resources. One of the best approaches to deal with such a situation would be to proceed with multi-disciplinary research. In this context it is important to identify a problem which has wide interest to many scientists and build up a research team on specific problem areas.

Management of Multi-disciplinary research

There are very few occasions of undertaking multi-disciplinary research projects in Sri Lanka. NARESA has encouraged team work as an alternative to individual research effort in order to draw expertise of several people to solve a common problem. However, multi-disciplinary research is not previously attempted on a complex ecosystem such as mangroves. There are numerous problems in conducting multi-disciplinary research. It is not easy to identify a common problem which will serve the interest of several researchers and satisfy their intellectual quest. Defining of the exact role of each person in the project could be also be difficult. The success of the research programme depend on the dedication and commitment of each researcher and their willingness to corporation in different aspects of the programme. The allocation of resources to various parts of the problem area need to be examined with great care. The advantage of undertaking multi-disciplinary research would be the optimum utilization of scarce resources. A considerable amount of resources can be efficiently utilized with the consultation of a research team. For example, transport can be wisely used in the implementation of a project by selecting a common site for research. The team research will also be useful in the exchange of ideas and mutual help among several researchers.

Research Direction in Mangroves

The research on mangroves in Sri Lanka has been given a big boost through the UNESCO/UNDP regional programme which intends to strengthen the capabilities of researchers in the mangrove ecosystem in the region. Sri Lanka has actively participated at the programme and remained committed to increase the research capability. One of the significant landmarks in mangrove research is the establishment of the National Mangrove Committee (NATMANCOM) in Sri Lanka under this regional programme. The NATMANCOM is the focal point for international collaboration and research planning in each country. UNESCO has funded a modest research project through the NATMANCOM in Sri Lanka to assess the status of Mangrove Ecosystem in the West Coast of the island. The Forest Department was involved in the initial planning and designing of the programme which has concentrated on three major activities involving four agencies in the country.

- Activity 1 — Inventory and distribution of existing mangroves in the West Coast of Sri Lanka — Forest Department
- Activity 2 — Socio economy status of human selected mangroves areas on the West Coast of Sri Lanka — NARA
- Activity 3 (a) — Studies on mangrove community structure and condition in selected locations on the project area
 - (i) Mangrove along the South West Coast of Sri Lanka with special reference to the Islets of Mangroves in Bentota Estuary — University of Colombo.
 - (ii) Survey of Flora & Fauna of Mangroves in the West Coast of Sri Lanka — University of Peradeniya

These activities were successfully carried out and research results are now available for future activities. It has been estimated that the mangrove areas amount to nearly 8000 hectares, of which a large extent is covered with severely disturbed mangroves and mangrove associate vegetation types. UNESCO envisages to strengthen the research programme to support research in mangroves and to demonstrate site-specific pilot projects for rational management of mangrove areas in different countries in the region. The major objective of this approach is to upgrade the knowledge and experience acquired from present activities and to increase the stock of knowledge about the ecosystem. It is expected to encourage more site-specific studies which helps to generate excellence in particular aspects of the mangrove ecosystem in different regions and to share this experience with other countries.

Development of Multi-disciplinary Research in Mangroves

The National Mangrove Committee of NARESA has developed an integrated programme of research in the Negombo Lagoon with the consultation of mangrove researchers in the country. The integrated project intends to direct research efforts of mangrove researchers to a common objective with a systematic and concerted plan of action. The major objective and rationale for the development of the project was based on the suitability of the site and the location of site around the research performing agencies. The major critical issue for the project formulation was the diminishing mangrove land in the lagoon, its impact on traditional fishery and need for the development of a rational management plan which could attract a number of economically important uses of mangroves in the project area. The objectives of the project was primarily developed according to the economic and management consideration and scientific and technical consideration. Therefore the integrated project will not lose sight of both the commercial and the scientific application of the project.

The major economic and social consideration of the integrated project is the examination of sustenance of fishery industry, retention of aesthetic values, generation of employment through the alternative sources of employment based on mangroves resources.

The health and other social factors commonly linked with mangrove ecosystem will be also analysed in the project.

The scientific consideration of the project covers multi-disciplinary fields ranging from sociology, medical and physical to biological sciences.

The site of Negombo apart from being closer to project executing agencies provide a rich source of data for researchers. The lagoon is well known for high fishery production and was largely covered by mangrove vegetation sometime ago. The mangrove vegetation is now under serious threat and near total destruction. The lagoon is subject to two monsoonal rainy seasons so that the physical cycles repeat twice a year. This provides adequate opportunities to speed up research studies.

The abiotic factors to be studied include salinity, pH levels, turbidity, temperature, sedimentology, river discharges, currents and wave action and other physical parameters. These studies are envisaged to carry out with the assistance of the Irrigation Department and the other research agencies and universities. A study of biotic factors of the lagoon are separated according to (a) primary producers and (b) consumers.

Under the study primary producer of mangrove ecosystem, several aspects including an inventory of mangrove plants with critical taxonomic evolution with the emphasis on pollen structure has been proposed. Palynological study to trace the history of occurrence of mangrove will be also undertaken. The project will also cover the distribution of mangroves with special reference to their diversity and dominance. Some physiological characters such as phenology, germination and nutrient requirement and ionic

balance for growth of mangrove seedlings has been already undertaken by Dr. Samarakoon of the Colombo University. The productivity of mangroves in the lagoon will be studied by NARA and it will include litterfall, litter decomposition and transport. Microbial studies on mangroves ecosystem to study phytoplanktons and phyobenthos, algae and flagellates will be also undertaken. The lagoon also commonly used by fisherman for brush-pile fishery. The economic benefit of brush-pile fishery and related studies will be undertaken by the University of Kelaniya.

The studies of consumers in the integrated project include investigations on the juvenile fish and prawns occurring in seagrass beds and mangroves, which is already being undertaken by Dr. Pinto at the Open University. The studies on commercially important penaid prawns in the Negombo lagoon in relation to catching methods are also carried out by Mr. Jayasinghe, NARA under this programme. Among other aspects of fauna related studies use the ecology and bionomics of mud crab, biology and production of mangrove moluscs and polychaetes. Other studies in mangrove flora proposed in the project include productivity and occurrence of phytoplanktons, seagrasses, algae and benthic productivity in the lagoon. In relation to management studies, the effects of aquaculture, human interaction with mangrove ecosystem, aspects of health and science education in mangrove areas will be undertaken.

The project includes a variety of scientific disciplines which will have to be emerged in the execution of the project. A large number of specialists in a wide range of fields of biological sciences, physical sciences, medical and social sciences need to bring together to accomplish the segments of the project. The agencies which are involved in the project range from government departments and research institutions to the universities. The project will be executed by different individuals who will be undertaking a particular area of problem in the integrated project. A considerable amount of preplanning

of the integrated project was carried out with assistance of research team to identify potentially useful areas and avoid possible duplication of work and determine priority areas. The results of previous research has been also carefully integrated in designing the project.

The execution of such an integrated project obviously need high level of manpower allocation and financial resources. Some of the areas mentioned above require basic research inputs and the areas such as nutrient cycling and food-chain studies need a considerable amount of financial resources. These areas are carefully investigated and will be carried out after cost-benefit analysis. The major objective of a multi-disciplinary research project is the simultaneous study of various aspects of the ecosystem intensely so that the knowledge generated will be horizontally applied to study the similar sites elsewhere.

Previous research work conducted in mangrove research is scanty and diffused because they were concerned with individual aspects. The proposed integrated programme expects to utilize the previous knowledge and bridge the gaps in the understanding of the ecosystem in a systematic manner.

Advantage and Pitfalls in Multi-disciplinary Research

Some of the advantages conducting such multi-disciplinary research is the greater interaction among experts in different branches of sciences so that, the application of research results become more meaningful. The target set by the research groups may be easy to realize and a team spirit will enhance the success of the project. It is however too early to postulate the benefits of such a programme. The publications of research results may pose some problems and the areas of overlaps need to be negotiated carefully without prejudices. It is important to generate co-operate research effort and to sustain the interest of researchers. The selection of priority areas and funds allocation to various parts of research

projects have to be carried out with care. The cost of some expensive research areas needs to be reduced with the consultation of the research group. However, the entire programme is expected to generate a rich source of information for multiple users.

Conclusions

Research priority selection in a complex ecosystem such as mangroves is a rather difficult process. There is much demand for academically interesting problems, however, the available resources for a large number of such projects are limited. A concerted effort has to be made to study site specific studies of an ecosystem in order to understand interacting forces. The

dynamics of such an ecosystem can be well understood by considering a multi-disciplinary research approach rather than conventional problem specific and uncoordinated series of research projects on the topic. Scientists in third world countries cannot afford the luxury of conducting research in isolation without forming critical masses. Mangrove research in Sri Lanka is now beginning to bring together a 'critical mass' of scientists who will be effectively working together towards a common objective rather than competing for scarce resources. However, the effectiveness of such a programme, needs to be evaluated with time and perhaps may offer an alternative approach to study a complex ecosystem in a systematic and cooperative manner.

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PRIORITIZING MULTIPLE USES OF MANGROVES FOR ESTABLISHING ECONOMIC DEVELOPMENT POLICIES FOR THE MANGROVES OF SRI LANKA

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(Paper presented at the special workshop for mangrove managers held in Phuket Island, Thailand in September 1986.)

Summary

The existing small area of mangroves in Sri Lanka is threatened as a result of population expansion and development. Aquaculture and land reclamation are major threats while extraction of molluscs and firewood adversely affect the ecosystem. Attempts are made to map and classify the mangrove ecosystem for multiple uses.

Introduction

The mangroves in Sri Lanka are discontinuously distributed along the coast, around lagoons, bays and estuaries covering an area between 6000-7000 ha. About 28 species of mangrove plants are found distributed forming a mixed vegetation. Mangroves in the dry zone occur together with saltmarshes. In such areas *Avicennia marina* is the dominant species.

1. The beneficiaries of the ecosystem

The chief beneficiary of the mangrove ecosystem in Sri Lanka has been the coastal inhabitants, mainly the fishermen. Traditionally they have used the mangrove ecosystem for their day to day existence. It is unfortunate that the current situation in the north has inhibited the utilization of the mangrove resource by the fishermen of the north.

It is only in recent years that large scale exploitation of mangroves, on commercial ventures such as aquaculture is taking place.

2. The extractible uses and their effect on mangroves

The coastal inhabitants derive benefits from the mangroves. They use the mangrove wood for making poles, fishing gear, fishing crafts, and tannins. They extract prawns, crabs and fish from the mangrove waters. The export of crabs, prawns and ornamental fish is a thriving business.

Some fishermen use the mangrove plants, especially *Avicennia marina* to make brush piles, a fishing method unique to Sri Lanka. However these operations seem to be less adverse on the ecosystem since the rate of extraction is not so rapid as to make a spectacular depletion of the resource or destruction of the ecosystem.

3. Extractible uses that are becoming a threat

3.1 Lime

The removal of molluscan shells for calcium carbonate is increasing after the total ban of the coral mining. Removal of *Telescopium telescopium*, in truck loads to the kilns from the mangroves is taking place.

Crassostrea sp., *Sacosstrea* sp., *Meretrix casta* and *Geloina coxans* are also removed from the mangroves to a lesser extent.

3.2 Firewood

Although there is no special preference for mangrove firewood, the inhabitants living in the coastal areas find easy access to mangrove forests and remove wood for kiln and bakery operations.

4. Operations that mutually exclude other activities

- 4.1 **Aquaculture:** Prawn culture is gaining grounds in Sri Lanka. Entrepreneurs are requesting for crown lands to be developed for aquaculture. When such requests are made the sight is examined.

If it is barren land (close to a mangrove patch) or when it is in the salt marshes (near mangroves) permission is granted with certain restrictions on the area.

Applicants are encouraged to go into semi-intensive and intensive aquaculture but never extensive aquaculture.

4.2 Land reclamation

Land reclamation of mangroves for building houses and hotels has taken place in some parts of Sri Lanka. Some of these activities would have been better planned after considering all the aspects of the mangrove land compared to other available land.

5. Some management strategies

5.1 Mapping

Since the distribution of mangroves has been estimated roughly and that, a few decades ago, attempts are being made to study and categorize the mangrove localities according to their quality. The new estimates show that the extent of mangroves much more than it was thought to be. Some areas have been mapped out by LANDSAT facilities with physical verification.

Some areas have already been identified to be set aside as reserves.

5.2 Integrated research programme

Since information is scarce on the socio-economics, biology, hydrology and ecology of the mangroves of Sri Lanka, a project has been launched by NARESA to involve many universities and research institution in an integrated research programme. It is expected that after one year of research, data collected would be useful to make better decisions and policies on the mangrove ecosystem in Sri Lanka. Already some of these projects have been completed.

5.3 Implementation of the law

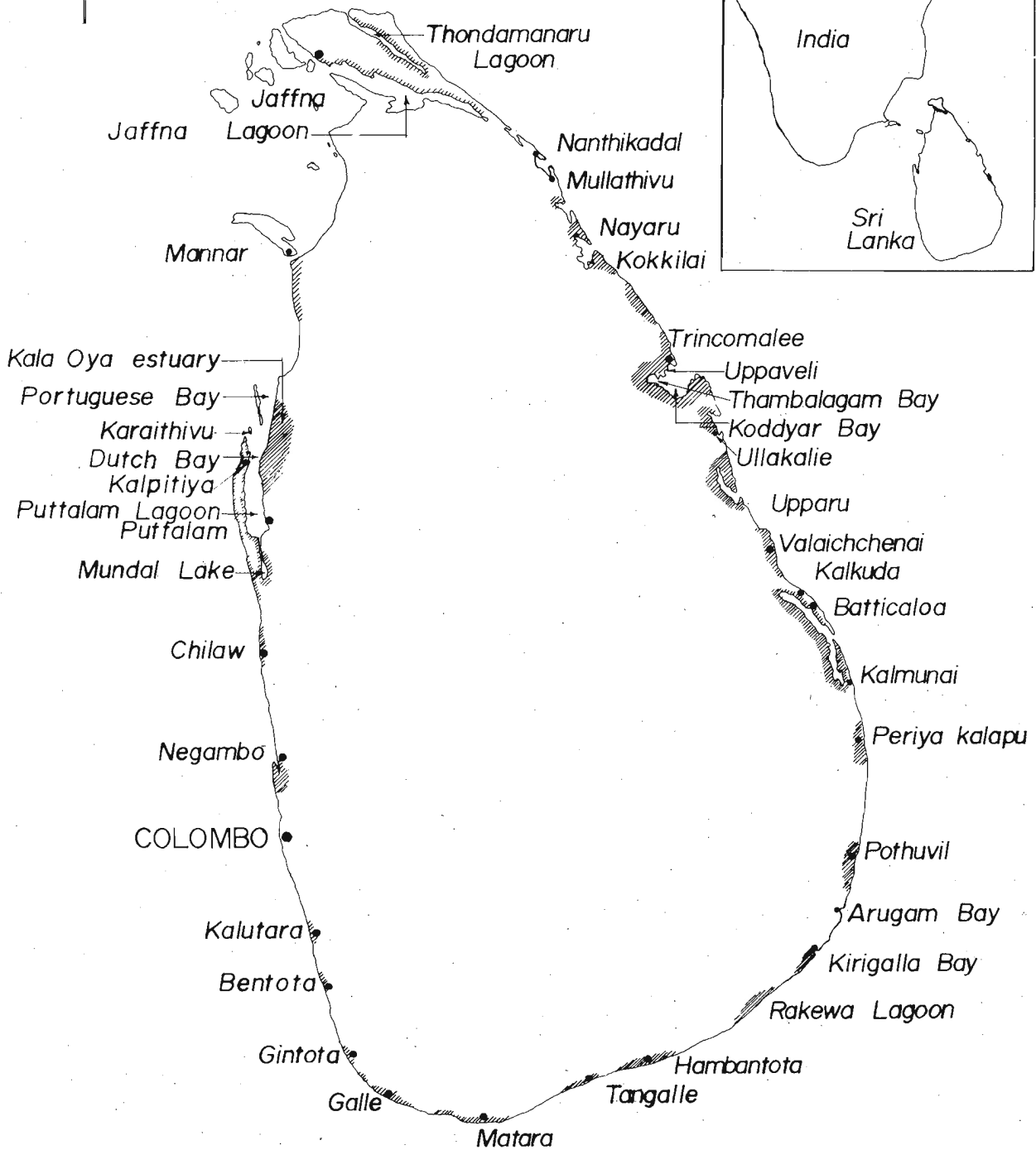
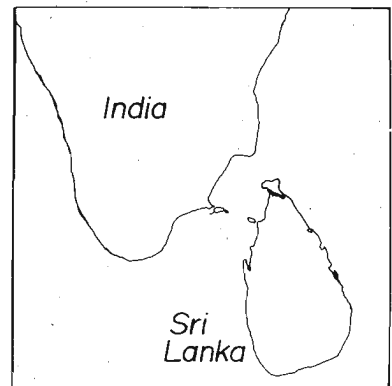
The forest ordinance prohibits the felling of trees in the mangrove as in other forests. The coastal area up to 300 m landwards and 2 km up the estuaries falls within the jurisdiction of the Coast Conservation Department. All activities that destroy the coastal habitat is forbidden. Yet implementation of the law has been a problem.

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SRI LANKA



0 15 30 45 60 Miles

SCALE