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Symposium on
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International Society for Mangrove Ecosystems (ISME)
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Editor's Note on the History of

Dr. Sanga Sabhasri's Involvement in Mangrove Research

In the early 1970s I was a member of a U.S. National Academy of Sciences committee studying the ecological and human effects of military use of herbicides in Vietnam. Herbicides had been sprayed heavily on the Vietnamese mangroves, with widespread destruction, and there was no place in Vietnam that was accessible at the time where relatively undisturbed mangroves could be observed safely. I mentioned this to Dr. Sanga Sabhasri and asked him if it might be possible to do baseline studies of mangroves in Thailand with which the destroyed mangroves of Vietnam might be compared.

Dr. Sanga responded by hiring a plane and organizing a reconnaissance flight over the extensive mangrove areas of Chanthaburi Province in southeastern Thailand. Few basic studies had been made up to that time of the Thai mangroves. It was clear from that flight and subsequent observations on the ground that there were large areas of mangroves similar in species composition to those in Vietnam that could be studied so as to establish baseline information on biomass production, forest regeneration after clearing, soils, etc.

Dr. Sanga quickly recruited and organized a team of Thai scientists to look at these marine forests. Among those he recruited was Sanit Aksornkoae from Kasetsart University. Sanit had worked previously with Dr. Sanga's team in our studies of the ecology of upland agriculture at Pa Pae, Mae Hongson Province. Sanit then went on to do his doctoral work at Michigan State University, with the support and encouragement of Dr. Sanga, under Dr. William Drew, who was also a member of the National Academy of Sciences Committee.

Soon after he had organized Thai research on mangroves Dr. Sanga made connections with UNESCO's interests in forests, and this led to his involvement and the involvement of other Thai scholars in international work on mangrove forests. The International Society for Mangrove Ecosystems was an outgrowth of these beginnings in international collaborative work.

International Society for Mangrove Ecosystems (ISME)

ISME was inaugurated on 23 August 1990 and the seat of the Society is Okinawa, Japan. ISME takes over from the UNDP/UNESCO Regional Mangrove Ecosystems projects. ISME is affiliated to ICSU (International Council of Scientific Unions) and is part of IUBS (International Union of Biological Sciences) through IABO (International Association of Biological Oceanography). The Society was certified as a Foundation on 23 October 1992 in Japan.

Contents

Mangrove Forests Protect the Coastal Environment

Jiro Sugi

Japan Association for Mangroves, Tokyo, Japan

The earth has a very long history, but remarkable progress and development of culture and civilization has occurred only during the past few centuries. The rapid increase in material culture is really surprising, and this has resulted in a transformation so that the earth itself has undergone many changes. However, such rapid progress has seriously affected the precious environment and resources of the earth, and has caused unexpected phenomena, including damage not only to human beings but also to the biosphere. This also poses difficult problems beyond human foresight, and we now have to discuss the merits and demerits of material culture in an attempt to cope up with these issues.

Today, at this International Society for Mangrove Ecosystems Conference, I would like to express my opinions about the problems facing coastal areas.

The earth's coastline, the border between the sea and land, is about 260,000 kilometers in length. We have few reliable statistics on mangrove covered coasts, but based on the coasts of the tropical and subtropical zones, we can estimate the figure from the length of these coastlines as follows.

	Asia	Africa	America	Australia	Total
Total length of coastline (km)	69,800	30,500	104,200	19,500	224,000
Continents (%)	75.7	97.9	84.6	85.2	85.85
Peninsula (%)	17.9	-	5.2	-	11.55
Islands (%)	6.4	2.1	10.2	14.8	8.38

Studies to date that have analyzed the geographical environment of these coastlines, especially those covered with mangroves, have never been complete. It seems that there have been too few surveys, experiments and studies to summarize accurately the contribution of mangrove forests to human society.

We can, however, classify some of the problems using the data collected by ISME, Japan Association for Mangroves and other institutions. There are many differences in the environmental conditions between the living land-based and sea-based ecosystems. The complex environment and ecosystems of coastal areas, which exist on the boundaries of the two spheres, are the important and interesting themes of our study. We should once again recognize this fact.

Considering the fact that mangroves have saved people from many of these hardships so far, we should encourage and promote the planting of mangrove trees both in the destroyed districts, and in new coastal areas using scientifically appropriate methods.

Now let me summarize the important problems of mangrove forests which are being studied at present from a viewpoint of science and technology.

(1) The vegetation characteristic of mangrove forests have generally been made clearer. However, many questions are left unanswered as to the artificial ecosystem of vegetation created by afforestation etc., plant physiology, the relation with other life in the ecosystem and especially damage from diseases and insects.

(2) The most important problem is that the ecosystems of artificially created forests, where trees are planted and grown in an artificial environment, differ from those of natural forests.

a. In the natural forest, the seeds of *Rhizophora* etc., which fall under the mother tree grow only when they are in the forest. The rest do not grow up around the mother tree and protect it. Some of the seeds leave the forest and drift to new places.
b. The important part of mangrove trees is their roots, which grow to be twice as large as in ordinary tree forms. The aerial roots have a thin chlorophyll layer on their surface. Some species consume oxygen produced in their roots without discharg-

(3) Reforestation in cleared forests and afforestation in new land have two main methods: sowing seeds directly and culturing young trees in plastic pots in a nursery. No definite conclusion has been reached as to the comparison between transplanting a single tree or planting more than one tree at certain intervals.

(4) Considering that mangroves require shade while young, we should use the shade method in the nursery. The percentage of shade and height are determined according to the relationship between ventilation and photosynthesis. We should be careful since new diseases and insect pests may arise in cultivated forests, in addition to crabs, barnacle in mud squilla, beetle insect, and other existing problems.

(5) The timing for transplanting young trees in the nursery is determined for each tree species considering the environment of the transplantation site.

(6) The zonation of trees after afforestation should be considered in advance. The succession of trees should also be considered.

Before starting on an afforestation project, there is need to define its purpose clearly:

A. Conservation of coastal environment and disaster prevention;

B. Production of forestry products (firewood and charcoal, pulp, stakes), (markets, transportation of lumber, processing, etc.);

C. Recreation facilities;

D. Silvo-fishery plans (relationship between fallen leaves or detritus and fish production).

ISME's Future Activity Plans

1. To conserve existing mangrove forests and create new forests along the coasts, lagoons, bays, brackish water lakes and rivers in the tropical and subtropical zones, ISME should work to protect existing forests, to revive land devastated by deforestation, and to find appropriate sites and develop new forests.

2. To make effective use of JAM's scientific achievements, ISME should maintain a close relationship with the members of both organizations with a view to making international contributions.

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ing it to the atmosphere.

c. There is a need to establish a method to estimate the maturity of seeds, and to develop methods of storing seeds. Considering the range of the spring and neap tides, terraces should be constructed and tests conducted to compare growth to obtain data for selecting the species of the vegetation for the replanting site.

Timber Production from Mangroves

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Introduction

The mangrove forest is a rich and diverse living resource of tropical and subtropical intertidal regions of the world. The mangrove forest is one of the most productive ecosystems with major renewable natural resources. Mangrove resources have long been of great importance to the subsistence of a large percentage of the human population. They are now of great economic significance both in terms of direct resource utilization for forestry and fisheries, and also in terms of their potential for protecting coastlines and maintaining estuarine ecological balance. The objective of this report is to discuss the main direct use of mangrove ecosystems for timber production in different parts of the world.

Natural Habitats and Distribution of Mangrove Forests

Mangroves are salt-tolerant forest ecosystems. They occupy intertidal areas along the coastline around islands and along rivers which are affected by sea water. Soils in the mangroves vary from muddy near the bank of rivers or coastlines to sandy in more inland area. The diversity of plant and animal species in mangrove ecosystems both plants and animals is paralleled by diverse water and soil-water salinities. Mangrove tree species can developed with water salinity ranging between 0.5 ppt to 36 ppt. The number of days of soil inundation is another important factor determining where mangrove species will grow. The most familiar tree species in tropical Asia are *Rhizophora, Avicennia, Sonneratia, Bruguiera, Xylocarpus, Lumnitzera* and *Ceriops. Conocarpus. Laguncularia, Rhizophora, Avicennia* are dominant species in tropical America. The common tree species in Africa are *Avicennia, Bruguiera, Ceriops, Lumnitzera, Rhizophora, Sonneratia* and *Xylocarpus.*

The world mangrove forest occupies an intertidal tropical and subtropical area totaling approximately 16,670,000 ha, including 7,487,000 ha in tropical Asia, 5,781,000 ha in tropical America and 3,402,000 ha in tropical Africa (Saenger *et al.* 1983: UNDP/UNESCO, 1987; Aksornkoae, 1993). Figure 1 shows the general geographical distribution of mangrove in the world.

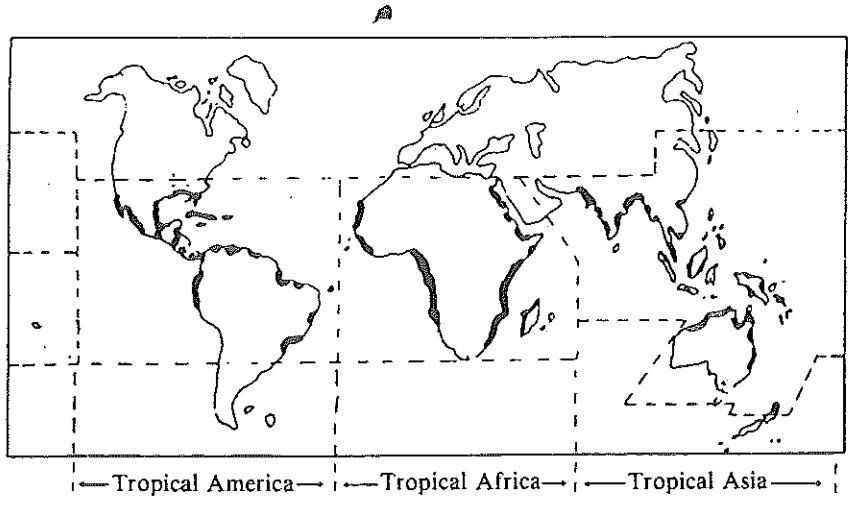

Figure 1. General geographical distribution of mangroves in the world.

Table 1 Timber-producing species and their uses

Genus *Rhizophora* *R. apiculata* *R. mucronata*	Piles, poles, posts, fences, mine timber, shipbuilding, rafts, furniture, tool handles, firewood charcoal, flooring, wood chips, fishing gear.
Genus *Bruguiera* *B. cylindrica* *B. parviflora* *B. gymnorrhiza*	Piles, poles, posts, ship-building, rafts, tool handles, firewood, charcoal, fishery tools, wood chips.
Genus *Avicennia* *A. alba* *A. marina* *A. officinalis*	Poles, posts, fences, paving blocks, wooden crafts, furniture, mortar and pestle, tool handles, wooden houseware, charcoal.
Genus Xylocarpus *X. granatum* *X. moluccensis*	Piles, poles, posts, fencing, railroad sleepers, general construction, caulking of boats, rafts, furniture, beams, doors, joists, musical instruments, flooring, firewood.
Genus *Sonneratia*, Genus *Lumnitzera*	Piles, poles, posts, fences, railroad sleepers, general construction, paving blocks, ship-building, caulking of boats, furniture, wooden houseware, beams, joists, charcoal.
Genus *Ceriops*	Piles, poles, posts, ship-building, rafts, furniture, cabinets, mortar and pestle, tool handles, firewood, charcoal, fishery gear.
Genus *Excoecaria*	Poles, posts, firewood.

Source: Saenger, Hegerl and Davie (1983); FAO (1994), Hamilton and Snedaker (1984)

Timber-producing Species and Their Uses

The products obtained from mangroves areas are variable and important. Timber is the main product of mangroves used by the people from many countries. Timber from different species of mangroves can be used for many purposes. Details of timber-producing species and their uses are shown in Table 1.

Timber Production From Mangroves in Different Parts of the World

Harvesting systems: Timber harvesting systems vary between different countries. The conditions or main constraints in selecting harvesting systems for each country are probably the climate, soils, slopes, and equipment. Careful consideration may also be given to the needs for coastal environmental protection especially to stabilize and prevent soil erosion, damage of strong wind, current and waves. Maintenance of the natural equilibrium of coastal ecosystems as the habitats for marine animals, spawning grounds for juvenile marine animals is also an important consideration. Some harvesting systems can be identified as follows: "clear cutting with alternate strips" used in Thailand (ISME, 1993) and in Venezuela (Hamilton and Snedaker 1984), "clear felling with retention of standards" used in Malaysia (Haron, 1981), and the "seed tree method" in Indonesia (Clough, 1993). Selection cutting systems are adopted by various countries (UNDP/UNESCO, 1987).

Wood production: There are very few data on wood production in various countries in different parts of the world. Timber production of many countries in the Asian and Latin America regions is shown in Table 2 and Table 3 respectively. Timber production in the Africa region is rarely reported (Table 4).

Depletion of Timber Production from Mangroves

It has been noted that vast areas of mangrove forests are being destroyed each year in many countries in different parts of the world, either intentionally or as a secondary result of other activities. The causes of destruction in various countries are very similar but the degree is different depending on specific purposes.

Table 2. Timber Production from Mangroves in the Asian Region

Country	Year	Mangrove Area, ha	Timber Production, m^3/yr.
Indonesia	1983	3,927,100	2,779,476
Malaysia	1990	445,820	2,506,845
Thailand	1993	168,676	193,145
Vietnam	1983	252,500	10,000-25,430
India	1989	426,300	72,903
Philippines	1988	135,725	224-2,684,720
			(1981) (1972)
Bangladesh	1985	401,600	no data
Other countries	-	Small areas	no data

Source: ISME (1993); Haron (1981); FAO (1985); UNDP/UNESCO (1987)

Table 3. Timber Production from Mangroves in the Latin American Region

Country	Year	Mangrove Areas, ha	Timber Production, m^3/yr.
Brazil	1991	1,376,255	9,000
Cuba	1992	529,700	110,000
Panama	1988	171,000	7,400
Colombia	1991	365,900	70,000
Venezuela	1990	650,000	12,912
Honduras	1992	121,340	80,000-120,000
El Salvador	1992	35,235	30,000
Costa Rica	1992	41,330	1,900
Nicaragua	1983	60,000	18,800
Other countries	-	-	no data

Source: ISME (1993)

Table 4. Timber Production from Mangroves in the African Region

Country	Year	Mangrove Areas, ha	Timber Production, m^3/yr.
Guinea	1990	385,000	no data
Sierra Leone	1979	383,761	no data
Nigeria	1981	972,314	4,000,000 (1990)
Cameroon	1991	350,000	no data
Tanzania	1991	115,467	no data
Madagascar	1966	327,000	no data
Senegal/Gambia	1988	500,000	no data
Others	-	small area	no data

Source: ISME (1993)

The main problem is that the population of each country is increasing and this has led to an increased demand for products including food, fuel, building materials, and of land for cultivation and for urban development. Over-exploitation and conversion of mangrove areas to aquaculture are important causes of mangrove destruction. Depletion of mangrove forests in each country from these causes has led to decreasing timber or wood production. In Thailand, for example, up to 658,570 m^3 of wood were extracted in 1975, but only 193,145 m^3 were harvested in 1993. The area of mangrove forest declined from 312,700 ha to 168,676 ha during the same period. Details of mangrove forest areas and timber production between 1975-1993 in Thailand are shown in Table 5.

Table 5. Mangrove Areas and Timber Production between 1975-1993 in Thailand

Year	Mangrove Area, ha	Wood Production, m^3
1975	312,700	658,570
1979	287,308	610,535
1986	196,427	376,869
1991	178,031	425,069
1993	168,676	193,145

Source: ITTO/JAM/Thai NATMANCOM (1994)

Plans for Increasing Timber Production from Mangroves

Many countries in different parts of the world are aware that the alarming rate of depletion of the existing mangrove areas results in a decrease of wood production. Plans for national development and rehabilitation have been set up and immediately implemented for many countries, especially in Southeast Asia. Some examples of mangrove rehabilitation in Asian region are shown in Table 6. No data are available on mangrove rehabilitation in the countries of other regions of the world.

Table 6. Areas of Mangrove Rehabilitation in the Asian Region (ha)

Country	Areas, ha (Years)
Indonesia	48,923 (1980-1992)
Malaysia	4,284 (1987-1992)
Thailand	7,848 (1992-1996)
	1,097 (1989-1994) Ngo,s
India	3,300 - 25,000 (1982-?)
Philippines	19,000 (1991-1995)
	25,000 (1996-2015)
Vietnam	16,794 (1973-1992) Can Gio.
	36,077 (1975-1985) Minh Hai.
Bangladesh	117,520 (1965-1993)
Myanmar	1,060 (1993-1994)

Source : ITTO/JAM/Thai NATMANCOM (1994)

Conclusion

Mangrove forests are very important and valuable natural resources which play a significant role in human life in various ways. In addition to the value and importance of mangroves for protecting coastlines and maintaining habitats for marine animals, timber or wood from mangroves is one of the most important products used for many human needs. Mangrove timber is used for such purposes as house construction, furniture, wood chips, fishing equipment, firewood, and for making charcoal. Silvicultural systems for timber harvest have been applied in many countries, especially in Southeast Asia, in order to manage the mangrove forests on sustainable basis. Records of annual timber production have been made there, while in other parts of the world many countries do not adopt any silvicultural systems for timber extraction. To achieve sustainable timber production from mangroves, each country should set up integrated mangrove forest management plan. The planning should be compatible with local conditions. Mangrove forests are natural and renewable resources. These resources must be managed sustainably not only for timber production but also for other multiple-use benefits.

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Non-Timber Products of Mangroves

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The economic importance of mangrove forests has long been recognized in tropical coastal zones. Besides being a source for timber and fuel, mangroves also provide us with many non-timber products. Information on their traditional uses has been extensively documented and can be further summarized as follows:

Tannin

In the mangroves, bark is important as a source of tannin and dyes. Extracts derived from mangrove bark (*Rhizophora, Ceriops, Bruguiera, Xylocarpus*, and others) are used for the manufacture of leather, ink for dyeing fishnets, ropes, sails and textiles. *Ceriops sp.* give the best quality tannins for leather production (FAO, 1982).

From 1936 to 1939, the Ca Mau peninsula of southern Vietnam producted an average of 1,500 steres (cubic meters) of bark. The maximum yield of 7,125 steres was derived in 1940 (Maurand, 1943) from *Rhizophora apiculata, Ceriops tagal* and *Bruguiera parviflora*. In the north of Vietnam, *R. stylosa, Bruguiera gymnorhiza* and *Kandelia candel* were used. The extraction of tannin has declined because of the decrease of mangrove forests. Recently, the use of tannin for dyeing nets has stopped with the introduction of nylon nets in many Asian countries and synthetic chemicals. The sole tannin factory in Ca Mau town, Minh Hai Province, for example, was closed down in 1987, because it could not compete with imported synthetic tannin for leather production (Hong and San, 1993).

Latin America countries, however, continue to extract vast quantities of tannin from their mangroves. In Panama, about 1,300 - 4,000 metric tons are extracted per year from *Rhizophora* (Aksornkoae, 1993).

Uses of Nipa Palm

Thatching material

The leaves of *Nypa fruticans, Pandanus* sp., *Licuala peltata* and *Phoenix paludosa* are frequently used by the dwellers in islands as thatching material for their huts (Dagar *et al.*, 1991).

The most commonly used species in the Southeast and South Asia is *Nypa fruticans*. Though the trend for conversion from timber to concrete houses presently exists in coastal villages, the demand for roof thatching shingles and for wall or partition constructions remains high (Chan and Salleh, 1987), particularly in southern Vietnam. According to the data of the first rural and agricultural census conducted in July 1994 by the General Statistical Department, the percentage of simple houses with nipa roof thatching in southern Vietnam is very high (Table 1).

The durability of nipa shingles for roof thatching is similar to that of *Livingstonia* leaves in northern Vietnam. A high pitched roof with closely stacked singles can last up to five years (Chan and Salleh, 1987) or 10 years (Hong, 1994). Nipa shingles are also frequently used for roofs of charcoal barracks, poultry and piggeries.

Nipa leaves are also used for other purposes. The fronds are used to wrap up a kind of sticky rice coconut cake, the leaf stalks are used for floats of fishing nets and the ribs are used for making brooms. The soft endosperm of immature seeds are eaten (Hong and San, 1993).

Pressed plank

Recently, the Institute for Forestry Science Studies of Vietnam has succeeded in producing pressed planks from nipa leaf stalk fiber for wall construction.

Table 1. The Rate of Nipa Palm Roof Thatching of Simple Houses Compared with Permanent and Semi-Permanent Houses in Southern Vietnam

Province or City	Simple Houses with Nipa Roof		Semi-permanent Houses		Permanent Houses	
	Number (1000s)	Rate (%)	Number (1000s)	Rate (%)	Number (1000s)	Rate (%)
Ho Chi Minh City	117	45.41	135	52.35	6	2.24
Ba Ria Vung Tau	42	46.6	41	46.1	7	7.3
Long An	148	65.71	46	20.6	31	13.69
Tien Gian	161	58.1	76	27.5	40	14.4
Ben Tre	165	69	56	23.6	18	7.4
Dong Thap	167	70.1	56	23.4	16	6.3
Vinh Long	11	67.5	39	22.4	18	10.1
Tra Vinh	162	85.8	19	10.2	8	4
Can Tho	204	79	38	14.7	16	6.3
Soc Trang	151	81.7	25	13.4	9	4.9
An Giang	215	72.8	65	22	15	5.2
Kien Giang	179	86.7	19	9.3	8	4
Minh Hai	241	80.8	41	13.8	16	5.4

Cigarette wrappers

Chan and Salleh (1987) recorded that in Malaysia the manufacture of cigarette wrappers from young unfolded leaf sheaths of nipa is flourishing. Consumers are mainly paddy farmers in the northern part of peninsular Malaya. Cigarette paper from nipa in Sri Lanka was also mentioned by Aksornkoae (1993).

Medicine

The sanitary condition of dwellers in and near mangrove areas are often poor, so diseases are common. The coastal people in developing countries have learned to use various parts of different mangrove species for medicine. The therapeutic uses in many countries are often similar despite the lack of contact between people living in different areas.

These traditional medicinal plants have not been studied scientifically or been subject to experimentation (Aksornkoae, 1993). Documents gathered from many countries and field investigations showed that there are 34 species of true and associated mangrove species that are used for treating about 45 diseases (Table 2).

Honey is a valuable commodity and is much in demand as a carbohydrate (Chaudhuri and Choudhury, 1994). Beekeeping and honey harvesting have little or none negative impact on the basic functioning of the forest. On the contrary, because of pollination of the trees by foraging bees, beekeeping may exert a positive influence on the mangrove forest (Hamilton and Snedaker, 1984). The amount of honey and wax in an area depends on the nectar and pollen yield, the foraging ability of the bees, the bee population and the weather (Chaudhuri and Choudhury, 1994).

Along the north coast of Vietnam, beekeeping is popular in the *Avicennia marina, Kandelia candel* and *Aegiceras corniculata* forests and mangrove stretches along the sea dykes. When these mangroves are in bloom, the hives are placed in temporary holes along the dykes to avoid sunlight and heat and to enable the bees to feed on the blossoms. When the blossoms are finished, the bees are brought inland where there are many trees and vegetables that have nectariferous flowers (Hong and San, 1993). Several tens of metric tons of honey are produced per year.

In Bangladesh, the mangroves are the main suppliers of honey and wax. Annually 200 metric tons of honey and 55 metric tons of wax are collected from

the Sunderbans alone (Das and Siddiqi, 1985). The Sunderban mangrove forests of India produces about 100 metric tons of honey annually. There are approximately 2,000 people engaged in this trade (Untawale, 1993). In China, mangroves are important areas for the development of apiculture (Ling, 1993).

In southwest Florida, using advanced beekeeping methods, the honey yield from black mangrove forests in 1982 - 1993 ranged between an estimated 0.21 and 0.57 kg per ha in 1993. The production was 6,980 kg of honey (Hamilton & Snedaker, 1984).

Food

According to Dagar and Dagar (1986) and Dagar *et al.* (1991) fruits of *Pandanus* are the staple food for the tribals of Andaman and Nicobar Islands. Radicles of *Rhizophora, Bruguiera, Sonneratia, Ceriops*, seeds of *Heritiera littoralis*, and tender leaves of *Acrostichum aureum* and *A. speciosum*, etc. are consumed as food articles by the uative population. Fruits of other plants such as *Abrus precatorius* (the seeds of which are considered to be poisonous), *Flagellaria indica, Nypa fruiticans*, the kernels of *Terminalia catappa* and the flowers of *Manilkara littoralis, Morinda citrifolia* and *Thespesia populnea* are consumed by one or another means by the Nicobarese and the Onge aborigines (Dagar and Dagar, 1986).

In Vietnam, several species of mangroves provided food articles for coastal people in the islands of Hai Phong, Quang Ninh provinces, particularly during the famine in 1945. They were also used by the guerrillas hemmed in by the American Navy troops in their resistance base at Ca Mau Cape. They obtained protein from several kinds of shrimps, fish, molluscs and crabs caught in the river and the mangrove mudflat (Hong and San, 1993).

Fodder

Many domestic animals graze on mangrove foliage. In terms of nutritive value, mangrove leaves are ranked among the best (Dagar *et al.* 1991). Hamilton and Snedaker (1984) tabulated the high nutritive composition of the foliage of *Avicennia marina. Ceriops tagal* and *Rhizophora mucronata. Avicennia* fodder is thought to be best for milk cattle and the fruit is believed to be as nutritious as cotton seed (Untawale, 1986).

Recently in Pakistan, northwestern India and Southeast Asia the mangrove forest area has decreased because of increases in the number of cattle and the lands for shrimp ponds and agriculture. On the other hand, tidal water salinity has intruded into range lands and pastures. Mangroves have been at the mercy of local people who exploit them to meet their needs and for grazing and browsing of their herds or camels. Many species have disappeared and areas of mangrove vegetation have been decreasing year after year (Ansari. 1986).

Fish Poison

With the recent development of shrimp culture, coastal dwellers have used the bark, root, latex, and seeds of several mangrove species as predator poison (Table 3).

Other minor forest products

Pneumatophores of *Sonneratia caseolaris* are fashioned into bottle stoppers and net floats (Jayewardene, 1986). Lateral roots of *Excoecaria agallocha* are traditionally used to make frames for sunhats (Hong and San, 1993). The leaves of many mangrove species can also be made into green fertilizers which help protect crops from diseases and parasitic fungi. *Avicennia* trees in the coastal area of North Vietnam have been stripped of their leaves for this purpose. For many years, knee roots and carvings made of driftwood of *Bruguiera* and stilt roots of *Rhizophora* have been used as decorative articles by inhabitants of the southern coast in Vietnam (Hong and San, 1993) and in some Indian islands (Dagar and al., 1991). Recently, the demand for fine handicrafts has increased and some species like *Xylocarpus granatum* and *X. moluccensis* with fine-textured, deep-brown wood have been used in statue carving. The wood of *Excoecaria agallocha* which is yellowish-white and fine-textured but less durable is used for toys (FAO, 1982).

Conclusion

Although many are used only locally, non-timber products have proved to be useful for coastal dwellers in developing countries. The recent economic development of many countries, together with the deterioration in area and quality of mangroves, has made a bad effect on the consumption of mangrove products.

Table 2. Medicinal Uses of Mangrove Species

Species	Part Used for Medicine	Indications and Uses
Abrus precatorius	Leaf paste	Abortifacient
Acanthus ebracteatus	Bark and roots	Water extract of boiled bark and roots helps reduce cold symptoms, cures skin allergies and diseases. Ground fresh bark accelerates healing when applied on abscesses or chronic wounds, mixed with ginger to treat malaria, mixed with grated licorice and honey to relieve back pain
Acanthus ilicifolius	Whole plant, leaves	Analgesic relief of swelling, controls leukemia, rheumatic pain, neuralgia
Acrostichum aureum	Rhizome ends	Wounds and boils. Boiled in water and given as an antidote to leaves poison victims
Avicennia alba	Heart wood	Water extract accelerate the discharge of menstrual blood
Avicennia marina	Leaves, trunk, bark	Skin abscesses, contraceptive
Avicennia officinalis	Fruits, seeds, bark and roots	Astringent, cures ulcers, aphrodisiac, maturate poultice
Barringtonia racemosa	Roots, fruits, kernels	Cures cough, asthma, diarrhea, used with milk to cure jaundice
Bruguiera parviflora	Bark	Poultice of the bark is used to treat scalds and burns
Bruguiera sexangula	Bark	Poultice of the bark is used to treat scalds and burns
Calophyllum inophyllum	Seed oil	Rheumatism, skin diseases and leprosy
Cerbera manghas	Seeds	Toxic, but used as cardiotonic
Ceriops decandra	Bark	Astringent, anti-diarrheaic, anti-emetic and anti-dysenteric; finely crushed bark is homeostatic; treats scalds and burns
Ceriops tagal	Shoots, bark	Decoction of shoots to treat malaria (substitute for quinine), astringent, wound cleaning
Clerodendron inerme	Leaves, dried roots	Jaundice (used by Nicobarese), febrifugal properties, leaf poultice to resolve buboes; water extract of the leaves used for cleansing wounds and as a skin parasiticide; treatment for colds, hepatomegaly, spleenomegaly and traumatic wounds
Crinum asiaticum	Bulbs, leaves	Tonic, laxatif and expectorant, used for biliousness, to treat tendinitis
Cynometra ramiflora	Leaves, roots, fruits	Ingredient of a medicine for skin diseases. A lotion from the leaves is applied externally for leprosy or scabies; purgative oil from fruits and roots is used for leprosy
Derris trifoliata	Trunks, roots, leaves	Laxative, expectorant, and can reduce effects of malnutrition in children
Excoecaria agallocha	Bark, latex, leaves	Laxative, treatment of leprosy , ulcers, epilepsy
Hibiscus tiliaceus	Roots, leaves,	Febrifuge operative, emollient, sudorific, diuretic and laxative
Heritiera littoralis	Seeds, bark	Decoction of seeds used in diarrhea and dysentery; treatment for haematuria
Ipomea pes-caprae	All of dry plant	Astringent, stomach ache, alternative, tonic, diuretic and laxative. Headache cure; preparation to hasten delivery for expectant mothers

Table 2. (continued)

Species	Part Used for Medicine	Indications and Uses
Pluchea pteropoda	Leaves	Treat scalds and burns; anti-dysenteric; febrifugal properties
Rhizophora apiculata	Bark	Water extract of boiled bark is used as astringent, anti-diarrhea and antiseptic
Rhizophora stylosa	Bark	Water extract of boiled bark is used as astringent, anti-diarrhea and antiseptic
Rhizophora mucronata	Bark	Water extract of boiled bark is used as astringent, anti-diarrhea and antiseptic
Scaevola taccada	Leaves	Febrifuge; treatment for headaches and cough
Terminalia catappa	Leaves, bark	Treatment of rheumatic joints; leaf juice for curing scabies, leprosy and other cutaneous diseases; treatment for toothache
Thespesia populnea	Leaves;	Stomach troubles;
	leaves and fruit;	curing scabies;
	bark	water extract is used for cleansing chronic wounds
Xylocarpus granatum	Bark, fruit and seeds	Febrifuge and used for dysentery, diarrhea and cholera; water extract is used for cleansing wounds
Xylocarpus moluccensis	Bark, seeds	Febrifuge and used for dysentery, diarrhea and cholera; water extract is used for cleansing wounds, insect bites
Wedelia biflora	Leaves	Used to cure wounds and cuts; leaf is used to cure headache

Sources: Bich and Chuong (1973); Chapman (1975); Coi (1995); Dagar *et al.* (1991); FAO (1994); Hong (1994); Jayewardene (1986); Ling (1993); Loi (1997); Supappibul and Kongsangchai (1982, from Aksornkoae 1993); Technical Staff, Philippine NATMANCOM (1986); Untawale (1993)

Table 3. Some Mangrove Species Used as Fish Poisons

Species	Part Used
Aegiceras corniculatum	Bark
Barringtonia asiatica	Bark
Barringtonia racemosa	Bark and fruit
Cerbera manghas	Leaves and latex
Clerodendron inerme	Sap of leaves
Derris elliptica	Bark
Derris scandens	Bark
Derris trifoliata	Bark
Dodonaea viscosa	Bark
Excoecaria agallocha	Bark

Source: Chaudhuri and Chaudhury 1994 Dagar, Mongia and Bandyopadhyay 1991; FAO 1985; The Fiji Mangrove Management 1986; Hong, Quynh and Tri 1988; Tomlinson 1988; Untawale 1993

Consequently, the restoration of mangroves to maintain the ecological equilibrium in coastal areas and to provide forestry and marine products for local dwellers has become an urgent matter which requires immediate attention.

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The Significance of Mangrove Products: Non Cultured Animal Resources

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Key Words : Mangrove Products - Non Cultured Animals

Abstract

This paper is a brief review of the significance of non-cultured animal resources from the mangrove ecosystems, in particular from the Southeast Asian region.

The mangrove ecosystem develops most extensively in the humid tropics along the protected coastal shores with muddy to sandy bottoms. Aside from its important ecological functions, the mangrove ecosystem also provides many important social and economic benefits for the people and is a source of forcign exchange for the country. For centuries coastal communities have depended for their livelihood on various resources from the mangrove ecosystem. One of these resources is the fauna that live in, or are occasional visitors to the ecosystems. The fauna of the mangrove ecosystem can be divided into two major groups: the aquatic component, such as crabs, shrimps, fish, snails, bivalves; and the terrestrial component, including the visiting animals, such as insects, crocodiles, birds, monkeys, snakes, lizards.

Introduction

Mangrove ecosystems develop most extensively in the humid tropics, where they are found along the protected coastal shores with muddy to sandy bottoms. Ecologically, mangroves represent a rather sharp transitional gradient between the marine and the freshwater environments. Therefore, only flora and fauna that have broad physiological tolerances can survive. Van Steenis (1958), for example, has mentioned a combination of factors that determine species ecological preference. These include the soil types (determined by hard or soft texture and the ratio between sand and mud); salinity (including daily variations), the annual average and length of time, depth and frequency with which the ground is submerged by tides; the tolerance of species to current and wave action; and lastly the general tolerance of eggs and larval stages of the fauna to the above mentioned factors.

Southeast Asia has been noted as one of the centers of distribution of the mangrove ecosystem in the world. There have been several reviews on the mangrove ecosystem of this region, e.g. Gomez (1980), Clough (1993) and the series of publications and reports resulted from the UNDP/UNESCO Regional Project on Mangrove (RAS/79/002 and RAS/86/120), covering eleven participating countries from Pakistan to Fiji. Numerous studies have been carried out in depth on mangrove ecosystems, but unfortunately the faunistic study are almost always the least well covered. Similarly, voluminous publications and reports have been accumulated on the economic importance of cultured species in the mangrove ecosystems such as shrimps, crabs, fishes, shellfishes and even crocodiles, but relatively few quantified studies have been made on the importance of non-cultured animal origin on the livelihood of coastal communities. Despite the limited information the author will try to prepare a brief summary on the subject, as requested by the ISME (International Society for Mangrove Ecosystems).

Faunistic Studies

There are few species of fauna that live exclusively in the mangroves. Probably it can be said that no animal is truly an obligatory mangrove dweller, but some species are strongly associated with mangroves. Example are those animals belonging to the marine elements, such as *Periophthalmus* spp. (fish), *Ellobium aurisjudae* (gastropod) and crustacean *Thalassina anomala* (Soemodihardjo, *et al.*, 1993).

Mangrove fauna can conveniently be divided into two major groups: the marine/aquatic components, which are more dominant and more diverse; and the terrestrial component, many of which are temporary visitors. Their association with the mangrove ecosystem is rather loose.

The aquatic component of mangrove fauna are predominantly species of crabs and snails. There are a few species of worms, bivalves, even coelenterates and echinoderms. It is difficult to list the total mangrove fauna, since there are so many different habitats and niches within the mangrove ecosystem, each of which supports a distinct community of fauna.

The terrestrial fauna in mangrove ecosystems are dominated by insects, birds and mammals, which live mostly in the mangrove canopy. Animals that live on the ground can also be mentioned for example wild pigs, mouse deer, wildcats, rats and lizards. Two monkey species which can often be seen in mangrove ecosystems are *Presbytis cristata* and the long tailed macaque *Macaca fascicularis*. Mangroves are also inhabited by various reptiles, such as the monitor lizard *Varanus salvator*, snakes, and the estuarine crocodile, *Crocodilus porosus*, which is becoming very scarce.

Rather complete lists of mangrove fauna in the Southeast Asian region can be found, for example, in Kartawinata *et al.* (1979) for Indonesia, Chan *et al.* (1993) for Malaysia, Aksornkoae *et al.* (1993) for Thailand, Hong and San (1993) for Vietnam.

Some scientists have used mangrove fauna for zonation studies. For examples, Verwey (1930) proposed one type of zonation based on the dominant species of crab. He recognized the following crab zonations in his study of mangrove ecosystems in Jakarta Bay: the *Sesarma taeniolata* zone, the *Uca consobrinus* zone, the *Uca signatus* zone, the *Metaplex elegance* zone and the *Scylla serrata* zone. Berry (1963) and Sasekumar (1974) identified faunal zonation in mangrove swamps in their studies in Malaysia, whereas Frith *et al.* (1976) used macrofauna in their zonation study of the mangrove ecosystem in Phuket Island, Thailand.

In addition to the obligate fauna, many other species use the mangrove ecosystem only as a temporary habitat for spawning, as a nursery or feeding area, or for temporary shelter. Some economically important species of shrimps are known to be mangrove dependent (MacNae 1968). Shrimp fisheries are strongly correlated with the distribution of mangroves (Martosubroto and Naamin, 1977; Sasekumar and Chong, 1987).

Although it is more difficult to quantify, it has also been recognized that a number of commercially important fish species use or are dependent on mangrove areas for at least part of their life cycle. Artisanal and commercial fishing activities are carried out in mangrove estuaries.

Non-Cultured Animal Resources

For centuries people from coastal communities in and around mangrove ecosystems have harvested animal resources from the ecosystem. In the early stages these activities were at a subsistence level and therefore were difficult to quantify. Many of these people harvested animals only part time, after tending their main occupations, such as fishing or farming. In recent years, however, there are a number of coastal communities where animals from mangrove ecosystem are harvested on a full time basis. Quantified figures are still difficult to obtain, but the following are a few examples from Southeast Asia.

Indonesia

Capture of fish and shrimps is done specifically in the tidal canals and creeks that criss-cross the mangrove ecosystem. In the mangroves of Segara Anakan (South of Central Java) and Grajagan (South of East Java), fish and shrimp are captured in the lagoon that forms an integral component of the existing mangrove ecosystem in the area. Various fishing techniques are used, namely trammel net, gill net, cast net, fish weir or trap, and hook and line.

The species composition of fish populations of mangrove communities depends on the physical and chemical condition of the habitat. In the mangroves associated with the coral reef of Pari Island, north of Jakarta, the fish population was dominated by *Geres macrosoma* (Hutomo and Djamali, 1979; Adrim *et*

al., 1984). At times, this species may account for 80% of the total catch. In the estuarine area of the Berau River (East Kalimantan), *Lates calcarifer* and *Scomberomorus guttatus* were the most abundant species. In the muddy habitat of the Segara Anakan mangrove, *Mugil cephalus* and *Cynoglossus lingua* were found to be the most common (Sujastani, 1989). These two species are known to be detritus feeders.

Segara Anakan lagoon at Cilacap-Central Java is a good example of a fully mangrove-influenced aquatic environment. The body of water covers an area of about 4000 ha with an average depth of 1.48 m. It is surrounded by an extensive mangrove forest. Currently the mangrove forest in this locality is estimated to cover an area of about 10,000 ha. In other words, the lagoon may be considered to be fully under the influence of the mangrove forest. Artisanal fishery is still practiced in this lagoon today. During 1976 - 1982 the annual fish production ranged from 98.9 to 939.6 ton/yr, with the average of 355.6 ton/yr. The catch was composed of 60% migratory species and 35% resident species while the rest were occasional visitors.

Apart from exploiting the pelagic component, capture fishery activities in mangrove ecosystems include also capture of commercially valued benthic organisms, including several species of molluscs and crustaceans. Among the molluscan species are *Anadara granosa, Ostrea cucullata, Geloina coaxans, Terebralia palustris* and *Telescopium telescopium. Anadara granosa* is the most widely consumed and marketed. This species inhabits mud flats adjacent to mangrove formations. According to Sumarno (1984) some 37,000 tons of *Anadara granosa* were harvested from Indonesia coastal area in 1988.

The big mud crab, *Scylla serrata* is the only mangrove-associated benthic crustacean which is commercially important. It enjoys a good local market, in particular to supply the increasing number of sea food restaurants where it brings a favorably high price. To a limited extent it is exported from Indonesia to Singapore and Malaysia. A baited trap is the most common gear used to catch this big crab. This crab is captured mostly in the mangrove forests of Segara Anakan, along the north coast of Java, and in South Sumatra and South Sulawesi.

In the past residents of Indonesian coastal communities also used to capture terrestrial animals, including various mammals, reptiles, snakes and birds, but their numbers declined rapidly. Many of these species, such as crocodiles and some species of birds (*Egretta* spp., *Halcyon* spp., *Ibis* spp, etc.), are now included in the list of threatened and endangered species.

Coastal villagers also take advantage of the spawning and nursery grounds of the mangrove environment by collecting milkfish fries, shrimp fries and cockle spats to be sold to brackish water pond operators for culture. For example, people from the east coast of Sumatra, in particular the Aceh province, collected milkfish fry and shrimp fry from waters on sandy to muddy bottom coastal beaches (Soegiarto and Soegiarto, 1996).

Malaysia

Many fishing activities are carried out within the mangrove waterways, although some of these may be illegal. The mudcrab (*Scylla serrata*) fisheries alone must contribute to significant economic returns but this has hardly been quantified. Wong *et al.* (1984) reported a landings of 152 tons from the east coast of Peninsular Malaysia in 1978, worth an estimated US$125,000,. They quoted a figure of 500 tons for Sabah. Even more lucrative is bag-net fishing in mangrove estuaries with its high grade commercial catches of prawn (*Penaeus monodon*) and pomfrets (*Pampus chinensis*). Khoo (1989) listed the species composition of bag-net catch in the Sungai Merbok mangroves in the state of Kedah. Unfortunately, no quantification of the economic return is available. Jothy (1984) estimated that in 1981 about one-third of the commercial species of fish and shellfish lauded in Peninsular Malaysia were mangrove or mangrove associated species. This represents a catch of some 209,000 tons of fish and shellfish with a value estimated at around US$250 million per annum. Khoo (1989) gives details of annual landings for 1986 of marine fishes associated with mangroves in Peninsular Malaysia.

Tang *et al.* (1981) compared the economic returns from fisheries as well as forestry activities and noted that the returns from fisheries far outweigh those from forestry products. They estimated the returns from fisheries in Matang in 1979 to be US$32.7 million.

Choy (1991) reported that "In Matang, a total of 2,543 fishermen operated the 1,357 boats licensed in the district. This excludes a large population which is indirectly employed in such activities as fish/prawn processing, servicing, repairs, boat-building, transportation and marketing. This figure excludes also those operating unlicensed boats." Of the 2,543 fishermen, about 50% work on board the 585 trawlers licensed in the district. The rest are mainly traditional fishermen and operate mainly traditional and passive gear such as gill nets, hooks and lines and fishing traps. These fishermen are also usually involved in the cockle industry.

Thailand

In Thailand, capture fisheries are spread throughout the marine, estuarine and coastal waters. On average, more than 1.8 million tons of marine fish were landed annually between 1978 and 1982, of which almost 130,000 tons were shrimp. Many of the shrimp from the capture fisheries in the country are mangrove-dependent species, such as *Penaeus merguiensis, P. monodon,* and *Metapenaeus* spp.

Mangroves also support artisanal fisheries. The people who live in or near the mangrove forests catch fish, shrimp, crabs and molluscs daily around the estuarine areas where mangrove exists. Unfortunately, there are no data available on the quantity of the catch. The most important species in the fish catch are mullet (*Mugil dussumieri*), sea bass (*Lates calcarifer*), tilapia (*Tilapia mossambica*), snake eel (*Ophichthyus microcephalus*), catfish eel (*Plotosus canius*), and milk fish (*Chanos chanos*). The most common species of shrimp are *Penaeus merguiensis*, P. *monodon* and *Metapenaeus* spp. Crabs are represented by only one species, *Scylla serrata*, while the important species of molluscs are *Nerita* sp., *Anadara* sp. and *Crassostrea commercialis.*

The importance of mangrove forests for artisanal fisheries is widely recognized. Mud crab, *Scylla serrata*, is the most important resource harvested commercially. For example, between 1977-1984, the *Scylla serrata* production in Thailand was quoted in the average of 4,525 tons/year with a value of 119 million baht (approximately 4.76 million US$). Many of the mangrove ecosystems in Thailand have high production of mud crabs that support the livelihood of fishermen from the surrounding villages, e.g. in the Ranong area (Aksornkoae *et al*, 1993).

The major methods used for mangrove fishing are push nets, barrier nets, crab net traps, gill nets, winged-set bag-nets, hooks and long-lines, stake nets, cast nets, and hand picking (Aksornkoae *et al.*, 1993).

Vietnam

The mangrove mud crab, *Scylla serrata*, is also very common in Vietnam, and crab catching is an important activity among traditional fishermen. The crab is caught by various baited hand traps or crab hooks. The products are sold locally or even exported to China and Hong Kong. There is no quantified economic study on the product. Fishing within and around mangrove forests is also carried out by Vietnamese fishermen. Various fishing gears are used, such as hooks and lines, baited portable fish traps, casting net, gill net, gape net, push net, etc.

The fish species vary widely depending on latitude, but there are 5-6 species which are common to all mangrove areas in Vietnam, such as *Setipinna laty, Pessodonophis boro, Lates calcarifer, Scalophagus argus*, and *Glossogobins giuris* (Hong and San, 1993). Some edible molluscs such as oysters, mussels and bivalves are also collected, mostly by women, from mangrove areas. They are sold on the local market.

Vietnam's mangrove forests previously supported large populations of tigers, crocodiles, monitor lizards, snakes, wild pigs and monkeys. These animals are hunted by people living in mangrove areas for meat or medicinal uses. The animals are either sold alive or as various animal parts, such as skin, bile, fur, bones, venom, etc. The skins of crocodiles, boas and other species of snakes are in high demand for making leather articles, such as handbags, belts, etc. (Hong and San, 1993).

There is no quantified economic study on the above-mentioned mangrove products from Vietnam. The excessive hunting and loss of habitats, e.g., during the infamous Vietnam war, greatly reduced the potential of mangrove areas as well as the animal

species that used to live within the ecosystem. For example, tigers have become extinct from the area and other animals are either endangered or threatened.

Conclusion

Although the examples are still limited and not quantified, it can be concluded that mangrove ecosystems support many aquatic and bottom-dwelling species as well as terrestrial animals. These contribute to the livelihood of the coastal peoples who live in and around the ecosystem. In earlier periods these resources were used at subsistence level, but more recently they have been used for commercial and even export-oriented activities.

Unfortunately, however, in recent years these potentials have been substantially reduced due to excessive exploitation and loss of mangroves as mangrove areas are converted to other uses. There is, therefore, an urgent need for rehabilitating the destroyed mangrove ecosystem and for developing community participation in managing and rationally using these highly important and unique ecosystem.

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Coastal Aquaculture Production: A Review

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Key words: aquaculture production, coastal, mangrove, finfish, molluscs, crustaceans, seaweeds

Introduction

Conventional fishing methods are still the main source of fish production in the world. The FAO predicted that the limits of production from "wild" marine resources would be reached in the 1990s. Between 1980 and 1990 global human population grew at rate of 1.75% per year. Marine fisheries production increased much faster than population growth, at a rate of 3.2% per year, while aquaculture was the fastest growing form of food production, increasing at approximately 9.6% per annum. FAO Fisheries Circular No. 884, issued in 1995 (FAO, 1995a), reviewed the recent trends in world fisheries. Statistics to 1992 indicated that the world catch of marine fisheries showed over-exploitation of stocks, and catches have been declining or even collapsing in most FAO Fisheries Areas, except in the Western Central Pacific (Area 71), Southeast Pacific (Area 87) and the Indian Ocean (Areas 51 & 57). Changes in fishing effort, reduction in fishing areas due to Exclusive Economic Zones, natural phenomena such as El Nino and environmental degradation have led to fluctuations in catches and in the status of stocks. This situation has helped to encourage the development of the coastal and marine aquaculture sector, particularly for high-value seafood products, which now account for at least 5% of global fish production (World Resources Institute, 1992). FAO fisheries statistics for the aquaculture production sector (FAO, 1995b) also suggested gradually increased production, and this trend is likely to continue.

Aquaculture Status

Due to limitations of data and data organization, global production, the present review uses the FAO Aquaculture Production report (FAO, 1995b), in which data were available only from 1984 onward. Information on aquaculture production of all coastal species is difficult to obtain with any level of accuracy. There are many reasons for this, including the failure of governments to collect valid and accurate data. Problems are caused by inconsistency in identification and naming of some species, disorganization of data collection, lack of interaction between the government sector and aquaculturists, commercial secrecy etc. In this review, the author has grouped production of the species known by synonyms with the valid name, and restricted the analysis to species that have been cultured, or maintained in captivity in coastal habitats or in brackish water. Perhaps the ongoing program to produce FAO "Species Identification Sheets" for each fishing area and "FAO Species Synopsis Series" can contribute to an improvement in the accuracy of the data in the FAO Yearbook of Statistics.

Total Aquaculture Production

In the periods between 1988 and 1989, total global fisheries production peaked at over 100 million M.T. Of this, 89.7 million M.T. was 'wild' fisheries production. On the other hand, aquaculture production increased 9.1-12.5% between 1990 and 1992. The increasing trend in aquaculture production is projected to continue as shown in Figure 1. It is useful to note that brackish water aquaculture production ranged from 5.9 - 8.3% of total aquaculture production while approximately half of the total production, (39-54 %), was in fresh and marine water (Figure 2). The high proportion of total production ascribed to the freshwater aquaculture sector can be explained by the success of nursery production and the ease with which, herbivorous species especially, can be reared. The presence of larger aquaculture businesses is believed to be an advantage in marketing and expanding aquaculture activities.

Since 1984, Asia has shown to be principal world producer of aquaculture products, providing 83.7% of

the total world output in 1984, and gradually increasing to 89.5% in 1993 (Figure 3). As global aquaculture is dominated by Asia, this review will focus mainly on the Asian Region.

By 1993, China produced approximately 70% of Asia's total aquaculture production, mainly originating from the fresh-water sector. India and Japan were the second and the third largest producers in Asia (Figure 4). The share of major cultivated species produced in brackish or mangrove environments is quite stable (Figure 5). Recent developments in aquaculture technology for the production of molluscs and prawns in coastal zones and have encouraged businesses to invest significantly in both activities. These contribute approximately 60-70% of the total aquaculture production, while the share of finfish and seaweed together was only 30%.

Major Species Culture

Most countries bordering the sea have developed traditions of coastal aquaculture. Based on FAO aquaculture production statistics (FAO, 1995b), there were more than 36 species of finfish, 25 species of crustaceans, 18 species of molluscs and at least, 6 species of seaweeds cultured worldwide in coastal habitats and near mangrove areas. Table 1 shows a checklist of species under cultivation in coastal habitats, mainly in Asia.

Production Under Different Culture Systems and Environments

Global aquaculture production can be divided into 3 categories: fresh, marine and brackish water. Each species shown in Table 1 is cultured differently depending on location, availability of suitable sites for development and the existence of entrepreneurs and finances. For this review, most of the species cultured in brackish water ponds or fish cages, as well as molluscs and seaweed cultured in coastal habitats are included.

Finfish Production

Several species of finfish are cultured in mangrove and coastal areas. Of the species considered, fish contributed approximately 2.1-3.4 % of global aquaculture production between 1984 and 1993. The annual growth rate of aquaculture production fluctuated between 5.3-9.2 % between 1984 and 1987 declining to only 0.5% in 1989, sharply increasing to approximately 20% in 1990, dramatically declining in 1992, before rising again in 1993 (Table 2 and Figure 6). These fluctuations are probably due to demand and supply mechanisms in the marketing systems and disease outbreaks.

Finfish culture in brackish water systems and mangrove areas is still in its early stage. Among the species that are now being cultured are milkfish (*Chanos chanos*), various species of tilapia including *Oreochromis aureus*, *O. mossambicus* and *O. niloticus*, giant perch or sea bass or barramundi (*Lates calcarifer*), estuarine groupers (*Epinephelus coides*) and to some extent, the snappers like mangrove jack (*Lutjanus argentimaculatus*), John's snapper (*Lutjanus johni*). These species are cultured in ponds, net cages and pens. Successful artificial breeding to produce fry of various brackish water species, as done for freshwater species, has made a significant contribution to aquaculture production and extension in brackish and marine environments. Supplies of fish fry, particularly those produced in hatcheries like *Lates calcarifer* and tilapia (*Oreochromis* spp.) are no longer a limiting factor. However, there are certain periods of the year when there are shortages of fry for species that are mainly gathered from the wild such as *Chanos chanos* and *Epinephelus coides* and other *Epinephelus* spp.

Milkfish (*Chanos chanos*) aquaculture in Southeast Asia, (particularly in the Philippines) contributed more than 67-78 % of total fish production. During the 1950s, 60s and 70s, the aquaculture industry was confined mainly to brackish water fish ponds. From the late 1970s through the 1980s and up to the present day, aquaculture industries have rapidly expanded and became more diversified, so milkfish production has risen very rapidly. For instance, many fish farmers have adopted semi-intensive, supplementary seeding for higher stocking density and feeding in milkfish culture. Using this method, production per hectare of milkfish cultured in the Philippines has increased from 500-1000 kg/ha/yr to 2000-4000 kg/ha/yr. Moreover,

multiple stocking methods are being developed and introduced to the more progressive farm operations. These yield harvests six times a year or more, which has also increased production rates (Rabanal, 1995).

Crustaceans

Only the Penaeid shrimps and palaemonid prawns which are known to be cultured in restricted coastal and mangrove areas are included in this section. These are the following species: *Penaeus monodon, P. merguiensis*, *P. chinensis*, *P. indicus* and *Metapenaeus* spp. of the *Penaeidae*, and *Macrobrachium rosenbergii* of the *Palaemonidae* in the eastern part of the world, and *Penaeus stylirostris* and *P. vannamei* in the west. Annual production growth for farmed crustaceans production increased 6.8-9.4% between 1984 and 1988, before declining to 3.6% in 1990 and then rising again (Figure 7). In 1993, the annual growth of farmed shrimp production was 12.4%, very close to the growth rate in 1992. These figures suggest to me that farmed shrimp production kept increasing as long as export prices were high. The Asian continent provides 75%-85% of farmed shrimp produced globally, while the rest comes from Latin America, South America and the USA. The proportion of farmed shrimp produced in Thailand, the largest producer in Asia and in the world, increased from 4.8% to 27.9% of global production between 1984 and 1993, and the proportion continues to rise. Ecuador had an 18.3% share of total world prawn production in 1984, but since then the proportion of production declined to approximately 10% in 1993 (Figure 8).

In 1995, the world's shrimp farms produced about 712,000 M.T. of whole shrimp, down less than 3% from the record production of 733,000 mt in 1994. The Western Hemisphere produced an estimated 154,000 M.T., an increase of 4% representing 22% of world production. The Eastern world produced an estimated 558,000 M.T., a decrease of 5% but still 78% of total global farmed production. Thailand again is the world's leading producer but production dropped slightly due to a viral disease, while Ecuador and Indonesia are the second and third largest producers.

There are three methods used for coastal shrimp production: extensive, semi-intensive and intensive. Culture periods for all types of systems range from 120 to 180 days. The extensive method is predominantly practiced by traditional fish farmers. Due to the increasing demand for shrimps in the last decade, semi-intensive and intensive practices were developed and successfully introduced. Production rates increased from 500 kg/ha/yr using extensive practice, to more than 3000 kg/ha/yr under the intensive system. However, intensive systems of shrimp culture are now being discouraged due to their adverse environmental impacts, while semi-intensive and improved extensive methods are again being promoted.

The biggest problem in shrimp farming at present is the deterioration of ponds due to uncontrolled feeding practices which have resulted in pollution of ponds and waterways. The occurrence of diseases will continue to result in reduced productivity in intensive farms. Environmentally friendlier culture methods such as semi-intensive with crop rotation systems, were suggested with the aim of reducing the occurrence of diseases and to ensure sustainable production with good returns to investment.

Molluscs

Molluscs are, by weight, the largest component of global coastal aquaculture production (Table 2). Overall production of molluscs has shown a gradually declining trend in proportion to total aquaculture production; 17.8% (1.9 million M.T.) in 1984 falling to 13.1% (29.7 million M.T.) in 1993. However, the total weight of production continues to increase (Table 2 and Figure 9). Only oysters, mussels and cockles which have been intensively cultured in coastal areas are included in this review. The major cultivated group are oysters (*Crassostrea gigas* and *C. belcherii*), mussels which are dominated by *Mytilus edulis*, *Mytilus* spp., *Perna viridis*, *Mytilus smaragdinus* and *Modiolus* spp. and cockles, especially *Anadara granosa* and *Arca* spp. Approximately half of the total mollusc production comes from aquaculture production of these species. (See also Table 2). These three major groups contributed approximately the same proportion of total aquaculture production from coastal and mangrove areas.

In Asia, oyster and mussel culture is already an established industry. The methods used are stake, hanging and tray, sometimes with slight modifications to suit the environment. Due to the low technology used, low capitalization and an expanding export market, oysters and mussels farmers are mainly small scale fishermen. Culture period of these species are

about 6-8 months from spat collection to harvest. Blood cockles, *A. granosa*, are usually cultured in mud flats in front of mangroves and require more intensive work than the other two species. About half the total cockle production comes from Malaysia, which produced 77,755 mt in 1993, while the rest were produced in China and Thailand.

Environmental conditions, such as the occurrence of 'red tide', and pollution by heavy metals, hydrocarbons and pesticides have adversely affected mollusc aquaculture production and marketing. On the supply side, coastal mollusc production levels are likely to be determined by the implementation of improved methods for spat collection in both oyster and mussel production and by seed supply for blood cockles. Site selection, culture methods and, subsequently, harvesting and marketing also influence production.

Seaweeds

FAO Aquaculture Production (FAO, 1995b) reported that seaweed production (ranging from 19.4%-32.5%), contributed approximately 20% to total world aquaculture production in 1984, and was 25%, about 5.6 million M.T., in 1993 (Table 2 and Figure 10). The report also suggested that Asia dominated global seaweed culture. In many cases seaweed culture is important for local consumption. Species of *Euchema*, *Gracilaria* and *Caulerpa* are the most widely cultured species in ponds, net cages and pens in Southeast Asia, especially in the Philippines, Malaysia, Indonesia and Thailand (See also Table 1). Other species which have been listed in the report were considered as open water species and should be regarded as different categories and are therefore not included in this review.

Seaweed culture is appropriate for local fishermen as it uses low technology, requires low capitalization and has high export demand. Depending on the site, seaweed farmers can produce multiple crops per year. The most usual farming systems adopted are bottom line and raft monoline within cages and ponds. Seaweed farming is being expanded in most countries which have lengthy coastlines like the above mentioned countries and those in the South Pacific. However, problems of heavy grazing and lack of seedstock have constrained the development. Lack of knowledge of biology and physiology of the species have limited the development of culture techniques and natural stock management. Ecological and physiological studies are needed to provide the basis for further aquaculture development in this area.

Farmed Shrimp Production in Thailand

Shrimp Culture

Extensive shrimp farm aquaculture has taken place along the shoreline and back mangrove in Thailand for more than 60 years. Stocking was achieved by tidal action. Natural food was used exclusively, and the tide allowed the water in the pond to be changed which kept the environment clean and minimized the risk of diseases leading to mortality. A sharp increase in this aquaculture activity occurred in 1947 when the price of salt fell significantly. After this, many salt pans were converted to be extensive shrimp ponds. Rice farmers in nearby mangroves and along the coastline were experiencing low yields due to the high salt content in the soil, whereas they could harvest shrimp for domestic consumption and local markets under low-tide conditions near their rice fields. With a relatively good price for shrimp, rice farmers also began to convert their rice fields to shrimp ponds.

Since 1974, the Department of Fisheries of Thailand have succeeded in hatchery production of *Penaeus monodon* and *P. merguiensis* and 3-4 years later farmers were encouraged to use additional stocks of shrimp seed and food in their traditional extensive ponds. This development led to semi-intensive shrimp aquaculture. Over the last 10 -12 years, intensive culture, which required substantial capital resources to supply seed, food, pond environmental management, water supply and irrigation, have been introduced from Taiwan. Since then, shrimp ponds have been expanded to nearby rice fields, mangrove areas, and to nearby public lands without mangroves.

Shrimp Production

The rapid expansion in shrimp farms, and in shrimp production also occurred in Thailand. In 1972, marine shrimp culture used only 9,056 ha and produced 991 tons of shrimp. By 1978, the area of shrimp farms increased to 24,169 ha, double that of the preceding year, while shrimp production had increased four-fold. The increasing production was probably a result of the introduction of semi-intensive

practice into traditional ponds. The area of shrimp ponds doubled again in 1987, with a correspondingly dramatic increase of approximately 368% in production since 1978 (Flaherty and Karnjanakesorn, 1995, See also Table 4 and Figure 11). Between 1987 and 1991, a major expansion in the number of shrimp farms has taken place, with the area of ponds increasing by 220% and shrimp production rising 615%. It is interesting to note that the area covered by shrimp ponds has declined since 1991, but production continues to rise (Table 4). Production in 1993 was about 140% above that of 1991. The productive area in 1993 was nearly equal to that in 1989, but production in 1993 was 240% higher than in 1989. The dramatic growth in production since 1987 can be explained by the introduction of intensive systems within the first few years and also by the improvement of aquaculture technology within the past 5 years.

Kongkeo (1995) and Tookwinas (1996) have pointed out several factors leading to shrimp farming success in Thailand. First, Thailand is situated in an ideal location with approximately 1,500 miles of coastline. Second, the availability of broodstock in the wild and post larvae supply from hatcheries has never limited aquaculture activities. The growth of the shrimp farm industry has also been facilitated by increases in the number of shrimp farm hatcheries operated by both the Department of Fisheries and the private sector. Third, Thailand has a long experience in aquaculture practice in both fresh and brackish water, and academic staff in both government and private sectors are available for research to improve aquaculture technology. Fourth, the development of infrastructure and supporting systems, such as roads, electric power supply, irrigation systems and food factories met the needs of shrimp farm operators. Fifth, Thailand has used unique culture technologies, especially site rotation and flexible management in terms of alternation between intensive and semi-intensive crops. Sixth, several universities in Thailand offer courses in aquaculture technology and related subjects to meet the demand of the aquaculture business for skilled staff. Seventh, shrimp farm businesses in Thailand are mainly small or medium-sized, which are easier to operate and more flexible than larger businesses existing in some countries.

Environmental Impacts of Shrimp Farms

In Thailand, mangrove forest have been logged for firewood and construction materials, or cleared to make way for agriculture, salt pans and aquaculture. Conversion of mangroves to aquaculture ponds, especially shrimp ponds, is common in Southeast Asia. Using mangrove forests for aquaculture and other uses means the loss of habitat of many mangrove-dependent species of flora and fauna. Such changes also affect freshwater supplies through salt intrusion upstream, particularly under low rainfall conditions. In certain soil types and under increasingly salty conditions, land can be difficult to reclaim for agriculture and silviculture. When large areas of mangrove have been converted to shrimp ponds, acid sulfates are exposed leading to poor production and mass mortality of stocks.

There are several potential impacts caused by day-to-day operation of shrimp farms. Currently, the quality of discharged water, outbreaks of viral diseases, chemical and drug usage, salinity intrusion into groundwater and the consequences of their discharge in natural environments are the main issues. As the major components of the discharges are dissolved and particulate organic matter, chemicals and bacteria enter the water (Tookwinas, 1996), they can cause rapid deterioration in water quality. Increased run-off of such organic discharges into coastal and semi-enclosed sea tends to lead to changes in species composition and, presumably, cause 'red tides' and outbreaks of several diseases as found elsewhere (Primavera, 1994, Vethaak and Rheinallt, 1992).

A Recent report from Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (1995) has emphasized concerns about the environmental impacts of coastal aquaculture. they have recommended the use of Environmental Impact Assessment (EIA) as part of the mechanism for managing aquaculture development and defining the potential ecological and human health effects of chemicals used by aquaculturists. The key issues of Ecological Impacts of Coastal Aquaculture Development and Guidelines for the Development of the Environmentally Acceptable Coastal Aquaculture identified by GESAMP (1991) are also given in Box I and Box II respectively. To minimize the environmental impacts, those guidelines should be followed, including

diversification by means of alternation between intensive and semi-intensive crops and rotations of the existing ponds with maximum use. The use of chemicals, antibiotics, fertilizers and stocking densities should be consistent with accepted guidelines. Reforestation should be carried out in coastal areas, to provide a buffer zone to support natural stocks of molluscs, shrimp, fish and other mangrove dependent species.

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Box I

Ecological Impacts of Coastal Aquaculture Developments

- Enrichment of nutrients and biodeposits
- Interactions with the food web
- Increase oxygen consumption
- Disturbance of wildlife and habitat destruction
- Interactions between escaped farmed stock and wild species
- Introduction and transfer of exotic species causes stress, and changed genetic characteristics
- Application of bioactive compounds (including pesticides and antibiotics)
- Longevity of inhibitory compounds in animal tissues e.g. antibiotics
- Discharge of inhibitory compounds in the aquatic environment
- Development of antibiotic-resistant microbial communities
- Chemicals introduced via construction materials
- Side effects of growth hormones or growth promotors which have been used to alter sex or productive viability and growth of cultured organisms

Source: GESAMP (1991)

Box II

Guidelines for the Development of the Environmentally Acceptable Coastal Aquaculture

1) Formulate coastal aquaculture development and management plans
2) Formulate integrated coastal zone management plans
3) Apply the environmental impact assessment (EIA) process to all major aquaculture proposals
4) Select suitable sites for coastal aquaculture
5) Improve the management of aquaculture operations
6) Assess the capacity of the ecosystem to sustain aquaculture development with minimal ecological changes
7) Establish guidelines for the use of bioactive compounds in aquaculture
8) Establish guidelines governing the use of mangrove wetland for coastal aquaculture
9) Assess and evaluate the true consequences of transfers and introductions of exotic organisms
10) Regulate discharges from land-based aquaculture through the enforcement of effluent standards
11) Establish control measures for aquaculture products
12) Increase public awareness of the safety aspects of consuming seafood
13) Apply incentives and deterrents to reduce environmental degradation from aquaculture activities
14) Monitor for ecological changes.

Source: GESAMP (1991)

Table 1 Species under cultivation in coastal areas

Groups/ Species	Countries	Methods of Culture
Molluscs		
Anadara granosa	Malaysia, Thailand, China	spread over mudflats
Arca spp.	Malaysia, Thailand, China	spread over mudflats
Perna viridis	Malaysia, Thailand	raft, stake and rack
Mytilus smaragdinus	? Thailand, Philippines	raft, stake and rack
Mytilus spp.	Philippines, European Countries	raft, stake and rack
Modiolus spp.	Thailand	raft, stake and rack
Crassostrea belcheri	Malaysia, Myanmar, Thailand, Sri Lanka	raft, hanging, rack, stake
C. iredali	Malaysia	raft, hanging, rack, stake
C. gigas	Hong Kong	raft, hanging, rack, stake
C. madrasensis	Sri Lanka	raft, hanging, rack, stake
C. rivularis	Vietnam	raft, hanging, rack, stake
Ostrea cucullata	Malaysia, Myanmar	raft, hanging, rack, stake
Crustaceans		
Scylla serrata	Thailand, Indonesia, Malaysia, Philippines, Vietnam	floating cages, ponds
Penaeus indicus	Vietnam	traditional ponds
P. merguiensis	Vietnam, Thailand, Malaysia, Indonesia, Philippines	traditional ponds
P. monodon	Vietnam, Thailand, Malaysia, Indonesia, Philippines	traditional ponds, semi/intensive
P. semisulcatus	Vietnam, Thailand, Malaysia, Indonesia, Philippines	traditional ponds, semi/intensive
P. stylirostris	Ecuador, Mexico, Honduras, USA	traditional ponds, semi/intensive
P. vannamei	Ecuador, Mexico, Honduras, USA	traditional ponds, semi/intensive
Macrobrachium rosenbergii	Thailand	ponds, floating cages
Finfishes		
Chanos chanos	Indonesia, Philipines	fish ponds
Oreochromis aureus	Africa	fish ponds
O. mossambicus	Africa	fish ponds
O. niloticus	Africa	fish ponds
Epinephelus akaara	Hong Kong	floating cages
E. awoara	Hong Kong	floating cages
E. tauvina	Hong Kong, Malaysia	floating cages
E. chlorostigma	Hong Kong	floating cages
E. coides	Thailand, Malaysia	floating cages
E. malabaricus	Thailand, Malaysia	floating cages
Lates calcarifer	Thailand, Malaysia, Hong Kong	floating cages
Lutjanus johni	Hong Kong, Malaysia	floating cages
L. argentimaculatus	Hong Kong, Malaysia	floating cages
L. russelli	Hong Kong	floating cages
Mugilids	Indonesia	fish ponds
Sparus berda	Hong Kong	floating cages
Rhabdosargus sarba	Hong Kong	floating cages
Chrysophrys major	Hong Kong	floating cages
Seaweeds		
Eucheuma cootoni	Malaysia, Philippines	stake, semi-raft, raft
E. alvarezii	Philippines	stake, semi-raft, raft
E. spinosum	Malaysis, Indonesia, Philippines	stake, semi-raft, raft
Gracilaria edulis	Sri Lanka, Myanmar	ponds, longline sting
G. verrucosa	Vietnam	ponds, longline sting
G. fisheri	Thailand	ponds, longline sting
Caulerpa spp.	Philippines	ponds

Table 2 Global production of main cultivated groups of Shellfish and Seaweeds

Years	Total Production (MT)	Total Fishes (MT)	Mugilidae	*Epinephelus* spp.	*Chanos chanos*	*Lates calcarifer*	Tilapia &other	Total Prawns	*Penaeus merguiensis*	*Penaeus monodon*	Total Molluscs	Coastal Molluscs	Oysters	Mussels	Cockles	Total Seaweeds	Coastal Seaweeds
1984	10459113	335036	7139	369	263431	1441	61444	183367	20605	52532	1866650	932792	862748	700398	303504	3401323	150224
1985	11230255	353980	7164	983	267388	1735	74019	218744	24968	55726	2017714	990787	919755	759341	338618	3354174	199365
1986	12289950	375567	9420	1237	284188	2440	75969	281035	27172	89373	2161496	1116554	936627	796603	428266	3196981	187065
1987	13250776	413885	8650	1674	305239	3635	91910	486040	28709	147822	2351501	1128195	975687	940905	434909	2844930	237955
1988	14634262	429690	10633	1571	317104	3658	92945	555720	29941	159156	2501779	1250167	1005318	1047704	448757	3132165	288547
1989	15208230	431426	10100	887	309096	8494	95846	598843	30353	208209	2457479	1171441	933775	1058697	465007	3282374	317080
1990	15768241	539510	10509	2614	399556	7097	112022	640007	26194	233972	2447081	1063962	875928	1080110	491043	3061160	349577
1991	17355685	524548	10794	1588	381806	10631	110662	787664	26749	310904	2513411	1056889	875810	1062987	574614	3831131	362027
1992	19826354	450260	11078	2169	308168	8714	111269	840964	27434	367379	2762574	1117972	953915	1060229	748430	4920024	425323
1993	22626168	468300	12410	5824	313191	10259	118525	771177	30671	415781	2967299	1207722	1019451	1046474	901374	5651014	453521

Table 3 Farmed production of marine shrimp by principal producers in the Eastern and Western Hemispheres

Years	Total Prawns	Thailand	Indonesia	China	India	Vietnam	Philippines	Other Asia	Total East	Ecuador	Peru	Colombia	Panama	USA	Honduras	Other	Total West
1984	183367	8827	19739	19300	10000	7600	28857	15775	112135	33600	1739	-	830	159	552	36	36916
1985	218744	10503	24001	40664	13000	7600	29037	17144	144100	30205	1468	880	1357	95	276	326	34607
1986	281035	11928	28999	82827	14000	9500	30461	45204	225353	30683	1644	1500	1740	615	792	462	37436
1987	486040	19387	42183	153272	15000	9500	35070	79878	357172	65653	3062	1500	1676	1207	1769	754	75621
1988	555720	50000	62243	199418	20000	11970	44185	34350	425186	67030	3500	3361	3127	1000	2724	1025	81767
1989	598843	89762	82196	185890	28000	18340	46997	22456	476454	64800	3353	3000	3095	682	3000	909	78839
1990	640007	115640	84945	184817	29985	19950	48370	15213	501556	68780	3000	6000	2830	900	3269	1130	85909
1991	787664	160881	116148	219571	35500	25650	47185	21685	629111	94738	5600	6045	3290	1600	4032	573	115878
1992	840964	184110	120137	206866	40000	28500	76757	15865	674422	101837	3771	8499	3350	2000	5500	1320	126277
1993	771177	215500	130000	87856	47000	33250	86211	9563	611092	76925	3109	6594	3200	3000	8124	1403	102355
1994	733000	225000	100000	35000	70000	50000			585000	100000		10000		-	10000		146600
1995	712000	220000	80000	70000	60000	50000			558000	100000		11000		1000	10000		154000

Table 4 Marine shrimp production in Thailand

Years	#Farms	Areas(ha)	Natural Production (Tons)	Aquac. Production (Tons)	Years	#Farms	Areas(ha)	Natural Production (Tons)	Farmed Production (Tons)
1972	1154	9056	66887	991	1984	4519	36791	104394	13006
1973	1462	11468	77525	1635	1985	4939	40768	91631	15840
1974	1518	12092	80093	1775	1986	5534	45367	102527	17885
1975	1568	12867	84501	2538	1987	5899	44769	106211	23566
1976	1544	12296	86139	2533	1988	10246	54778	85870	55632
1977	1437	12410	117363	1589	1989	12545	71165	85204	93494
1978	3045	24168	121009	6394	1990	15072	64605	83012	118227
1979	3378	24675	109392	7064	1991	18998	75332	106495	162069
1980	3572	26036	110278	8063	1992	19403	72796	91616	184884
1981	3657	27459	122707	10727	1993	20027	71886	93086	225514
1982	3943	30792	156523	10090	1994	20500		94000	225000
1983	4327	35537	127854	11549	1995	20750			220000

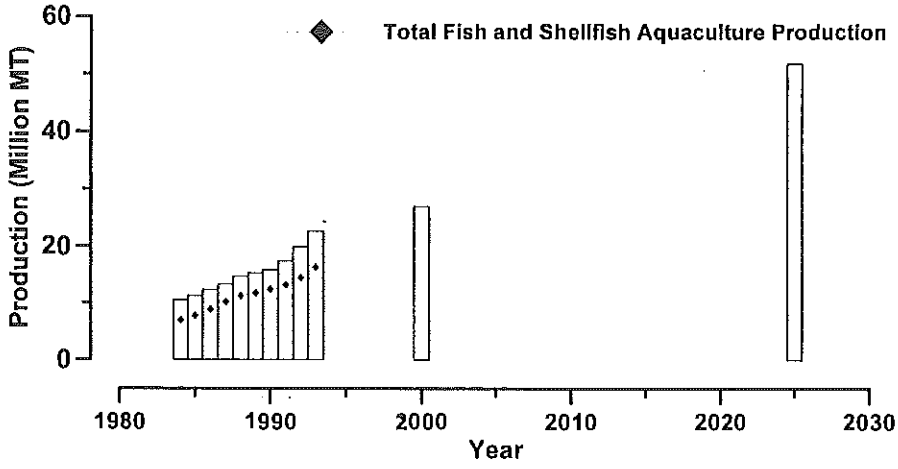

Figure 1. Global aquaculture production and projected production (Adapted from Csavas, 1994).

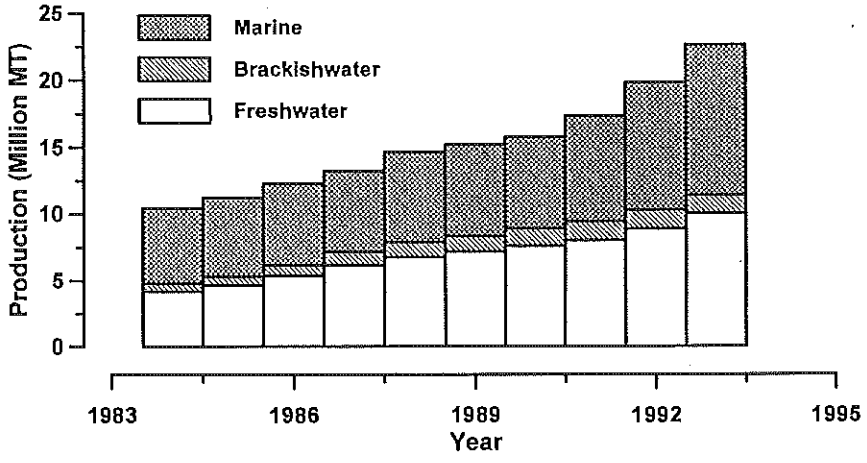

Figure 2. Aquaculture production by major environmeut.

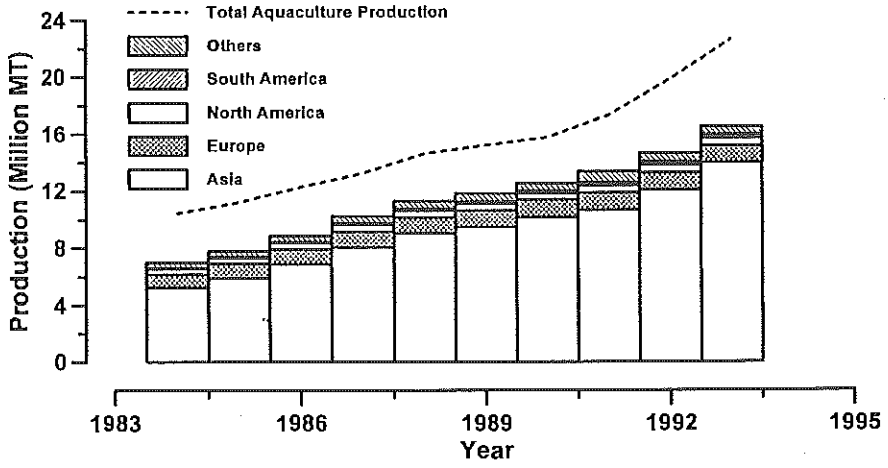

Figure 3. Aquaculture production by continent.

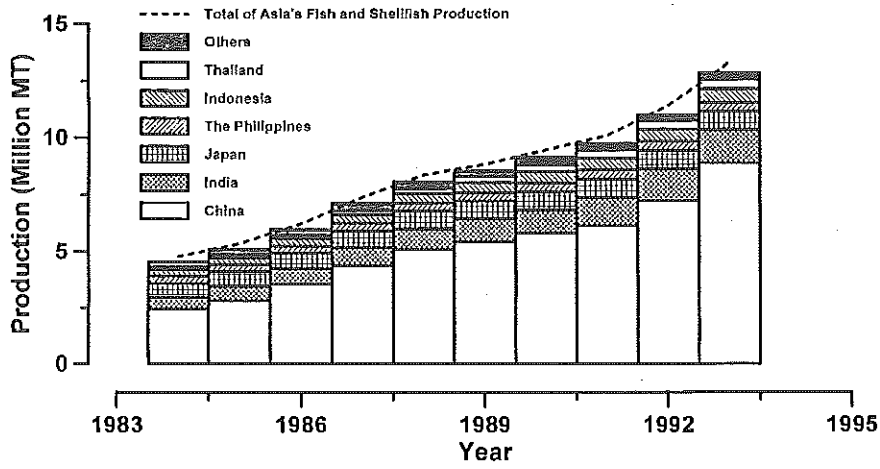

Figure 4. Fish and shellfish production and principal producers in Asia.

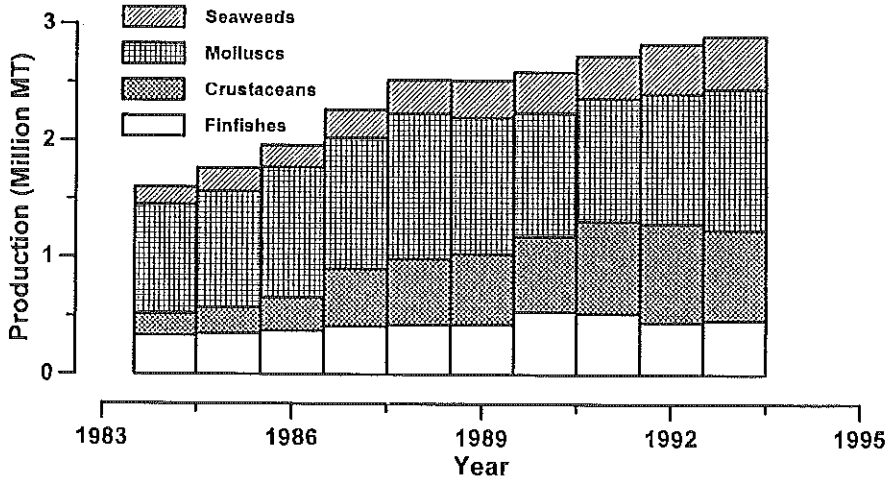

Figure 5. Global production of major cultivated groups.

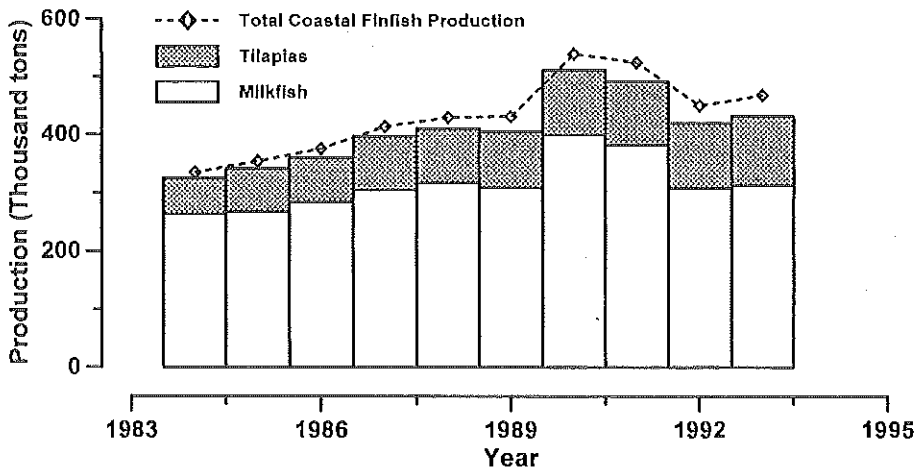

Figure 6. Total coastal finfish production and production of principal cultivated groups.

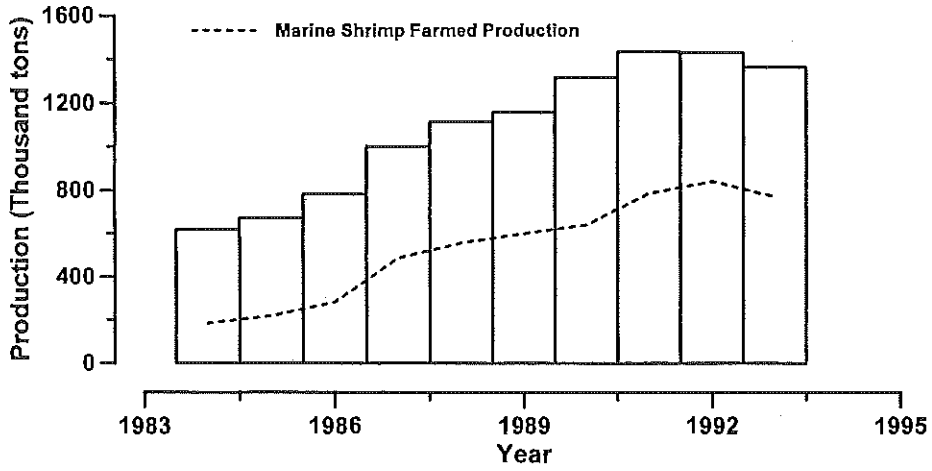

Figure 7. Global crustacean aquaculture production and farmed production of coastal marine shrimp.

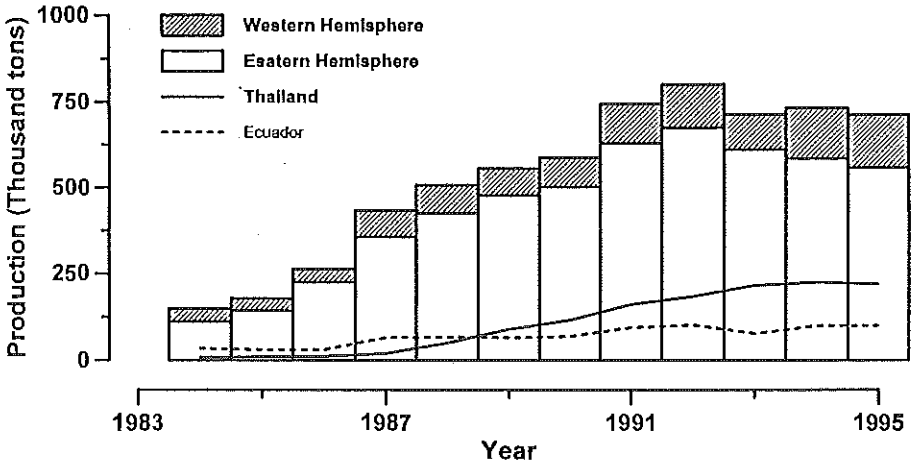

Figure 8. Farmed production and principal producers of marine shrimp.

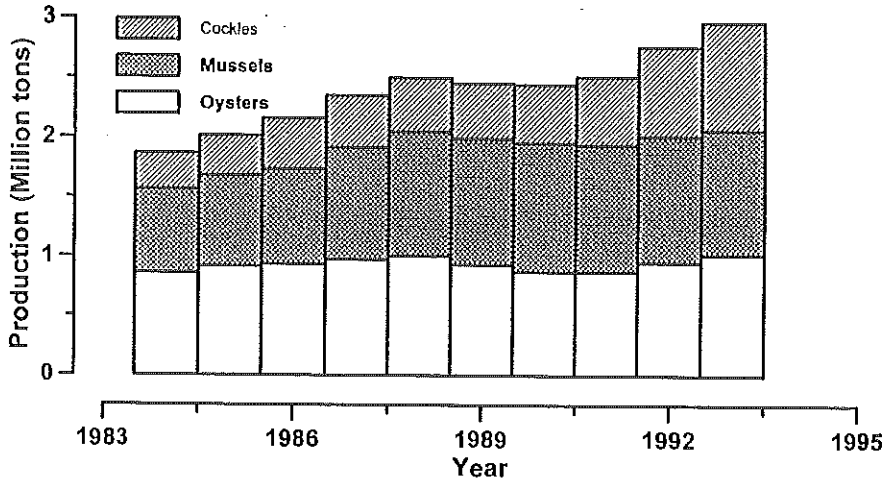

Figure 9. Coastal mollusc production by main cultivated groups.

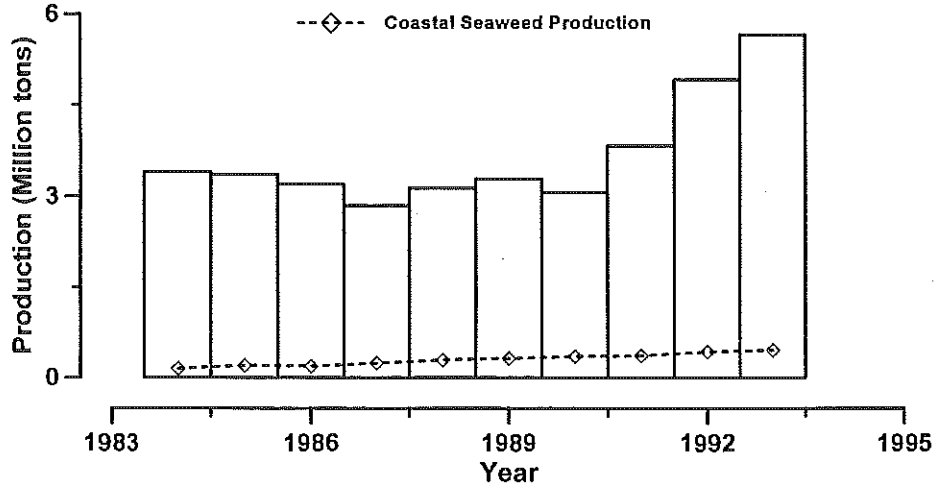

Figure 10. Global seaweed production and coastal seaweed production.

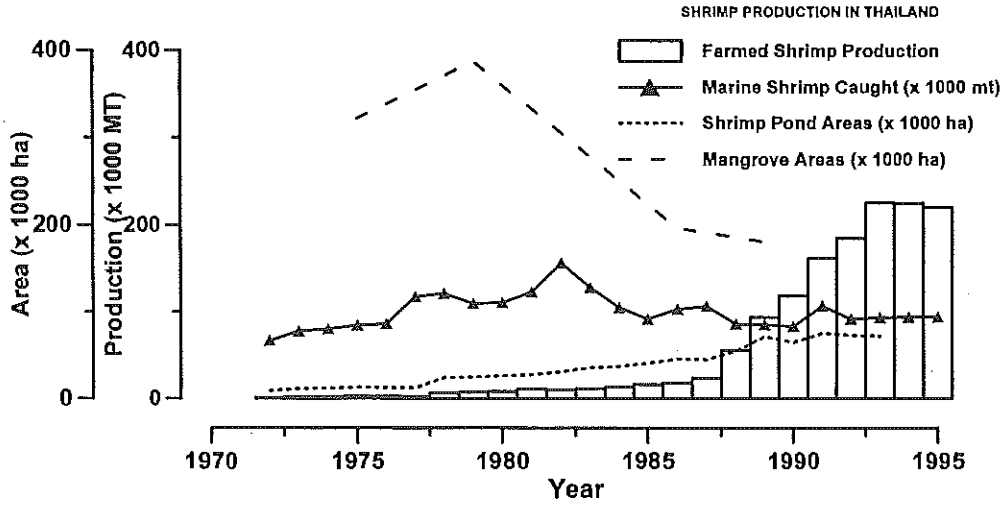

Figure 11. Shrimp farmed aquaculture production and mangrove areas of Thailand.

Significance of Mangrove Biodiversity for the Environment and as a Resource

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Abstract

Mangrove ecosystems harbor diverse arrays of flora and fauna, especially in Southeast Asia. Mangroves are known to be important habitats for numerous economic marine species. Mangroves are very productive systems that link between inland terrestrial landscapes and the nearshore marine environment. Mangrove biodiversity plays many vital roles that can be categorised as follows:

1. Uses that permanently change the ecosystem
   (Urbanisation, industrialisation, agricultural/aquacultural development, and construction of infrastructures).

2. Extractive uses
   (Food from the sea - fisheries and mariculture, forestry, bioactive compound extraction).

3. Non-extractive uses
   (Recreation activities, education and conservation, ecotourism, ecological processes or ecological services, such as coastal protection, land building, biofiltration, nursery grounds of economically important animals, etc.).

The roles of mangroves in providing ecological services that maintain nearshore marine environment, and provide food and refuge to a variety of fauna are emphasized and discussed. Problems, threats and recommendations will be presented.

Bioactive Substances from Mangrove Resources

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Abstract

The mangrove forest is one of the primary features of coastal areas and plays a significant role in coastal development. Mangrove areas are economically exploited, especially for timber and fishery products. Comprehensive knowledge about other aspects, such as active substances obtained from the mangroves, is less easily available. This paper attempts to review use of the mangroves as a source of bioactive substances by coastal people in various countries. Most of the available information, however, concerns the mangrove flora. There is an urgent need to elucidate this local knowledge scientifically. As for the nutritive value of mangroves, some species such as *Avicennia marina*, *Ceriops decandra*, *Rhizophora mucronata* and *Sesuvium portulacastrum* are found to be alternative sources of forage and feed for animals in saline coastal areas. Interestingly, many mangrove species are used for medicines. Well-known medicinal species include *Acanthus ilicifolius*, *Excoecaria agallocha*, *Xylocarpus granatum* and *Avicennia* spp. In addition, scientific information relating to some chemical and biological components of *Ipomoea pes-caprae*, *Pluchea indica* and *Acanthus ebracteatus* are mentioned.

Introduction

The mangrove ecosystem is one of the important ecosystems in the tropics and has great economic and ecological value. Like tropical dry land rain forests, mangrove forests have played an important role in the economies of peoples in the tropics for thousands of years, and constitute a reservoir and refuge for many unusual plants and animals. In both developing and developed countries, mangrove ecosystems support both commercial and recreational fisheries and provide many other direct and indirect services. As the mangrove forests are abundant in biological activity, they provide habitats for species which are adapted to a saline tidal environment. The mangroves also provide habitats for a large number of diverse migratory waterfowl and terrestrial animals, and are very important as habitats of aquatic organisms.

Mangrove flora can be classified into true mangroves and mangrove associates. True mangrove species consist of plants which are absolutely confined to salt or brackish water, while mangrove associates are plants which belong to the littoral zone and/or inland vegetation but can frequently be found with back mangroves (Santisuk 1989). Currently available information on mangrove flora in Southeast Asian countries indicates that most of the 46 true species of mangrove flora in Southeast Asia occur in all countries. A few species are found only in some countries. For mangrove fauna, this includes marine as well as terrestrial species (MacNae, 1969). The terrestrial animal species, however, are not necessarily wholly dependent on mangroves. Their presence in the mangrove forest is simply a part of their activities in looking for food or shelter. Marine species are usually dominated by two groups of animals, namely *Mollusca* and *Crustacea*. Many temporary inhabitants enter the mangrove forest in addition to the permanent dwellers.

At present, millions of human coastal dwellers throughout the region depend on mangroves for their livelihood. They often exist at a subsistence level but are in balance with the trees and tides. Such harmony between the people of the coast and the mangroves has persisted for centuries. Mangrove areas have also been commercially exploited, particularly for fishery and timber products. In addition, among the non-timber products derived from the mangrove forest are tannin, medicine, dye, and nipa sap for sugar, vinegar, wine-making and foods. Over the years, mangrove exploitation has shifted from the simple gathering of timber and fishery products to commercial-scale enterprise. The use and conversion of mangrove areas for aquaculture, salt works, human settlement, agriculture and industrial sites is now commonplace. This continuous exploitation of mangrove areas has resulted in depletion of the resources. Because of this problem, the

mangrove forest has been an important subject of concern for resource planners and managers.

To date the majority of work on mangrove exploitation has focused on timber and fishery uses. Little work has been done on other activities such as the production of non-timber products. The use of mangrove resources for medicines or as a source of active substances is an interesting topic for study, but the information available is minimal and poorly documented. In addition, there is the problem of a lack of research and scientific proof on most medicinal aspects of mangrove usage. This paper explores information relating to various sources of bioactive substances reported from the mangrove resource, particularly those derived from plant species. Their traditional uses, based on the vast experience of the local people in each country are reviewed. The knowledge obtained may be a useful basis for further research and development.

Nutritional Value of Mangroves as Forage and Feed

The earliest recorded uses of mangroves are those associated with the direct and indirect products that could be obtained from them. Walsh (1977) cites references to the use of mangrove as early as 325 BC, describing an aphrodisiac effect of seedlings of *Rhizophora* when ingested, and their use in some potions in Arabia. By the 13th century, in the Middle East, mangroves were established sources of "food, fuel, medicine for curing sore mouths, and tanning leather" (Saenger, 1985).

In some countries waterlogging and salinity is a problem affecting rangelands and pasture. Generally, these saline soils are not productive for either food or fodder crops. An alternative source of forage and fodder in arid, semi-arid and saline coastal areas are the plants known as halophytes. There are numerous examples of domestic animals feeding on mangrove foliage, for example, camels in the Middle East; cattle, camels and goats throughout Asia; and water buffalo in parts of Asia and Australia.

Mangrove foliage can be used safely as fodder, feed, meal, concentrate or roughage, since it contains significant quantities of all necessary minerals, vitamins, amino acids, proteins, fat and crude fiber necessary for the growth and nourishment of livestock (Hamilton and Snedaker, 1984). A comparison of the chemical analysis of mangroves with that of alfalfa reveals that mangrove foliage is even better for nutritional purposes than alfalfa, the "queen of foliages" (Janick *et al.* 1981). *Sesuvium portulacastrum* L. is a pioneer species present in mudflat areas in Thailand. This plant is also used widely as forage and feed for cattle and pigs and even as a vegetable for human consumption. Table 1 shows the major components of leaves of three species of mangrove growing in Pakistan.

Mangrove fodder appears to be superior to other types of fodder because it contains significant quantities of common salt and iodine since it grows in marine habitats. Salt and iodine are a necessary requirement for the nourishment and growth of livestock. Most nonhalophytic types of fodder are deficient in iodine. Hamilton and Snedaker (1984) cited references to feeding trials with mangrove which have shown them to have nutritive value for livestock. When milk cows were fed on *Rhizophora mangle*, milk yields increased. Feeding trials of sheep with *Avicennia* spp. meal in Madras have also proved to be promising. Poultry feed made from dried mangrove leaves and twigs has been found to be nutritious and comparable to other high quality feeds now in use. When mangrove feed was used as a supplement to common poultry feed, the weight of the chicks increased. Chemical analysis of mangrove meal indicates its suitability for use as poultry feed because it contains most of the required nutrients.

Some mangrove plants can be consumed by humans. The hypocotyls of *Bruguiera* spp. and *Kandelia candel* contain starch. After being sliced, soaked in water for several hours to rinse out the tannin substance, and then ground into powder, they can be made into cakes or used as sweetened stuffing for pastry. Salted seeds of *Avicennia marina* can be eaten for breakfast (Lu Chang and Lin Peng, 1985). Some species of mangrove trees have been identified as foods of two sympatric monkeys in Indonesia (Supriatna *et al.* 1989). Ten species of mangrove trees have been found to be consumed by these monkeys. The three species of *Avicennia*, especially the fruits, are among the most common species eaten by those monkeys (Table 2).

Table 1. Analyses of Composition of Foliage of Three Mangrove Species from Pakistan

Species	Moisture (% wet weight)	Na	K	Crude Fat	Crude Fiber	Crude Protein	Ash	Digestability (%)
				(% dry matter)				
Avicennia marina	65.41	5.52	0.45	4.18	16.04	10.8	16.30	62.60
Ceriops decandra (*roxburghiana*)	62.02	2.76	0.59	5.35	14.59	5.9	10.02	97.38
Rhizophora mucronata	68.90	3.45	0.62	2.68	11.30	4.7	14.00	77.10

Source: Hamilton and Snedekar 1984.

Table 2. Chemical Composition of Some Food Plant Parts Eaten by *Macaca fascicularis* and *Presbytis aurata* at Muara Gembong Mangrove Forest

Species	Parts	Water (%)	Ash (%)	Crude fat (%)	Protein (%)	Carbohy-drates (%)	Calories (Cal)
1. *Avicennia alba*	Leaves	65.16	6.99	0.45	6.28	21.12	113.65
	Fruits	53.84	1.59	0.36	4.19	40.02	180.08
	Roots	67.11	5.15	0.98	2.57	24.19	115.86
2. *A. marina*	Leaves	74.22	3.11	2.34	5.24	15.09	102.38
	Fruits	66.06	0.72	0.31	3.56	29.35	134.43
	Roots	62.74	3.47	2.16	3.71	27.92	145.96
3. *Bruguiera gymnorrhiza*	Leaves	68.90	4.25	1.32	4.81	20.72	114.00
	Fruits	57.35	1.37	0.82	2.85	37.61	169.22
4. *Aegiceras corniculata*	Leaves	40.78	5.00	5.80	5.29	43.13	245.88
5. *Sonneratia alba*	Leaves	74.77	0.83	0.76	3.05	20.59	101.40
	Fruits	74.08	0.72	0.66	2.21	22.33	104.10
	Roots	68.06	1.24	0.42	1.74	28.54	124.90

Source: Supriatra *et al.* 1980.

Ethnomedical Uses of Some Mangrove Plants

Chinese people living in coastal areas use mangroves for medicine, *Acanthus ilicifolius* is used to cure skin itches and abscesses and *Bruguiera gymnorrhiza* fruit is used for curing diarrhoea (Su Sheug Jin, 1989). The marine environment is quite similar throughout Southeast Asia. Mangroves in Indonesia are not so different from those in Thailand, or in Malaysia, the Philippines, Singapore, or even Myanmar, Cambodia and Vietnam. Moreover, the human environment in this region also has some similarities which make the problems related to mangrove exploitation or ethnomedical uses almost common to the area, at least within the ASEAN regional group.

Some plants found in mangrove forests can be used as alternative medicines, but scientific proof of their effectiveness and research into possible side effects is still needed before they can be widely recommended. Various parts of certain species of mangrove species contain active substances that have the property of curing various ailments. These active substances from mangroves are used in many parts of the world and represent a traditional activity in certain regions. It is well known that herbal medicine is a tradition in China. Mangrove plants have wide-scale uses

as medicines in this country. Their roots, bark, leaves and fruits have certain medical effects. Despite modern medical developments, folk recipes using mangrove are still popular among local people. A few published studies have dealt with certain aspects of active substances in mangrove ecosystems but most of them are in the local languages. The present paper, therefore, provides an opportunity to examine the status of medicinal uses in various countries.

In Indonesia, the bark of *Xylocarpus* spp. may be used to treat diarrhoea and cough, the leaves of *Excoecaria agallocha* may be used for epilepsy, and the leaf juice of *Acanthus* spp. may relieve rheumatism (Soegiarto and Soemodihardjo, 1985). In Cambodia, three mangrove species are well known for medical purposes; *Acanthus* sp. is used to treat kidney stones, *Bruguiera parviflora* is used to treat thrush in children and *Avicennia alba* is used to treat diarrhoea by local people (Viboth and Ashwell, 1995). In Vietnam, several mangrove species, including true mangrove and associated mangroves, have been used as herbal medicines. Eleven species of mangroves, which are used as traditional medicines are listed in Table 3 (Phan Nguyen Hong and Hoang Thi San, 1993). In addition, Vietnam's mangrove forest, especially in Minh Hai, previously supported a large population of tigers, varans, crocodiles, snakes, wild pigs and monkeys, many of which are now endangered. These animals are hunted by people living in mangrove areas for meat or medicinal uses.

A report from the Philippines on medicinal values of some mangrove species (Zamora, 1989) is shown in Table 4:

Another report from the Philippines also listed medicinal and other uses of some of mangrove species (Jara, 1985) as shown in Table 5.

In Fiji, mangroves have provided a variety of products and services to the coastal people for centuries. Traditional uses of some mangrove tracheophytes are listed in Table 6 (Pillai, 1985).

Different mangrove species in India are used by local people for medicinal purposes (Untawale, 1985). Some of the uses are given in Table 7.

Table 3. Mangrove Species Used for Herbal Medicines in Vietnam.

No Species	Use	Part of Plant Used
1. *Acanthus ilicifolius*	Treating rheumatic joints and neuralgia	Leaf
2. *Acrostichum aureum*	Applying to wounds and boils	Pounded rhizome
3. *Ceriops tagal*	Used as substitute for quinine in malaria	Decoction
4. *Clerodendron inerme*	Removing pain in jaundice	Leaf
	Febrifugal properties	
	Curing buboes	Poultice of leaves
5. *Heritiera littoralis*	Treating diarrhoea and dysentery	Decoction of seeds
6. *Hibiscus tiliaceus*	Used as febrifuge, emollient	Root
	sudorific, diuretic and laxative	
	Curing pimples	Leaf
7. *Ipomoea pes-caprae*	Astringent, touic, diuretic.	Plant
	laxative	
8. *Pluchea pteropoda*	Febrifuge, headaches	Leaf
9. *Thespesia populnea*	Curing stomach troubles	Leaf
10. *Wedelia biflora*	Curing wounds and cuts	Leaf
11. *Xylocarpus granatum* and *X. moluccensis*	Febrifuge and used in dysentery	Bark

Source: Phan and San 1993.

Table 4. Mangrove Plant Species Possessing Pharmaceutical Values

Species	Part Used	Therapeutic Use
Excoecaria agallocha	Latex	Ulcers
	Leaves	Epilepsy
Avicennia officinalis	Fruits	Astringent
	Seeds	Ulcers
	Bark, roots	Aphrodisiac
	Seeds, roots	Maturative poultice
Xylocarpus granatum	Fruits, seeds	Diarrhea
X. moluccensis	Seeds	Insect bites
	Seeds, bark	Astringent
	Fruits, seed	Antidiarrheic

Source: Zamora 1989.

By interviewing mangrove dwellers in Ranong, Thailand, Aksornkoae *et al.* (1985) found that three common mangrove species were used as medicine. They are: *Acanthus* spp; *Bruguiera parviflora* and *Avicennia alba*. *Acanthus* is used to treat kidney stones. The whole plant is boiled in water and the patient drinks the solution instead of water, half a glass each time until the signs and symptoms of the kidney stone disappear. For *Bruguiera*, the whole plant is boiled in water, the solution is drunk twice daily after meals to relieve constipation. *Avicennia alba* heartwood is used to treat thrush in children. The heartwood is rubbed against a coarse stone into fine particles and then lime juice is added to these fine particles and stirred vigorously to make a paste. This paste is spread in a thin film on the child's tongue twice daily before meals for three days.

In another study, K. Suparbpiboon and J. Kongsangchai (1982) compiled information on medicinal uses of mangrove in Thailand. The claimed efficacies in Thai traditional use are shown in Table 8.

Some Scientific Research on Medicinal Uses of Mangroves in Thailand

Some investigators have conducted research to assess the chemical and biological activities of mangrove plants. The following information is from Thailand:

a) ***Ipomoea pes-caprae* (Linn.) Sweet. (Medicinal Plant Information Center, 1992)**

This plant is perennial belonging to the family *Convolvulaceae*, commonly creeping along the sandy beaches, often rooting at the node and having milky juice. The plants are commonly found along sea shores in many tropical countries. The whole plant is used for the treatment of wandering swelling in different parts of the body caused by 'wind element' (*pen lom*); skin diseases and as an anti-inflammation caused by jelly-fish allergy. Its seed is used for the treatment of fatigue. For the treatment of jellyfish allergy, leaves are pounded and applied over the allergic area. The plant's chemical constituents are found to be as follows.

Leaves: actinidol, citric acid, ergomitrine, ergotamine eugenol, fumaric acid, inorganic elements, iso-adenostylone, malic acid, d-(+)-malic acid, (-)-mellein, succinic acid, D-(+)-tartaric acid.
Aerial parts: behemic acid, benzoic acid, butyric acid, caproic acid, caprylic acid, essential oil, melissic acid, myristic acid, N-pentatriacontane, potassium chloride, (-sitosterol, sodium chloride, n-triacontane.
Whole plant: citric acid, fumaric acid, hyperoside, isoquercitrin, isoquercitrin monoacetate, malic acid, quercetin-3-galactoside, quercetin-3-glucoside, quercetin-3-(6 -O-acetyl)-(-D-glucopyranoside, quercetin-3-O-Na salt, succinic acid, tartaric acid.

Table 5. Medicinal and other Uses of Some Mangrove Species in the Philippines

Species	Uses
Acanthus ebracteatus Vabl.	Leaf juices applied to the scalp to preserve the hair.
A. ilicifolius L.	Crushed fruit is said to make a good blood purifier aud dressing for boils and snake bite.
Acrostichum aureum L.	Succulent fiddleheads are edible raw or cooked.
Aegiceras corniculata (L) Blanco	Bark and seed contain a fish poison.
Avicennia alba Bl.	Bark and seed contain fish poison
	Resinous substance exuded used for birth control purposes.
	Ointment made from seeds useful for relieving smallpox ulceration.
A. marina (Forsk.) Vierh.	Source of pollen and strong flavoured honey for supporting bee colonies;
A. officinalis L.	Seeds eaten after leaching and cooking
Bruguiera gymnorrhiza (L) Lamk.	Bark used as seasoning for raw fish
	Pneumatophores used in planting rituals by burying tubers so that tubers will grow big.
B. sexangula (Lour.) Poit	Young leaves, fruit embryos, center of radicles are cooked and eaten as vegetable
	Fruit chewed as substitute for sireh or betel;
	Lotion from fruit used as medication for sore eyes;
	Leaves contain alkaloids that are tumour inhibitors;
	Roots made into incense wood.
Ceriops tagal (Perr.) C.B. Rob.	Bark infusion used as treatment for obstetric and haemorhagic conditions
Excoecaria agallocha L.	Copious milky sap is exceedingly irritant and toxic; used as fish and arrow head poison;
	In the Philippines causes blindness and is used as medication for tooth ache.
Lumnitzera littorea (Jack) Voigt	Decoction of leaves said to be used as cure for thrush in infants.
Oncosperma filamentosa Blume	Fleshy fruits preserved; Terminal buds for vegetable; Flowers added to rice as seasoning.

Source: Jara 1985.

After pharmacological activities and clinical trials were carried out, *Ipomoea pes-capre* is recommended for relieving allergic symptoms caused by jelly fish toxins.

b) *Pluchea indica* (Linn.) Less. (Medicinal Plant Information Center, 1992)

The plant is a shrub, 0.5 - 2 m high, much branched, glabrous and belongs to the *Compositae* family. Plants are widespread from India, Indo-China and Malaysia to Taiwan and thrive in moist lowland, along swamps, sea shore and back mangrove. It is commonly grown as medicinal plants. Its ethnomedical uses and chemical constituents are as follows.

Part Used and Ethnomedicinal Uses:

Roots: for longevity; treatment of any disorders causing cachexia or wasting diseases and dysuria with urinary stones or discharges.

Whole plant: treatment of dysuria with urinary stones or discharges and disorders of urination; as a diuretic.

Stem: treatment of disorders of urination, hemorrhoids, nasal polyposis ; as diuretic.

Table 6. Traditional Uses of Some Mangrove Tracheophytes in Fiji.

Species	Uses
Abrus precatorius	Seeds are extremely poisonous, they are boiled to dissipate the poison
Barringtonia racemosa	Fruits are used as fish poison
Calophyllum inophyllum	Infusion of leaves used as eye wash; oil from fruit used as liniment, hair dressing oil
Cerbera manghas	After reducing the leaves to a pulp by chewing, they are stuffed in hollow teeth
Clerodendron inerme	Sap of leaves is used for washing dishes; used as fish poison; used as medicine
Excoecaria agallocha	Used as medicine for treating leprosy; sap is an irritant, and is believed to cause blindness

Source: Pillai (1985)

Table 7. Some Mangrove Species used for Medicinal Purposes in India

Species	Part Used: Purpose
Acanthus ilicifolius	Leaves: for rheumatic disorders
Bruguiera spp.	Leaves: for blood pressure
Caesalpinia nuga	Pods, roots and leaves: for medicine
Carapa obovata	Gum, resin: for medicine
Cynometra ramiflora	Leaves, oil from fruits and roots: for leprosy
Excoecaria agallocha	Latex, leaves, bark: for several ailments
Xylocarpus spp.	Bark: for astringent, febrifuge

Source: Untawale 1985.

Bark: for longevity; treatment of nasal polyps, haemorrhoids, any disorders causing cachexia or wasting diseases.
Leaves: for longevity; treatment of haemorrhoids, any disorders causing cachexia or wasting diseases.
Flowers: treatment of dysuria with urinary stones or discharge.
Seeds: treatment of nasal polyp and haemorrhoids.
Unspecified part: used as diuretic.

Chemical Constituents:
Leaves: 3-(2 ,3 -diacetoxy-2 methyl-butyryl)-cuauhtemone.
Aerial parts: 9-hydroxylimalyl glucoside, linaloyl apiosyl glucoside, linaloyl glucoside, terpene glycosides, plucheosides A and B.

Based on phamacological activities and clinical trial data, *Pluchea indica* seems to be effective as a diuretic. However, more studies seeking to isolate active components and more phamacological studies should be carried out.

c) ***Acanthus ebracteatus* Wall: (Subhadhirasakul, S. *et al.* 1993)**

The plant is a shrub belonging to the *Acanthaceae* family. The leaves are spiny, dark-green and deeply lobed. The plant is very common in all mangrove areas and all tidal rivers. According to the research, a dried powder extract from the stem and leaves was obtained after boiling the plant in water. This was then formulated into cream preparations at concentrations of 10%, 2% and 1% respectively. These preparations were tested for their efficacy on eczema (itching) patients. The symptoms of patients in the experimental group were improved, but less than that of the control group (treated only with the cream base). This finding could have resulted from the irritating effect of *Acanthus* extract which caused hypersensitivity in some patients.

Table 8. Mangrove Species Used for Herbal Medicine in Thailand

Species	Part Used	Ethnomedical Uses
Acanthus ebracteatus	Whole plant	Antipyretic, treatment of skin diseases, smallpox, abscesses, detoxification, ulcers, and for health promotion
Acanthus ilicifolius	Whole plant	Same as *A. ebracteatus*
Avicennia officinalis	Leaves	Treatment of bone pain, urinary disorders, bronchial asthma, stomach disorders, detoxification
	Seeds	Treatment of abscesses
Ceriops decandra	Bark	Treatment of diarrhea, vomiting, amebiasis; used to stop bleeding
Ceriops tagal	Bark	Treatment of infected wounds
Clerodendron inerme	Leaves	Treatment of malaria, infected wounds, anti-inflammatory, treat itching, skin diseases
	Root	Antipyretic, to treat common cold, hepatitis, hepatomegaly, spleenomegaly
	Seed	Antiflatulent
	Fruit	Treatment of amebiasis
Cycas rumphii	Stem apex	Treatment of abscesses and detoxification
Derris trifoliata	Whole plant	Used as laxative, carminative, expectorant
Dischidia rafflesiana	Leaves	Treatment of chronic otitis
	Root	Anti-fatigue
Excoecaria agallocha	Wood	Smoke from burning wood used for treatment of leprosy
	Heartwood	Antipyretic, carminative, mucolytic
	Root	Anti-inflammatory
	Leaves	Anti-epileptic
Rhizophora apiculata	Bark	To treat diarrhea, nausea, vomiting, amebiasis; as antiseptic and to stop bleeding
Rhizophora mucronata	Bark	Same as *R. apiculata*
Thespesia populnea	Fruit and leaf	Treatment of scabies
	Bark	Used to irrigate chronic wounds
	Root	Used for health promotion
Xylocarpus granatum	Seed	Treatment of diarrhea, amebiasis
	Bark and fruit	Treatment of cholera, infected wounds
Xylocarpus moluccensis		Same as *X. granatum*

Source: K. Suparbpiboon and J. Kongsangchai 1982.

Some chemical constituents reported in *Acanthus illicifolius* L. are as follows: flavonoids, fatty acid, triterpenoids, saponin, octacosanol, stigmasterol, 2-benzoxazolinone, stigmasterol glucoside, sitosterol, cholesterol, campesterol, and 28- isofucosterol.

d) *Sapium indicum* (Mock Willow or Gurah)

A small tree reaching 20 m. high belongs to the *Euphorbiaceae* family. It grows in hard mud or clay at sites near the back mangrove. It has slender, often hanging branches. The species could be something of a pioneer in the marginal habitat between inner mangrove and coastal forest. It has several uses and is

accordingly well-known in the villages. A green dye is obtained from it. The ripe seeds are eaten. They have a slight medicinal action, and care must be taken to avoid the latex because it is apt to blister the skin. The fruits are taken by children to play marbles. The wood burns well (Corner, 1952).

Coastal people in Southern Thailand use its leaves to ferment rice for making flour. It is believed that its fruits can be used to kill crabs in the paddy fields. By spraying fruit powder at about 6 liters per hectare, the activities of crabs will be slowed down and they will be dead within 3 days. The chemical constituents of this species have not been reported.

Conclusion

Uses of mangroves as a source of bioactive substances are reviewed in this paper. Most of the information on the use of bioactive substances is for traditional uses of mangrove flora. Mangrove foliage is found to be used safely as fodder, feed and meal, since it contains significant quantities of all necessary minerals, vitamins, amino acids, proteins, fat and crude fiber necessary for the growth and nourishment of livestock. Various parts of certain plant species of mangrove contain active substances that have have traditionally been used to treat various ailments. Use of these active substances from mangrove occurs in many parts of the world and represents a traditional activity. There needs to be proper and judicious management of the mangrove resource. The preservation and conservation of these resources should be taken seriously now for the benefit of generations to come.

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Biodiversity in Mangroves

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Abstract

Biodiversity is understood as species richness, ecosystem complexity and genetic variability. 1.4 to 1.6 million species of living organisms were known to science, but 5 to 30 million species were considered to be humble guess of the existing organisms. Biodiversity in mangroves in terms of species richness is probably by far the less than any other types of terrestrial forest ecosystems. But mangroves are unique in building a complex of ecosystems, marine and terrestrial. Interactive function of component agents of a mangrove system is still less understood. Only a little is known about mangrove ecosystem. The way of living of the organisms, interactive and interdependent relationships of the groups of organisms, existing physiologically active compounds intermediating the relations should be more attracting mangrove researchers' attention. In order to serve for the people's welfare in the future, conservation and rational use of mangrove resources on sustainable basis should further be pursued. It is highly recommended mangrove researches to redirect their target into conservation and non-destructive, sustainable use context.

Significance of Biodiversity Conservation in the Mangroves of Bangladesh

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1. Introduction:

Mangroves in Bangladesh occur as natural and manmade planted forest. The natural mangrove forest in the country constitutes the largest contiguous patch of mangroves in the world. These forests play a significant role as resource base for a number of products such as timber, firewood, thatching material, raw material for paper and hardboard industries, honey, bees' wax, shell etc. The aquatic system supports fisheries and a major source of natural shrimp fry for an extensive areas of shrimp culture in the coastal areas of Bangladesh. It is also an area of outstanding ecological importance for its land building abilities and for the protection of life and property of the coastal population of the country. The area is of global significance for its unique biodiversity and habitat for a number of globally threatened plants and animals. Map 1 shows the distribution of mangroves in Bangladesh.

In the past more than double the present mangrove area has been converted to agriculture, fisheries and other development works. Despite strong commitment on the part of the government to manage the scarce resources of the mangroves it is increasingly threatened by natural and manmade phenomena. Efforts are needed to protect the unique biodiversity of the mangroves through maximizing the benefit from the mangrove areas of Bangladesh. This paper discusses the significance of biodiversity conservation in the mangroves of Bangladesh in the light of the above mentioned facts.

2 Area and distribution

2.1 Natural mangroves: The coastal region of Bangladesh lining the Bay of Bengal were once covered with extensive mangrove forests. Palynological records reveal that mangrove forest in the Bengal delta existed about 5000 yrs B.P. It is known as "Bada" in the south west region of Bangladesh and as "Paraban" in the Chittagong region. Subsequently these forests are known as Sundarbans in the English literature. At present the natural mangrove forest is limited to the Sundarbans lying south of Satkhira, Khulna and Bagerhat districts and occupies 10,000 Km^2 including the Indian part of the forest (the Indian part is 40 % of the total). A small patch in the Patuakhali district occur as remnant of once dense mangrove forest in the district. In the Chittagong region mangrove used to occur along the entire coast from the mouth of the river Karnafuli up to Bakkhali and also along the Naf river. Almost all patches of natural mangrove area have been converted to agricultural land, shrimp ponds and salt pans. The last remaining part of the natural mangroves in the Chittagong area known as Chakaria Sundarbans have been cleared for shrimp cultivation after 1988.

2.2 Manmade mangrove ecosystem: Establishment of mangrove plantations on the newly accreted islands and mudflats along the coastal line of the Bay of Bengal is one of the innovative and most successful programmes of the Forest Department in the country. As the coastal afforestation program proceeded, it became apparent that the plantations could provide other benefits for the coastal people and resulted in the setting of additional objectives . This includes to a) provide forest products for a range of uses; b) develop forest shelter belts to protect life and property of the inland people from tidal surges; c) inject urgently needed resources into the national economy i.e. timber and land; d) create employment opportunities in rural communities; e) create an environment for wildlife, fishes and other estuarine and marine fauna.

At the beginning the plantation program started with an annual planting of approximately 320 ha. The plantation program was given added impetus during 1973. From July 1980 the World Bank (IDA) UNDP/FAO began financial support to the mangrove afforestation project which between 1960 and 1980 planted 32,000 ha. The Forestry I project (IDA)

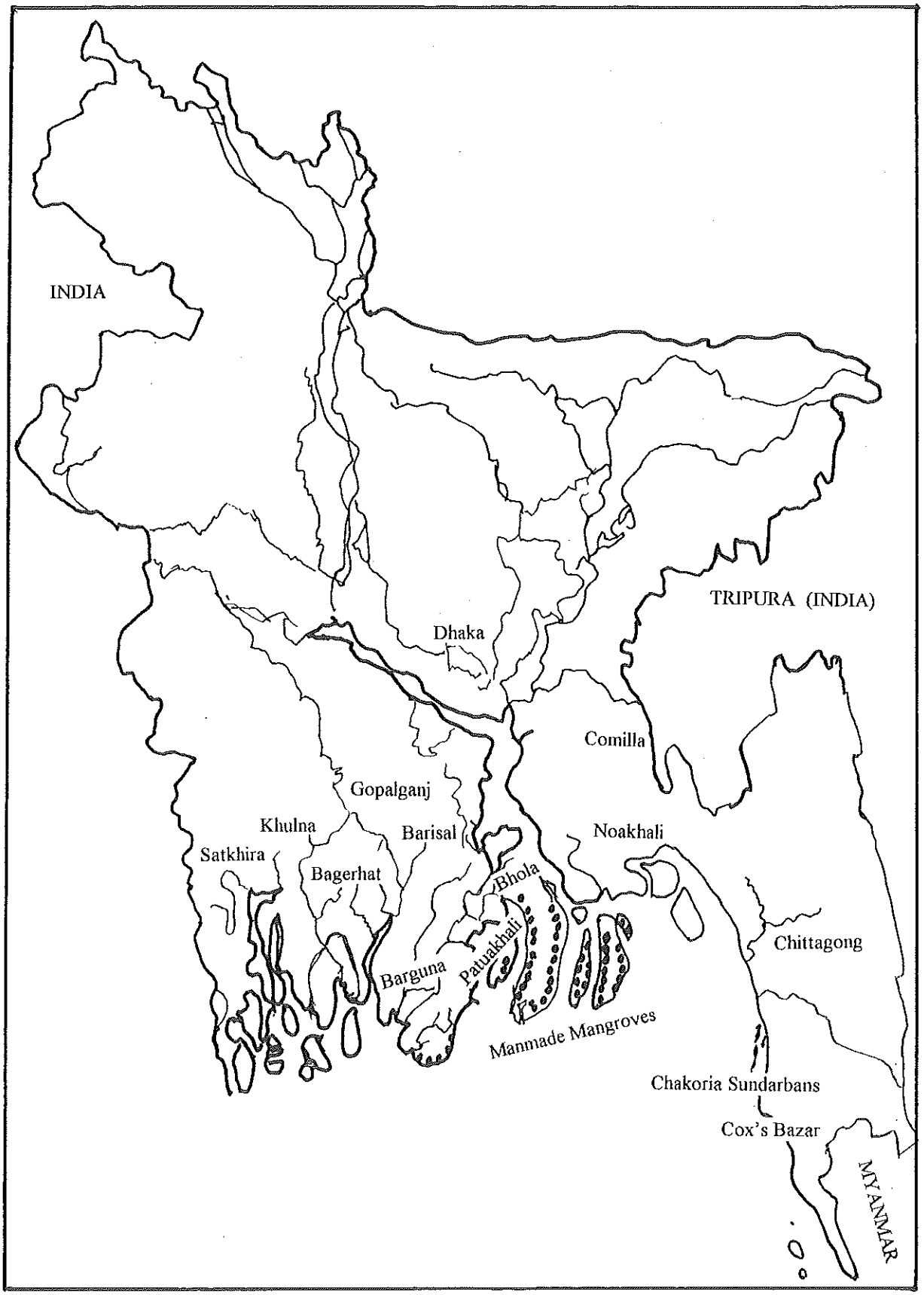

Fig. 1. Natural and manmade mangroves in Bangladesh.

planted an additional 30,5000 ha area and forestry II project planted a further 35000 ha upto 1991. Total coastal planting from 1960 to 1999 should exceed 140-150 thousand ha.

3 Direct benefit use of plants:

3.1 Natural mangroves (Sundarbans): The Sundarbans mangrove vegetation is one of the most botanically diverse ecosystem in the world. The spermatophytic floral element in the sundarbans and the adjoining reclaimed areas consists of 245 genera and 334 species (Prain, 1903). No fewer than 123 occur in the present Sundarbans reserved forest (Karim, 1994 in Hussain and Acharya, 1994).

Sundarbans plant resources are harvested for a wide range of wood and non wood products . It is the single largest source of timber and firewood in the country. The forest accounts for 45% of the nations timber, fuelwood demand. The Khulna News print mill, Hardboard mill and match factories are dependent on the supply of raw materials from the Sundarbans. The important timber yielding species include *Heritiera fomes* (*Sundri*), *Excoecaria agallocha* (*Gewa*), *Avicennia officinalis* (*Baen*), *Sonneratia apetala* (*Keora*), *Bruguiera* spp (*Kankra*). *Ceriops decandra* (*Goran*) form a high quality fuelwood. Brush wood from *Heritiera fomes* (*Sundri*) and *Cynometra ramiflora* (*Singra*) are used raw materials for hardboard mills and also as fuelwood. Besides, almost all other species like *Rhizophora, Hibiscus tiliaceus* (*Bhola*) are used as fire wood. The non-wood plant products include thatching materials from the fronds of *Nypa fruticans* (*Golpata*), house posts from *Phoenix paludosa* (*Hantal*), mat making from *Typha angustifolia* (*Hogla*), *Cyperus javanicus* (*Malaya*). Table 1 & 2 shows the wood products aud the revenue earnings from the Sunderbans. The standing value of the timber is calculated as Tk 47 billion or US$ 1.2 billion or US$ 1.34 billion using minimum and maximum annual sale prices achieved at *sundri* timber auctions.

3.2 Manmade mangrove ecosystem: As a result of the early trial and error approach to plantation only two species, *Sonneratia apetala* and *Avicennia officinalis*, showed encouraging survival rates. As a consequence, these two species were preferred for raising the mangrove plantation. About 80% of the plantation area consisted of mono-specific stand of *Sonneratia apetala*. About 15% of stands consisted of *Avicennia officinalis* with remaining areas consisting of *Excoecaria agallocha, Bruguiera sexangula,* and *Ceriops decandra* (Saenger and Siddiqi, 1993).

The dominant plantation species *Sonneratia apetala* usually attains height of 20 m and a girth of 2.5 m. Diameter increment being 13 mm per year. Drigo *et al.* (1987) calculated the MAI of the species in 4 forest divisions. It ranges from 9.4 m^3/ha/year at Patuakhali to 7.9, 7.5 and 5.8 m^3/ha/year at Barisal, Noakhali and Chittagong respectively. An estimate of current growing stock in some reports accounts for more than 0.6 million m^3 (Saenger & Siddiqi, 1993).

At present wood products from the forest are not officially harvested but the people of the offshore islands are almost wholy dependent directly on mangroves for fuelwood and construction material. The mangrove areas in the coastal region is used by local people for grazing and fattening buffaloes.

4. Direct use of animals and animal products:

4.1 Fisheries:

The Sundarbans aquatic subsystem supports important fisheries resources with estimates ranging from 1% to 5% of the total fish harvest of Bangladesh (FAO, 1995). The inshore and esturaine fishery area, is considered to lie from north latitude 21° 5' which approximates the 2m isobath and follows the present reserved area, up to where most of the traditional fishing is said to occur (Shahid, 1985). FAO reports consider 6 species of fish and 3 species of crustaceans of high commercial value. These are *Hilsa ilisha* (*Hilsha*), *Pangasius pangasius* (fatty catfish), *Plotosus canicus* (canine eeltail catfish), *Latus calcarifer* (Barramundi), *Pomadasys hasta* (White grunt), *Johinius argentatus* (Silver jewfish), *Panaeus monodon* (Tiger shrimp), *Macrobrachium rosenbergii* (giant freshwater prawn) and *Scylla serrata* (mud crab), estimates of yields of fisheries resources vary due to inadequate information.

Crabs: Until the late 1980s crabs were given little attention, but in recent years edible crabs have become a much sought-after aquatic resource which has high economic value. The edible mud crab (*Scylla serrata*)

Table 1. The yearly harvest of wood products from the Sundarbans in m^3 x 1000

Name of species	86-87	87-88	88-89	89-90	90-91	91-92	92-93	93-94
Sundri	74	116	110	66	21	48	92	36
Gewa	173	165	145	171	189	200	182	126
Baen	4	2	4	2	0	0	0	0
Keora	4	1	1	1	0	0	0	0
Kankra	1	2	3	1	0	1	0	0
Sundr/FWD/B	7	12	15	4	2	0	0	0
Goran	27	26	23	23	23	16	20	69
Singra	2	13	15	6	11	13	8	0
Amur	0	0	2	0	0	0	0	0
Ors	1	0	71	9	14	9	11	12
Total	293	337	389	283	260	287	313	243

Table 2. The production and revenue of nonwood plant products in the Sundarbans

Products	Unit	84-85	85-86	86-87	87-88	88-89	89-90	90-91	91-92	92-93	93-94
Golpata	tx1000	61	62	71	79	68	67	72	72	67	68
Hantal	tx1000	8.9	5.4	6	7.8	8.4	7.2	6.7	9	6	6.7
Grass	tx1000	9.3	11.01	11.7	13.4	13.5	11.6	7.1	4.6	5.7	5.1
					Revenue in Tkx1000						
Golpata		2,160	3,760	3,825	4,215	3,976	6,723	5,799	5,822	5,447	5,906
Hantal		0.39	142	170	210	223	339	334	448	391	339
Grass		25	33	94	108	119	104	57	37	73	.78

has now high demand for export. The estimated total yield of this species from the Sundarban is 39.2 t per year.

Shrimp fry production: About 80% of the nations total (107,000 ha) tiger shrimp farm area is located along the vicinity of the northern border of the Sundarbans. These farms are mostly dependent on the supply of fry from the rivers of the Sundarbans. Estimates vary from 200,000 to 400,000 fishermen in the Sunderbans, 80% of which catch crabs and shrimp fry (Moss 1996). An indirect estimate of *Penaeus monodon* fry collection indicated 1613 million from the Sundarbans (Moss 1995) whereas the FD records only 231 million.

Economic valuation of the fisheries has been seriously hampered by the lack of good record on which to base calculations. There have been no definitive stock assessments or inventories, even in the past and there is considerable debate over some of the data which have been collected (Mitchell, 1995) The Sundarbans fisheries have been valued in terms of the annual catch rather than the size of the stocks. True economic value of the fish harvest was estimated Tk 3.94/kg and estimated production is 76,700 t, Then the annual economic value of the fishery is Tk 134 million per year. This is equivalent of 2,325 million Tk invested at 13% interest rate. The value of total annual shrimp fry production is estimated by multiplying the number caught by economic value (Tk 325/1000). This gives a total value of shrimp fry production of Tk 54 million per year. An investment of Tk 4.16 billion at 13% would yield the same amount annually.

Fisheries in manmade mangrove: The significance of manmade mangrove also lies on the use of a great variety of fish and shrimp species that make use of this ecosystem in different manners. Like the Sundarbans a large number of fishermen collect

shrimp fry from the area. Seasonal fishermen also visit some of the islands for fishing during the dry season.

4.2 Oysters, shells and lime production:

Molluscs known as *Jhinuk* are harvested from the Sundarbans for lime burning. There are at least 5 species of bivalves in estuarine areas and the mangrove floor of the SRF (Chantarasri, 1984) of which the giant oyster (*Crassostrea gigas*) is the most economic species, these shells range from 15.2 to 38.2 cm width and weight between 15g and 2410 g for a single side. In 1993. The estimated production was 3,650 mt. An estimated 2030 oyster collectors involved in operating oyster collection in the Sundarbans.

4.3 Honey and bees wax gathering:

Collection of wild honey from the wild honey bee colonies *Apis dorsata* has been practiced for centuries in the Sundarbans. Honey collectors are also the poorest section of the local community. Table 3 shows the production of Honey and Bee's wax from the Sundarbans.

4.4 Wild animals:

Sundarbans animal products particularly the Royal Bengal tiger, is highly valued for skin and chinese medicine. According to an estimate the present population of tigers varies between 350-450 (Tamang, 1993). Hunting of this species is completely banned under wildlife preservation Act of Bangladesh. But Illegal killing of this species is not uncommon in the region. Deer meat is an important component of human diet and valued as honoured dish among the local community. Although in the past hunting for deer was allowed, this is banned by law at present, but killing of deer by illegal hunting still takes place.

Skin of Crocodile, Monitor Lizard, Rock Python and Turtle meat has high demand in the local and international market. Decline of the population of these animals has been reported but no systematic study on the status of population of these highly valued animals are available. Turtle eggs are known to be sold in local markets.

5. Tourism:

The rare wilderness value of the Sundarbans and its unique biota attracts a number of national and international tourists. According to an estimate 15,000 day visitors make local visits in the Sundarbans of which about 4% visitors are foreign tourists. There is a strong growing demand for facilities for recreation and relaxation for local tourists in the country. The tourism value of the Sundarbans shall greatly increase in the future. Apart from domestic tourism Sundarbans has great potential for attracting international tourists.

6. Socioeconomic dependence

People living in close proximity to the Sundarbans Reserve Forest (SRF) are most likely to depend on its resources to satisfy many of there day to day needs, such as food, fuel, materials for the construction of houses, boats, furniture and fishing implements medicinal herbs and many other items for trade. It is difficult to put and exact boundary within which such dependence exists mainly because the zone of influence is never so sharply defined. According to MARC (1995) the physical proximity zone would consist of a primary influence zone of 0-10 km band and a secondary influence zone of 10-20 km band. Survey of MARC (1995) also shows that total number of persons directly involved in SRF resource exploitation is about 291 000. There would be approximately 2.3 persons more depending on each of Sundarbans Reserved Forest harvester . If secondary activities are included then the total number of people involved would be considerably higher . The studies revealed about 46% of income being derived directly from SRF resources. The extent of dependence seemed to vary from area to area. The district lying in the eastern side showed substantially lesser dependence than did the western districts. Patuakhali 26%, Bagerhat 36%, Khulna 50% and Satkhira 59%. The level of dependence was similar among the poor and the rich all ranging between 40% and 46%. About two thirds of the household respondents reported some degree of dependence on the SRF resources for subsistence. It was 38% for seven months or more and 21% dependence was virtually for the whole year. The survey also revealed income related dependence on the SRF 45% of the bottom third not depending at all for subsistence. 24% and 36% of the middle and upper thirds depend on SRF respectively .

Table 3. The production of Honey ,Wax and Oyster from the Sundarbans.

Products	Unit	84-85	85-86	86-87	87-88	88-89	89-90	90-91	91-92	92-93	93-94
Honey	maunds	6,853	6,015	6,130	5,956	2,652	3,909	5,634	4,265	4,890	2,841
Wax	maunds	1,713	1,504	1,533	1,487	670	975	1,407	1,159	1,223	710
Oyster							2,960	2,470	3,080	3,380	

Study also indicated that at present about 80 % of the derived annual level of employment of the people who enter in to the forest are connected with harvesting fisheries products (Mitchel, 1995). Total number of man-days worked per year is 32.74 million which represent 112,000 full-time jobs. Most of this employment is seasonal and part time. So the total employment figure is many times greater, Shiva (1995) and MARC(1995) estimated the figure between 600,000 - 1,200,000.

The population along the main coastline is significantly dependent on the newly planted mangroves along the shelving coastline. There are some islands allotted where the government has given part of the land to the landless people who depend on the forest produce. The afforestation program provides employment opportunity for local villagers. It is estimated that 5 million man-days of employment has been provided over the last 25 years. During the winter season a large number of people migrate to many islands for fishing . The details of socioeconomic dependence of the people living there is yet to be clearly understood.

7. Indirect use:

7.1 Biodiversity and ecological function:

7.1.1 Flora of natural mangroves:

This ecosystem is unique in its biotic elements in relation to other mangroves of the world. The mangrove forest is a mosaic of vegetation types with varying density and height depending on the variation of environmental settings and management regime. The Sundarbans forest has been classified into 14 major forest types based on height of the forest strata and the density of the species. This vegetation thus formed provides niches for a diverse flora and fauna which include a number of threatened plants and animals. Though not considered as mangrove vegetation type the sandy flat coastline also support stranded vegetation consisting of herbaceous vegetation and scattered trees. The vegetation is important grazing area for ungulates, warblers and reptiles. Pockets of depressions in the swampy islands also supports reeds and sedges. This habitats has a value in itself because of its importance as nursery ground for a number of fishes and prawns. The fishes in the water and tall trees surrounding the depression provide an ideal habitat for egrets and other birds.

The diversity of mangrove plants of the Sundarbans. The tree species are represented by 22 families representing 30 genera (Karim, 1994 in IUCN). Unlike other mangroves in the world the dominant tree species in the Sundarbans is *Heritiera fomes* . Avicenniaceae are represented by 3 species, Meliaceae are represented by 3 species, Combretaceae are represented by 2 species and Sonneratiaceae are represented by 2 species. The shrubs and scandent shrubs are represented by 12 species belonging to 11 genera. 13 species belonging to the family Orchidaceae and seven epiphytic ferns have been reported from the forest. One orchid *Cirrhopetalum roxburghii* Lindl is reported to be endemic to the Sundarbans (Prain, 1903).

The algal flora of the Sundarbans is a poorly studied component of the Sundarbans ecosystem. Islam Nurul (1976), recorded 165 species of benthic marine and brackish water algae from the coast of Bangladesh. Many of the specimens were collected from the Sundarbans and its vicinity. Islam and Karim (1993) studied the soil algae of the Sundarbans. The Division Chlorophyta is represented by 6 genera and 9 species. Division Cyanophyta is represented by 9 genera and 16 species. Division Bacillariophyta is represented by 16 genera and 35 species while the Euglenophyta is represented by 2 genera consisting of 2 species.

7.1.2 Fauna of natural mangroves:

The Sundarbans rich diversity of wild fauna is unique heritage for the mankind . More than 350 species were listed for the Sundarbans which is higher than most other similar regions of the world. The

faunistic richness of the ecosystem is due to the varied nature of the environment and the ecological niches provided by the varied forest structure. A number of animals that were found in the region are either extinct from the ecosystem and population status of some species is threatened. It supports the last remaining viable natural population of the globally threatened species Royal Bengal Tiger (*Panthera tigris tigris*.) This species has been included in the CITES schedule I. The estuarine crocodile *Crocodilus porosus* and the Gangetic Dolphin that inhabit the estuaries of Sundarbans have also been considered as globally endangered. Table 4 shows the list of globally threatened animal species which find their habitat in the Sundarbans. The value of a tiger was considered to be US$50,000. The total opportunity value of the tiger population was estimated as US$2 million or Tk.80 million. Similarly for 20,000 spotted deer population it was calculated as Tk.100 million (Mitchell, 1995)

Seven species of Culicoid mosquitoes, one species of midges and at least a morphotype of gnats and Tabanidae were collected. Mosquito populations were at their highest at Burigoalini, biting midges at Dhangmari and tabanides at Katka. No known vectors of malaria and dengue were found in the Sundarbans.

7.1.3 Flora of man-made mangrove ecosystem:

These man-made mangrove forests support a number of species in addition to the planted mangroves, these species have colonized the area as a natural process of succession. Recent surveys revealed that at least 30 species belonging to 9 families colonized the area. Among the species *Porteresia coarctata,* a wild variety of rice, is common. The natural population of this species provides genetic pool to the development of salt tolerant varieties of rice in global plant hybridization program.

7.1.4 Fauna of man-made mangrove ecosystem:

The coastal habitat diversity - the intertidal mud and sand banks, sand dunes, creeks and channels, grasslands, and forests attract diverse animals. This include more than 200 species of mammals, amphibian, reptiles, birds and insects. Coastal areas of Bangladesh lie at the crossroads for the migratory birds between central Asian-Indian and East Asian-Australasian flyways. The last 10 years surveys conducted by NACOM estimated about 73 species of shore birds. This represents one of the highest concentration of shorebirds as far as the global species and population are concerned. Birds use the areas as their feeding, roosting and staging ground. A number of globally threatened species of warders have been using the area as their wintering ground (Khan, 1996) which includes Asian dowitcher, Nordmans Greenshank, Spotted Redshank and Spoon billed sand piper.

The Forest Department also has introduced deer and monkeys in some of the islands from the Sundarbans. The deer population has tremendously increased in those islands. Since the trees have grown above browsing height of the deer there had been no damaging effect on the existing vegetation. Some of the domesticated buffaloes which were released for fattening did not turn up to the owners. These buffaloes remaining in the wild for several generations acquired different behavior than the domesticated counterpart. Thus these manmade mangrove possess great potential for introducing a wide variety of animals adapted to mangrove environment.

7.1.5 Protection:

Mangrove ecosystem perform a variety of ecological functions such as protection from the cyclones, pollution abatement and energy conversion these are difficult to measure and even more difficult to describe in dollar value. However values are estimated for the principal indirect uses of the system by pricing the particular benefit by calculating the cost of an alternative investment that would yield a benefit of similar value or alternative investment against storms. The Southwest area water Resources Management Project (1993) estimated that the coastal defenses that would be required in the absence of the Sundarbans would be 2200 km of cyclone/ flood embankments. This would require a capital investment of Tk 16 billion and an investment of Tk 2.46 billion would be needed the opportunity value of the SRF protective function in these term was estimated at about Tk 18.46 billion equivalent to US$0.54 billion (FAP-4 report).

7.1.6 Land building and coastal protection:

These man-made mangrove ecosystem has achieved its functions as accelerating land building and consolidation of accreted land in the area with due success . It was observed during the intense cyclone of April 1991 that the intensity of damage to coastal embankments, life and property of the people were higher where there was no mangrove plantation indicating the

Table 4. The globally threatened animals found in the Sundarbans

Taxonomic group	No of species present in the SRF	Threatened species	Threatened status
Mammals	32	*Panthera tigris* (Tiger)	E
		Rhinoceros sundaicus	EX
		Bubalus bubalis (wild buffalo)	EX
		Cervus duvauceli	EX
		Axis porcinus	EX
		Platanista gangetica (Shushuk)	E
		Muntiacus muntjak	
		Felis viverrinus (Fishing cat)	CITES II
		Felis chaus (Jungle cat)	CITES II
		Lutra perspicillata (Smooth Iudian otter)	K,CITES II
Birds	315	*Leptoptilos javanicus* (Lesser adjutant)	
		Halietus leucorhymphus (Pallas Fish Eagle)	R
Reptiles	35	*Crocodylus palustris*	EX
		Python molurus (Python)	V
		Batagur baska (estuarine terrapin)	E
		Varanus bengalensis (Monitor lizard)	CITES II
		Lepidochelys olivacea (Olive ridley turtle)	CITES I
		Aspideretes hurum (Peackok Soft Shell)	CITES I
		Aspideretes gangeticus (Gangetic Soft Shell)	CITES I
		Kachuga tecta	CITES I
		Chelonia mydas(Green turtle)	
Amphibians	7	*Rana hexadactyla(Green Frog)*	CITES I

achievement of protective function of mangrove plantation. This man-made ecosystem itself was subjected to damage during the cyclone. Most of the plantation showed clear sign of recovery within 5-6 months with the exception of the areas where excessive silt deposit resulted (Saenger & Siddiqi, 1993).

7.1.7 Marine Production:

Based on some broad assumptions that 60% of the total shrimp industry and 20% of the white fish industry is dependent to some extent upon the flow of nutrients from the mangrove, it was estimated that three is an annual derived production of Tk 3.4 billion. With a net present value at 13%, a further Tk 26 billion is dependent on SRF.

Potential and Problem for development:

The mangrove ecosystem in Bangladesh exists in a continued process of creation and destruction of the ecosystem, and the state of knowledge on the significance of mangroves in Bangladesh is fairly comprehensive.

The fragility of the mangrove ecosystem is well known due to the openness of the system boundary and intricate linkage of this ecosystem with the upstream and down stream activities. This ecosystem remains in a dynamic equilibrium with the natural coastal process and delta development . But increasing human pressure greatly disturbs these processes which affect the ecosystem component. Depending on the intensity of disturbance the affect varies in different

areas ranging from complete destruction to the erosion of values of the ecosystem .

The natural mangrove areas are increasingly becoming scarce resources. The Sundarbans remains as the last natural mangrove area to protect some of the globally threatened plant and animal species. Irreversible changes may result in a loss of existence value of the biodiversity of the Sundarbans ecosystem. The unique biota of the Sundarbans are irreplaceable heritage of the mankind.

The Chakaria Sundarbans which was considered as one of the oldest mangrove has been destroyed for shrimp cultivation within a decade. The Sundarbans which still protected against encroachment are also subjected to overexploitation of resources. Environmental damage caused by the upstream withdrawal of freshwater due to a number of barrages on the Ganges and huge structural changes of the spill areas through construction of embankments have been expressed in the continued decline in productivity and damage to the forest structure of the Sundarbans ecosystem.

The Sundri top-dying phenomenon is a subject of great concern for the long-term sustainability of the resources and conservation of the ecosystem. Generally it is felt that the cause is a synergistic effect of predisposing, inciting and contributing factors outside the control of the forest department. The devastation caused by the top-dying phenomenon can be greatly improved through enrichment plantation followed by salvage felling (Karim, 1994). In the past Forest department raised some trial plantations in the Sundarbans with mangroves and non mangroves. The subject has been vividly reviewed and it was observed that plantation with indigenous mangrove species of the Sundarbans could be of great success and implemented without any delay (Karim, 1995 a, b). This program shall generate local employment and release the pressure on the forest due to other destructive uses.

The value of the resources and services that has been indicated for the mangroves in Bangladesh lies in its role for protection and biodiversity conservation (Table 5) which is mainly dependent on the maintenance of good forest cover. Given the present condition of top-dying of sundri unabated the productive potential of the ecosystem shall be further eroded. Perhaps within 30-40 years the entire Sudarbans will have to undergo remedial management of the vulnerable remnants. Salvage felling without any treatment to improve the stocking of the forest may lead to irreversible degradation of the site. The present knowledge of success of mangrove plantation with indigenous species in the Sudarbans should form the basis of enrichment plantation in the Sundarbans immediately (Karim, 1995). The manmade ecosystem can be manipulated to realize further benefit use and biodiversity conservation.

The man-made mangrove ecosystem was also faced with a number of problems due to erosion, and pests of the forest crop. The success of the introduced wild ungulates in the newly accreted islands have great potential for consumptive use of the animals with well thought out plan. However sandy beaches and mudflats require strict protection.

The present fisheries resources exploitation are not only causing great harm to the resource itself it is also threatening the future crop of the forest. Alternative technology and employment opportunity in the vicinity of the forests can release the pressure on the ecosystem from such an unsustainable uses.

Recommendations:

Ideally in the context of multiple benefit the mangrove ecosystem provide, the management of the mangrove resources should be tuned to a multiple use integrated resource management system.

A good management requires good scientific information for sustainable management of the resources. This shall require adequate understanding of the sustainable limit of the resource being used and also the impact of one use on the other which is lacking or not adequate for scientific management in the mangrove areas of Bangladesh.

An informed public opinion and institutional flexibility to accommodate great participation of local community in the management of the resources is needed for development, sustainable utilization and protecting rich biodiversity of the mangrove ecosystem. As a first step towards that direction an awareness and conservation education program

Table 5. Summary of total direct and indirect benefits of Sundarbans Forest

Products	Annual Rev	Capital Equivalent	Standing Value	Estimated Total	
	Million Tk	Million Tk	Million TK	Million TK	Million US$
Wood	715.66	5,505	47,202	47,202	1,180
Golpata	22.6	174		174	4.34
Hantal & grasses	0.6	5		5	0.11
Animal Products					
Fish	302.44	2,326		2,326	58.16
Shrimp fry	541.2	4,163		4,163	104
Apiculture	2.2	17		17	0.42
Molluscs					
Miscellaneous	2.42	19		19	0.47
Total Direct Value of animal products					
Total Direct Value				53,906	
Flood and Storm protection	320	2,462	16,000	18,462	462
Existence Value	100	769		839	21
Value of Dependent Product	3,371	25,930		25,930	650
Biodiversity Value	?	?	?	?	?
Total Indirect Value	**3,791**	**29,161**		**45,231**	**1,133**
Gross Value	**5,378.12**	**41,370**		**99,137**	**2,480.5**
Management Cost of FD	34.17	263		263	6.57
Net Present	**5,344**	**41,107**		**98,874**	**2,473.93**

involving local community should be implemented at non government level.

Besides the government agencies the non government organizations should be encouraged to undertake participatory research to supplement both for information and awareness building for the sustainable utilization of resources

Efforts should be made to undertake bufferzone development schemes to provide alternative income to the people who are making the destructive use of the resources. NGOs should be encouraged to undertake development schemes awareness building activities in the bufferzone.

Silvicultural system should be based on adequate scientific information and ecological principles. Action should be taken to rehabilitate top-dying affected areas with enrichment plantation. Research should also continue to find the cause of top-dying and improve the rehabilitation techniques of the ecosystem.

Research should continue on the development of fisheries resources and impact of use of fisheries resources on the sustainable productivity of forest should be undertaken.

Action plan for conservation of threatened animal and plants should be undertaken to save the threatened plants and animals.

In the light of the present understanding of the role of coastal plantation areas for protecting an important bird area of a large number of globally endangered birds it is imperative that the objective of the coastal afforeststation should be redefined.

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Significance of Mangrove Ecosystems for the Coastal People in Ayeyarwaddy Delta, Myanmar

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Abstract

During 1993, a socioeconomic study was made on the mangrove dependent people of Ayeyarwaddy in an attempt to unravel the problems besetting these people, in an environment where the resources on which they are just managing to survive, are fast eroding.

The Ayeyarwaddy Delta is the most densely populated division in the country, with 442 persons per sq. mile i.e. three times that of the whole country. An attempt was made to classify the population in the study area into residents and migrants. There are more migrants in Latputta than in Bogalay. The migrants in current parlance may well be called economic refugees for there is more opportunity in fishery occupations, as there are riverine as well as off-shore fisheries that offer good opportunities in Latputta.

Again among the three occupations, fishery and forestry workers combined exceeded the paddy growers in Bogalay. The conclusion is that due to the still remaining mangrove resource base, there are more residents than migrants in Bogalay.

All three occupations, paddy growers, fishery and forestry workers, nonetheless are in direct contact with the mangrove wetlands ecosystems. These three occupations combined comprise 64.58% of the households in Bogalay and 57.61% in Latputta. The most popular occupation in Bogalay is paddy cultivtion, followed by fishery and forestry work. Fishery is highly represented in Latputta but with equal proportions of paddy growers and forestry workers.

In Latputta the mangrove resource base is almost denuded while at Bogalay there are still some intact mangrove resources.

Using income generation and net savings to indicate financial status, the Bogalay study group is in comparatively good standing compared with the Latputta group. However, in terms of their general situation and looking at all factors combined, people in these area just survive. All along the riverside one can see ramshackle dwellings indicating the lack of building materials and poorly built houses, which reflect the financial status of the population.

Aside from some 30-33% with educational qualifications up to the primary level and monastic education the people in the study areas do not have much higher education.

The people are quite aware of the dwindling production from the mangroves and the hardships they have to face in getting the forest products, and they are now prepared to participate in efforts on reforestation. This is a most welcome and a positive gesture. The production of firewood and charcoal in the region accounts is most discouraging as this region has the largest deficit among the seven fuel-wood-deficit regions in the country.

Finally in order to motivate further partnership with the people in rehabilitation works, extension works, together with demonstration plots of agroforestry, agro-silvi-fishery, participatory forestry, etc., will play major roles in showing the significance of mangrove ecosystems for the coastal people in Myanmar.

Introduction

The Forestry Consultancy Group (F.C.G) under contract with UNDP/FAO project MYA/90/003/A/01/12, Feasibility Study on Mangrove Reforestation, has undertaken a socioeconomic study as stipulated in the Terms of Reference of the contract which read as follows:

Description of Activities/Services.

a) Study project documents produced under MYA/ 90/003 and other documents of relevance for the study;

b) Design a socioeconomic study covering quantitative as well as qualitative data on population and land-and-water use systems typical for the study area;

c) Select strata of population and land-and-water use systems typical for the study area;

d) Select by random sampling, villages and households from the selected strata;

e) Carry out a socioeconomic study through interviews with local government officials, village leaders and households members;

f) Identify needs and scope for rural extension activities and in particular to identify primary target groups needs, problems, indigenous technical knowledge, and their own developed strategies or suggestions to solve their problems;

g) Review existing rural institutions in the area and their actual and potential role in rural development activities and in particular the role of forestry extension in such activities;

h) Present some preliminary results of the study in a mangrove seminar-cum-workshop;

i) Prepare a concise report on its findings and recommendation according to approved FAO format, which report should be discussed fully with local counterparts / supervisor(s) and presented in draft form to the officer in charge of MYA/90/003.

Field study was begnn in January 1993, and completed in February. The study areas were chosen in consultation with The Township Forestry Officers of Bogalay and Latputta. These townships were chosen because Bogalay is a representative area of some good mangroves and Latputta is representative of an almost totally denuded mangrove area.

There are three main sectors of the rural economy dependent on the mangrove ecosystems. In rank order they are agronomy, fishery and forestry in Bogalay, and Fishery, agronomy and forestry in Latuptta. These ranking are in terms of number of households engaged in the said occupations.

Background Information on the Ayeyarwaddy Division

Ayeyarwaddy Division is one of the most important divisions of the 14 States and Divisions in Myanmar. It is said to be the granary of the country, as around 70% of the country's rice requirement is met from the paddy production of this division. In addition to paddy the division is one of the main sources of firewood and charcoal to Yangon and its environs.

The division is well watered by rain and tidal waters, and is therefore ideal for paddies and fishing. The oxbow lakes are good fishing grounds. The division is, therefore, a major producer of fish, prawns, crabs and their products such as fish-paste, dried prawns and fish. The fisheries are both near shore and off-shore. Fish breeding is one of the foremost industries practiced in the hinterlands. Linked with the preservation of fish, salt production from the brine also is one of the major industries of the division.

Besides forestry, fishery and agriculture, there are some manufacturing industries such as the jute mill at Myaungmya, glass factory at Pathein, the oil fields and electricity generation from gas turbines around Myanaung, and the cement factory at Kyangin. With these resources, the division has been contributing a substantial share to the national economy.

The division has an area of 13,566 sq. miles. There are 26 townships comprising of 207 wards and 1922 villages. The population stood at 4,994,061 during the 1983 census. The population density was 368 persons/sq. mile, which was the highest in the country. The sex ratio then was 99.4 males to 100 females. Rural and urban population then stood at 85.1% and 14.9%. Age distribution then was 37.3% for age under 14 years old, 55.2% for ages from 15 to 59 years, and 7.5% for age 60 years and over. The dependency ratio was 0.81 for the division as a whole, but 0.86 and 0.89 for Bogalay and Latputta respectively. With an

inter-censal growth rate of 1.89% between 1973 and 1983, the estimated population in 1993 was around 6,022,998, or 444/sq. mile.

Objectives of the Socioeconomic Study

Objectives of the socioeconomic study were as follows:

To collect baseline data on parameters related to the social and economic status of the mangrove-dependent rural communities in selected villages of Bogalay and Latputta.

To determine the status of the remaining, but fast-dwindling mangrove resource, and to plan and find solutions.

To see that production from all three sectors meets the people's needs, and to share the excess produce with other regions to help the national economy.

To find solutions to maintain agricultural productivity which has been adversely affected in the near-coastal regions by tidal intrusion, and affected and on higher ground by acidification processes.

To foster the people's awareness of needs to safeguard environmental stability and to arrest degradation of the mangrove wetland ecosystem to enhance the productivity of all sectors dependent on the mangroves.

To stimulate people's participation in reforestation endeavor to establish community fuelwood plantations in the public forests, and to introduce agroforestry systems where feasible.

To arouse public awareness of provisions of the new legislation for public sector involvement in establishing local supply and commercial firewood plantations.

To alleviate the poverty of rural people dependent on the mangrove ecosystem by harmonizing the three sectors involved in the use of the resource base (farming, fishing and forestry), with a view to sustaining productivity and helping to boost the rural economy.

Finally to foster people's awareness and stimulate their participation through extension activities using all available media.

Background Information on the Ayeyarwaddy Resource Base

In addition to regional use, the Ayeyarwaddy Delta has supplied a great deal of firewood and charcoal to the consumers in Yangon. The quality of biofuels in the past was excellent, as there were many species of mangroves well known for producing quality firewood and charcoal, such as *Heritiera fomes*.

Besides being the wood energy bank, the mangal communities of the delta also provided a host of forest products useful to man, such as *Ceriops tagal*, well known as a species used for house posts, and also poles for the most important timber industry. Species producing timber for other construction uses were also abundantly available from those mangrove forests.

The status of significant mangrove species in the Ayeyarwaddy District as reported in 1924 and in 1984 after 60 years of over-exploitation is shown in table 2.

The stock of *Heritiera fomes* at present is mostly the regrowth of saplings. Large size trees are a rarity. The stock of other of useful-sized trees of other mangrove species has also dwindled so that the remaining

Table 1. Population and Dependency Ratio (D.R.) from the 1983 Census

Age Groups	Total Division	D.R.	Total Bogalay	D.R.	Total Lataputta	D.R.
0-14	1,863,890	0.68	120,046	0.76	99,285	0.79
15-59	2,757,047	---	157,843	---	126,283	---
60 +	373,124	0.14	16,336	0.10	12,948	0.10
Total	4,994,061	0.81	294,225	0.86	238,516	0.89

Table 2. The status of significant mangrove species in the Ayeyarwaddy District as reported in 1924 and in 1984 after 60 years of over-exploitation.

Species	Percent of Area	
	1924	1984
Heritiera fomes	67.10	18.11
Cynometra memosoides	11.62	1.88
Ceriops tagal	11.59	6.74
Sonneratia apetala	0.79	0.23
Bruguiera spp.	0.66	1.65
Sonneratia caseolaris	0.20	0.76
Blanks	8.04	
Total	100.00	29.37

mangrove area in Ayeyarwaddy is the last stronghold for this invaluable wetlands ecosystem.

The main causes of forest depletion now in Ayeyarwaddy are the conversion of mangrove forests to paddy fields, encroachment into the forest areas and heavy over-cutting, mainly for biofuels. All three of these causes are equally responsible.

Table 3 shows the classification of land use for the Ayeyarwaddy Division in 1983. Table 4 shows the land use classes and the status of forests in 1991.

In 1983 there was a total of 3,515.55 sq. miles of forest reserves and public forest lands. By 1991 there was 3,292.28 sq. miles of closed and degraded forests, a decrease of 223.27 sq. miles (6.35 %) over a span of 8 years.

Methodology of Data Collection for the Socioeconomic Study

Two sets of questionnaire forms were designed. One was for village elders and selected villagers to give their views and attitudes on the resources and the issues and problems they have come across. The other form was to collect information on the socio-economic status of individual households in the villages.

In the Bogalay study area, 7 villages (1.44%) were chosen out of 487 in the first stage of sampling. At the second stage, 144 households (3.43 %) were chosen from a total of 4199 households. In Latputta 8 villages (2.03%) were taken from amongst 395. At the second stage of sampling, 184 households (8.56%) were selected out of the total of 2,159. Samples were taken carefully to include three main occupation groups (farming, fishing and forestry) and also to represent poor, middle class and well-off among the paddy growers.

The analyses were done on the three occupational groups, as the study was concerned primarily with the relationship of the mangrove dependent people and their socioeconomic welfare.

Socioeconomic Data Base

Demographic Data

Populations in the selected area for 1983 and 1993 are shown in table 5.

The total population, population and gender composition of households in the Bogalay and Latputta study areas are shown in table 6. There were 49.32% males and 50.68% females in Bogalay and 49.71% males and 50.29% females in Latputta.

Educational status by gender for Bogalay and Latputta is shown in table 7.

The proportion illiterate or with only monastic or primary levels were slightly higher among females. The distribution of educational levels is consistent with the idea that primary education is considered to be sufficient in the rural setting. Only 21.9% of both sexes combined pursued higher education in the Middle and High levels, and a mere 1.1% of both sexes got the university education. Household sizes by occupation are shown in table 8.

In Bogalay the mean household sizes according to occupation vary between 5.3 and 5.9, except for the two households of fishery products processors where the mean was 6.5. The mean of the entire population was 5.6 with the standard deviation of 2.2. In Latputta, except for the small number of households in such occupations as non-paddy growers, processors of fishery products, and salt production, the mean

Table 3. Classification of land use for the Ayeyarwaddy Division in 1983.

Land Use	Acres	Percent
Agricultural Land	4,373,956	49.57
Forest Reserves	1,779,758	20.17
Public Forests	470,197	5.33
Cultivable Land	645,443	7.32
Non-cultivable Land	1,554,146	17.61
Total	8,823,500	100.00

Table 4. Land use classes and the status of forests in 1991.

Land Use	Area in sq. miles	Percent
Closed forests	1,905.79	14.05
Degraded forests	1,386.49	10.22
Shifting cultivation	452.90	3.34
Non forest	8,744.78	64.46
Water bodies	1,076.06	7.93
Total	13,566.02	100

household sizes did not vary much from that of the entire study population.

Population and dependency ratio (D.R) in Bogalay and Latputta in 1993 are shown in table 9.

The age 0 - 9 year old age group, are considered to be dependents on the working population. Soon after their primary education young children start working on small odd jobs to earn money or help the family in daily work. The older people in the study area were healthy enough to work even beyond 60 years of age so the age of old-age dependency was, therefore, taken as 65 years and over.

Residential Status

Residential status of the villagers in the study area may be stated as shown in table 10.

The criterion for determining residential status, whether native or the migrant, varies with the particular study. In the country-wide census taken in 1983, a household member who stayed for 6 months was taken as native to the place. In this study no such criterion was used. The household head was simply asked whether he or she belonged to the village. The majority of households in the Latputta study area did not consider themselves to "belong to" their respective villages. They were, in fact, migrants from other places and working in the paddy lands as Latputta had a great deal of mangrove land converted to paddies.

Financial Status of the People in Bogalay and Latputta

Distribution of occupations of households depending on the mangrove in Bogalay and Latputta is presented in table 11.

In the Bogalay study area the proportion of households depending on paddy cultivation and fishing were about equal, but in Latputta fishing was the major occupation.

Mean income (in kyats) generated by in Bogalay and Latputta households is shown in table 12.

Mean expenditures incurred by households for Bogalay and Latputta are shown in table 13.

Table 5. Populations in the selected area for 1983 and 1993.

Year		1983			1993 (Projected)		
		Total	Rural	Urban	Total	Rural	Urban
Bogalay	No.	294,225	252,335	41,890	353,419	303,101	50,318
	%		85.76	14.24		85.76	14.24
Latputta	No.	238,516	210,841	27,675	262,398	235,602	26,796
	%		88.40	11.60		89.79	10.21

Table 6. Total population, population and gender composition of households in the Bogalay and Latputta study.

Bogalay

Sample Villages	Households		Sample Household Members		
	Total	Sample	Total	Male	Female
Kunthichaung	244	15	91	49	42
Damathukha	82	7	35	16	19
Satkyun	566	15	90	38	52
Setsun	864	31	182	85	97
Ahmar	386	26	136	69	67
Kadonkani	2,006	34	168	84	84
Total number	4,199	144	803	396	407
Total percent		3.43		49.32	50.68

Latputta

Sample Villages	Households		Sample Household Members		
	Total	Sample	Total	Male	Female
Hlwaza	264	30	152	81	71
Yedwinzeik	50	10	59	27	32
Ayardawngu	210	20	98	51	47
Danizeik	57	13	82	42	40
Peinnegon	359	18	122	52	70
Thitpok	247	31	165	78	87
Polaunggyi	359	31	166	83	83
Kaingthaung	604	31	186	98	88
Total number	2,150	184	1,030	512	518
Total percent		8.56		49.71	50.29

Table 7. Educational status by gender for Bogalay and Latputta.

Educational Level	Gender	
Level	Male	Female
Illiterate	1.60%	2.60%
Monastic and Primary Levels	30.20%	33.70%
Middle Level	8.70%	5.80%
High Level	4.10%	3.30%
University Education	0.50%	0.60%
Total	45.10%	46.00%

Household ranking of expenditures for various items in Bogalay and Latputta is shown in table 14.

In Bogalay the five highest items in order of rank were food, clothing, more than one item, health, and education, whereas in Latputta they were food, more than one item, health, clothing, and education.

Recommendations and Conclusion

Recommendations

Land use policies for forestry, agriculture and fisheries has to be resolved once and for all since many of the forest reserves were either deforested or encroached for agriculture and fishery developments.

Table 8. Household sizes by occupation.

Location	Bogalay			Latputta		
Occupation	House holds	Mean Sizes	Standard Deviation	House holds	Mean Sizes	Standard Deviation
Paddy growers	41	5.9	1.9	24	5.8	2.8
Non-paddy growers	5	5.6	1.7	1	7.0	--
Forestry	17	5.4	1.9	24	5.9	2.6
Fishing	35	5.6	2.5	58	6.2	2.2
Fishery products	2	6.5	0.7	4	4.5	1.3
Salt production	--	--	--	3	7.0	1.0
Other	44	5.3	2.6	70	4.9	1.6
Entire population	144	5.6	2.2	184	5.6	2.2

Table 9. Population and dependency ratio (D.R) in Bogalay and Latputta in 1993.

Age group	Bogalay	D.R	Latputta	D.R
0 - 9 years	156	0.25	251	0.33
10 - 64 years	625	--	758	--
>64 years	22	0.04	21	0.03

Table 10. Residential status of the villagers in the study area.

Location	Households	Residential Status	
	Sainple	Native	Migrants
Bogalay	144	86 (54.70%)	58 (40.30%)
Latputta	184	54 (29.35%)	130 (70.70%)

The last vestiges of the delta mangroves should be rehabilitated speedily through natural forest regeneration techniques such as "Regeneration Improvement Felling (R.I.F.), aided by reforestation of the completely denuded and enchroached areas.

Reforestation attempts should be carried out through Community Participation.

Agro-forestry, agro-silvi-forestry and participatory forestry should be encouraged and implemented.

Demonstration plots for agro-forestry, agro-silvi-forestry and participatory forestry should be constructed, and the extension wing of the Forest Department has to be strengthened to encourage the environmental awareness of the local communities.

Income generating activities such as eco-tourism should be encouraged.

Conclusion

The people in the study area and also in all of the Ayeyarwaddy Delta depend on this mangrove ecosystems. If the system breaks down all these rural communities as well as urban population will suffer. Their survival rests with the immediate reshabilitation of these denuded mangrove communities.

Table 11. Distribution of occupations of households depending on the mangrove in Bogalay and Latputta

Bogalay

Occupation	Mangrove Dependent				Other Occupation		Total	
	Main Occupation		Subsidiary Occupatiou					
	No.	Percent	No.	Percent	No.	Percent	No.	Percent
Paddy	29	20.1	8	5.6	4	2.8	41	28.5
Non-Paddy	1	0.7	2	1.4	2	1.4	5	3.5
Fishing	29	20.1	3	2.1	3	2.1	35	24.3
Fishery Products	2	1.4	---		---		2	1.4
Forestry	12	8.3	3	2.1	2	1.4	17	11.8
Other	---		11	7.6	33	22.9	44	30.5
Total	73	50.6	27	18.8	44	30.6	144	100.0

Latputta

Occupation	Mangrove Dependent				Other Occupation		Total	
	Main Occupation		Subsidiary Occupation					
	No.	Percent	No.	Percent	No.	Percent	No.	Percent
Paddy	9	4.9	10	5.4	5	2.7	24	13.0
Non-Paddy	1	0.5	---		---		1	0.5
Fishing	39	21.2	10	5.4	9	4.9	58	31.5
Fishery Products	1	0.5	1	0.5	2	1.1	4	2.2
Forestry	15	8.2	2	1.1	7	3.8	24	13.0
Salt Production	2	1.1	---		1	0.5	3	1.6
Other	---		16	8.7	54	29.4	70	38.1
Total	67	36.4	39	21.2	78	42.4	184	100.0

Note: Subsidiary mangrove dependent occupations are mutually exclusive to the main occupations.

Table 12. Mean income (in kyats) generated by in Bogalay and Latputta households.

Income Generating Occupation	Mean Household Income	
	Bogalay (Kyats)	Latputta (Kyats)
Paddy Cultivation	75,141	39,689
Non-Paddy	141,000	70,000
Forestry	75,147	47,512
Fishing	94,412	47,653
Fish Products	42,500	52,750
Salt Production	---	72,667
Other	87,532	33,553
Entire population	85,449	41,872

Table 13. Mean expenditures incurred by households for Bogalay and Latputta.

Income Generating Occupation	Mean Household Expenditures	
	Bogalay (Kyats)	Latputta (Kyats)
Paddy Cultivation	61,510	35,937
Non-Paddy	96,398	72,000
Forestry	71,724	44,107
Fishing	65,302	46,872
Fish Products	44,275	42,187
Salt Production	---	141,667
Other	71,642	32,213
Entire population	67,733	41,099

Note: It was extremely difficult to get the correct information on both income as well as expenditure.

Table 14. Household ranking of expenditures for various items in Bogalay and Latputta.

Item	Household Reports of Ranking of Expenditures	
	Bogalay	Latputta
Food	144	180
Fuel	14	19
Education	27	50
Health	45	83
Clothing	87	73
Residence	14	3
Utilities	7	4
Social	24	5
More than one item	70	131
Total households	144	180

Fig. 1. *Kandelia candel. Avicennia officinalis* (background)

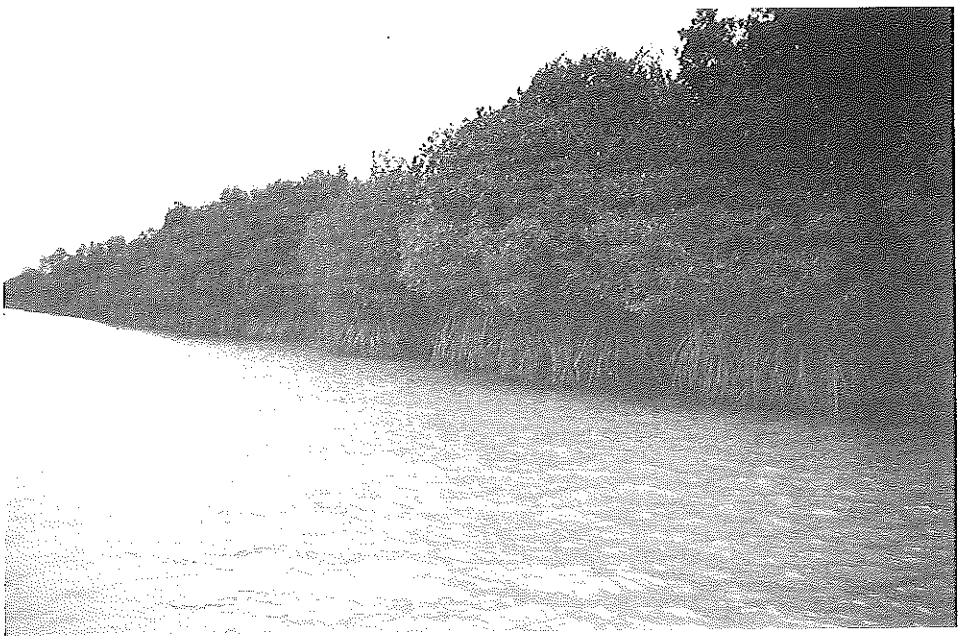

Fig. 2. *Rhizophora apiculata*

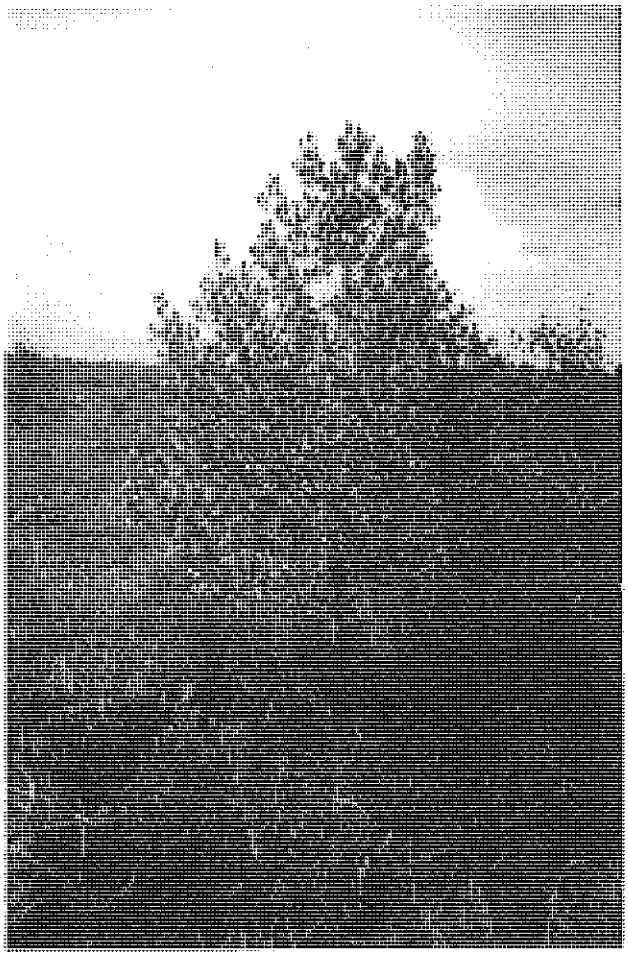

Fig. 3. *Lumnitzera racemosa*

Fig. 4. *Heritiera fomes*

A Note on Indonesian Efforts in Developing Community-Based Management of the Mangrove Ecosystem

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Abstract

Indonesia is blessed with rich and diverse renewable and non-renewable natural resources. One of the renewable natural resources is the mangrove ecosystem. Indonesia has 4.25 million hectares of mangrove ecosystem, probably one of the largest areas of mangroves of any country in the world. Mangroves are distributed on all the major islands of Indonesia. The largest concentration, approximately 70 percent, is found in Irian Jaya Province.

High population density on Java and in large cities combined with increasing economic development activities in the coastal areas have resulted in severe impact on the mangrove ecosystem. In addition, the increasing drive of human society with its technological manipulations is almost always accompanied by undesirable side effects. However, since changes are inevitable, it is necessary to develop the best means to ensure that they will have the fewest possible negative impacts and that ecological principles are closely followed in their implementation.

One of the efforts in conservative, sustainable use and rehabilitation of mangroves in Indonesia is by community participation. This paper briefly describes the distribution and condition of mangrove ecosystems in Indonesia and the problems and efforts in developing community-based management.

Introduction

The Indonesian archipelago is located between two continents, Asia and Australia, and between the Pacific and Indian Oceans. It is the largest archipelago in the world composed of more than 17,000 islands. Seventy percent of the archipelago is covered by the sea. The coastlines extend to more than 81,000 km, probably comprising one of the longest national coastlines in the world. Along the shores of the Indonesian islands, one can find various coastal resources that are of great importance to the majority of the Indonesian people. One of these resources is the mangrove ecosystem.

This paper summarizes the knowledge, the problems and the efforts, with an emphasis on community participation in managing mangrove ecosystems in Indonesia.

Mangrove Ecosystems in Indonesia

In Indonesia, mangrove ecosystems develop well along the leeward coastlines of most of the large islands. The following is a brief review of present knowledge of mangrove ecosystem in Indonesia. For more detailed reviews see Kartawinata *et al.* (1979), Soegiarto (1980; 1991) and Soemodihardjo (1984).

a. Area and Distribution

Earlier authors including MacNae (1974) and Van Steenis (1941 and 1958) stated that mangrove ecosystems in Indonesia were only one to two million hectares in area. However, intensive surveys and mapping in recent years using satellite imagery and aerial photography, have produced an official figures of 4.25 million hectares (Darsidi, 1984). This may still be an underestimate (Soemodihardjo, 1984). However, due to population pressure and increasing demands for land for development activities, the mangrove area at present has probably been reduced to less than 2.5 million hectares.

The mangrove areas are distributed throughout the islands of the Indonesian archipelago (Table 1). About 70 percent of the mangrove ecosystem in Indonesia is found on Irian Jaya. In general, it is still in pristine condition. In contrast, only about 50,000 hectares are left of the mangrove ecosystem on Java which is the most disturbed. The largest remaining mangrove stand

Table 1. Distribution of mangrove ecosystem in Indonesia (after Darsidi, 1984)

Province		Areal coverage (ha)
1.	Aceh	54,836
2.	North Sumatra	60,000
3.	Jambi	65,000
4.	Riau	276,000
5.	South Sumatra	195,000
6.	Lampung	17,000
7.	West Kalimantan	40,000
8.	Central Kalimantan	10,000
9.	East Kalimantan	266,800
10.	South Kalimantan	66,650
11.	Jakarta	95
12.	West Javaz	28,513
13.	Central Java	13,577
14.	East Java	7,750
15.	Bali	1,950
16.	West Nusa Tenggara	3,678
17.	East Nusa Tenggara	1,830
18.	South Celebes	66,000
19.	Southeast Celebes	29,000
20.	North Celebes	4,833
21.	Moluccas	100,000
22.	West Irian	2,943,000
	Total 4,251,011	3,158,041

in Java is found in Segara Anakan, Cilacap, on the south coast of Central Java.

b. Uses

For centuries Indonesian people have used mangroves for firewood, charcoal, tanning dyes, timber and for the construction of boats. The following genera are frequently used for those purpose: *Rhizophora*, *Bruguiera*, *Ceriops*, *Avicennia*, *Nypa* and *Oncosperma*. Nypa leaves can be used for various things, such as thatched roofs, baskets and cigarette "paper". The stalks of the flower are cut off and the sap is tapped for making brown sugar or the fermented palm wine or "arak". These traditional uses of mangroves resources go hand in hand with larger scale exploitation using higher capital investments and technologies. For example, Riau Province in Sumatra has long been a center for charcoal production from mangrove trees. The product is exported to Singapore, Malaysia and Hong Kong. There are 836 kilns operating in Riau (Soegiarto, 1991). Exports of charcoal in 1982 amounted to over 22,000 tons at a total price of slightly over one million U.S. dollars.

Export of mangrove logs is also a lucrative business. These logs originate in Sumatra, Sulawesi and Kalimantan are exported to Japan and Taiwan for conversion to wood chips. In 1978 the export of logs amounted to 382,737 tons. In 1981 West Kalimantan alone exported 25,409 tons. Some Japanese-Indonesian joint chip mill enterprises have started operation in Indonesia. An example is Chipdeco, in East Kalimantan.

Mangrove wood is also used as raw materials for one large paper mill in Gowa, South Sulawesi. At the Gowa plant, bamboo is used as basic raw material but supplemented by mangrove wood and also eucalyptus. Experience has shown that a process with a ratio of 80% bamboo and 20% mangrove produces a very good quality paper (Rachmat 1975). Presently, a paper mill has been established by a joint American and Indonesia company using mangrove chips in West Irian.

c. **Some Environmental Problems**

Mangrove ecosystems can prevent erosion and stabilize coastlines. They also serve as a habitat for spawning and as nursery for many economic important species and even probably as a pollutants trap. Most of the environmental problems in mangrove ecosystems are related to the modes of exploitation to which they are subjected. Conversion of mangrove areas to other uses, such as intensive fish and shrimp pond culture, for rice production or for industrial development is also occurring (Soemodihardjo 1984).

Although mangrove soils are generally marginal for agriculture (Notohadiprawiro 1979), conversion of mangrove land for this purpose has occurred in some parts on Indonesia. Important examples are in Cilacap, Indramayu and Sukamandi (Sukardjo and Akhmad, 1982). Other agricultural uses of mangrove land for coconut plantations occur in Riau Province and in other parts of Sumatra, where they are often developed by coastal communities of Bugis origin.

Extensive mangrove land conversion has been carried out for brackish water fishponds or "tambak". There are about 180,000 hectares of "tambak" distributed mainly in Java, Sulawesi and Sumatra (Suwito 1982). Traditionally, the "tambak" ponds are used to raise milkfisk (*Chanos chanos* Forsk), whereas *Mugil cephallus*, *Tilapia mossambica* and penaeid shrimps (*Penaeus* spp.) are secondary products. In order to raise foreign exchange earnings from the fisheries sector, many private companies in cooperation with local authorities have constructed about 100,000 hectares of new "tambak" for rearing the highly priced tiger prawn (*Penaeus monodon*) in the last five year. Although much of the new "tambak" will be constructed in the other islands, a certain percentage still will be constructed in Java. For example, on the north coast of West Java alone some 10,000 hectares of new "tambak" have been constructed for prawn culture (Tim Ekosistem Mangrove, 1984).

In recent years the demand for mangrove land for human settlement, industrial estates, ports and other facilities has increased rapidly. Around the cities of Jakarta and Surabaya, a large portion of mangrove land has been or is being converted into housing complexes, industrial sites, warehouse compounds, harbor developments and recreational areas (Soemodihardjo, 1984).

Water pollution is another form of pressure exerted on mangrove ecosystem. The Showa Maru oil spill, in the Singapore Strait in 1975, resulted in widespread death of mangrove trees along the coast of islands adjacent to the site of the spill. Even three years after the spill, the affected mangrove areas did not show any sign of regeneration (Soegiarto, 1981). Continuous low level exposures to refinery effluents is also detrimental to mangrove ecosystems. Sulthoni *et al.* (1982) reported a high mortality of mangrove seedlings immediately after the Cilacap oil refinery began to operate in 1977.

d. Management and Conservation

Responsibility for managing mangroves in Indonesia is in the hands of the Department of Forestry. In Java this function is delegated to the "Perum Perhutani" (State Forest Corporation) and to the "Perum Inhutani" for mangrove areas outside Java.

In order to maintain mangrove ecosystems the Indonesian government, through the Department of Agriculture and Department of Forestry, has regulated the cutting of mangrove forests. Green belts of 50-200 m of mangrove must be retained along the coast and 10-20 m must be retained along river banks. This regulation was first announced in 1975 by the Directorate General of Fisheries and was soon followed by a regulation of the Directorate General of Forestry. These two regulations were combined in 1984 and co-signed and announced by the Minister of Agriculture and the Ministry of Forestry. The green belts serve not only to preserve the ecological functioning of mangrove ecosystems, but also to ensure the natural regeneration process of the mangroves in the region.

Unfortunately, the uniform width of green belt for the entire Indonesian archipelago was considered inappropriate. Therefore, after some studies and discussions, the Indonesian National Committee on Mangrove Ecosystem proposed that a formula for determining the width of the mangrove green belt in coastal area should be developed replacing the uniform width. The proposed formula takes into account the width of mangrove ecosystem in the area, the slope of the coastline and the tidal range. This formula now has been announced and put into effect as an integral part of Presidential Decree No. 32 (announced in July 1990), on the Management of Protected Forest Areas. This formula is now applied throughout Indonesia. For detail information on the considerations at arriving at this formula, see Soerianegara (1987).

Another effort in conserving the mangrove ecosystem in Indonesia is by establishing a protected and conservation area. To ensure that natural ecosystem will still exist for future generations, a number of nature reserves have been established in Indonesia. Many of these reserves are located in coastal areas, and some have mangrove components. Currently there are 13 reserves which have the protection of mangroves as a principal aim (Soegiarto *et al.* 1982). Mangroves are also found bordering 14 other protected areas where they are of secondary interest. Nine more proposals for mangrove reserves have been approved by provincial governors, and a great number of proposals are currently being processed at the Directorate General of Forest Protection and Nature Conservation. Surveys and studies of those proposed sites are now underway. They are carried out jointly

by the Directorate of Nature Conservation, Center for Research and Development in Oceanology, Center for Research and Development in Biology, some universities and the World Wildlife Fund of Indonesia.

Organization and Cooperation

While the principle responsibility for managing mangrove forests is in the hands of the Department of Forestry, research programs and other relevant activities on mangrove ecosystems are carried out by a number of government agencies, research institutions and universities. In order to coordinate the activities and efforts of these bodies a National Mangrove Committee (NATMANCOM) was established in 1980. Currently the committee has some twenty members, representing government agencies and development programmes pertaining to mangrove ecosystems. The membership is reviewed and updated every two years.

The following are some of the Committee's activities:

- to coordinate research programs on mangroves
- to prepare lists of institutions and agencies dealing with mangrove programmes
- to prepare a directory of mangrove scientists
- to compile and update a bibliography on mangrove research in Indonesia
- to grant limited amounts of financial support for research
- to develop and enhance regional and international cooperation on mangrove ecosystem.
- to organize a scientific seminar on mangrove ecosystem every four years.

The purpose of this seminar is to review the state of knowledge, to evaluate research results and to plan and give direction for future research programs. So far, five national seminars on mangrove ecosystem have been organized. The first seminar was held in February 1978 in Jakarta, the second was in August 1982 in Baturraden-Purwokerto, Central Java, the third was in 1986, in Denpasar- Bali, the fourth was held in August, 1990 in Lampung (South Sumatra), and the fifth was held at the University of Jember, East Java in September, 1994. Proceedings of the seminars are published within one year after the seminar.

Rehabilitation

One of the positive management activities of the Perum Perhutani is the replanting of damaged mangrove forests in Java. More than 5,000 hectares of damaged mangrove forest have been rehabilitated in Cilacap in the last three years (1993). Over 10,000 hectares of disturbed mangrove areas on the north coast of West Java have also been replanted since 1976. *Rhizophora* and *Avicennia* seedlings were used in the north coast of West Java rehabilitation programs, whereas *Rhizophora* and *Bruguiera* spp. were used in the Cilacap mangrove areas. The survival rate of replanting was reported between 60-75 percents.

A new approach called "tambak empang parit" (channel fishponds) has been initiated on the north coast of West Java to take into account socio-economic factors. This new approach is a means by which people who live in the surrounding areas may catch or culture fish in the broad channels around the rehabilitated mangrove forest areas for their daily livelihood (Soegiarto, 1984); Tim Ekosistem Mangrove, 1984).

Developing Community Participation

Through the "tambak empang parit" pattern, the community, in particular the fishing community, started to realize and observe the opportunities as well as the role mangrove ecosystems could play to increase their income and to enhance their livelihood. Slowly but consistently, through the untiring efforts of the NATMANCOM in cooperation with various government agencies, provincial government, universities, non-government organizations (NGOs) both decision makers, planners and the community at large are starting to understand the various functions of mangrove ecosystem. It should also be noted that the cooperation through foreign assistance, e.g. JICA (Japan International Cooperatioan Agency) or private organizations, such as OISCA (Organization for Industrial, Spiritual and Cultural Advancement), ISME (International Society of Mangrove Ecosystem), Nature Conservancy, etc. are of utmost important for developing that understanding as well as for developing community participation.

Although conflicts are still very strong between the development driven activities versus the conservation and sustainability programmes, more and more efforts in the rehabilitation of damaged mangrove ecosystems are being implemented. The government agencies, e.g., Department of Forestry and the State Forestry Corporations, consistently replant mangrove trees and rehabilitate mangrove ecosystems every year. For example, this takes place in the Cilacap area, around the cities of Jakarta, Surabaya, Semarang and elsewhere. A recent plan has been made to plant mangrove trees along 65 km of the main road along the northern coast of West and Central Java, partly for beautification but partly for mangrove rehabilitation. However, the more satisfactory development is that now more and more coastal communities start planting mangrove trees on their own initiatives. Examples are found in Medan, North Sumatra, in Jambi, around Jakarta, in East Java such as Surabaya, Gresik, and Banyuwangi, and Ambon in the Moluccas, just to name a few. Some of these communities have received the prestigious "KALPATARU AWARD" from the President as environment rehabilitators. This award is presented by the President based on the recommendation of the Office of the State Minister on Environments. It is given on June 5, every year, as part of the Environment Day celebration.

Developing Community Based-Management

It is now recognized that there is an urgent need to develop community-based management on mangrove ecosystems in Indonesia. There are a number of factors that contribute to this urgency.

International Factors:
- there are conflicting policies on development and conservation
- in some cases there are also policy conflicts between the central government and the provincial/local authorities
- there are failures of weak enforcement of the existing rules and regulations
- there is inadequate data and information on the role and function of mangrove ecosystem
- there are inadequate numbers of skilled, educated and motivated manpower, particularly in local conditions
- there is increasing population pressure on land and its resources.

External Factors:
- environment and community-based management has become a global issue, reinforced by NGO participation
- open market and free competition increases exploitation and conversion of mangrove land into prawn and fish culture, and for other purposes.

Currently, Indonesia is developing community-based management on a Biosphere Reserve (Gunung Leuser National Parks) and coral reefs (Coral Reefs Rehabilitation and Management Programme-COREMAP). Under these projects, in various specific sites, the members of communities who live in and around the ecosystem will be trained to increase their awareness on relevant environmental issues and the sustainability of resources utilization. At the same time they will also be provided with alternative jobs to generate income. Lastly, the community members will also be given the opportunity to participate in developing group responsibility to protect the environment as well as to sustain the utilization of resources.

A similar approach is also being developed for mangrove ecosystems. This approach capitalizes on the rather successful efforts of community participation on mangrove tree planting and mangrove ecosystem rehabilitation.

Conclusion

Indonesia originally had about 4.25 million hectares of mangrove ecosystems distributed along the leeward coasts of most of the major islands. Some of these forests have been over-utilized and are in a critical state, some are moderately utilized, and the rests are still in pristine conditions. Due to conflicting land use policies, and irrational utilization of natural resources, the mangrove ecosystem is under a severe stress. It is encouraging to note increasing community participation in tree planting and in the rehabilitation of damaged mangrove ecosystems. At the same time planners and decision makers are now more open to innovative, integrated, multidiciplinary as well as multisectoral approaches to development, including the newly developed idea of community-based

management. However, the difficulties should still be fully realized and we should harbor no illusion that the task ahead will be easy and smooth.

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Some Environmental Consequences of Mangrove Conversion in Malaysia

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Abstract

In Malaysia, the livelihood of coastal communities has been traditionally dependent on mangrove ecosystems. With the rapid pace of development in recent years, extensive areas of mangroves have been converted to other land use. The most significant is the conversion of landward mangroves to agriculture. Bunds have been constructed along the coastline to prevent the ingression of seawater. Behind the bunds, the reclaimed mangroves are cleared for agriculture while fronting the bunds, a buffer belt of seaward mangroves is retained.

Due to strong wave actions and nearshore currents, an increasing number of localities along the Straits of Malacca is experiencing severe coastal erosion. The buffer belt of seaward mangroves is being eroded away. The process is aggravated by the diversion of freshwater from rivers for irrigation which in turn impedes the inflow of sediments essential for mangrove nourishment and establishment. Cheniers, which are being washed ashore, are causing mortality and dieback of mangrove trees and natural regeneration.

In a number of localities, coastal erosion is so severe that the bunds have ruptured and the ingression of seawater has resulted in the destruction of extensive agriculture land. The problem is partly attributed to the encroachment of illegal settlements and shrimp ponds into the mangrove buffer. Engineering structures in the form of rock revetments to protect the bunds are extremely expensive and have to be maintained regularly. Efforts to reforest such areas have failed. Invariably, the problem has also adversely affected the local fishing communities whose livelihood is dependent on the sustenance of mangrove ecosystems.

It is therefore becoming clear that any attempt at altering the natural processes essential for sustenance of mangrove ecosystems will inevitably be accompanied by adverse environmental consequences that are extremely difficult to resolve. Often, the ecological price to be paid surpasses the socio-economic benefits of converting mangroves to other land use.

Significance of the Mangrove Ecosystem for Coastal People in Pakistan

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Abstract

The Indus Delta in Pakistan, the fifth largest delta in the world, is in grave danger of permanent environmental damage. The 600,000 hectare Delta is covered with mangrove forests, which are an important natural resource. The mangroves help to stabilize the overall climate and general environment as well as providing habitat for various species of wildlife, such as fish, crabs and shrimps. The alarming rate of decline in the mangrove area is therefore a cause of concern. The last 20 years have seen a drastic reduction in mangrove areas: in 1977 there were 263,000 ha, in 1990, 158,500 ha, and in 1995, only approximately 130,000 ha. The basic reason for this decline is a reduction in the freshwater supply flowing down the Indus River.

Mangrove trees are the predominant source of fuel and fodder for the villagers. The average consumption of mangrove wood per household is 8 kg a day. Based on the estimated number of households in each village, the total consumption per year is 502,248 tons. This use of the natural resources puts considerable pressure on mangroves. The survival of this natural resource is threatened, and if these factors remain unchecked, the mangroves will essentially be destroyed. This would affect the lives of numerous fishermen and have implications for the fishing industry as well.

Efforts are underway to rehabilitate the mangrove ecosystem along the coast of Pakistan. Experimental and small scale plantations with *Rhizophora* spp. and *Avicennia* spp. have given very good results under social forestry projects and IUCN's Korangi Ecosystem Project. More areas are expected to be rehabilitated under the ongoing World Bank mangrove project. The social forestry programs aims at extension and motivation of the local population through demonstration plantations in coastal villages. Community-based organisations are considered important in facilitating the proper behavioral changes in coastal people and enhancing their environmental awareness.

Additional measures, like villagers' participation in planting operations, enforcement of rotational grazing, public health programs, apiculture, enhancement of protection measures by government departments etc., will also help. Social surveys of the coastal villages, concentrating on use of resources and local management practices, are used to begin dialogues with villagers on the most appropriate means of mangroves and fishery management. While all this is very important, in the final analysis, it is the involvement of people and the harnessing of their power for mangrove rehabilitation that will play the decisive role. Therefore a social forestry approach in mangrove rehabilitation, as adopted in other parts of the world, is considered vital.

Introduction

The Indus Delta covers an area of some 600,000 hectares, stretching to the south of Karachi about 200 km, beyond the Indian - Pakistan border. This is a very large area, comparable to the forested area of the Sundarbans of Bangladesh, the largest area of mangrove forest in the world. However, not all of the area in the Indus Delta is covered by mangrove forest. There are 17 major creeks, extensive mudflats and about 130,000 hectares of mangrove forest. Of these, 50,000 hectares can be classified as dense mangrove stands.

The most significant characteristic of the Indus Delta is that it receives on average only about 220 mm of rainfall per year, and gets no rainfall at all some years. This contrasts with the Sundarbans which receive 10 to 20 times this amount. The Indus mangrove ecosystem was built up by, and is critically dependent on, the fresh-water and silt flows from the Indus River. The shortage of rainfall, the high temperatures, and the decline in flow of fresh-water down the Indus as a result of dams and barrages, means that salinity in the creeks often exceeds that of sea water (45 ppt is

common in comparison to the usual 35 ppt of sea water).

Under these conditions, it is probably safe to say that the Indus Delta mangroves are the largest area of arid climate mangroves in the world. Not surprisingly the species diversity is low. Of the 8 species of mangrove recorded, *Avicennia marina* predominates, accounting for over 90% of the forest cover. Other species such as *Ceriops tagal, Aegiceras corniculata* have very small localized stands. Until recently, when it was re-introduced, *Rhizophora mucronata* had been eliminated from the Indus Delta, probably because of over-exploitation.

Importance of the Indus Delta Mangrove Ecosystem

It is only within the last decade that the importance of the mangroves in the Indus Delta has become appreciated. Even today the attitude persists that the Delta is wasteland with no economic importance. Some still consider that any freshwater released below the Kotri Barrage is wasted.

Because of the aridity and high salinities of creeks and soil, the growth of mangroves is slow and very dependent upon the topography. The best growth of *Avicennia* occurs nearest the creek banks where the roots receive daily tidal inundation. The largest trees may reach about 10 m, but the normal height range is from 1 to 5 m. This means that the mangroves can not be regarded as highly productive from a forestry point of view. In fact they are classified as protection forests. The mangroves provide considerable protection against the full force of the south-west monsoon from May to September. The presence of Port Qasim, Pakistan's second largest port which can take ships up to 50,000 tons, some 30 km up Phitti Creek, is an indication of the protection afforded by the mangrove forest. In addition, the creeks are configured in such a way that virtually no dredging is required to maintain the channel within the mangroves.

Probably the greatest economic importance of the mangroves comes from fisheries. This is an indirect benefit, since the mangroves provide food and shelter during some stages of the life-cycle of some 80% of the commercial species caught in Pakistan waters. Of greatest export importance are the prawns and shrimp of which about 25,000 tons are caught annually. They make up 68% of the value of Pakistan's nearly US$100,000,000 fish export income.

Although not a significant timber resource, the mangroves are used by the coastal villagers for fuelwood and fodder. *Avicennia* wood does not make as good fuelwood as other mangrove species, e.g., *Rhizophora*, but it is used extensively by local people. It is rarely sold outside of the coastal areas. Nevertheless, within the port area along the north edge of the Indus Delta there are about 100,000 people who use a total of about 502,248 tons of mangrove firewood each year.

Avicennia leaves are an excellent food for animals and are collected regnlarly by the villagers. In addition to collecting for cattle, sheep and goats kept in the villages, it has been estimated that at certain times of year about 16,000 camels are herded in the mangroves. These activities put considerable pressure on the existing stands of mangroves nearest coastal villages, to such an extent that many mature stands are stunted from over grazing, browsing and lopping.

Environmental Stresses on the Mangrove Ecosystem

The severest environmental stress which the mangroves face is the result of the reduction of freshwater flow from the Indus. This reduces loads of silt and nutrients. Whilst mangroves, especially *Avicennia* are able to survive in sea-water, without regular freshwater input, it is unlikely that they will thrive indefinitely.

The estimated available freshwater flow of the Indus is about 84 million acre feet (MAF) per year (See Appendix 1). The Indus Delta was formed with this order of freshwater flow into the sea, carrying with it some 400 million tons of silt. Over the last 60 years man has built dams, barrages and irrigation schemes, to such an extent that the flow reaching the delta is now less than 35 MAF. Development proposals indicate that the flow may be reduced further to about 10 MAF. The quantities of silt discharge are now estimated to 100 million tons per year, and may be reduced to about 30 million tons in the future.

The reduced flow of the Indus means that the already high salinities in the creek and soil pore water will become higher. It is not unusual to find salinities of more than 40-45 part per thousands (ppt) in some areas, well above that of normal sea water. The high salinity tends to stunt the growth of both trees and animal life. This will have a significant impact upon the mangrove forests, and there are signs of stress already in a seemingly ageing population of trees with lack of substantial reproduction in some areas.

The reduction in flow of silt takes on an even greater significance when the rise in sea level as a result of global warming is considered. It has been estimated that mangroves with significant silt discharge can maintain themselves by accumulating silt when the sea level rises at rates as high as 2.5 mm per year. Without adequate silt discharge the mangroves will have difficulty in maintaining themselves if the sea level rises at 1.2 mm per year. Over the last 100 years the sea level has been rising at a rate of 1.1 mm per year and this rate may increase with global warming. It is probable that the Indus Delta mangrove forest will be unable to maintain itself if the rate of rise of sea level increases.

Apart from these longer term threats to the survival of the Indus Delta mangroves, there are pressures from over-grazing and lopping for fuelwood and fodder, which result in stunted trees in some areas. Within the vicinity of Karachi there are other pressures resulting from the steady growth of a major industrial city of over 9 million people. In addition to untreated domestic waste, which flows into the river and streams and then into the creeks, there are significant industrial discharges from major industries such as steel mills, refineries, power stations, etc., and from tanneries and textile mills. Tanneries perhaps represent the most serious source of pollution, since the waste has a higher heavy metal content than waste discharged from larger industries.

The effect of pollution on the mangroves themselves is probably slight. They are able to survive and may even flourish in the localized discharges of fresh water and with the high nutrient status of many wastes. However, many of the faunal populations will be seriously affected by contamination. This may have an indirect effect upon the mangroves by reducing the efficiency of breakdown of mangrove leaf litter. The changing character of soil and water pollution also has great significance by introducing contaminants into the human food chain if fish and crustacea are caught for human and animal food in contaminated creeks.

Within the next ten years it is expected that some major new developments in the tourism sector will have opened up in the areas adjacent to, and including the mangrove areas. The creeks represent an important resource for recreation, water sports and eco-tourism for a city that has relatively few such resources near by. Such development will change the relationship of the local people with the mangroves, and will add stresses to the environment unless developments are planned sensibly. Preservation of the areas for viewing wildlife, such as migrating water fowl, dolphins and mangrove jackals, are anticipated and the idea of a Biosphere Reserve is being discussed.

Development Strategy

Pakistan initiated its afforestation and reforestation programme in 1985. So far over 7000 hectare have been brought under mangrove plantation throughout the Indus Delta. An additional area of 3000 hectares has been restocked with *Avicennia marina* through assisted natural regeneration. All this has been done with the assistance of UNDP/UNESCO Regional Mangrove Project, the IUCN Coastal Ecosystem Unit, and from the Sindh Forest Department budget. Different indigenous and exotic species with some commercial utilization were used in the experimental plantation and it was found on the basis of their growth performance, that *Avicennia marina* and *Rhizophora mucronata* from the Pakistan coast were the predominant species. About 95% of the artificial plantations in the Delta are of these two species.

A socio-economic survey was conducted in 1990 to investigate the dependence of the coastal population upon mangroves. It was found that 100,000 people are directly dependent upon mangroves in the Delta. They did not have even sufficient quantity of fresh water for drinking purposes. Therefore, a social forestry program of inland species has a remote chance of success. As a result of the survey a few thousands container plants were supplied to the villagers to grow in their kitchen garden, street, school, health centers, etc. This

was an attempt to establish woodplants in the coastal villages. Through IUCN a mass scale program of planting mangrove species was launched in the coastal villages. All these efforts were to create alternate sources of fuelwood and fodder and to reduce their dependence upon the intertidal mangrove. The container plants and propugales of *Avicennia marina* and *Rhizophora* were supplied to the local villages, and technical know how was provided them to grow in the vicinity of their village. Two to five-year-old crops of mangroves are growing in Rehri coastal villages, and fisherman are maintaining them for their fuelwood and fodder. The establishment of these mangrove plantation areas is a step towards joint forest management, when the community will harvest the crop established by the government.

It is hoped that after the natural resource will better be managed and ecosystem will be protected from degradation the awareness of environmental factors is created among the coastal people.

Conclusion

Wise or sustainable use of natural resources depends upon people living in the villages near by. People buy resources from the area, people discharge their waste into the surrounding environment, and people make decisions about the area without ever having gone there. Wise use management attempts to work with all these different levels of people, either directly or indirectly. The local people, whose livelihood often depends upon the environment and the natural resources are the most important people to convince of necessity for conservation.

In working with the people, especially villagers who may be somewhat marginalised, such as people in fishing communities, it is important to provide nondestructive economic uses of the resources rather than hopeful exhortation. From the point of view of the mangroves, the total area is too large for the government to police or to propose unpopular protective measures. There have to be very real economic incentives to preserve the resources. These may take the form of encouraging honey production, private plantations, or charcoal production from planted *Rhizophora*, or developing appropriate forms of shrimp culture and jobs for wildlife tourist guides. They may take the form of encouraging the use of alternative sources of fuelwood and fodder. Successful conservation of the resources will be more to likely develop out of consultation with the local people about what they see as their needs in relation to their environment, rather than by imposing something dreamed up by a project.

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Appendix I Problems in the Area of Korangi Coastal Villages

PROBLEMS	PRIORITY			
	I	II	III	Total %
	100.00	100	100.00	
	601.00	601	601.00	
Lack of Water Supply	70.2	6.0	2.0	78.00
	422	360.00	12	
Provision of Gas	3.5	9.0	8.0	20
	21.00	54	48	
Provision of Electricity	9.0	38.9	8.0	56.00
	54.00	234	48	
Lack of Roads and Streets	1.3	6.2	8.8	16.00
	8	37	53	
Lack of Schools	1.8	4.2	8.7	15.00
	11	25	52	
Lack of Health Facilities	3.2	6.80	16.0	26.00
	19.00	41	96	
Sanitation	4.80	16.50	I6.1	37.00
	29	99	97	
Allotment / Lease	3.2	2.5	6.3	12.00
	17	15.00	338.00	
Availability of Public Transport	2.0	4.80	9.3	16.00
	12	29	56	
Garbage Collection / Cleanliness	0.2	0.30	0.8	1.33
	1.00	2	5	
High Tension Line	0.2	0	0.0	0.2
	1	0	0	
Need for Jetty	0.2	0.00	0.2	0.20
	1	0.00	1	
Use of Narcotics	0.20	0.0	0.00	0.2
	1.00	0	0.00	
Any Other	0.0	1.30	0.7	2.00
	0	8.00	4	
No Problem / No Response	0.5	3.5	15.10	19.1
	3.00	21	91.00	

Appendix II Average annual (and seasonal) discharge volumes down stream of Kotri barrage

Period	Discharge volume (MAF)			Percentage Reduction	Construction with Year
	Annual	Kharif	Rabi		
1940-54	84.7	73.8	10.9	10.0	400 million tonnes silt
	79.9	69.7	10.2	12.9	Barrages
					Kalabagh (Jinnah)-1955
					Kotri-1955
					Marala-1956
					Taunsa-1958
					Guddu-1962
1966-76	46.0	44.4	1.6	45.7	Warsak dam-1965
					Mangla dam-1967
					Chashma barrage-1971
1977-92	35.2	33.1	2.1	58.4	100.0 million tonnes
1992 onward	10.0			after water accord between the provinces	35.0 million,tonnes

Sources : IPD

Socioeconomic Significance of Mangroves for Coastal People of India: A Changing Scenario

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Abstract

The importance of mangrove ecosystems with particular reference to the coastal population of India has been realised recently. Natural calamities like cyclones, floods, famine, siltation and erosion are directly related to the mangrove formations and their use along the Indian coast. Major deltas like Gangetic Sunderbans, Mahanadi, Krishna, Kaveri, Pichhavaram and Muthupet along the east coast of India show the excellent growth of mangroves.

The coastal population depend on mangrove-related resources for their socioeconomic needs such as fuel and fisheries, as well as for other by-products like honey, timber, tannin, coal, fruits, etc. Under extreme climatological conditions in the Gulf of Kachchh, mangroves are considered very important.

Recently, other aspects like Mangrove Protected Areas (MPA), ecotourism, aquaculture and agriculture have shown great significance. Although the economic gains for coastal people have increased through these activities, the mangrove ecosystem itself has become endangered in certain areas. Hence aquaculture and Kharland Development activities, have been under ecological pressures. The Ministry of Environment and Forests of the Government of India has come out with Gazette Notification on Coastal Zone Regulations for sustainable use and conservation of mangrove areas along the Indian coast.

Introduction

Mangrove regions were considered as wasteland of little value, and hence were reclaimed to a great extent all over the tropics. However, during recent years, mankind has recognized the ecological and socioeconomic significance of the mangrove ecosystem. Global efforts are being made to conserve and protect the world mangrove resources, and to exploit them on sustainable basis. The commercial and traditional products from the mangrove ecosystem range from construction wood to medicine, honey and fisheries. The mangroves are a potentialy sustainable source to meet the increasing needs of developing countries in the tropics. Mangroves have contributed sigmificantly to improving the economies of Southeast Asian countries like Thailand, Philippines and Malaysia. Lately, the Government of India has shown keen interest in conserving and restoring these important coastal habitats. The present paper discusses the status of mangroves in India and their socioeconomic and management aspects.

Status of Mangroves

Areal extent:

Recent surveys have estimated mangrove cover of approximately 315,000 ha in India (Table 1). Almost 80% of the mangroves occur along the northeastern coasts of Orissa and West Bengal, and the coasts of the Andaman and Nicobar group of islands. The major mangrove formations covering over 267,000 ha occur in the deltaic regions (Table 2). The Ganges (Sunderbans) Delta by itself contains 78% of this area (Fig. 1A). Other deltaic regions except Mahanadi (Fig.1B) and Godavari and Krishna (Fig.2) show relatively poor mangrove regions. The Gulf of Kachchh (Cutch) and Gulf of Khambyat (Fig. 3) and Kerala, along the northwest aud southwest coast, respectively, have the most degraded mangroves (Table 1). In Maharashtra, Goa and Karnataka along the central west coast, though mangroves are degraded, luxuriant pockets of mangroves occur at several localities (Table 1). Few of the islands of Andaman and Nicobar group (Andaman Sea) still have mangroves in their pristine condition. About 25% of the Indian mangrove region exists mainly in the north, middle and south Andamans (Jagtap, 1992). The Lakshadweep group of islands (Andaman Sea) are almost devoid of mangrove vegetation except at Minicoy (Jagtap *et al.*, 1993).

Table 1. Status of Mangroves along the Indian Coast

State	No. of species	Area (ha)	Regions: Major formations	Condition	Source
West Coast					
Gujrat	9	37,000	Gulf of Kachchh	Mostly degraded	Gupta and Naik, 1987 Jagtap and Untawale (unpublished data)
Maharashtra	17	21,000	Ratnagiri & Raigarh Districts	Degraded	Jagtap *et al.*, 1992
Goa	14	2,000	Mandovi & Zuari estuarine complex	Degraded	Jagtap, 1985
Karnataka	13	5,000	Haldi, Kolar and Chakra estuarine complex, Coondapur	Degraded	Jagtap *et al.*, 1993
Kerala	10	Negligible	Kollam, Kumarhan and Kunhimangalam	Totally degraded	Jagtap *et al.*, 1993
East Coast					
Tamil Nadu	18	10,000	Killami, Muthupet, Chatzom, Puthupattinam, Talanayar	Degraded	Anon., 1987
Andhra Pradesh	26	20,000	Godavari & Krishna Delta, Coringa, Guntur District	Partially degraded	Anon., 1987
Orissa	36	21,000	Mahanadi Delta	Partially degraded	Patnaik and Choudhary, 1989
West Bengal	22	120,000	Sundarbans - 24 Paraganas District	Moderate	Anon., 1987
Islands					
Andaman and Nicobar (Andaman Sea)	27	78,000	Middle, North, Little and South Andamans, Baratang and Nicobar	Good	Jagtap, 1985, 1991, 1992
Lakshadweep group (Arabian Sea)	3	Negligible	Minicoy Island	In the process of formation	Untawale and Jagtap, 1984; Jagtap *et al.*, 1993
Total	50	314,500			

Floristic composition and ecological status:

Mangrove flora in India is composed of 60 exclusive species belonging to 20 genera (Naskar and Guha Baxi, 19). The greater number (36) species occur along the east coast in Mahanadi delta (Orissa), whereas minimum of 9 species occur from the Gulf of Kachchh in Gujrat. Mangroves like *Avicennia alba*, *A. marina*, *A. officinalis*, *Rhizophora apiculata*, *R. mucronata*, *Sonneratia alba* form the dominant mangroves along the mainland coast. However, in the Andaman and Nicobar group of islands 80% of the mangroves are dominated by *Bruguiera* and *Rhizophora stylosa*. Species of *Xylocarpus* and *Heritiera* are totally absent from the west coast and can be observed along the east coast and in a few islands of Andaman and Nicobar. *Kandelia candal* has a restricted distribution only along the mainland coast.

Uses

Traditionally mangrove ecosystems are used for various purposes such as agriculture, fisheries, pisciculture, salt pans, fodder, manure, firewood, timber, medicine, etc.

Agriculture:

Agriculture has been the major occupation of Indians until the early 1960's. The earliest settlements developed in low lying areas along the coastal stretches. The settlers then reclaimed mangrove regions for

Table 2. Major Mangrove Areas in the Gulf and Deltaic Environments of India

Region	State	Mangrove area (ha)	Source
West Coast			
Gult of Kachchh	Gujrat	11,000	Untawale, 1980
East Coast			
Gangetic	West Bengal	200,000	Anon., 1987
Mahanadi	Orissa	21,458	Patnaik and Choudhary, 1989
Godavari	Andhra Pradesh	10,000	Anon., 1987
Krishna	Andhra Pradesh	10,000	Anon., 1987
Cauvery	Tamil Nadu	15,000	Anon., 1987
Total		267,458	

agriculture and use, and protected the same by constructing embankments, bunds and sluice gate to check intrusion of saline water and floods. Generally, reclaimed mangrove regions are used for paddy cultivation and called as "Khazan land". Besides paddy, coconut, ragi and pulses are cultivated in the reclaimed mangrove regions.

Mangrove related fisheries and aquaculture:

The mangrove regions of India have been reported (Jagtap et al., 1993) to be rich in fishes (105 spp.), shellfishes (20 spp.) and crustaceans (229 spp.). Many fauna are commercially exploited by capture and captive fisheries.

The capture fisheries mainly consist of species of *Meretrix*, *Crassostrea*, *Peneus monodon*, *Scylla serrata*, *Mugil cephalus*, *P. indicus*, *Metapenaeus* spp., *M. persica*, *Chanos chanos*, *Etroplus suratensis* and *Lates calcarifer* from mangrove regions proper and from estuarine waterways.

The captive fishery includes fish and prawn farming in the mangrove regions. The salt-affected, water logged, tidal regions in the vicinity of mangrove environments are commonly used for the paddy cum prawn farming and for salt production. Permanent fish ponds are generally close to the estuary or adjoining river tributaries fringed with mangroves. Such farms are bounded by mangrove mud and strengthened with laterite boulders. The flow of water is regulated by sluice gates. The methods of fish culture are traditional and involve a composite culture of wild stock.

Aquaculture activities (Dwivedi, 1978) from mangrove regions have been estimated to produce prawns and fish up to 2300 kg per ha per year. The average yield of captive fishery from Sundarban mangroves varies from 700-1000 kg per ha per year, while Kerala brackish waters yield 785-2135 kg per ha per year of prawns and fish. However, the yield in a particular aquaculture pond in the reclaimed mangrove regions, remains reasonable for 3 to 5 years. Ponds are generally abandoned due to increased acidity, resulting in lower production. Thus aquaculture in the mangrove regions affects the long term status of the region by creating an imbalance in coastal waters. Taking into consideration irreparable damage due to aquaculture activities in certain regions, the Government of India came out with Gazette notification on Coastal Regulation Zone (CRZ) during the middle of 1990.

Salt pans:

The brackish water and reclaimed mangrove areas have been used for salt pans. The major salt work is done in the Gulf of Kachchh in Gujarat. However, in other regions of the coast these salt pans are used as fish ponds from July to December and the annual yield is estimated to be about 350 kg per ha. The ponds are drained and dried, during the rest of the period and used for salt production by taking spring tide for the extraction of salt.

Manure:

The mud from the mangrove swamps is periodically removed and used as a manure for paddy and coconut plantations, as it is rich in nutrients, minerals and humus. Generally the mud is removed during

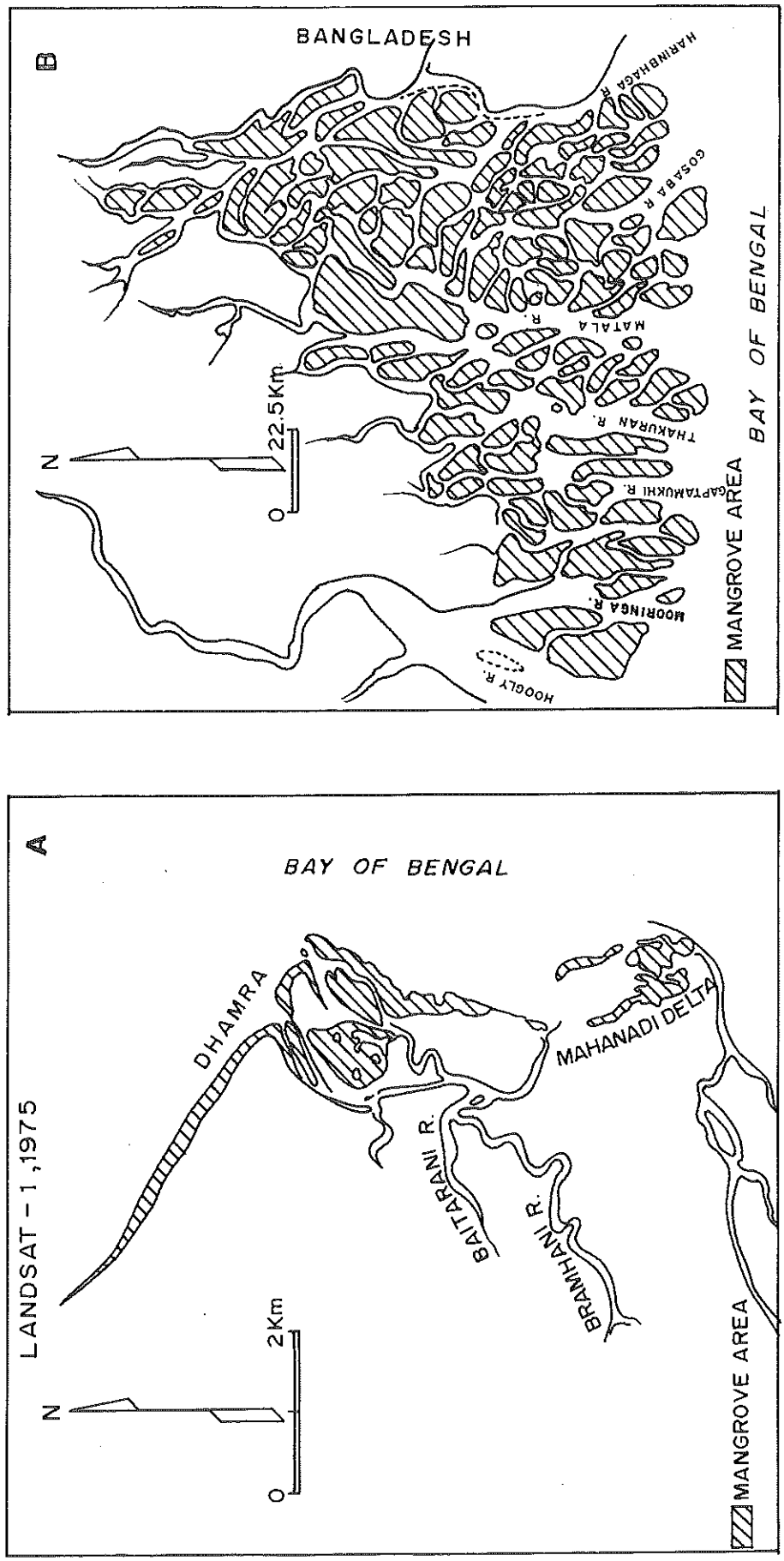

Fig. 1. Mangroves along the East Coast of India (A: Sundarbans, B: Mahanadi Delta).

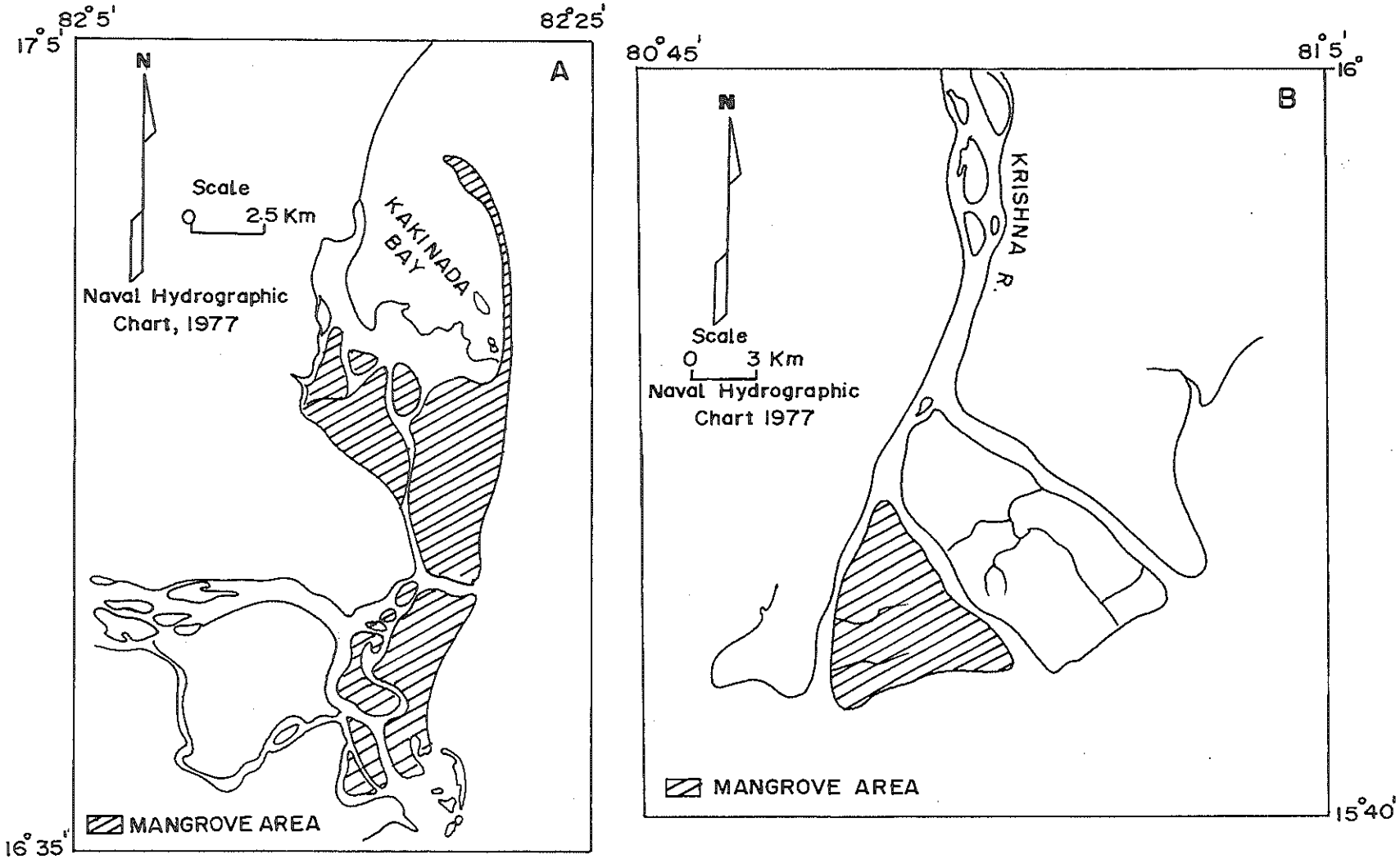

Fig. 2. Mangroves along the East Coast of India (A: Godavari Delta, B: Krishna Delta).

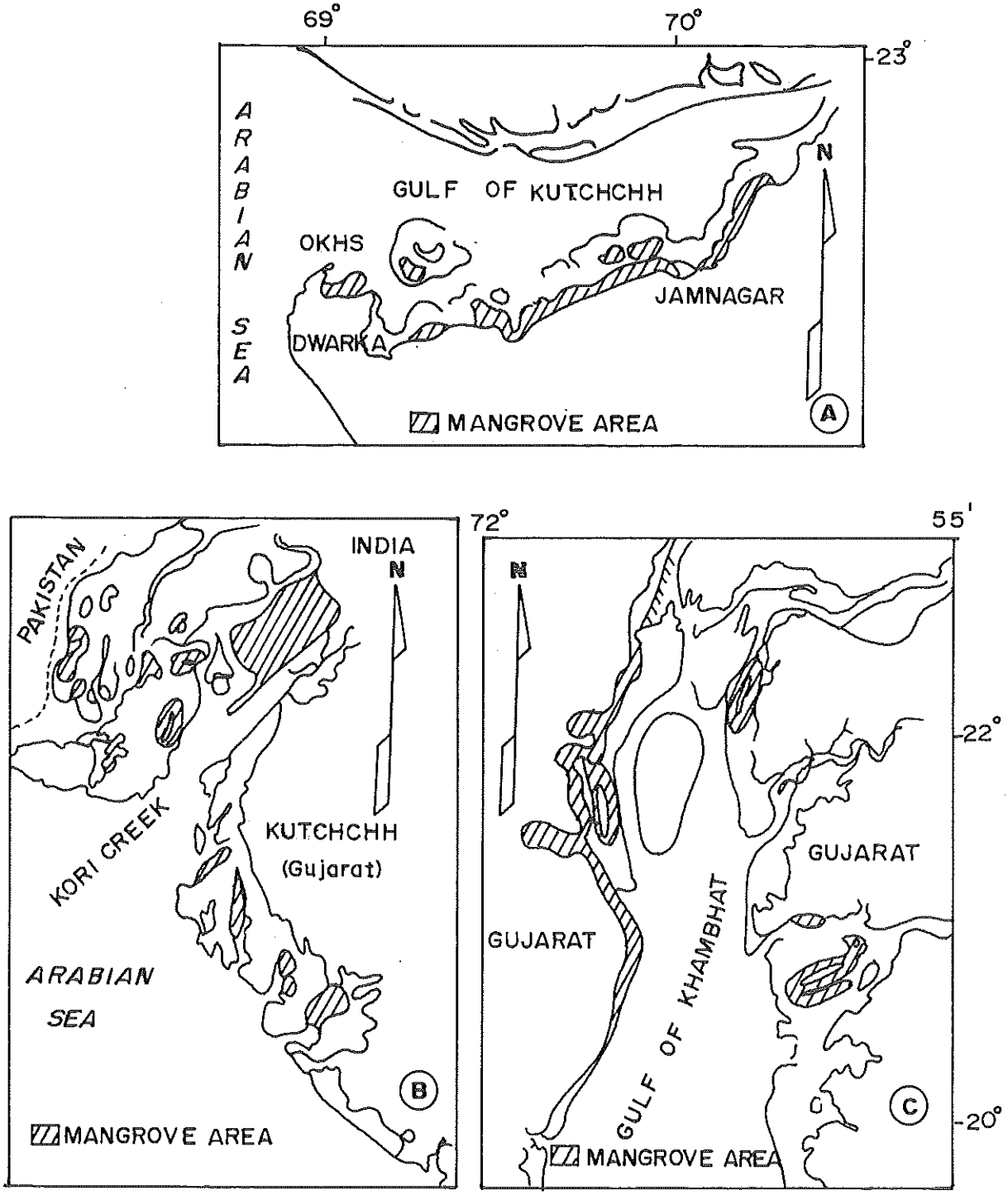

Fig. 3. Mangroves along the Northwest Coast of India (A: Gulf of Kachchh, B: Kori Creek, C: Gulf of Khambhat).

April and May and spread in the farm. It gets leached of any excess salt during rainy season. The mangrove slash (leaves and small branches) is spread and dried in the farm and burnt. The ash acts as a fertilizer.

Fodder:

The leaves and fruits of few mangrove species like *Avicennia* and *Sonneratia* species are used as fodder for domestic cattle and goats.

Tannins:

The mangrove bark and other plant parts are rich in alkaloids, tannins and polyphenols. The bark of mangroves, particularly *Rhizophora* and *Bruguiera* spp. are used for low grade tannin.

Medicine:

Extract from leaves and fruits of *Acanthus* spp. are used for dressing wounds and rheumatic disorders. Similarly, extracts of *Salicornia brachiata* are used as antiseptic. A decoction of *Rhizophora* leaves is used to cure jaundice. Bark and the leaves of *Excoecaria agallocha* are used for different ailments. Roots and stems of *Derris heterophylla*, an associate mangrove, are used for narcotizing the fishes. The extract from *Bruguiera* leaves is effective in reducing cholesterol.

Recreation and Wildlife Sanctuaries:

The luxuriant mangroves at Chorao of Goa aud in the Gulf of Kachchh, 24-Pargana in West Bengal, Bhitarkanika of Orissa, Andaman and Nicobar island have been the best wildlife sanctuaries. Over 119 bird species have been reported from these mangrove regions. Sundarban mangroves are well known for Royal Bengal tiger and marine life. The mangrove forest at Bhitarkanika, along the east coast is protected for crocodiles. These sanctuaries are a great attraction for national and international tourists, students and researchers.

Firewood and Mangrove Timber:

Mangroves are mainly exploited for timber and used in minor construction by rural communities. The smaller branches are used for fuel, fencing for house and farms, and as stakes for fishing nets. Species of *Avicennia*, *Sonneratia*, *Rhizophora* and *Bruguiera* species are used extensively for this purposes. The wood of *Bruguiera* and *Xylocarpus* is harder. Trees of these species were overexploited resulting in a restricted distribution of these species along the Indian coast. The constant and indiscriminate cutting of mangroves has resulted in the disappearance of large mangrove areas along the coast.

Food and Vegetable:

The ripe fruits of *Sonneratia caseolaris* are eaten and used in the preparation of pickles and chutney. The tender tip of the mangrove-associated fern, *Acrostichum aureum*, *Akur*, is used as a vegetable. Similarly, *Salicornia brachiata*, an obligate halophyte growing in the supralittoral regions, is used as a vegetable. *Ceriops tagal* thickets have a potential for honey collection.

Conservation and Management:

Mangroves in India have been severely degraded due to their overexploitation. During last couple of decades the mangrove regions have been reduced by over 30% (Table 3), mainly due to lack of proper management. Lately, efforts have been made at various levels for the protection and sustainable use of these habitats, through National Mangrove, Coral and Wetland Committee (NATCOM). The national mangrove plan suggested by NATCOM is depicted in Fig. 4. A few of the luxuriant mangrove regions in the country have been identified as "Biosphere Reserves" for germ plasm and wildlife preservation (Tables 4 and 5).

Technical knowledge for nursery development and mangrove afforestation has been developed and distributed to various concerned organizations. The restoration of the mangrove habitats have been initiated and continued. Though afforestation activities began after 1986 with great enthusiasm, they have not gained momentum due to lack of encouragement. The Ministry of Environment and Forests of the Government of India took the enormous damage and the constant increase of anthropogenic pressures on the coastal habitats into consideration, and issued Gazette Notification Act, 1990, creating the Coastal Regulation Zone (CRZ). This was done in order to prevent ecological imbalance and degradation caused by developmental activities. The mangroves and other ecological sensitive ecosystems have been classified, and activities within them are regulated under 6(1) category 1 (CRZ-I). Construction of beach resorts, hotels, and lodging houses have been totally discouraged in areas like marine parks, mangroves, coral reefs, breeding and spawning grounds of fish, wildlife habitats and

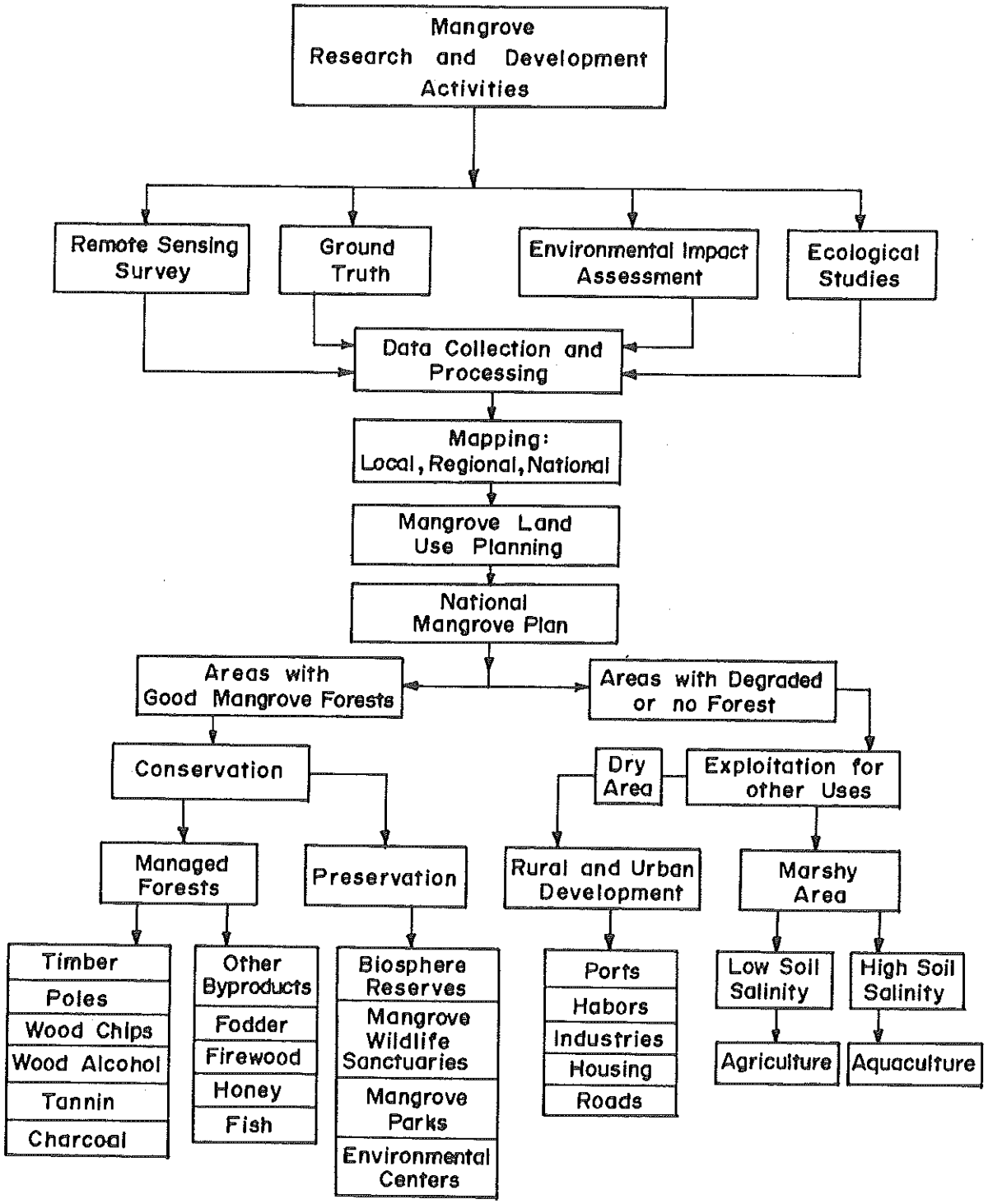

Fig. 4. National Mangrove Plan for India.

Table 3. Percentage Reduction in the Area of Mangroves along the Indian Coast from 1975 to 1990-95

Region	Mangrove area (ha) During 1975	Mangrove area (ha) During 1990-95	Reduction in Mangrove area (%)
West Coast			
Gujrat	115,000	65,000	43
Maharashtra			
Kerala			
East Coast			
Tamil Nadu	21,000	16,350	22
Andhra Pradesh			
Orissa			
West Bengal			
Islands			
Andaman and Nicobar Group of Islands	119,000	78,000	34
Total	255,000	159,350	38

Source: Blasco, 1975; Anon., 1987; Jagtap *et al.*, 1993

Table 4. Biosphere Reserves in Mangrove Regions of India

State	Locality	Responsible Organization	Name	Year Established	Approx. area (ha)
West Coast					
Goa	Chorao	State Forest Department and World Wildlife Fund (WWF) Goa Division	Salim Ali Bird Sanctuary	1987	178
Maharashtra	Bombay (Mahim)	WWF, Bombay Division	Natural Park	1987	200
Gujrat	Gulf of Kachchh	Marine Park Authority, Jamanagar	National Marine Park	1992	Not estimated
East Coast					
Tamil Nadu	Muthupet, Chatram, Puthupatinam and Talanayar	State Forest Department	Reserve Forest	-	-
Andhra Pradesh	Coringa	State Forest Department	Wildlife Sanctuary	1978	236
Orissa	Bhitar Kanika	State Forest Department	Sanctuary	1975	60
West Bengal	Haribanga,	State Forest Department	Tiger project	1975	60
	Sajnekhali, Halliday and Lothian	State Forest Department	National Park bird sanctuary	1989	1,700
Islands Andaman and Nicobar Islands					
South Andamans	Wandoor	Andaman and Nicobar Forest Department	National Marine Park	-	-

Table 5. Mangrove Regions Identified and Proposed for Mangrove Conservation by NATMANCOM

State	Locality	Nodal Agency
West Coast		
Kerala	Venbanad	Kerala Agriculture University, Trivendrum
Karnataka	Condapur	Shivaji University, Kolhapur, Maharashtra
Goa	Mandovi-Zuari estuarine conplex	National Institute of Oceanography, Dona Paula, Goa
Maharashtra	Achra	National Institute of Oceanography, Dona Paula, Goa
Gujrat	Gulf of Kachchh	Gujrat University, Ahmedabad Saurashtra University, Rajkot
East Coast		
Tamil nadu	Pichavaram	Annamalai University
	Point Calimere	Trichy University
Andhra Pradesh	Godavari Delta	Andhra University, Waltair
	Dhitar Kanika	Utkal University and Regional Plant Research Centre - Bhubaneshwar
West Bengal	Sundarbans	Calcutta University
Islands		
Andaman Islands	North Andamans	Pondichery University, Botanical Survey of India (BSI), Zoological Survey of India
Nicobar Islands	Nicobar	Agricultural Research Institute, Port Blair

such other areas notified by the Central or State Government (Anon., 1990).

Very large scale hatcheries and fish farm activities posed a great danger to the mangroves in particular, and to the coastal zone in general. Construction of shrimp culture ponds has been banned on areas under agriculture, salt pan, mangrove forest and wetland, and on land used for public purposes. According to the CRZ notification (Anon. 1990) all aquaculture, shrimp industries and shrimp farms and ponds have to be demolished and removed quickly. It has been made mandatory to carry out Environmental Impact Assessment (EIA) studies, before any development is initiated along the coastal stretches. Environmentally friendly activities are generally encouraged, based on experts' recommendations. It is also mandatory for the concerned agency to provide disaster management plans. The coastal states have drawn up CRZ management plans, wherein due priority for protection and conservation has been given to mangroves.

Various recommendations based on expert suggestions have been provided by NATMANCOM for the sustainable use and conservation of mangroves. These important coastal habitats of the country can be better used and managed with strict enforcement of Coastal Regulation Zone regulations.

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Significance and Contemporary Condition of Mangrove Forests in Thailand

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Introduction

The importance of mangroves to the Thai population is well recognized. People have depended on mangrove forests for many purposes, including firewood, charcoal, timber and other minor products e.g., tannin and wood tar. The significance of mangrove forests in fishery production has also long been understood. Many commercially important fish, shrimps, crabs and various kinds of mollusks use mangroves as their nursery ground and shelter during juvenile stages. Moreover, mangroves still play a great role in building alluvial plains and protecting coast areas against tidal waves, and typhoons as well as preventing soil erosion. Mangrove plants are the primary producers of the ecosystem and play an important role in maintaining carbon dioxide balance.

Mangrove forests occur in Thailand along the shoreline of the Gulf of Thailand and on the west and east coasts of the peninsula on muddy shores and low-lying bogs of river and along stream estuaries at levels between low and high tides. The best developed natural mangrove forest in the country was once found along the west coast of the peninsula especially in Ranong, Phang-nga, Krabi, Trang and Satul provinces. Now most of these mangroves, as well as the mangroves along the coasts of the Gulf of Thailand are mainly classified as secondary growth because they have suffered heavy felling and conversion to other uses for many years. This is especially the case in the areas on the upper part of the Gulf such as in Petchaburi, Samut Prakarn, Samut Sakorn and Samut Songkram provinces.

Status of Mangroves

In 1961, there were 367,900 ha of mangrove forests in Thailand. Thirty-two years later, in 1993, the mangrove area had decreased to 168,683 ha, less than half of their original size. Huge areas of mangroves have been converted and reclaimed for urbanization, mining, agriculture and aquaculture. During the period from 1985-1990, mangrove forests were cleared mainly to make room for shrimp ponds. The shrimp culture business expanded very quickly because of its high, short-term profits, even though older ponds were abandoned due to recurring water pollution problems. The most of the remaining mangrove forests in Thailand is concession forests. Productivity of the forests has declined because of clear-felling for timber and charcoal industries. Widespread illegal felling of trees have occurred because the potential annual timber production was far smaller than the demand for raw material of the industries.

The depletion of mangroves in Thailand has been brought about by a combination of the following factors: First, the use of mangrove resources has been unplanned and random. Second, rules against illegal encroachment have not been enforced strictly enough. Third, rehabilitation of degraded mangrove areas has been belated and insufficient. Fourth, only a little has been done to raise awareness among people about the importance of the mangrove ecosystem. Finally, there has been little cooperation between relevant agencies and between the agencies and rural communities.

Traditional and Contemporary Significance of Mangrove Forests in Thailand

Mangrove forests in Thailand have been traditionally used by local people for many decades. The significance and values of mangroves are as follows:

Timber products

Charcoal

Mangrove tree is harvested mainly for the production of charcoal. Charcoal has traditionally been used for daily cooking by coastal villagers, and in recent

years it has also been exploited as commercial product. Various tree species can be used for charcoal-making, but *Rhizophora* spp. are the predominant ones. The size of wood used in charcoal-making is 5 cm and over. Wood from these species is heavy, dense, hard and produces charcoal that is high in calorific value and low soot production. Consequently, mangrove charcoal also sells for a better price than charcoal produced from other tree species. Charcoal produced from mangrove wood is popular not only in Thailand but also in other Southeast Asia countries. In the last decade, the average charcoal production from mangrove forests in Thailand was estimated at more than 700,000 m^3 per year.

Firewood

Mangrove wood is an important source of cooking fuel for coastal villagers. Firewood is usually obtained from small-sized trees. It is mainly used for daily cooking purposes; the rest is burned as an insect repellent. In Thailand, some villagers also earn their daily income from selling firewood. The most common mangrove species used for firewood are *Ceriops* spp., *Avicennia* spp., *Xylocarpus* spp., *Heritiera* sp., *Excoecaria* sp., *Bruguiera* spp., and *Lumnitzera* sp.. *Rhizophora* spp. are also used for this purpose but their use is limited since charcoal industry demands the majority of this wood.

Poles and fishing gear

Poles are used mainly for foundation pilings, scaffolding and fishing stakes. In Thailand, the use of *Excoecaria agallocha* for foundation piling is quite extensive. *Rhizophora* spp. is also used for this purpose. Some of the fishing equipment used by mangrove-dwellers is made with mangrove wood. Mangrove poles made from *Rhizophora* and *Bruguiera* spp. are used for crab traps. Drift gill-nets and winged set-bags are other types of fishing gear that are made of mangrove poles, commonly from *Rhizophora apiculata* and *Bruguiera*.

Construction material

People living in and near the coastal areas use mangrove wood especially for construction materials. Usually, they build their houses on raised platforms supported by piles. The traditional house is made entirely of mangrove products. Wood of various mangrove species can be used for different parts of the house. The wood of *Rhizophora*, *Avicennia*, *Bruguiera* and *Xylocarpus* are commonly used for columns, bracing, wall-beams and roof-frames. Floors and platforms are made from wood of *Rhizophora* and *Bruguiera* species. However, the use of mangrove woods for house construction is limited to mangrove communities. *Avicennia* and *Xylocarpus* can be used for furniture because the heart-wood has a beautiful texture.

Non-timber products

Tannin extraction

Tannin is a mangrove forest product that has a variety of uses, such as the manufacture of ink, plastic and glue. It is also used for dyeing fishing nets and leather. Tannin is extracted from the bark of mangrove trees. Pengpreecha (1977) determined the amount of tannin from different mangrove species and found that *Rhizophora* bark contains about 27%, tannin by weight, *Bruguiera gymnorrhiza*, 41% and *Ceriops tagal*, 46%.

Wood distillation

Wood distillation from mangroves is rarely practiced in countries other than Thailand. The only distillation plant in this country, built about 15 years ago, is situated at Kapur district, Ranong province, on the west coast of Thailand. Raw distillate from mangrove wood (*Rhizophora apiculata*) is collected from the vents of a charcoal kiln by condensation. This raw condensate is essentially pyroligneous acid. A more complicated process is required to fractionate this into acetic acid, methanol and wood tar. The percentage yields of acetic acid, methanol and wood tar that can be extracted from pyroligneous acid are very low: 5.5, 3.4, and 6.6 percent, respectively (Kongsangchai, 1982). This process is not cost-effective. There are also technical difficulties in the extraction.

Medicine

Another traditional use of mangrove species is as medicine. Certain species of mangroves contain active substances that have the power to treat various ailments. However, these traditional medicinal practices have not received scientific investigation and experiments. Suparphaibool and Kongsangchai (1982) inventoried medicinal plants by interviewing mangrove dwellers in different parts of Thailand. Their paper

and the FAO (1985) report concluded that various species of mangroves can be used for medicines.

Nipa

Nipa palm, a common monocotyledon plant in mangroves, is a very useful species. Young leaves of Nipa are used like cigarette paper for wrapping tobacco. Mature leaves are used for thatch. The young inflorescence can be tapped for sugar which is usually fermented to make wine for domestic uses. Nipa fruit is also eaten by Thai people.

Other indirect products

Capture fishery

Mangrove waters are rich in detritus used by fish and shellfish for food. The major fishery species in mangroves are detritivorous fish, crabs, crustaceans and mollusks. In Thailand, capture fisheries extend throughout marine, estuarine and coastal areas. During 1978-1982, an average of more than 1.8 million metric tons of marine fish were landed annually. Over 7% of the catch was shrimp. Many of the shrimp obtained from the capture fisheries in the country are mangrove-dependent species e.g., *Penaeus merguiensis*, *P. monodon*, and *Metapenaeus*. The people who live in or near mangrove forests catch fish, shrimps, crabs and mollusks daily around the mangrove estuaries. Unfortunately, there are no data available on the quantity of this catch. The predominant species in the fish catch are mullet (*Mugil dussumieri*), sea bass (*Lates calcarifer*), tilapia (*Tilapia mossambica*), snake eel (*Ophichthis microcephalus*), cat fish eel (*Plotosus canius*) and milk fish (*Chanos chanos*). Crabs are represented by only one common species, *Scylla serrata*, while the important species of mollusks are *Anadara* and *Crassostrea commercialis*.

Culture fishery

Aquaculture is widely practiced in the mangroves of Thailand. Most of the culture fisheries are shrimp farms which are mainly found in coastal areas along the Gulf of Thailand. These farms have been operated during the last two decades. More than ten thousand tons of shrimp produced in 1982 came from nearly four thousand farms, occupying a total area of about 30,000 ha. The average production is about 325 kg per ha. Some of them operate on a subsistence basis. They are only productive for the first three or four years and are then abandoned. This inefficient and wasteful practice results in the degradation of large mangrove areas. It may also adversely affect the yield of the coastal shrimp capture fisheries. Recently, there has been a significant improvement in the average yield achieved by such aquaculture operations. This is due to better management and the widespread introduction of pumping. However, to conserve mangrove forests intensive and semi-intensive culture should be emphasized to maximize yields and benefits, rather than more extensive culture or expansion of farm areas which produce low yields and fewer benefits.

Mollusks have also been cultivated on the mudflats near mangrove areas in Thailand. Even though mollusks are not raised in the mangrove areas themselves, mangroves are still very important as a source of dissolved and suspended nutrients for the growth and productivity of mollusks. The total area of mollusk culture is quite limited, as in Rayong, Chanthaburi, Chumphon, Phang-nga, Krabi, and Satul provinces. The important species of mollusks cultured in Thailand include horse mussel (*Modiola senhausenii*), green mussel (*Perna veridis*), blood cockle (*Anadara granosa*) and oyster (*Crassostrea commercialis*).

Management of Mangrove Forests

Natural forest

The natural mangrove forests in Thailand have been operated for timber production since 1961. The shelterwood system with a minimum girth limit was retained and a number of additional regulations were added. The number of trees to be left in the cutting areas was to be determined according to the condition of the mangroves and the size of trees in each area. The felling cycle was fixed at 15 years. During the implementation of this silvicultural system (1961-1969), it was found that it was difficult to supervise and control field operations. In many areas the stock was depleted and the land degraded. Some areas were left with only non-commercial species. It was also difficult to harvest the sheltered trees without damaging the potential regeneration areas. Therefore, the management plan for mangrove forests was revised in 1969. Clear felling in alternate strips was then applied. Rotation was set at 30 years with a felling cycle of 15 years. This is

practiced by dividing the area into 15 coupes, forming an angle of 45 degrees with the tide, with cutting in alternate strips. The results of this silvicultural system are believed to be promising. This system continues in use up to the present. The exploitation of mangrove trees is operated under concessions. The period of a concession is fixed by the issue of a long-term permit, lasting 15 years. This cutting system gives a higher yield, and regeneration within clear-felled areas has also improved because once the trees within the allotted strips are cut, the forest can be managed effectively on a sustainable yield basis.

At present, more than two-thirds of the remaining mangrove forest areas in Thailand is managed under concession regulations. The major use of mangrove wood under these concessions is for timber products. Approximately 90% of the wood is used for charcoal making.

Some mangrove areas have been declared to be parts of National Parks, such as in Ranong, Phang-nga, Phuket, Krabi, Trang, Satul and Prachuab Kirikhan provinces. The Phang-nga National Park in Phang-nga Province, southern Thailand is the best known marine park. The mangrove habitat covers a large area of this park.

Mangrove forests in many provinces e.g., Trat, Nakhon Si Thammarat, Pattani, Ranong, Phuket, Phang-nga, and Satul, were managed for education and conservation purposes. Three mangrove research stations were established in Ranong, Phuket and Nakhon Si Thammarat provinces; and four mangrove seed production centers were established in Trat, Phang-nga, Nakhon Si Thammarat and Satul provinces. These stations and centers control designated areas to protect the mangrove forests. Various agencies are supported by the Thai government to cooperate with the Royal Forest Department, the core organization, in conducting research on mangrove management and its ecosystem. These agencies include the National Research Council, the National Environment Board, the Department of Fisheries and universities. Moreover, many international organizations such as CIDA, AIDAB, USAID, JSPS, UNDP, UNESCO, FAO and others, support research programs on mangrove development, rehabilitation and conservation in Thailand.

Mangrove plantations

Due to the tremendous increase in demand for fuel wood, poles, charcoal and wood-chips, there is an increasing need for enhanced production. This can be achieved through the establishment of mangrove plantations. The preferred species for planting are *Rhizophora apiculata* and *Rhizophora mucronata*. Other species such as *Bruguiera, Ceriops, Xylocarpus* and *Avicennia* spp., have also been planted.

The following are some important practices used in establishing *Rhizophora* plantations in the country.

Site preparation

In practice, little effort is needed for site preparation before planting since clear felling and intensive removal practices leave very little residue. If debris is left, it is cleared from the waterway and burned, if possible. In areas where *Acrostichum aureum, Acrostichum speciosum* and *Acanthus* spp. are abundant, weeding and cleaning are necessary before planting. Muddy areas with frequent tides along the coastlines or river banks are the most suitable sites for *Rhizophora* planting. Under these condition, planting *Rhizophora* is quite successful because *Rhizophora* seedlings can grow quickly and show low mortality (Aksornkoae, 1975). In areas above the normal tide level, small canals are dug to facilitate sea water flooding, and after planting, *Rhizophora* seedlings can grow successfully. However, this practice is only applied to small areas.

Spacing and planting techniques

In Thailand, *Rhizophora* species are generally planted by using propagules at a spacing of 1 x 1 m or 1.5 x 1.5 m. Aksornkoae (1975) and Raksakaeo (1976) conducted a comparative study on productivity and mortality of *Rhizophora* seedlings planted with different spacing. They found that *Rhizophora* planted at 1 x 1 m and 1.5 x 1.5 m show the highest productivity and lowest mortality rates.

The planting technique of *Rhizophora* is simple. Laborers carry small bundles of propagules. With every step, they bury approximately one-third of the total length of one propagule into the soft mud. *Rhizophora* plantations are also maintained by villagers particularly at Yeesarn village in Samut Songkhram Province. Plantations are mostly harvested to produce

small-sized charcoal on an 8 to 10 year rotation,. The spacing between planted trees is rather narrow, approximately 0.6 x 0.6 m. The wood from private plantations is also mainly used for charcoal making In addition to *Rhizophora* plantation, *Ceriops tagal* is also planted with a spacing of about 0.5 x 0.5 m, by villagers especially at Thungka village in Chumphon Province. The *Ceriops* trees from this plantation are mainly used as poles for cultivation of green mussels. Some are used for firewood. Rotations of the plantation range from only 4 to 5 years. *Xylocarpus granatum* and *Avicennia* spp. are planted in some areas for firewood but this practice is on a very limited scale.

Maintenance

During the first year of planting, very little weeding is required. After that *Acrostichum aureum* and *Acanthus ilicifolius* are the major weeds covering the plantation area. *Derris trifoliata* and *Finlaysonia maritima* may also be present. Thus, weeding is necessary in the second year after planting but herbicides are not recommended in this practice.

Thinning of some trees may be carried out when the growth rate and productivity decrease. However, natural thinning generally occurs since high density planting is common in mangrove plantations. Aksornkoae *et al.* (1989) recommended in their report that the first thinning should be done after 5 to 6 years in plantations with 1 x 1 m planting space, where the rotation is set at 15 years.

Pest and Diseases

Pest and diseases in mangrove plantation are not serious as compared with other terrestrial forest plantations. However, Chaiklom (1983) reported that the 2 - 3 years old *Rhizophora* plantation at Sumut Songkram were attacked by foliage eating larvae (*Cleora injection*), and borers (*Poecilips fallax*) in the larvae and adult stages, tunneled into and fed on the propagules. In some places, the borer infested large number of planted seedlings of *Rhizophora* spp. The seedlings are most susceptible to beetle attack within 3 - 4 months after planting.

In mudflat areas, various types of marine organisms infest mangrove seedlings, particularly *Rhizophora* plantations along the coast of the Gulf of Thailand. Barnacle and oyster spat generally settle onto the whole hypocotyl or lower part of the stems. The extra weight of these organisms results in deformation and damage to young seedlings. This infestation occurs mainly near the mouth of the river and estuary where the area is frequently inundated by sea water and the substrate is soft mud. Another marine organism which attacks the stem of trees in the plantation is the *Teredo* marine wood borer.

Crab infestation is also common in mangrove plantations. The *Uca* and *Sesarma* crab species usually girdle the root collar and eat the feshly cambium of propagules. The higher elevation areas which are infrequently flooded by sea water are affected by the mud lobster, *Thalassina anomala.* A mud lobster always makes a mound and causes undulant substrate and changing soil conditions. The mounds also obstruct the tides which normally flood into the area. This is detrimental to the growth of mangrove seedlings (Jintana, 1993).

Mangrove plantations in Thailand belong either to the Royal Forest Department (RFD) or to private individuals. The RFD's plantation are maintained mainly for ecological conservation and protection and for seed production. Private plantation have been managed for more than half a century. The rotation is fixed primarily according to the use of timber from the plantation, about 8 - 12 years for charcoal production. This rotation is used because at this age the trees will be about 4 - 8 cm in diameter at breast height, a size which is suitable for the production of good quality charcoal and which fetches a higher price than larger size charcoal.

Conclusion

In Thailand, inhabitants in mangrove areas depend almost entirely on mangrove resources and believe that sea and mangrove are the origin of life. Mangrove forests not only provide them with essential products, such as food, medicine, fuel wood, charcoal, fishery grounds, construction material, etc., but also protect the coast from the heavy monsoon and from the occasionally very strong winds from typhoons. The Thai government nowadays recognizes the importance of the mangrove ecosystem, has established policies and regulations, and has formulated an action plan especially for mangroves. Although some obstacles to implementation still exist, there appears to be a positive

trend in mangrove management with an increase of mangrove area, more sustainable use of the resources, more efficient action against illegal encroachment, and more cooperation between relevant groups of people.

The public in Thailand is becoming increasingly aware that mangrove forests, which were once an important source of many resources are being destroyed. The coastal population have had to face many problems resulting from destruction of mangroves, such as the depletion of fishery production, coastal erosion, marine pollution, sea water intrusion into their cultivated land, etc. Various conservation groups have been formed by these communities in their attempt to save their resource base. In addition, an international network to study and conserve the mangroves has been set up namely ISME. It now remains to be seen if the present progress and awareness will result in the restoration and sustainable development of productive mangroves.

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Socioeconomic Parameters of Mangrove Ecosystems

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Abstract

Mangrove forests are of great influence as the main component of ecological system. They perform as nursery grounds for aquatic resources, and maintain coastal biodiversity. The exploitation of mangrove forests will result in the decline of the production capacity of coastal resources, and communities relying on coastal resource will be adversely affected.

Though the government has undertaken several projects to rehabilitate the coastal resources of the Gulf of Thailand, the rate of degradation of the mangrove forest is still rapid. The trend of mangrove forest conversion in the Western and Inner Gulf is repeating itself on the Andaman Sea coast. It is important for every agency and sector to identify effective ways to prevent this from happening to the Andaman Sea coastal resources.

Introduction

The purpose of this paper is to discuss the current status and the soeio economic consequences of mangrove utilization in Thailand. There are 19 countries in Asia with mangrove forests covering an area of about 8.4 million ha, or around 46 percent of the world's total. Thailand has about 168,000 ha of mangrove forests or approximately 1 percent of the country's total land area, and about 1.08 per cent of the world's mangrove forest areas. The mangrove area of Thailand ranks ninth among the Asian countries that have tropical zones.

Mangrove forests are one of the primary features of the tropical and sub-tropical coastal ecosystem. Definitions of the mangrove forest generally embody two different coneepts. The first concept refers to an ecological group of evergreen plant species belonging to several botanical families. The second concept implies a complex of plant and animal communities. Mangrove forests are important as a main component of the ecological systems of the coastal areas. They provide timber and other forest products. They also act as a nursery ground for aquatic resources and help to maintain coastal biodiversity.

Exploitation of coastal resources destroys the natural functions of mangrove forests, resulting in environment degradation. Consequently, the productive capacity of coastal resources declines and communities relying on coastal resources are adversely affected.

Current Status of Mangrove Forest in Thailand

Location and Area

The coast line of Thailand is 2,600 kilometers long. Mangrove forest covers 936 kilometers or 36 percent of the total coastal length. Mangroves occur in the upper part of the Gulf of Thailand and the southern and southeastern parts of the country on the seashore, around coastal lagoons and along rivers at elevations between low and high tides.

The mangrove forests in Thailand have been declining rapidly since 1961. Total mangrove forests in the country dropped from 367,900 ha in 1961 to 168,883 ha in 1993. Thus, in just three decades, the mangrove in Thailand was reduced by more than 50 percent. The average rate of deforestation in mangrove forest is about 2.45 percent (Table 1).

Table 2 shows the distribution of mangrove forest in different coastal regions of Thailand and their changes between 1975 and 1993. As of 1993, about 79 percent of mangrove forests were along the Andaman Sea coast. The rest is scattered along the Western (10%), Eastern (8%), and Inner (3%) Gulf.

Changes in the mangrove forest areas vary substantially between regions. The Andaman Sea coast area lost the most area of mangrove forest between

Table 1. Mangrove Forest Area in Thailand 1961-1993

Year	Mangrove Forest Area (ha) Total Area	Decline in ha	Decline (%)
1961	367,900		
1975	312,700	55,200	15
1986	196,436	116,264	37.2
1991	173,600	22,836	11.6
1993	168,883	4,917	2.8
Total 1961 - 1993		199,217	54.1

Source: Royal Forestry Department

1961 and 1993, 57,853 ha. However, the converted area was only around 30 percent of that region's 1975 area, and the reduction rate was also the lowest among the region, an annual rate of 1.9 percent. The highest reduction rate was in the Inner Gulf coast, about 10 percent per annum. The converted areas of the Inner Gulf coast totaled 31,136 ha, equivalent to around 85 percent of that region's total mangrove area in 1975 an annual rate of about 10%. The conversion of the mangrove area in the Eastern Gulf coast was also high. Its reduction rate was about 7 percent per year.

As can be seen, despite its relatively small proportion of the total, the mangrove forests in the Inner Gulf coast of Thailand were exploited at the highest rate, followed by those in the Eastern and Western Gulf coast. The Andaman coast, with the largest mangrove forest region in Thailand still had relatively rich mangrove resources. The region has also the lowest rate of conversion of mangroves in the country.

The Main Causes of the Mangrove Forest Conversion

The trends of mangrove conversion in different areas in Thailand indicate the patterns of mangrove forest exploitation in the country. In earlier times, mangrove forests were damaged from over-exploitation of the forest and from agricultural land and human settlements. Over the last decade, the main form of mangrove exploitation has been shrimp farming because of its high short term return. Partly due to uncontrolled management, and partly due to other factors, the environment was deteriorated rapidly and risk production increased. Studies show that in general, shrimp farming in a single location is profitable for only 5 years. After that, the risk is so high that the rate of return becomes negative (see, e.g., Wanna Artnarong, 1991). As a result, shrimp farmers move to new mangrove forests and continue their exploitative land conversion. The recent pattern of mangrove forest conversion in Thailand is largely due to this type of shrimp farming practice. This form of exploitation started in the Inner Gulf of Thailand, then expanded to the Eastern and Western Gulf of the country (see MIDAS, 1995). Now the Andaman region is seriously threatened.

This trend is reflected in Table 3. Shrimp farm area in the Inner Gulf of Thailand increased to its peak in 1989 and had declined by 55% in 1993. Similarly, the shrimp farm area in the Western Gulf nearly doubled between 1988 and 1991, and then dropped in 1993. In contrast, the shrimp farms in the Eastern Gulf increased by 150% from 1988 to 1993. Although in absolute term, the shrimp farming area on the Andaman coast is still low, the rate of increase in shrimp farm area during the 6 year period was 330%. The time trend of shrimp farming in the Western Gulf is similar to the Inner Gulf pattern, but the Eastern Gulf and the Andaman areas do not show signs of a decline in area.

What happens to abandoned shrimp farms? Experience in the inner gulf of Thailand indicates that the abandoned shrimp farms have been left idle. The environment has been so severely affected that the areas can not be cultivated profitably. No doubt the biodiversity and habitat in the coastal regions has also been heavily affected. This inevitably affects those who rely on these natural resources.

Economics of Small Fishery Households and Shrimp Farmers

Mangrove forests are the most important renewable resources for small fishing households who directly and indirectly rely on coastal fishery resources. Mangrove forest areas also provide several sources of cash income to the people in the areas, such as charcoal, firewood, poles and other construction materials. Most small fishing households live in small village communities at the edge of the forest or along the channels within an estuary.

Table 4 shows the change in number of small scale fishing households between 1985 and 1995. During the period, the number of small scale fishing

Table 2. Distribution of Mangrove Forest Areas and Loss by Region 1975-1993

Region	Area (ha)		Converted	% Change	Average Annual Reduction	
	1975	1993	Area (ha)	1975-93	Area	Rate (%)
Andaman coast	191,700	133,847	57,853	30.2	3,214	1.9
Eastern Gulf coast	49,000	13,048	35,952	73.4	1,997	7.0
Inner Gulf coast	35,500	5,363	31,136	85.3	1,730	10
Western Gulf coast	35,500	16,425	19,075	53.7	1,060	4.2
Total	312,700	168,683	144,016	46.1	8,001	3.4

Table 3. Shrimp Farm Areas by Region, 1988-1993 (ha)

	Year				
Regions	1988*	1989*	1990*	1991*	1993**
Andaman coast	910	1,341	1,545	2,951	3,949
Eastern Gulf coast	10,368	15,474	15,925	21,518	25,984
Inner Gulf coast	27,512	31,260	21,553	20,393	14,157
Western Gulf coast	15,988	23,091	25,582	30,628	20,902
Total	54,778	71,166	64,605	75,332	64,992
Change (%)	22	30	-9	17	-14

Source: *Fishery Department
**Royal Forestry Department

households increased from 46,005 to 53,313, an average annual rate of increase of 1.5% per year. The table also suggests that there are still many low-income fishing households relying on the fishery resources, while those who are able to do so have to increase their fishing efforts by investing in boats and engines.

In contrast, the number of shrimp farms increased more than four-fold from 1985 to 1995, from 5.6 thousand to 25.1 thousand households (Table 5). The shrimp farming area increased from 34,718 ha to 67,316 ha over the same period. Thus the average shrimp farm size declined from 6.2 ha to about 2.7 ha. These changes of number of shrimp farm households and areas reflect the enormous structural changes of the mangrove forest to shrimp farming. This also suggests the potential effects of those changes on small fishing families as compared with shrimp farmers.

The Potential Impacts of Mangrove Forest Conversion

Several impacts of mangrove forest conversion can be envisaged. The conversion of the mangrove forests to shrimp farms generates substantial income for shrimp farmers and creates various downstream effects on the economy of the country in general. The positive effects are not without the price. The unsustainable use of mangrove forest resources creates tens of thousands of hectares of agricultural waste land. It damages the ecological systems in the coastal areas. and reduces the productive capacities of the coastal resources. Most importantly, these resources are vital to the survival of the small fishing households which increase over time. Deterioration of the natural resources, together with the expansion of small fishing households, implies potential severe effects on their earning capability.

Impact on Income

Based on a statistical report, Table 6 shows cost and return of coastal small scale fishing households and Table 7 costs and returns from shrimp farming.

Table 4. Changes in Number of Small Scale Fisbing Households (HH) by Type of Boat

Type	1985		1990		1995		Change	
	Total HH	%	Total HH	%	Total HH	%	Total HH	%
1. Without boat	3,208	7	1,595	4	3,343	6	135	4
2. With boat	42,797	93	40,828	96	49,970	94	7,173	17
2.1 With non-powered boat	7,319		4,494		N/A		N/A	
2.2 With outboard powered boat	26,791		28,814		N/A		N/A	
2.3 With inboard powered boat	8,687		7,519		N/A		N/A	
Total	46,005	100	42,422	100	53,313	100	7,308	21

Source: National Statistics Office, Fisheries Census

Table 5. Shrimp Farm Area and Number of Households 1989 - 1992

Year	Total Households*	Area (ha)**
1989	5,604	34,718
1990	15,072	64,606
1991	18,998	75,332
1993	N/A	64,992
1995	25,125	67,316

Source : * National Statistics Report
** Fisheries Department

The 1990 statistics showed that the average net income of the coastal small scale fishery households was less than Baht 40,000 (25 Baht = US$1). In contrast, the average net income of intensive shrimp farm per ha per crop in the same year was about Baht 178,125. Using the conservative average farm size of 2.4 ha per household and average 1.5 crops per year, the average net income of shrimp farm household can be as high as Baht 641,250 (US$25,650).

Comparing the differences between incomes of the small scale fishery and shrimp farm households suggests potential effects of conversion of mangrove forests to shrimp farms. Shrimp farmers potentially receive more than twenty five times the income of small-scale fishers. The fishers, on the other hands, are more vulnerable to environment changes of the resources. While shrimp farmers are able to move to new resource rich area, small scale fishing households, with their subsistence income have very limited alternative options. Thus the potential negative social impacts seem high.

Impact on Coastal Resources

Production

Due to the unsustainable use of mangrove forests for economic activities and human settlement, the mangrove ecosystem has been rapidly damaged. This has affected small scale coastal fishery production.

Table 8 shows coastal fishery production in the different regions. In 1992, production from small scale fishing was about 154,467 tons or 5.6% of the country's total coastal production. Coastal fishery production reached its peak of 159,825 tons in 1988. After that, coastal fishery production fluctuated and declined. Comparing differences in the production of small scale fishing among the regions, the Andaman coast was more stable, while production in the Gulf of Thailand fluctuated. This suggests a reduction in the capacity to provide resources to meet the demand for the coastal fishing productions in the near future.

Pollution of Coastal Sea Water

The quality of sea water is an indicator of the richness and abundance of coastal resources. The 1993 statistical reports of the Water Quality Management Division and Pollution Control Department show that the quality of the water in the lower Cha Phaya, Bang Prakong, and lower Tha Jeen rivers flowing south to the Gulf of Thailand is below the normal standard of the sea water. The main factors causing water pollution are community settlement along the coast, tourist activities, waste water from factories, and shrimp farms.

Discharged water from shrimp ponds contains salt and organic substances, some toxic chemicals used for

Table 6. Cost and Return of Intensive Shrimp Farm per Hectare per Crop in 1990

1.	Gross income			
	Yield per hectare 5,437.5 kg, Farm price 150 Baht/kg			
	Value of production per hectare (Baht)			815,625
2.	Costs			
	Young shrimp	59,919		
	Feed	311,963		
	Gasoline, oil, electricity	49,956		
	Pond cleaning and repair	39,031		
	Family labor	22,512		
	Hired labor	20,588		
	Other	13,644		
	Total variable costs		517,612	
	Land tax and land rent	5,200		
	Interest	22,743		
	Opportunity cost of land	33,131		
	Depreciation	58,606		
	Total fixed costs		119,681	
	Total Costs			637,293
3.	Net Income per Hectare (Baht)			178,338

Table 7. Cost and Return of Small Scale Coastal Fishery, 1993

1	Income from fishery (Baht)		
	Cash from selling marine animals	64,950	
	Marine animals for home consumption	6,216	
	Gross income		71,166
2.	Costs (Baht)		
	Capital funds		
	Crew, workers	6,526	
	Gasoline	11,363	
	Equipment and materials	4,306	
	Ice	766	
	Other materials	699	
	Boat maintenance	1,520	
	Power maintenance	1,497	
	Interest	554	
	Other	239	
	Depreciation of equipment	4,324	
	Total costs		31,774
3.	Net income (Baht)		39,392

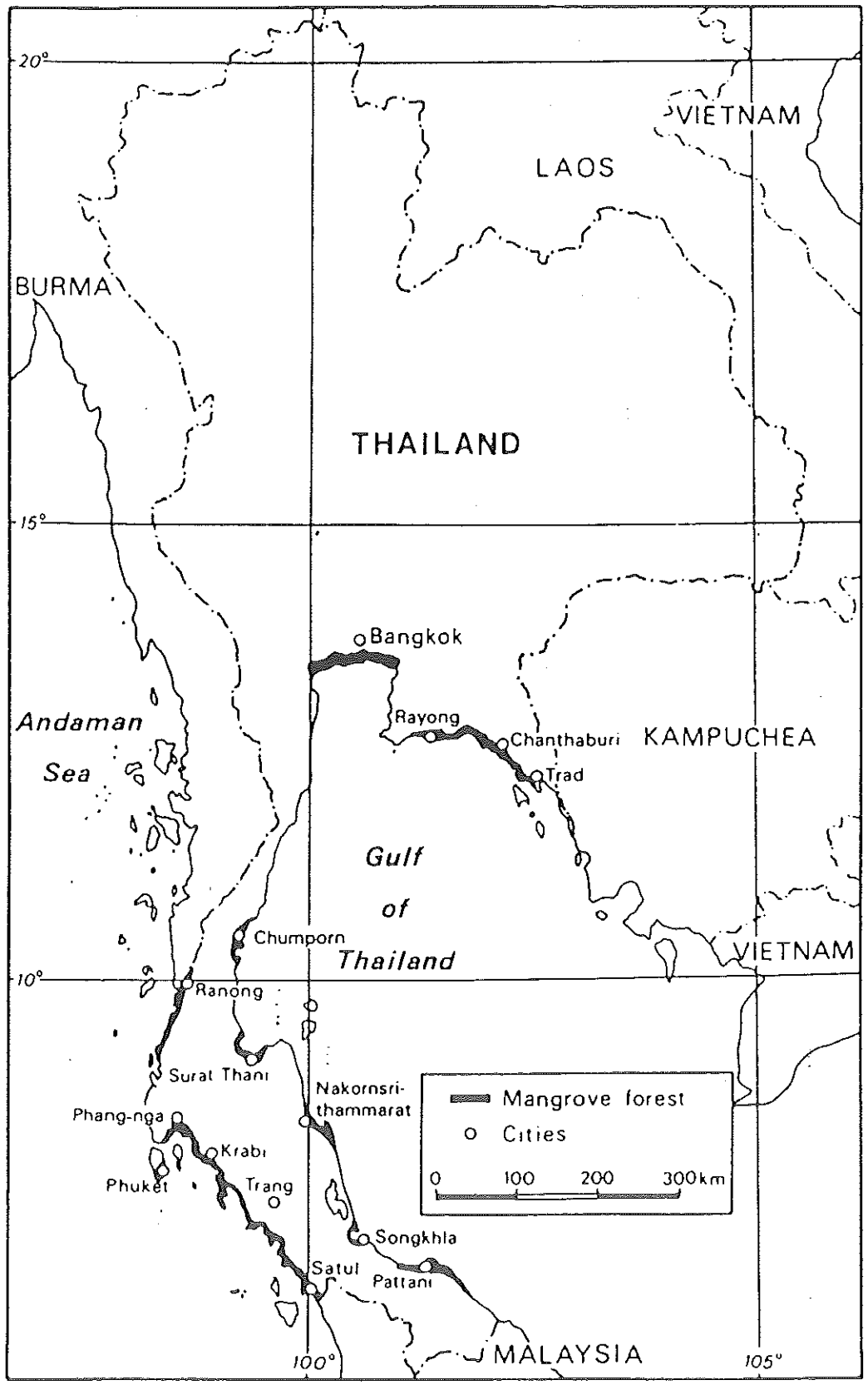

Fig. 1. Distribution of mangroves in Thailand.

Table 8. Production Statistics for Small Scale Sea Fisheries, 1984 - 1986 (Thousands of Tons)

Year	Total Fisheries Production	Total Small Scale Fish Production	Small Scale as % of Total Fisheries	Production of Gulf of Thailand	Total (%)	Production of Andaman Coast	Total (%)
1983	1,973.00	138.4	7.00	N/A	N/A	N/A	N/A
1984	1,997.20	141.4	7.1	120.6	85.3	20.3	14.7
1985	2,309.50	146.8	6.4	123.1	83.8	23.7	16.2
1986	2,540.00	155.3	6.1	133.3	85.8	22.00	14.2
1987	2,337.20	159.4	6.8	136.3	85.6	23.1	14.4
1988	2,370.20	159.8	6.7	136.6	85.5	23.2	14.50
1989	2,362.20	150.00	6.3	127.9	85.3	22.1	14.7
1990	2,478.60	154.1	6.2	130.9	84.9	23.2	15.1
1991	2,736.40	153.1	5.6	129.3	84.5	24.0	15.7
1992	2,752.50	154.5	5.6	130.9	84.7	23.6	15.3

killing shrimp predators, chemical fertilizers, lime and other minerals. As a result of the organic digestion process, high quantities of carbon dioxide, hydrogen sulfide, ammoniac nitrogen and nitrite are produced. The discharge of water from shrimp ponds to the sea is one of the major sources of the water pollution in the coastal areas.

The study of Thongchai Suntisook indicates that there are about 74 species in mangrove vegetation in Thailand. The dominant forms are *Rhizophora* spp., *Sonneratia* spp., Verbenaceae, Combretaceae, etc. According to the IUCN Plant Red Data Book, six species of the mangrove vegetation are endangered namely *Aegialitis rotundifolia*, *Aglaia cucullata*, *Brownlowia tersa*, *Bruguiera hainesii*, *Heritiera fomes* and *Merope angulata*.

Prospect

The conditions described above indicate impacts from coastal resources in the Gulf of Thailand. Small scale fishery households and shrimp farmers in the inner part, and some of the western parts of the Gulf are highly affected. The damage has become a big burden for society. The government needs to provide a large budget to rehabilitate coastal resources, such as construction of a water treatment system at the lower part of Tha Jeen and Chao Phaya rivers. In addition, a study of investment in rehabilitation of coastal resources and abandoned shrimp farms in Samut Songkhram province shows that 2,500 million baht is required to solve this problem. Moreover, the government had provided the irrigation of sea water project in the areas of Songkhla, Nakorn Si Thammarat and Chantaburi provinces.

In the past the rehabilitation of coastal resources has not yielded satisfactory results. Despite cooperation of the various involved parties with the operation their efforts could not improve the on-going deterioration quickly enough. Regardless of the high cost of these activities, there is still some damage that cannot be economically valued. If the pattern of mangrove forest conversion in the Thai Gulf is repeated for Andaman coastal resources that would leave other questions to be considered, for example, whether to start making operation plans and what kind of measures should be used before it is too late.

Conclusion

This study shows that the conversion of mangrove forest during the past three decades has undoubtedly affected small scale fishery communities who depend on the coastal resources. Because of their low economic status, these people cannot move to a new habitat to change their occupation. At the same time, the impacts from mangrove forest destruction have affected coastal farmers, especially shrimp farmers. However, with better economic status, shrimp farmers still have opportunities to move to new mangrove

forest. Therefore, in order to prevent the coastal destruction cycle, it is necessary to set up a clear policy and effective measures for a sustainable use of coastal resources.

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Mangrove Ecosystem Conservation - Issues and Their Management

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Introduction

The importance of interdependent relationships between all living organisms (plants, animals and microorganisms) is now well recognized. The relationship between the mangrove ecosystem and mankind, particularly coastal people, is an important one. This is due to the significance of mangroves in socioeconomic, ecological and scientific terms. Mangroves also have great value to naturalists, displaying a composite and wide variety of living organisms. Conservationists' strong emotional attachment to nature has added humanistic and aesthetic values to the mangroves which also serve as an important habitat for endangered animal species, especially mangrove-dependent species such as shore birds, fishing cats, crab-eating monkeys, manatees, otters, saltwater crocodiles, horseshoe crabs, fiddler crabs, and several species of fishes and turtles. These values have led to the formation of a new agenda in terms of conservation activities relating to biodiversity, since the survival or extinction of rare species in mangrove ecosystems, and developing sustainable systems for the use of mangrove resources, are both issues of great international concern.

The depletion of mangrove habitats during the last three and a half decades has proceeded rapidly, particularly in Thailand where less than half of the original areas remain. The underlying reasons for this come down to rapid population growth, and exploitation of these areas by people seeking a quick economic return. This exploitation takes many forms, such as conversion of mangrove habitat to shrimp farms, real estate development, mining, road construction and urban expansion. These types of changes cause a reduction in the biodiversity and genetic variety which are components of the overall life support systems in coastal areas, and also have a negative impact on the earning potential and opportunities for the mangrove-dwelling people. Efforts to manage and conserve resources on a sustainable basis have been delayed in several countries because of conflicts in ideas and interests between policy makers, users, resource managers and others. The present rate of destruction and degradation of mangrove ecosystems has now reached crisis proportions. If this trend continues, not only will plant and animal resources be reduced, but the well-being of mangrove dwellers will be challenged. The mangrove community will become unstable and, thus, the sustainable use of mangroves will be out of reach.

The Concept and Necessity for Conservation

Conservation traditionally means to save, to preserve and to take care of the resources such as water, soil, forestry, or wildlife, and to maintain them for future use. L.W. Allen (1959) has noted that "Conservation is interpreted as a kind of resource use which results in the greatest good for the largest number of people for the longest time." The meaning of "conservation" is further defined as an attempt to save generic stocks, genetic variety within species, numbers of species and ecosystem diversity.

The reasons for the urgent need to conserve mangroves can be summarized as follows:

1) To retain the value of mangrove products, such as timber products including logs, lumber and also non-timber products which consist of fuelwood, fish, crabs, oysters and shrimp. These marketable products of mangroves are abundant in a stable system.

2) To keep the public utility value where mangrove ecosystems provide ecological services such as absorption of carbon dioxide, capture of solar energy via photosynthesis, protection from erosion along coastal areas, protection of inland areas from storms and high waves, storage and recycling of nutrients, and absorption of some pollutants.

3) To retain and enhance the ecological-scientific value including, the ecological perspective which describes the critical nature of interdependence

between species and habitats. The scientific perspectives emphasize the structures, functions, and processes of the diversity of plants, animals and microorganisms in the mangrove ecosystem and the intrinsic importance of biodiversity in nature. The output of research and development into the biological and genetic resources can be used for pharmaceutical and food industries.

4) To benefit from the esthetic, naturalistic and recreational values of mangrove ecosystems. Ecotourism in mangrove areas can provide not only satisfaction and an appreciation of nature but, also, revenue and employment opportunities for mangrove dwellers in several mangrove reserve areas.

5) To use the educational and humanistic values also raises the need for conservation, since the natural habitats and species variety in different mangrove ecosystems can be used as teaching grounds for students of environmental management, and as nature centers for those who enjoy and value nature. These values are clearly significant to the coastal people and are now becoming even more important for demonstrating the need for coexistence between mankind and nature. This set of values can be used as a yardstick for those who engage in the management and conservation of mangrove ecosystems, particularly planners, policy makers and resource managers, who will be responsible for ensuring that mangrove ecosystems will be used sustainably in the future.

The Present Status of Conservation Activities and the Utilization of Mangroves

In the period 1991-1994, the International Society for Mangrove Ecosystems carried out various projects concerning the state of conservation and sustainable utilization of mangrove forests in the South-East Asia - Pacific, Latin America and African regions. The "Report on Economic and Environmental Values of Mangrove Forests and their Present State of Conservation in the South-East Asia and Pacific Region" was edited by Barry Clough in 1993. The Report was published with the cooperation of the International Tropical Timber Organization (ITTO), the International Society for Mangrove Ecosystems (ISME) and the Japan International Association for Mangroves (JIAM). It reported that people living near the coasts and estuaries of South-East Asia and the Pacific have had a long association with the mangroves. Traditionally, mangrove forests provided food firewood and other resources needed for the sustenance and livelihood of local villages. Mangrove resources have also been used to produce medicinal plants, dyes and alcohol. In Indonesia, Malaysia and Thailand there is an urgent need for standard methodology to be used in the assessment of the environmental, cultural and socio-economic value of the mangroves. As a result, mangrove forest areas have been destroyed and converted to other uses such as tin mining, salt ponds, shrimp farms, human settlements and industrial sites. Only a small proportion of the mangrove areas in South-East Asia are designated and set aside as nature reserves, parks and amenity forests.

L.D. Lacerda edited a report on the conservation and sustainable use of mangrove forests in Latin America in 1993. The report was published by the International Tropical Timber Organization and the International Society for Mangrove Ecosystems. Uses for mangrove products such as firewood, charcoal and tannin in this region are similar to those in Asia. For Africa, E.S. Diop (included in Lacerda's 1993 report) found that mangrove ecosystems vary from one sub-region to another and depend essentially on rainfall, fresh water, nutrient supply, temperature and the quality of the substratum. The latter factors are noticeably more favorable on the eastern coast of Africa, which partially explains why the diversity of mangrove species on the Indian Ocean coast is greater than on the Atlantic coast of the continent. As in Asia, mangroves in Africa are used as a source of firewood, timber, aquaculture and for tourism activities and development of ports.

Considering the range of activities undertaken to communicate and cooperate in research relating to mangrove conservation during the last decade, it can safely be concluded that the importance of mangroves as life-sustaining ecosystems and the need for their conservation is clearly recognized.

The Strategy for Conservation

It has been noted that methods for assessing mangrove resources have been developed and discussed for some time. The results have been used to assist in identifying areas that merit the highest conservation priority.

In 1990, the International Union for the Conservation of Nature and Natural Resources (IUCN) presented a long-range plan for preserving the earth's living resources, and for managing them on a sustainable basis. The World Conservation Strategy has three major goals: 1) Maintain essential ecological processes and life-supporting systems. 2) Preserve genetic diversity. 3) Use species and ecosystems sustainably.

The basic strategy for mangrove conservation is relatively simple. More mangrove ecosystems must be categorized as natural reserves, parks and sanctuaries. This will, at a minimum, protect mangroves from other land uses. The protected mangroves or conservation zones will maintain species and genetic diversity and provide areas for scientific investigation, education, recreation and cultural interest. The conservation zones will also provide coastline protection and breeding grounds and shelter for aquatic animals such as fish, crabs, shrimp, oysters and other shellfish. In order for mangrove conservation zones areas to be implemented effectively, it is imperative that the socioeconomic status and educational level of local inhabitants be improved. Also, for effective coordination at the decision- and policy-maker level, expert representation in the field will have to be increased so that the aim of sustainable utilization of mangrove resources will be attained.

Conclusion

The conservation of mangrove ecosystems has been an important agenda item for international organizations for more than two and a half decades. UNESCO, with support from UNDP and other agencies, has launched research and training programs in the South-East Asia and Pacific regions. The Government of Japan and the International Tropical Timber Organization have provided funds to support training, seminars, workshops and research into mangrove ecosystems around the world. Public awareness of the importance of mangrove resources for coastal fisheries and plant products is increasing. However, the mangrove-dwelling people in many parts of the world remain below the poverty line. It is difficult to restrain these people from interfering with mangroves since the mangrove species are their main source of food and of firewood for cooking. The concept of community or social forestry is an alternative means of managing mangrove ecosystems where local people depend on mangrove resources. Ecological sustainability requires some flexibility in the utilization and management of resources.

The ultimate goal for all of us must be to use the mangroves resources sustainably and to apply the best of science and technology to properly develop and manage these important coastal resources.

Sustainable Use and Eco-Eco-Management of Mangroves (Ecologically Wise and Economically Profitable)

Marta Vannucci

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There appears to be no doubt that the human population of the world has grown beyond the carrying capacity of space-ship Earth. Much of the growing world production is corroding the capital, stored as fossil fuels. Sustainable production is a function of productivity, or rate of production. Biological productivity is ultimately linked to the total photosynthetic capacity of the Earth's ecosystem. There are no reliable estimates of the contribution of mangroves to total world productivity. We know, however, that the mangrove vegetation responsible for the photosynthetic activity of the system is specifically adapted to grow under environmental conditions and places such as no other community is capable of colonizing. Not much primary production, or carbon fixation, takes place world wide in conditions of absence of light (what is termed dark fixation or chemosynthesis). Chemosynthesis does not carry much weight in terms of total global productivity; it is restricted to abyssal depths of the oceans, the deep sea vents, and particular places on the surface of the Earth such as geysers, caves and certain soils and waters. Because of frequent anoxic conditions and scarce or nil light penetration, soils and waters of the mangroves may have a significant, though small but measurable amounts of dark carbon fixation, i.e, synthesis of organic matter in the absence of light. Phytoplankton primary productivity in mangrove waters is usually as small as two to four orders of magnitude lower than primary productivity of coastal waters and much smaller than estimates of primary productivity of the whole ecosystem. In the middle or higher reaches of the mangroves, photosynthetic primary production of waters may go down to nil. The forest is undoubtedly the main source of synthesis of organic matter, and therefore, wise use and management of the mangrove forest is the basic requirement to achieve sustainable use of the mangrove system.

ISME stands for conservation and rational use and management of the mangroves of the world, because mangroves are a unique ecosystem that if ever destroyed cannot be easily substituted for by any other natural ecosystem, and can only be reconstituted at the cost of much effort in time and money.

There are few if any, pristine ecosystems left in the world and total conservation appears impossible to advocate. The highest mountain peaks, abyssal depths of the oceans and space are already soiled by human litter and pollution. This applies also to mangroves.

All ecosystems, natural and manmade, are in a continuous process of evolution and change; the best that we can do is to use our understanding of the structure and dynamics of the system to manage it wisely and thus ensure production for an indefinite amount of time in the future. Production is of two kinds: one is entropic and maintains the system according to the second law of thermodynamics, the other is extractive and this is where man comes in, removing from the system those resources that are valuable for his survival and monetary profit. Man can also have a beneficial role towards safeguarding and promoting the health and productivity of the system through appropriate maintenance, particularly by using biological and biosystem management methods.

Apart from often substituting one ecosystem for another, direct or indirect human interference in any ecosystem has been exclusively for those two reasons: management and extraction.

Human direct interferences in the mangroves are those we all know about. They mainly refer to obtaining immediate benefits in terms of goods for shelter, food, clothing, medicines and transport. However, the production, and the rate of production or productivity of these resources taken locally, are also influenced by human activities elsewhere and must be considered for the management of mangrove ecosystems.

Without going as far as the ozone hole, global warming and rise in mean sea level, which all affect

everything on Earth, just one example from daily reality in the mangroves is the hydrological regime. From the catchment area, sometimes as far as thousands of kilometers away, to the damming and channelizing of rivers downstream, or the building of sea walls, human interference affects in one way or another, positively or negatively, the mangroves of the deltas, estuaries, and coastal plains and shallows. While it might not be possible to stop human interference in the world waterways, we can try to manage the mangrove forest so it may have time to adjust to environmental changes. Most relevant are changes in total river discharge, salinity and temperature of waters and soils, silt content, dissolved oxygen and chemicals, residence time of the waters in the swamp and, in general, all climatic changes and all uses of the mangrove itself.

Bearing in mind that the single factor which is the *sine qua non* requirement for the maintenance of the mangrove ecosystem are tidal horizontal and vertical movements, management practices must adapt also to other changes in the biotic and abiotic environment.

Though local management of mangroves, including replanting, was practiced by many coastal people, large scale management of extensive areas over a considerable period has taken place in the Sunderbans of the joint delta of the Ganges-Brahmaputra for about 120 years and in the Matang forest of Malaysia, for about 90 years. In both cases, the reference guideline for management has been the inundation regime, though the tides follow a different pattern in either place. Both are managed as production forests, including the waterways, but the guiding principles of the management systems are entirely different, because both the ecological and the socio-economic realities are different. The two systems, however, have one factor in common: they are both revised at regular intervals, which is usually a period of five years. Also records of changes, including production, are kept for later reference and analysis. Both in the Sunderbans and at Matang the management practices have proved to be sound, though inevitably there are production highs and lows, as is the rule in all natural and man-made ecosystems. A steady state condition is impossible to achieve, mainly for two reasons: first, because there are inherent changes over time in the system itself and in the adjoining systems, and second, because of changing socio-economic conditions. This latter factor, coupled with unprecedented human population pressure, in addition to the lag of the adaptive capacity of the system, is the main cause of ecologically unbalanced situations, if not downright disasters, in many parts of the tropical belt.

In the selective system, as practiced in the mangrove forests (Sunderbans), only trees above a prescribed diameter are harvested and natural regeneration ensures future stocking of the forests (Siddiqi 1990). "The canopy never remains open, the selection system is not only helpful to wildlife, it has all the merits over the clear felling system except that the economic return is lower....The forest remains almost virgin" (Siddiqi, 1996). To this I would add that yearly economic return is lower, but the system lasts over decades and probably centuries.

The management practice at Matang is different. Total felling takes place in blocks 20-50 m wide, at an angle with the waterway currents. The blocks to be cut are selected by a rotation system and a few mother trees are left standing for natural replanting.

In conclusion, an ideal mangrove management system recognizes natural changes and provides for sustained production of the resources. It does so by managing local hydrology, avoiding stagnant waters, by replanting species that are important for the conservation of the system, for biodiversity and for socio-economic requirements of coastal populations. Appropriate management can also be successful in reforesting degraded and denuded intertidal areas and afforesting areas previously devoid of mangroves, as in coastal new accretions.

As an example, in the Ganges-Brahmaputra delta, mud banks have been consolidated by afforestation, mainly using *Sonneratia apetala* and *Avicennia officinalis* as pioneer colonisers. They are then turned over to mixed agriculture and tidal forestry and forestry above tidal levels. These forests include diversified commercially valuable species of mangroves, and they establish a green belt for protection against cyclones. Productive multiple species forests are established by increasing species diversity and introducing second storey species under a closed canopy. At the same time, the upper tidal zone is afforested with mangrove associate trees and shrubs tolerant to salinity levels higher than those of tidal waters.

After the *Rhizophora* had been cut down to fuel the boilers of the recently built railways during the last quarter of the XIX century the mangroves of the Karachi area in Sindh had become an almost exclusive *Avicennia* forest with other species only found infrequently. Besides re-introducing *Rhizophora* to rehabilitate the often degraded forest, a large area is now being reforested with a variety of species because of the ecological advantages provided by mixed forests and because of the socioeconomic value of some of the less common species. In the Indus River Delta proper, the mangroves were degraded because water discharge from the Indus River was reduced, by excessive cutting of *Avicennia* for fuel and fodder, and by pollution. Reforestation is being carried out by different techniques, appropriate to the place, suitable for the changing socioeconomic environment and allowing for changes in agricultural practices and crops of the delta.

On the other hand, destructive practices such as total felling of mangroves for engineering works, for wood chips, for aquaculture ponds (mainly shrimp), must always and on all accounts be condemned because they cause an abrupt change in the ecosystem so that spontaneous recovery and spontaneous regeneration has no chance to take place. Methods of assisted regeneration have been developed for such situations where degradation of the environment has gone beyond limits of natural recovery potential. Often assisted regeneration is possible and worthwhile, though expensive and time consuming.

Finally I would mention that no single resource can be exploited to the level of its full production potential without causing a decline in the production of the other resources of the same ecosystem. In other words, no single resource should be exploited to its *maximum* potential turnover rate. Each resource can conveniently be exploited only to its *optimum* production potential. The goal to be achieved is a balance among the output of the several sympatric resources. Because the rates of productivity vary with species, time and place, the overall production of each and all resources lumped together, varies over time. Hence there is a periodic need to adjust and revise practices for use and management practices specially where mangroves cover a very large area.

The forest is the most conspicuous element of the mangroves and it is this element that creates the ecosystem. However it is not the only component that gives valuable resources to mankind. The forest gives timber for a variety of uses and also provides man with minor forests products, important among them *Nypa* palm that produces fronds for roofing and partitioning of houses, sugar, alcohol and vinegar from the sap and edible fruit. The most valuable forest trees are *Rhizophora* spp. for a variety of uses, and *Avicennia* spp. for fuel and fodder and reforestation of difficult areas. *Avicennia* spp. can do this thanks to their wide tolerance to temperature extremes and different soil conditions. *Heritiera* spp. and *Excoecaria* are tolerant of long periods of soil exposure to air above inundation levels. *Sonneratia* spp. are useful for consolidating the build up of coastlines with abundant alluvial deposits, such as the new coastal accretions. Also the grass *Porteresia coarctata*, a species of wild rice, produces edible seeds and its establishment indicates stabilization of the ecosystem. Species of other genera and families each have their properties and are best made use of to occupy the different ecological niches that the forest offers. All species of mangrove plants must be considered for management, including the fern *Acrostichum*, a weed, for the sake of biodiversity, for ecological and for socioeconomic reasons, though not all may occur in the same mangrove.

Though dominant, the forest is only one of the many elements of the mangrove ecosystem. The waters, soils, macro- and microfauna, resident and migratory species, the algae, fungi, lichens, mosses, epiphytes, parasitic plants and other parasites and microorganisms are all an integral part of the mangroves. Each has its role to play for the stability and health of the system. The richer the biodiversity, not only in timber species but of all plants and animals, the more ecological niches are created, the more stable the system becomes. Imagine a human population suddenly deprived of all cooks, or all farmers or school teachers or thieves and robbers. Only under such circumstances one would realize how each one plays a decisive role, positive or negative forcing on the system for smooth functioning. For example, crabs aerate the soil and break down vegetal matter thus facilitating recycling of nutrients, but they also ring and thereby cause the death of propagules of Rhizophoraceans, thus influencing biodiversity. Interestingly enough in years when the monsoon failed and water salinity was very

high, saplings of *Rhizophora* were covered with barnacles that protected the propagules from ringing by crabs; however many of the saplings that had not yet grown above high tide level died because their leaves were covered by barnacles that prevented photosynthesis to take place. Taller saplings developed well after escaping successive action by two pests: first crabs and later barnacles (Karachi area, 1987-1989; personal observation). Fluxes of populations of different species tend to compensate for each other. This contributes to the stability of the system as well as ensuring that some species may be available to take over when another decreases. This is a common ecological phenomenon to be considered for wise ecosystem management. Immoderate favoring of a few species for immediate monetary gains may cause imbalance and possibly irreversible damage to the system.

The waters of mangroves are usually particularly rich in nutrients, trace elements and compounds necessary for organic production. The waterways of the mangroves usually sustain a rich fauna of both adults and young of many species. These range from unicellular to pluricellular animals that spend part or all of their lifetime in mangrove waters, for shelter, food and for some of them, also for reproduction. Much of the dissolved and particulate matter of the mangroves is carried out to the coastal seawaters. Accordingly, human populations of the tropical coastal zone are mainly composed of fishing communities who exploit both captive and capture fisheries. Animal excreta and high temperature favor high numbers of microorganism and intensive recycling of nutrients.

The main source of primary and secondary production, which is the forest with its associate fauna, is destroyed when mangroves are totally felled for setting up shrimp ponds under intensive cultivation. Artificial inputs of energy, mainly in terms of food, aeration of the water and hatcheries, are expensive substitutes for some of the services that mangroves offer to mankind free of cost. Intensive shrimp farms produce large amounts of commercially valuable shrimp in a short time, but they are not able to sustain the same level of production for more than two or just a very few years. The bonanza quickly comes to an end and with it the quick gains. The system collapses and leaves behind it degraded land, no mangroves, and no aquaculture to speak of.

Traditional silvi-aquaculture or agri-aquaculture (rice plus fish and shrimp) systems, like the *pokkali* and the *bheri* of India, or the *tumpak-sari* of Indonesia have been practiced for many centuries without decrease in productivity. Their total production ha/yr, however, is only one-half to one-third that of the intensive production systems with costly energy inputs of shrimp pond culture, over the same period of time, say one year. Over long periods of time, however, traditional systems are more productive.

Not only the forest, but the waters and the entire system must be managed in an ecologically sound manner and with deliberate interest in the production of several economically important resources. With these realities in mind, the goal of achieving sound and long term profitable use and management of the mangroves should be achieved, always bearing in mind also the value of minor products.

Eco-eco-use and management take one very near to the ideal, obviously impossible goal of "eating one's cake and keeping it".

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Legislation and Community Forestry

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Abstract

Current legislation aims to control the management of forest resources. Yet, under the present economy, there are no signs that deforestation will stop. The attempt to increase forest production through traditional plantations has not been very successful. There is, however, a strong movement among environmental and social non-governmental organizations (NGOs) to include communities in the management of forest resources. In recent years this has occurred in community forest activities initiated by villagers in the mangrove areas in southern Thailand. Community forestry is new tool bringing new solutions to environmental and social problem. The new tool is needed to enable the Royal Forest Department (RFD) to serve the country's social and environmental requirements. Community forestry legislation is still needed. This will enable an environment of collaborative management between the RFD and the communities, rather than the unequal, paternal relationship that has prevailed in the past.

Introduction

Many Asian countries are rich in biological resources. This is due to climatic diversity especially in South Asia and Southeast Asia. Diversity of topography, including mountain ranges, creates pockets with distinct subclimates. This is further enhanced by diversity of geology and specialized habitats and soils, which in turn create a mosaic of vegetation. In many places ecological fragmentation and isolated forest types are frequently associated with endemism (Ashton, 1994).

Asian countries are also rich in cultures, which are reflected in the large number of spoken languages used by indigenous peoples. After man accessed natural resources, he learned how to make use of them and manage the resources. Two kinds of local wisdom developed over time: use of species and ecosystem management. This local wisdom is transferred from generation to generation. Community forestry combines the natural and social systems, where the human component has close interrelationships with other components of the system. It is an adaptation of the way of living to surrounding nature. Community forestry has been embedded in the culture of the regions. In Thailand, it was mentioned in the law of King Mangrai, the first king of Chiang Mai in the 13th Century A.D. (Wichienkeeo and Wijeyewardene (1986).

The Breakdown of Harmony

Thailand has passed several stages of forest resources degradation, as have several other Asian countries. Royal Forest Department (RFD) was founded in 1896, exactly one hundred years ago. The main objective was to consolidate and regulate the harvest of timber and non-wood products mainly for export and domestic uses. The fundamental forest law is the Forest Act, B.E. 2484 (1941), which is still in effect today. The objective of the law is to control timber cutting and logging in order to control illegal cutting. Forestry regulations are extended outside forest reserves to selected species, e.g., teak and yang. Cutting of this two reserved species, wherever they exist, must be by permit from the RFD.

The idea of setting up protected areas and watershed management schemes began after World War II. The Wildlife Reservation and Protection Act, B.E. 2503 (1960) and National Parks Act, B.E. 2504 (1961) were passed later. Human activities are strictly prohibited in these protected areas. The first Economic and Social Development Plan was implemented in 1961 with the aim of transforming the country from an agriculture based economy to an industrialized economy through the promotion of import substitution and agricultural industries. Most income at the time was from agricultural products, e.g., rice, corn, cassava, kenaf, rubber, sugar cane, and from timber. Investments in infrastructure, road and dams were

emphasized. Many forests were destroyed in these processes.

The National Reserved Forest Act, B.E. 2507 (1964) was passed in order to slow down deforestation by including forests into the National Forest Reserves. By demarcation of National Forest Reserves, one million households living on forest lands became illegal encroachers. Thereby these people lost their land or their traditional tenurial rights. Since 1970, long term (30 years) logging concessions covering more than 500 forests had been granted. This was consistent with a policy to increase foreign exchange earnings and economic growth.

These policies usually (1) favored the wealthy and influential people while depriving or alienating the rural poor; (2) favored large operators; (3) promoted cash crops and cash animals. As in many other countries, deforestation is usually blamed on the poor. In fact, deforestation is the result of social injustice. Forest land is the victim of the tragedy of the commons phenomena, where exploitation is by all, and no one is responsible for protection and maintenance. This leads to the attitude "mue krai yao, sao dai sao au" which means "it's your opportunity, if you don't take it someone else will."

The situation was further aggravated by the Indochina War and political turmoil. Together, these policies and conditions resulted in the construction of strategic roads, and the influx of refugees and others, which caused the remarkable decrease of national forest cover from 53.3% of Thailand's land area in 1961, to only 26.6% in 1991 (RFD Statistics). Drought and flooding have been the recurrent events since the 1980's. Following a serious landslide in the south of Thailand, a logging ban in national forests was imposed in 1989. This was the desire of Thai society.

In 1992, the 7th Economic and Social Development Plan aimed to increase protected areas from 15% to 25% of the country's land area. The protected area systems to be managed by the state include (1) national parks and forest parks; (2) wildlife sanctuaries and non-hunting areas; and (3) watershed class I. This led to expansion of the area protected by the RFD to one million rai (6.25 rais = 1 ha) or 160,000 ha of mangrove forest (see Table 1).

Reforestation efforts began in Thailand 1906, but only 3.8 million rai (608,000 ha) of governmental plantations is reported to exist. Another attempt was made in the 1980s to lease the degraded forest land to establish private forest plantations. However, there have been serious conflicts on plantations established on public lands that villagers have occupied or used areas for other purposes like community forests. In some cases, villagers destroyed the planted seedlings. In some cases, the system was abused by concession holder who cut patches of old growth forests. Serious conflicts and protests, led by non-governmental organizations (NGOs) in 1990 resulted in a ban on commercial-scale forest plantation development by the private sector on state forest land.

The Forest Plantation Act, B.E. 2535 (1992) was passed with the objective of promoting private plantations on private land. As of April 1995, only 1,509 private plantation owners had registered plantations on a total area of about 20,000 rai (3200 ha), very small numbers (Tongpan, 1996).

The Impact of Increased Emphasis on Conservation Forestry

The government tried to force people to move out of the forest under the Khor Jor Kor (KJK) regulation in 1992 and other schemes concerning people living in protected areas. There was such a fierce social reaction against these schemes that the attempts have ceased. The KJK had to be stopped. Nonetheless the attempt to move people, especially the ethnic communities who have resided in the forests for centuries, out of wildlife sanctuaries and national parks is still going on at the field level. As recently as November 1996, ethnic communities living in the national park were ordered to move, but they refused to move. They were supported by NGOs. Later, the decision was made at the ministerial level to halt the scheme to resolve the conflict.

RFD surveys revealed that about 164,000 people live within national parks and wildlife sanctuaries and about 800,000 people live in important highland watershed areas. Conflicts related to attempts to move people out of these areas have already occurred. These conflicts will be more difficult to resolve in the future. The problem is how should people live in the

Table 1: The Decline of Forest Cover and the Progressive Declaration of Protected Areas

	Percentage of Total Land Area	
Year	Forest Cover	Protected Areas
1961	53.3	---
1966	---	0.9
1971	---	1.0
1973	43.2	---
1976	38.7	4.9
1978	34.2	---
1981	---	6.8
1982	30.5	---
1985	29.4	---
1986	---	10.2
1988	28.0	---
1989	27.9	---
1991	26.6	12.7
1996	---	27.5

protected areas? The expansion of protected area systems should make use of the lessons learned from the past.

Implications for Mangrove Forests

Logging concessions in mangrove forests will expire soon, and it is likely that these concessions will be permanently banned. The expiration of mangrove concessions will result in encroachment and conversion to shrimp ponds which is the most serious cause of mangrove destruction in Thailand. Protection and conservation methods must be more efficient if the mangrove forests are to be protected. Partnership must be established, and the measures taken must restrict the use of mangrove forest for non-forestry purposes.

Small-scale fishermen living along sea coasts, like small farmers, are heavily dependent on products from local forest resources. Products from upland community forests other than food, medicine and other utilities, include water which is essential for rice farming and gardening. Thailand is rice-culture country. Water is thus a unifying factor and driving force for people to manage and protect community forest. Thus community forests are widespread in mountainous areas of Northern and Northeast Thailand (see Figure 1). By analogy products from mangrove community forests include fishery products. Pa Bu, an old Muslim fisherman of Ban Tungtong, Khao Mai Kaew, Amphoe Sikao, Trang Province has informed us that the fishery products including crabs, shrimps, fish have increased after villagers practiced community forestry. The villagers' activities included replanting of mangrove species on once-degraded areas and cooperative protection of the forest.

Mangrove community forests have increased during the last few years. Examples of successful mangrove community forests are shown in Table 2.

The increase of community forests in recent years reflects the dynamic response to shortages of forest resources and environmental degradation. People nowadays have a good understanding of the importance of forest resources. In several cases in Thailand community forestry has resulted in:

- Stopping deforestation. Communities manage and protect forest resources.
- Alleviating rural poverty. On the macro scale, Thailand is successful in national economic growth, but on the micro scale several rural villagers have collapsed, migrating to urban areas or to clear other forest lands.
- Building the community cooperation which strengthens the community's ability to solve its own problems.

In Thailand, the nation's vision seems to be toward collaborative management. People now ask for active participation, though it is rather slow to materialize. There is a strong movement among NGOs and communities for participation in the management of natural resources. In forestry, in fact, Mr. Dietrich Brandis, the First Inspector-General of Forest in India, used to advocate the collaborative relationships between the Forest Department and local communities for forest better management (Ahmed, 1996). The concept is, however, still new to present-day foresters. Some units of the RFD are attempting to reorient their

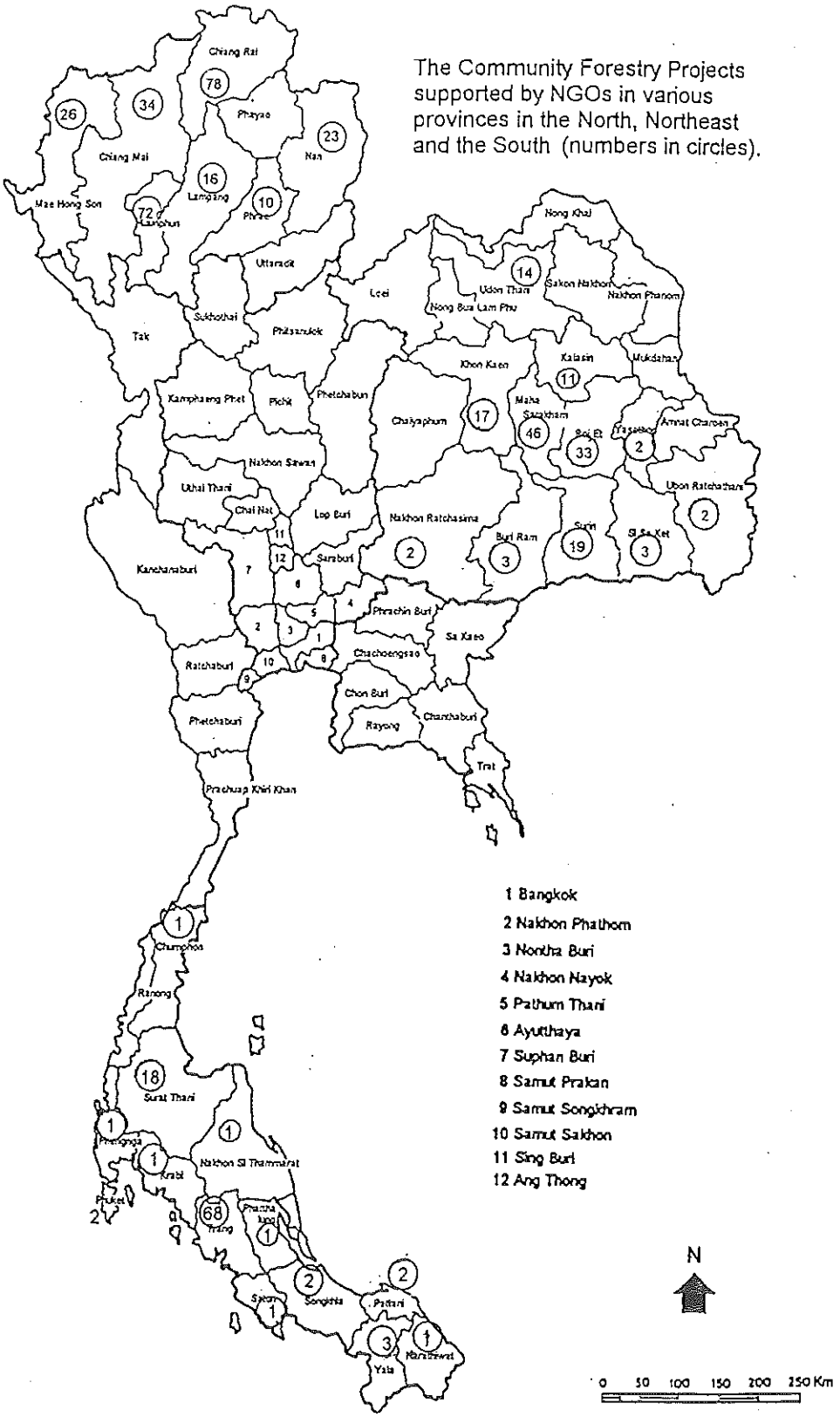

Fig. 1. The Community Forestry Projects supported by NGOs in various provinces in the North, Northeast and the South (numbers in circles).

Table 2. Some mangrove Community Forests in Southern Thailand

Province	Location	Area (ha)
Trang	1. Ban Tungtong, Tambol Khao Mai Kaew, Amphoe Sikao	94
	2. Ban Hua Hin, Tambol Bo Hin, Amphoe Sikao	141
	3. Ban Pak Klong - Ku Hun, Tambol Bo Hin, Amphoe Sikao	153
	4. Ban Lam Makham, Tambol Khao Mai Kaew, Amphoe Sikao	140
	5. Ban Seam Mai, Ban Lam and Ban Tung, Tambol Ko Sukon	128
	6. Ban Pra Muang, Tambol Na Klua, Amphoe Kantang	264
	7. Ban Mod Ta Noy, Tambol Ko Li Bong, Amphoe Kantang	249
	8. Ban Chang, Tambol Mai Fad, Amphoe Sikao	128
	9. Tambol Ko Li Bong, Amphoe Kantang	80
Phuket	Chaierm Prakiat Community Forest, Ban Pa Klok, Tambol Pa Klok, Amphoe Thalang	64
Phang-nga	1. Tambol Bang Toey, Moo 6, and 8, Amphoe Muang	240
	2. Ban Yaa Mi, Tambol Ko Yao Yai, Amphoe Ko Yao	208
Krabi	1. Khao Kha Nab Nam Community Forest, Mae Nam Krabi, Tambol Klong Prasong, Amphoe Muang	354
	2. Ban Laem Sak, Tambol Laem Sak, Amphoe Aow Luk	13
Pattani	Ban Da Toh, Tambol Lampho, Amphoe Yaring	56
Surat Thani	Lilet Community Forest, Tambol Lilet, Amphoe Pun-Pin	320

personnel toward collaborative forest management through several training courses, but in the field this has not really progressed. In many cases, villagers fight to do community forestry, and in many cases foresters refuse to join their efforts by explaining that existing laws do not allow them to do so. Community forestry has no legal status. The time has now come to legitimize community forestry in Thailand. The old laws claim rights over all forests and forest activities and even trees (e.g., teak and yang), on private property. That is, the laws control forest resource management. Abuses of law have been frequent. We need better instruments to manage forest resources, to assist in rural development. Community forestry offers one hope to reach these goals. Above all, community forestry is the tool to maintain cultural integrity and traditional ways of life. Strong cultures are found in the rural villages. Community forestry also provides the proper way of management, i.e., the collaboration between the Forest Department and the communities, rather than the Forest Department just bossing communities around.

Conclusion

As in other Asian countries, the current legislation in Thailand was designed to control forest resources. In the global era, the relationship between people and the forest has changed very fast. The society wishes forestry to serve the nation in more social and environmental aspects. A new tool is needed to enable forestry development in these dimensions. Community forestry is the solution.

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ACTIVITIES OF

THE INTERNATIONAL SOCIETY FOR MANGROVE ECOSYSTEMS (ISME)

ISME was founded in 1990 as a society to promote study and research concerning mangrove ecosystems, with the ultimate goal of laying the bases for rational, sustainable use and management of these resources. A non-governmental and non-profit-making organization, ISME brings together interested scientists, professionals and institutions working for the conservation and better use of the mangroves of the world.

The Society is affiliated to the ICSU family of organizations as a constituent part of the International Union of Biological Science (IUBS) through the International Association of Biological Oceanography (IABO), and has observer status with several organizations of the United Nations.

ISME organizes and cosponsor conferences, seminars, symposia and working group meetings; to organize lectures and courses; to publish both scientific and popular articles. ISME promote mangrove ecosystems research and extension activities for snstainable management, rational utilization, rehabilitation and conservation of mangrove ecosystems. Since 1995, ISME has been implementing a two month mangrove training course, financed by JICA. The number of participants for the last three years sums up to 20 from 17 countries. As of March 1998, ISME has 667 individual members and 34 institutional members from 73 countries.

While its Secretariat is located in Okinawa (Japan), ISME undertakes to implement projects anywhere in the world where the expertise of its members can be of service. Through its newsletter, the Society provides an open forum for discussion leading to the optimum modalities of attaining its objectives. In addition, ISME has co-operated with the International Tropical Timber Organization (ITTO) to promote mangrove research.

As well, ISME organizes annual training courses, sponsored by the Japan International Cooperation Agency, and publishes educational and professionals papers as well as videos. Thus far, the following have been produced:

ISME Mangrove Ecosystems Occasional Papers

No. 1. 1993. Mangrove Nurseries in Bangladesh, by N. A. Siddiqi, M. R. Islam, M. S. S. Kahn, and M. Shahidullah;

No. 2. 1998. Trace Metals Biogeochemistry and Diffuse Pollution in Mangrove Ecosystems, by Luiz Drude de Lacerda.

ISME Mangrove Ecosystems Proceedings

No. 1. 1993. Proceedings of a Workshop on Conservation and Sustainable Utilization of Mangrove Forests in Latin America and Africa Regions, Niteroi, Brazil 28-30 May 1993;

No. 2. 1993. Proceedings of a Workshop on Conservation and Sustainable Utilization of Mangrove Forests in Latin America and Africa Regions, Dakar, Senegal, 20-22 January 1993;

No. 3. 1994. Proceedings of VII Pacific Science Inter-Congress Mangrove Session, Okinawa, Japan, 1-2 July 1993;

No. 4. 1997. Proceedings of Symposium on Significance of Mangrove Ecosystems for Coastal People, Hat Yai, Songkla, Thailand, 19-20 August 1996.

ISME Mangrove Ecosystems Technical Reports

No. 1. 1993. The Economic and Environmental Values of Mangrove Forests and their Present State of Conservation in the South-east Asia/Pacific Region. (an ITTO/ISME Project);

No. 2. 1993. Conservation and Sustainable Utilization of Mangrove Forests in Latin America and Africa Regions, Part I - Latin America. (an ITTO/ISME Project);

No. 3. 1993. Conservation and Sustainable Utilization of Mangrove Forests in Latin America and Africa Regions, Part II - Africa. (an ITTO/ISME Project);

No. 4. 1994. Study of Chokoria Sundarbans Using Remote Sensing Techniques, by A.M. Choudhury, D.A. Quadir, and Md. Jinnahtul Islam. (with the support of AEON Foundation).

Slide Set Programme for Children

1994 - A Slide Programme of Environmental Education for Vietnamese Children, entitled "Know Your Mangroves", 73 slides and textbook;

1995 - A Slide Programme of Environmental Education for Children, entitled "Know Your Mangroves", 2nd edition, 76 colour slides and textbook;

1996 - Video on mangroves of Fiji, entitled "What the Tides Bring";

1997 - Video on mangroves of Thailand, entitled "Living with Mangroves".

Outputs of ITTO/ISME Project:
"Manual and a world natural mangrove atlas for mangrove ecosystem restoration"

- Non-technical publication: Journey Amongst Mangroves;
- Technical manual: Restoration of Mangrove Ecosystems;
- Atlas: World Mangrove Atlas.

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