UNEP

United Nations Environment Programme

UNEP/GEF South China Sea Project

GEF

Global Environment Facility

NATIONAL REPORT

on

Mangroves in the South China Sea

PHILIPPINES

Mr. Florendo Barangan
Focal Point for Mangroves
Coastal and Marine Management Office
Department of Environment and Natural Resources (CMMO-DENR)
DENR Compound Visayas Avenue
Diliman, Quezon City 1100, Philippines

Table of Contents

List of Tables, Figure and Annexes

1. INTRODUCTION

In the Philippines, being the maritime nation, boasts with 7,107 islands with a coastline of 36,289km is dependent on a major extent on a healthy coastal environment. Indeed, Philippine coastal areas and seas have served as the lifeblood of communities near and far for hundreds of years if not thousands of years. The Philippines was said by "experts" to be endowed once upon a time with inexhaustible coastal resources. However, it is now on the verge of irreversible descent. The public attributes this condition due to excessive pressures exerted by ever increasing population, unscrupulous exploitation, industrialisation and lack of ecosystem appreciation.

2. MANGROVE DISTRIBUTION

The Philippines is a large archipelago of approximately 7,107 islands, with a coastline of 36,289km – third longest in the world, 822 coastal municipalities and 74 coastal cities. These coastal zones are naturally endowed with resources of great socio-economic and ecological significance, mainly the reason why historically, cities grow rapidly along these areas. Coastal zones became centres of social, economic, recreational and other activities, making it vulnerable to man-made pressures. Coastal zones should have been maintained to sustain its environmental services to include food source, shoreline stabiliser, wildlife habitat, natural breakwater and spawning/breeding grounds of aquatic species. Among these major ecosystems, mangroves occupy a highly strategic position in the economy and ecology of the coastal areas in the country. The largest remaining mangrove areas are located in Palawan and Quezon in Luzon, Samar provinces in the Visayas, and Zamboanga del Sur, Zamboanga Sibugay, Surigao del Norte and Sulu provinces in Mindanao as shown in Figure 1.

Figure 1 Mangrove distribution in the Philippines.

According to Tomlinson, (1986 as cited in Ong, *et al.*, 2002), 35 of these species (1 hybrid, 1 variety, and 33 species) and several associate species are found in the Philippines. In term of distribution of number of marine species among coastal ecosystems, mangrove community has 370 species including seagrass, seaweeds, corals, other invertebrates, fish, mammals, and reptiles (DENR, 1998).

Based on the survey conducted, as of 1984 a total area of 232,065ha of mangrove forest in the Philippines were recorded as cited in Philippine Forestry Statistics with geographical distribution per major islands shown in Table 1.

Table 1 Mangrove forests areas of the Philippines.

Category	Luzon Area in Hectares	Visayas Area in Hectares	Mindanao Area in Hectares	Palawan Area in Hectares	Total Area in Hectares
Reproductive Bush	2,583	63,893	23,692	22, 915	113,083
Young growth	14,186	1,226	84,471	9,200	109,083
Old growth	-	-	4,582	5,317	9,899
Total	**16,769**	**65,119**	**112,745**	**37,432**	**232,065**

Source: Forest Management Bureau, 1984.

Of the estimated total mangrove forest area, approximately 49% is classified as reproductive bush, 47% as young growth and 4% as old growth. The major genera are of the *Rhizophora*, *Bruguiera*, *Avicennia*, *Xylocarpus*, *Sonneratia*, *Heritiera*, *Ceriops*, *Excoecaria* and *Nypa*. Most of these are timber yielding, while *Xylocarpus* and *Ceriops* are used for the extraction of dyes and *Nypa* is used for thatching leaves and tapping of juice for brewing alcohol.

In view of the drastic decrease of mangrove forests from 450,000ha in 1920 to 232,065ha in 1984, the Department of Environment and Natural Resources of the Philippines, adopted few conservation measures. Presidential Decree No. 705 was promulgated which enforces: (1) a seed tree method of silvicultural system for mangroves, wherein 20 seed trees per hectare are to be retained; (2) adaptation of 50-year rotation; and (3) regulation of annual allowable cut. Besides these thousands of hectares of denuded mangrove areas in the form of open mudflats, sandy beaches and mine tailing areas are available for restoration. Small-scale afforestation with species such as *Rhizophora apiculata, Bruguiera cylindrica, Avicennia officinalis and Ceriops tagal* has been undertaken at various sites of the country.

The forested mangrove area has decreased greatly from an estimated coverage of 450,000ha in 1918 to less than 120,000ha in the late 1990s (DENR, 1988, 1998). The most rapid decrease in mangrove coverage occurred during the 1960s and 1970s when national policies encouraged the expansion of aquaculture. Today; fishponds cover about 289,000ha; most of which were formerly mangroves thus; and the culprits of mangrove degradation was due to conversion of mangrove areas into shrimp farming/aquaculture. It was revealed that for the period of 1967-1988, the average rate of decline was about 8,000ha annually.

Mangrove stands remaining in the country are mostly found on the southern and western provinces and islands of Mindanao, eastern island provinces of the Visayas and the whole islands of Palawan. Less than 5 percent of existing areas in old or primary growth forest is found in Palawan. Most mangrove forests in the Luzon and Visayas islands are secondary growth or in plantations. Mangroves are now of much lower quality and cover less than one-third of their original range.

Based on the satellite pictures interpreted by the NAMRIA which had been used as the statistics for mangroves in the Philippines, the reported total mangrove areas are 248,813 hectares. The major regions where substantial mangrove areas are found are presented in Table 2.

Table 2 Regions and provinces where concentration of mangrove stands are observed.

Regional geographic location in the Philippines	Total regional mangrove area (ha)	Province with most mangrove area in region	Mangrove forests (ha)
Southwestern Luzon	58,032	Palawan	54,143
Autonomous Region of Muslim Mindanao	46,218	Sulu	24,701
Eastern Visayas	39,294	Samar	16,337
Northeastern Mindanao (CARAGA)	26,731	Surigao del Norte	16,823
Western Mindanao	22,328	Zamboanga del Sur	11,681

However, information shows that there is inconsistency in the presentation on the extent of mangrove forests in the Philippines. It had been reported there were less than 120,000ha in 1998 contrary to what had been stated in the previous paragraphs.

With the foregoing result of analysis of the satellite pictures, the DENR is presently validating the reported mangrove stands in all the 64 coastal provinces of the Philippines. Latest records reveal there are provinces especially in the coasts facing the South China Sea which were not detected in the satellite imagery but ground validation shows there are small patches of mangrove stands in such provinces. These are the provinces of Ilocos Norte, Zambales, Bataan, Pampanga and Bulacan, all in Luzon. The reported 248,813ha in 2003 can increase to about 300,000ha when the ground validation is completed. Moreover, the mangrove statistics after 1988 were projections which had been constantly decreasing due to destructions and on the conversion of some areas to other uses, specially for prawn/fishpond purposes and for charcoal and fuelwood production.

From 1989 to the present, there had been an increased plantation establishment of mangroves in the country. There were international supports for reforestation with the assistance of the ADB, JBIC, USAID, WB, to mention some, other banking institutions, non-government organisations, academe, people organisations and individuals who had contributed much to the increase in mangrove forests nationwide.

One documented accomplishment of coastal communities is what had been initiated by an old man in Banacon Island, Getafe, Bohol (Central Philippines). He started planting in small patches in 1957 which was followed by his neighbours when they observed the good effect in increasing fisheries production in their area. That small island of Banacon which is about 15ha of land area has now man-made mangrove forests of about 500 hectares. That old man, because of his initiation to start mangrove reforestation in that small island, received some awards, one of which he received from the Food and Agriculture Organization of the UNDP in Bangkok in the mid-90s. The same mangrove area is now a show window where interested organisations, groups of fisherfolk and individuals often frequent to see for themselves the successful contribution of an old man who led his neighbours improved the mangrove ecosystem in a small fishing village.

Species composition of mangroves in various regions of the country

The composition of mangroves in various regions of the country representing sixty four (64) sites revealed *Rhizophora apiculata* is the most dominant mangrove species, followed by *R. mucronata, Avicennia* marina *Sonneratia* alba and *Ceriops tagal*. There are twenty eight (28) true mangroves species and thirty four (34) mangrove associates. The samples in each region are in the original Coastal Environmental Programme, or Coastal and Marine Management Programme sites now including those sampled in the UNEP/GEF/SCS Project.

It could likewise be deduced that there are more representative true mangrove species and associates in Cagayan Valley (Northern Luzon), Quezon, Palawan, Western and Central Visayas. Because of the limited number of samples in Mindanao, the values were likewise low. Studies on the composition of other areas especially in the natural stands remaining expectedly can enhance the information. Another activity which should be undertaken is to gather more information on the menstruational attributes of mangrove stands to have an indication of the productivity of these stands based on productivity of timber and other major products derived from mangroves. This, however, is not an immediate priority since harvesting of timber for lumber is totally banned by the government.

3. THREATS TO MANGROVES

In the Philippines, mangroves are among the major marine ecosystems, which include seagrass and coral reefs, which have suffered the extensive damage and greatest degradation because of their relative inaccessibility and long history of conversion to aquaculture ponds. Estimates of the country's mangroves were not made until 1918 although ponds were already on record since 1863. The former comprised not only primary and secondary forests but also vast stands located near Manila of *Rhizophora* cultivated for firewood and *Nypa* shingles.

In recent times, over-exploitation and destruction of mangroves due to human activities have caused heavy damage to these ecosystems worldwide. Mangrove soil is generally marginal for agriculture, yet conversion of mangrove land for agriculture is widespread. In several parts of the world mangroves have been destroyed to create shrimp, ponds which cannot sustain their production over time due to acid sulphate soils, viral diseases, etc. Mangrove destruction is also due to a variety of other reasons: the need for fuel wood, oil prospecting and production, conversion to cattle ranching, salt industry and coastal development everywhere (harbour, urban and industrial development, airports, power plants and others). International and national demand for mangrove forest resources and land is at present one of the main causes of the destruction of mangroves. Poor polices and

legislation (lack of enforcement) also contribute to mangrove destruction and degradation. This is partly due to the fact that information on mangroves and their importance is often lacking or inaccessible. During the last decade approximately 1,000km² of mangroves have been destroyed annually. Mangroves are not wastelands and their destruction, for whatever purpose, invariably results in ecological degradation and social impoverishment of local people. The restoration of degraded mangroves can be extremely costly and time-consuming.

All biotic and abiotic factors acting on mangrove ecosystems vary between and within countries. Over and above this, anthropogenic factors have induced changes in almost all the mangroves of the world, predominantly in a negative manner. Significant changes of all sorts became increasingly damaging during the second half of the 20th century. The changes have affected the distribution, extent and health of single mangrove species and of the ecosystems as a whole. The coastal zone everywhere in the world is extremely dynamic. It may be described as a chaotic system where an infinitely large number of variables are in constant and relentless interaction. The chaotic nature of coastal zone systems makes the impact of changes hard to anticipate and often dramatic.

Mangroves are home to many marine fishes and provide livelihoods for millions of people, but the opinions of local residents regarding their management have seldom been sought. Public awareness regarding mangroves and their conservation is often lacking. Thus, it is an urgent need to bring people and nations together to apply the knowledge and wisdom of experience to use the mangrove forest judiciously.

Offshore fisheries are of considerable importance in the Philippines. There have been few studies to look at the effect on mangrove loss, although anecdotal evidence suggests there have been reduced yields. Mangrove forests used to be source of tanbark for the tannin extract industry, while now there is little or no commercial extraction of timber and mangrove wood is widely used locally for fuel, charcoal and for the manufacture of poles and piles. There has been some mangrove afforestation, notably in the Sulu Archipelago and the Central Visayas, including Negros, Bohol and Cebu, much of this carried out at the local and community level. Research into afforestation methods is also underway. Traditional or non-destructive fishing within mangrove areas is still important, notably in Bohol, Sulu, Tawi-tawi and Cebu. Target species include shellfish and crabs as well as fish caught by net or line. The greatest loss of mangrove areas has been caused by the development of large areas of brackish fishponds, increased from 90,000ha in 1952 to over 210,000ha today. Mangrove reclamation for agricultural or urban development is significant in some areas. Although some legislation exists for the protection on mangroves, for example all of the mangroves of Palawan and other sites have been declared as mangrove forest reserve; there is still evidence that such protection is not effective on the ground.

Research according to Ong, *et al.* (2002), a few pristine mangrove areas were re-discovered because of their relative inaccessibility (e.g., Aurora and Isabela provinces, and Dinagat-Siargao Islands in Surigao del Norte) and peace-and-order threats (e.g., Western Samar and Sta. Cruz Island in Zamboanga City). Even a very small forest patch, such as the 75ha mangroves of Ibajay, Aklan (the largest contiguous mangrove in Panay Island), can feature as many as 20 mangrove species, a further confirmation of the country's remarkable mangrove diversity.

Mangrove decline of 120,000ha from 1984 to 1995 maybe traced to exploitation by coastal dwellers and conversion to agriculture, salt ponds, industry and settlements. However, aquaculture remains the major cause – around the world, half of the 279,000ha of mangrove lost from 1951-1988 were developed into culture ponds. Ninety-five percent of Philippine brackish water ponds in 1952 up to 1987 were derived from mangroves. Mangrove – to – pond conversion and its attendant socio-economic changes have been documented in detail for the village Lincod in Maribojoc, Bohol and for the Municipality of Batan, Province of Aklan.

Pond construction was also the culprits of the mangrove degradation; its peak occurred in the 1950s and 1960s at 4,000 to 5,000 hectares per year with the government incentives in the form of loan. The Fisheries Decree of 1975 (P.D.704) mandated a policy of accelerated fishpond development and A.O. 125 extended 10-year fishpond permits and leases to 25 years. During the Shrimp Fever of the 1980s, pond development again increased to 4,700 hectares per year.

Another widespread mechanism by which mangroves have been lost from the public domain is when local residents or even outsiders stake claim on mangrove areas paying to municipal governments a real estate tax. Because local government are hard – pressed for cash, they accept taxes without checking whether the status of the given area is forest reserve, protected mangrove or alienable and disposable (A&D). These claims are generally handed down to family members or "sold" to other parties. A prerequisite to legal ownership through issuance of titles is having the area declared A&D by the government, if the interested party has adequate finances. And so many mangrove areas passed from government jurisdiction to private hands-through de facto (real estate tax) and or legal means.

According to Dixon's work (1989) as cited by Melana *et al.* (2000), valued a complete mangrove ecosystem at US$500 to 1,500 per hectare/year. This represents the minimum monetary value that would be lost when such mangroves were converted to other land uses.

Various mechanisms both natural and human-induced activities commonly destroyed and degraded mangrove ecosystem. They are subjected to many biological, physical and chemical stresses because of public ignorance of the capabilities and limitations of mangrove forests including poor valuation methods to quantify non-market goods compared to cost accounting available for residential, commercial and industrial development. The mangrove ecosystems are increasingly threatened and under various kinds of pressures: increasing population, construction, development, tourism, aquaculture development, including short-term management policies and programmes.

Apart from the human impacts and natural threats to the mangrove ecosystems they were also subjected to various land use. The root cause of these threats is failures of existing management system to include:

- *Information failure* – Failure to appreciate the full ecological functions of mangrove ecosystem as well as their biological basis;
- *Market failures* – Failure to correctly value the mangrove ecosystem or where the cost and benefits do not coincide and where the mangrove ecosystem is sacrificed due to their non-market valuation; and
- *Intervention and/or policy failure* – A policy result from ineffective governmental interventions to correct market failure in the form of subsidies, credit and inter-sectoral policy inconsistency.

4. ECONOMIC VALUATION

In deciding to maximise economic gain from mangroves, discussions usually focus on the "economic rent" which should be charged to users for alternative uses of the habitat area. In one research effort to determine an optimal system for leasing out mangrove areas for fishpond use, three management scenarios were compared: (i) mangrove plantation; (ii) managed naturally regenerated mangroves; and (iii) unmanaged under-stocked stands.

The value of wood products from mangrove plantation generates more revenues than alternatives (ii) and (iii) but for practical purposes, scenario (ii) was recommended as a basis for economic rent for mangrove habitats converted to fishpond the higher value in all three options is not the wood products but the fish products (US$538/ha) dependent on the existence of the ecosystem. This amount can be considered as a minimum economic gain from a healthy mangrove ecosystem as shown in Table 3.

Table 3 Estimated net annual economic value of Philippine mangrove areas for different levels of management.

Level of management	Wood products (US$/ha)	Fish products (US$/ha)	Total (US$/ha)
(i) Mangrove plantation	156	538	694
(ii) Managed naturally regenerated	90	538	628
(iii) Unmanaged under stocked stands	42	538	580

Note: Wood harvest value based on average price of about US$12/m^3 of wood; fish products based on average annual weight of fish and shrimp/ha associated w/ mangrove areas and an average price of US$0.80/kg; values based on Philippine pesos. US$1 was equal to 25 pesos in 1991.

5. INSTITUTIONAL ARRANGEMENT AND NATIONAL LEGISLATION

The DENR has jurisdiction over mangrove resources as provided for in P.D. 705 or the Forestry Code of the Philippines. Various issuances enacted pursuant to PD 705 include: DAO 15, 1990, on mangrove conversion and conservation; DAO 96-29, s 1990, on awarding of mangrove stewardship contracts; and DAO 76, 1987, on establishment of buffer zones in mangrove areas.

The Local Government Units (LGUs) were also given jurisdiction over specific aspects of mangrove management including that of conversion, as well as implementation of community-based forestry projects (including integrated social forestry projects) subject to the supervision, control, and review of DENR (R.A. 7160, Sec 71 (2) (i), (ii). The pertinent guidelines to the effect the devolution of these functions are spelled out in DAO 30, 1990. Community-based forestry projects refer to DENR development projects involving local communities, which include the integrated social forestry projects, family, and community forestry Programmes, and other similar projects. On the other hand, the management, protection, and development of all other areas outside communal forest remain with DENR.

The Community-based Forest Management Agreement (CBFMA), E.O. 263, 1995 and its IRR as outlined in DAO 96-29 provided tenurial instrument available for communities who wish to manage their mangrove resources. The CBFMA integrates all other forms of tenurial instruments developed by the DENR including the Mangrove Stewardship Agreement and the Community Forest Management Agreement (CFMA).

Cutting of all mangrove species is prohibited under R.A. 7161: "An act incorporating certain sections of the National Internal Revenue Code of 1977, as amended, to PD 705, as amended, otherwise known as the 'Revised Forestry Code of the Philippines' and providing amendments thereto by increasing the forest charges on timber and other forest products." The law does not provide any exemption.

There are some incentives provided to people's organisation (POs) for participating in CBFM Programmes. These include: (i) exemption from paying rent; (ii) exemption from payment of forest charges as per R.A. 7161; (iii) consultation by government on all proposed projects affecting CBFMA area; (iv) preferential access to DENR financial assistance; and (v) all incomes and proceeds from sustainable management of forest resources will rebound to the benefit of the CBFMA holder.

6. MANAGEMENT PERSPECTIVES

The keys for attaining productive and effective mangrove restoration efforts can be effectively achieved through: (a) understanding of the ecology and morphology of mangroves; (b) environmental requirements or suitability of species; (c) economic and ecological value of mangroves; and (d) the degree to which they are currently damaged by human activities. This particularly done considering that the management and conservation of mangroves is effected by a need for a variety of policies and the ways these policies affect the mangrove. They range from indirect (unsustainable exploitation of mangrove resources) to direct effects. In addition, the laws related to conservation, management and utilisation are not often effectively enforced; hence, coastal law enforcement component should be strengthened to be an effective tool for implementation of conservation and protection policies. In general, change in the use of mangrove systems has been undertaken with inadequate consideration of the goods and services. Over the years, policy changes had shifted continuously. These policies need to be identified and their implications be fully analyzed so that appropriate adjustment or reforms can be instituted.

Therefore, this calls for reform of the policy and institutional framework for mangrove management to create wider participation in the management processes. The implementation of appropriate policy instrument and mechanisms is needed that could curtail sustainable management that undermines the efficiency of resource use and development.

At this point in time, we must review and harmonise existing policies and establish new policies that identify sustainable management as the overall framework across all sectors towards integrated ecosystem management approach. Intersectoral relationships as well as the economics, social and biophysical and environmental aspects must be fully recognised and duly considered in any development activity to minimise mangrove problem or conflict. Hence, policy goals must recognise the diversity of interests related to the conservation and management of mangroves to include as follows:

6.1 Socio-economic aspect

- Any developmental programmes needed by the coastal inhabitants should be prioritised;
- Need to integrate economic and ecology to quantify the monetary values of mangrove ecosystem;
- Build on local people's awareness of mangrove conservation;
- Stewardship agreements should be issued primarily to coastal communities; and
- Joint-venture programme and/or sharing should be promoted as a management scheme.

6.2 Ecological aspect

- Utilisation of mangrove resources should be based on the sustainable limits of particular mangrove areas;
- All mangrove forests should be brought under sustainable management;
- All management efforts should be focused on the prevention of degradation rather than restoration;
- More realistic economic valuation of space and resources within mangrove ecosystems;
- Integrated assessments of the environmental and socio-economic costs and benefits of alternative uses of such systems; and
- Research on mangrove ecosystem that is, scientific information and data to include studies of human habitation and traditional uses of mangrove ecosystem in order to evaluate actual and potential use of the resources from both the natural and social science perspectives.

7. PROGRAMME OF ACTIONS

- ***Promote public awareness of mangrove forest issues***. Public awareness should be intensified through Information, Education and Communication (IEC) advocacy and promoting the intrinsic values of mangrove ecosystem to be perceptive on the protection and conservation programme of the government. Its central tenet is to promote the rights of local coastal peoples, including fishermen, in the sustainable management of coastal environs.

- ***Participation in management decisions is essential at all levels***. This builds up the bottom-up model by encouraging local level to form management associations and become the effective managers of their coastal resources.

- ***National agencies with jurisdiction over coastal resources need to assist LGUs and provide technical support***. The capacity of local governments to manage their coastal environments and resources is limited, thus, they need technical guidance to mentor in order to achieve significant output facilitated by national agencies.

- ***Collaboration and synergy among agencies is essential***. Integration and collaboration of all institutions with a mandate and concern for coastal resource management. Partnership management of mangrove resources including local communities and NGOs. Collective and sustained efforts by government and the people concerned must be fostered.

- ***Mangrove policies and LGUs should be based on a comprehensive approach***. Improve legal mechanisms to control mangrove misuse. Develop adequate policy and legislation to protect mangrove resource and on ensuring adequate enforcement.

- ***Multi education and communication strategies are required to build a wise base support for CRM***. Management efforts should first be directed towards winning the hearts of coastal communities people must be oriented first for better understanding the issues before they will take action to solve them. This could be done through networks of constituency groups to support initiatives, thus ensuring better sustainability of efforts.

- ***Proven technical interventions must be pursued and applied appropriately***. The viable coastal management interventions must be pursued, such as integrated planning, habitat protection and management, improved law enforcement, environmentally sensitive livelihood options and others.

REFERENCES

DENR, 1988. Mapping of the natural conditions of the Philippines. Final Report. Swedish Space Commission, Solna, Sweden.

DENR, 1998. Philippine Forestry Statistics of 1995. Forest Management Bureau, DENR.

Forest Management Bureau, 1994. Mangrove Forest of the Philippines. Manila.

Melana, D., J. Atchue III, C. Yao, R. Edwards and E. Melana, 2000. Mangrove management handbook. DENR-Coastal Resources Management Project. Cebu City. 98 p.

Ong, P.S. L.E. Afuang and R.G. Rosell-Ambal (eds.) 2002. Philippine Biodiversity Conservation Priorities: A. Second Iteration of the National Biodiversity Strategy and Action Plan. DENR-PAWB, CI-P, UP Center for Integrative Development Studies-Biodiversity Conservation Programme and Foundation for the Philippine Environment, Quezon City, Philippines.

Annex 1 Scientific names, family names and some common names of true mangroves and associates in the Philippines.

No.	Philippine Mangrove Species (Tree/Shrub/Vine/Grasses/Fern/Palm)	Family	Common name
1	*Acacia farnesiana*	*Mimosaceae*	
2	*Acanthus ebracteatus*	*Acanthaceae*	*Tigbau*
3	*Acanthus ilicifolius*	*Acanthaceae*	*Deliuario*
4	*Acrostichum aureum*	*Pteridaceae*	*Lagolo*
5	*Acrostichum speciosum*	*Pteridaceae*	
6	***Aegiceras corniculatum***	***Myrsinaceae***	***Saging-saging***
7	***Aegiceras floridum***	***Myrsinaceae***	***Tinduk-tindukan***
8	***Aegiceras lanata***	***Myrsinaceae***	
9	*Alstonia macrophylla*	***Moraceae***	
10	*Avicennia eucalyptifolia*	***Avicenniaceae***	
11	*Avicennnia alba*	***Avicenniaceae***	*bungalon puti*
12	***Avicennia lanata***	***Avicenniaceae***	***Piapi***
13	***Avicennia marina***	***Avicenniaceae***	***Bungalon***
14	***Avicennia marina var. rumphiana***	***Avicenniaceae***	***piapi***
15	***Avicennia officinalis***	***Avicenniaceae***	***Api-api***
16	*Barringtonia asiatica*	*Lycythidaceae*	*Butong*
17	*Barringtonia racemosa*	*Lycythidaceae*	*putat*
18	*Brownlowia lanceolata*	*Tiliaceae*	*Maragomon*
19	***Bruguiera cylindrical***	***Rhizophoraceae***	***Pototan lalaki***
20	***Bruguiera gymnorrhiza***	***Rhizophoraceae***	***Busain***
21	***Bruguiera parviflora***	***Rhizophoraceae***	***Langarai***
22	***Bruguiera sexangula***	***Rhizophoraceae***	***Pototan***
23	*Caesalpinia crista*	*Fabaceae*	*kalumbibit*
24	*Caesalpinia nuga*	*Fabaceae*	*sapinit*
25	*Camptostemon philippinense*	*Bombacaceae*	*Gapas-gapas*
26	*Centrosema sp.*	*Leguminosae*	
27	*Cerbera manghas L.*	*Apocynaceae*	*baraibai*
28	***Ceriops tagal***	***Rhizophoraceae***	***Tangal***
29	***Ceriops decandra***	***Rhizophoraceae***	***Malatangal***
30	*Chromolaena odorata*	***Euphorbiaceae***	
31	*Clerodendrum siphonospathus*	*Verbenaceae*	
32	*Derris trifoliate*	*Fabaceae*	*Mangasin*
33	*Dolichandrone spathacea*	*Bignoniaceae*	*Tui*
34	***Excoecaria agallocha***	***Euphorbiaceae***	***Buta-buta***
35	*Flagellaria indica*	*Flagellariaceae*	
36	*Glochidion littorale*	*Euphorbiaceae*	*Dampol*
37	*Glochidion mindorense*	*Euphorbiaceae*	
38	*Heritiera littoralis*	*Sterculiaceae*	*Dungon late*
39	*Heritiera sylvatica*	*Sterculiaceae*	
40	*Hibiscus tiliaceus*	*Malvaceae*	*Malubago*
41	*Intsia bijuga*	*Leguminsae*	*Ipil*
42	*Intsia retusa*	*Leguminosae*	*Ipil laut*
43	*Ipomea pes-caprae*	*Convolvulaceae*	*lambayong*

Annex 1 *cont.* Scientific names, family names and some common names of true mangroves and associates in the Philippines.

No.	Philippine Mangrove Species (Tree/Shrub/Vine/Grasses/Fern/Palm)	Family	Common name
44	***Kandelia candel***	***Rhizophoraceae***	
45	*Kleinhovia hospita*	*Sterculiaceae*	*Tan-ag*
46	***Lumnitzera littorea***	***Combretaceae***	***Tabau***
47	***Lumnitzera racemosa***	***Combretaceae***	***Kulasi***
48	*Mallotus papillaris*	*Euphorbiaceae*	
49	*Morinda bracteata*	*Rubiaceae*	
50	***Nypa fruticans***	***Palmae***	***Nipa***
51	*Oncosperma tigillaria*	*Palmae*	***Anibong***
52	***Osbornia octodonta***	***Myrtaceae***	***Taualis***
53	*Pandanus tectorius*	*Pandanaceae*	
54	*Pemphis acidula*	*Lythraceae*	*Bantigi*
55	*Phanera integrifolia*	*Caesalpiniaceae*	
56	*Pluchea indica*	*Compositae*	*Kalapini*
57	*Pongamia pinnata*	*Fabaceae*	*Bani*
58	*Prosopis vidaliana*	*Legumisae*	
59	***Rhizophora apiculata***	***Rhizophoraceae***	***Bakauan lalaki***
60	***Rhizophora mucronata***	***Rhizophoraceae***	***Bakauan babae***
61	***Rhizophora stylosa***	***Rhizophoraceae***	***Bakauan bangkau***
62	***Rhizopora lamarckeii***	***Rhizophoraceae***	
63	*Sapium indicum*	*Rhamnaceae*	
64	*Scyphiphora hydrophyllacea*	*Rubiaceae*	*Nilad*
65	*Sesuvium portulacastrum*	*Aizoaceae*	*Dampalit*
66	***Sonneratia alba***	***Sonneratiaceae***	***Pagatpat***
67	***Sonneratia caseolaris***	***Sonneratiaceae***	***Pedada***
68	*Strophantus cumingii*	*Apocynaceae*	
69	*Teijsmanniodendron hollrungii*	*Verbenaceae*	
70	*Terminalia catappa*	*Combretaceae*	*Talisay*
71	*Thespesia populnea*	*Malvaceae*	*Banalo*
72	*Thespesia populneoides*	*Malvaceae*	
73	*Tristellateria australasiae*	*Malphigiaceae*	*Binusisi*
74	***Xylocarpus granatum***	***Meliaceae***	***Tabigi***
75	***Xylocarpus moluccensis***	***Meliaceae***	***Piagau***
76	***Xylocarpus rumphii***	***Meliaceae***	

Annex 2 Mangrove species known to occur in the Philippine Islands (CEP/CMMP Sites including UNEP/GEF/SCS).

				Regions													
No.	Philippine Mangrove Spp. (Tree/Shrub/Vine/Grasses/ Fern/Palm)	Family	Common name	1	2	3	4A	4B	5	6	7	8	9	10	11	13	Fre-quency
1	*Acacia farnesiana*	*Mimosaceae*	aroma				1	1									2
2	*Acanthus ebracteatus*	*Acanthanceae*	tigbau		6	1	1	3		1	1						13
3	*Acanthus ilicifolius*	*Acanthanceae*	deliuario		6	1				1							8
4	*Acrostichum aureum*	*Pteridaceae*	lagolo		4	1	1				1						7
5	*Acrostichum speciosum*	*Pteridaceae*				1					1						2
6	***Aegiceras corniculatum***	***Myrsinaceae***	**saging-saging**		**10**	**1**	**1**	**6**	**5**	**1**	**2**		**1**	**1**			**28**
7	***Aegiceras floridum***	***Myrsinaceae***	**Tinduk-tindukan**		**9**	**1**	**1**	**7**	**5**	**1**	**3**		**1**		**2**		**30**
8	***Aegiceras lanata***	***Myrsinaceae***							**2**		**1**	**1**		**1**		**1**	**6**
9	*Alstonia macrophylla*	*Apocynaceae*															0
10	***Avicennia eucalyptifolia***	***Avicenniaceae***															**0**
11	***Avicennnia alba***	***Avicenniaceae***	**bungalon puti**				**1**			**1**	**2**						**4**
12	***Avicennia lanata***	***Avicenniaceae***	**piapi**	**1**		**1**									**1**		**3**
13	***Avicennia marina***	***Avicenniaceae***	**bungalon puti**	**1**	**10**	**1**	**1**	**7**	**5**	**2**	**9**	**1**	**1**		**2**		**40**
14	***Avicennia marina var. rumphiana***	***Avicenniaceae***	**piapi**	**1**		**1**		**5**		**1**			**4**				**12**
15	***Avicennia officinalis***	***Avicenniaceae***	**api-api**		**11**	**2**	**1**	**5**	**5**	**3**	**5**	**1**	**3**	**1**	**1**		**38**
16	*Barringtonia asiatica*	*Barringtoniaceae*	butong		11			1									12
17	*Barringtonia racemosa*	*Barringtoniaceae*	putat		6												6
18	*Brownlowia lanceolata*	*Barringtoniaceae*	maragomon														0
19	***Bruguiera cylindrica***	***Rhizophoraceae***	**pototan lalaki**	**1**	**5**	**1**		**6**	**5**	**1**	**3**				**1**		**23**
20	***Bruguiera gymnorrhiza***	***Rhizophoraceae***	**busain**	**1**	**9**		**2**	**7**	**5**	**2**	**2**				**1**		**29**
21	***Bruguiera parviflora***	***Rhizophoraceae***	**langarai**		**5**		**1**	**5**	**2**	**1**		**1**	**2**				**17**
22	***Bruguiera sexangula***	***Rhizophoraceae***	**Pototan**		**9**		**1**	**6**	**2**	**4**	**2**	**1**	**1**		**1**	**2**	**29**
23	*Caesalpinia crista*	*Fabaceae*	kalumbibit														0
24	*Caesalpinia nuga*	*Fabaceae*	sapinit		11	1		1									13
25	*Camptostemon philippinense*	*Bombacaceae*	gapa-gapas					4	5	1					1		11
26	*Centroserma* sp.	*Leguminosae*				1		1									2
27	*Cerbera manghas L*	*Apocynaceae*	baraibai		5												5
28	***Ceriops tagal***	***Rhizophoraceae***	**tangal**	**1**	**12**		**1**	**6**	**4**	**3**	**2**	**1**	**1**		**3**	**2**	**36**
29	***Ceriops decandra***	***Rhizophoraceae***	**malatangal**		**11**		**1**	**5**	**5**	**1**	**5**		**1**	**1**	**1**		**31**
30	*Chromolaena odorata*	*Euphorbiaceae*				1		1									2
31	*Clerodendrum siphonospathus*	*Verbenaceae*				1											1
32	*Derris trifoliate*	*Fabaceae*	mangasin		6	1											7
33	*Dolichandrone spathacea*	*Bignoniaceae*	tui		4										1		5
34	***Excoecaria agallocha***	***Euphorbiaceae***	**buta-buta**	**1**	**12**	**1**	**1**	**2**	**5**	**1**	**6**				**2**	**1**	**32**
35	*Flagellaria indica*	*Flagellanaceae*				1		1									2
36	*Glochidion littorale*	*Euphorbiaceae*	dampol					4									4
37	*Glochidion mindorense*	*Euphorbiaceae*						1									1
38	*Heritiera littoralis*	*Sterculiaceae*	dungon late		11	1		2		1	1						16
39	*Heritiera sylvatica*	*Sterculiaceae*						2									2
40	*Hibiscus tiliaceus*	*Malveceae*	malubago		9	1		3									13

Annex 2 *cont.* Mangrove species known to occur in the Philippine Islands (CEP/CMMP Sites including UNEP/GEF/SCS).

				Regions													
No.	Philippine Mangrove Spp. (Tree/Shrub/Vine/Grasses/ Fern/Palm)	Family	Common name	1	2	3	4A	4B	5	6	7	8	9	10	11	13	Fre-quency
41	*Intsia bijuga*	*Leguminosae*	ipil														0
42	*Intsia retusa*	*Leguminosae*	ipil laut														0
43	*Ipomea pes-caprae*	*Convolvulaceae*	lambayong		9	1		2									12
44	***Kandelia candel***	***Rhizophoraceae***						**1**									**1**
45	*Kleinhovia hospita*	*Sterculiaceae*	tan-ag														0
46	***Lumnitzera littorea***	***Combretaceae***	**tabau**		**2**	**1**		**3**	**5**	**1**	**2**	**1**			**2**	**1**	**18**
47	***Lumnitzera racemosa***	***Combretaceae***	**kulasi**		**1**	**1**		**2**	**5**	**1**	**5**			**1**	**1**	**1**	**18**
48	*Mallotus papillaris*	*Euphorbiaceae*				1		1									2
49	*Morinda bracteata*	*Rubiaceae*		1	3								1	1			6
50	***Nypa fruticans***	***Palmae***	**nipa**	**1**	11	1	1	5	5	2	2		1		2	3	**34**
51	*Oncosperma tigillaria*	*Palmae*	**anibong**														0
52	***Osbornia octodonta***	***Myrtaceae***	**taualis**	**2**	5		1		3	1	4					1	17
53	*Pandanus tectorius*	*Pandanaceae*		1	10	1											12
54	*Pemphis acidula*	*Lythraceae*	bantigi		5		1	1	5	1					1		14
55	*Phanera integrifolia*	*Caesalpiniaceae*				1		1									2
56	*Pluchea indica Linn*	*Compositae*	kalapini														0
57	*Pongamia pinnata*	*Fabaceae*	bani	1	8											1	10
58	*Prosopis vidaliana*	*Leguminasae*				1		1									2
59	***Rhizophora apiculata***	***Rhizophoraceae***	**bakauan lalaki**	**2**	**11**	**1**	**2**	**8**	**6**	**4**	**10**	**2**	**9**	**1**	**3**	3	**62**
60	***Rhizophora mucronata***	***Rhizophoraceae***	**bakauan babae**	**1**	**9**	**2**	**1**	**8**		**4**	**4**	**1**	**8**	**1**	**2**	2	**43**
61	***Rhizophora stylosa***	***Rhizophoraceae***	**bakauan bangkau**	**1**	**4**		**1**	**5**		**1**	**9**	**2**	**2**		**2**		**27**
62	***Rhizopora lamarckeii***	***Rhizophoraceae***															**0**
63	*Sapium indicum*	*Rhamnaceae*															0
64	***Scyphiphora hydrophyllacea***	***Rubiaceae***	**nilad**		**11**	**2**	**2**	**5**		**1**	**1**				**2**		**24**
65	*Sesuvium portulacastrum*	*Aizoaceae*	dampalit			1		1			2						4
66	***Sonneratia alba***	***Sonneratiaceae***	**pagatpat**		**8**	**2**	**1**	**7**		**3**	**4**	**1**	**6**		**2**	2	**36**
67	***Sonneratia caseolaris***	***Sonneratiaceae***	**pedada**	**1**	**9**			**4**		**2**	**3**	**2**		**1**	**1**	1	**24**
68	*Strophantus cumingii*	*Apocynaceae*															0
69	*Teijsmanniodendron hollrungii*	*Verbenaceae*															0
70	*Terminalia catappa*	*Combretaceae*	talisay		12	1	1	1		1	2						18
71	*Thespesia populnea*	*Malvaceae*	banalo					5									5
72	*Thespesia populneoides*	*Malvaceae*						1									1
73	*Tristellateria australasiae*	*Malphigiaceae*	binusisi					1									1
74	***Xylocarpus granatum***	***Meliaceae***	**tabigi**	**1**	**9**	**1**	**1**	**6**		**1**	**1**	**1**	**4**	**1**	**1**	1	**28**
75	***Xylocarpus moluccensis***	***Meliaceae***	**piagau**		**9**			**4**									**13**
76	***Xylocarpus rumphii***	***Meliaceae***															0
	True mangroves[1]			**14**	**23**	**15**	**19**	**24**	**17**	**24**	**24**	**13**	**15**	**9**	**20**	**13**	**27**
	Associates			3	17	18	5	22	2	7	7	0	1	1	3	1	34
	All Species			17	40	33	24	46	19	31	31	13	16	10	23	14	61

[1] *The true mangrove species are highlighted by* ***bold.***

United Nations Environment Programme

UNEP/GEF South China Sea Project

Global Environment Facility

NATIONAL REPORT

on

Mangroves in the South China Sea

THAILAND

Dr. Sonjai Havanond
Focal Point for Mangroves
Department of Marine and Coastal Resources
92 Pollution Control Building, Phaholyothin 7 (Soi Aree)
Phayathai, Bangkok 10400, Thailand

Table of Contents

List of Tables and Figures

1. GEOGRAPHICAL DISTRIBUTION AT THE HABITAT LEVEL

1.1 Map

Thailand covers an area of 512,820 square kilometres of land. The country has 2,614 kilometres of coastline, about 50% of which is fringed with mangrove forest. The extent of mangrove forestation has changed dramatically in Thailand over the past 30 years. A recent survey conducted in 1996 by Charuppat and Charuppat (1997) estimated the total remaining area of mangrove forest to be in the region of 167,582 hectares. Of this total mangrove area, approximately 80% is located on the peninsular west coast of the Andaman Sea. The GEF project for which this report has been prepared will focus on the remaining 20%, which is located at various points along the coastline of the Gulf of Thailand. Figure 1 represents locations of Mangrove Areas in Thailand.

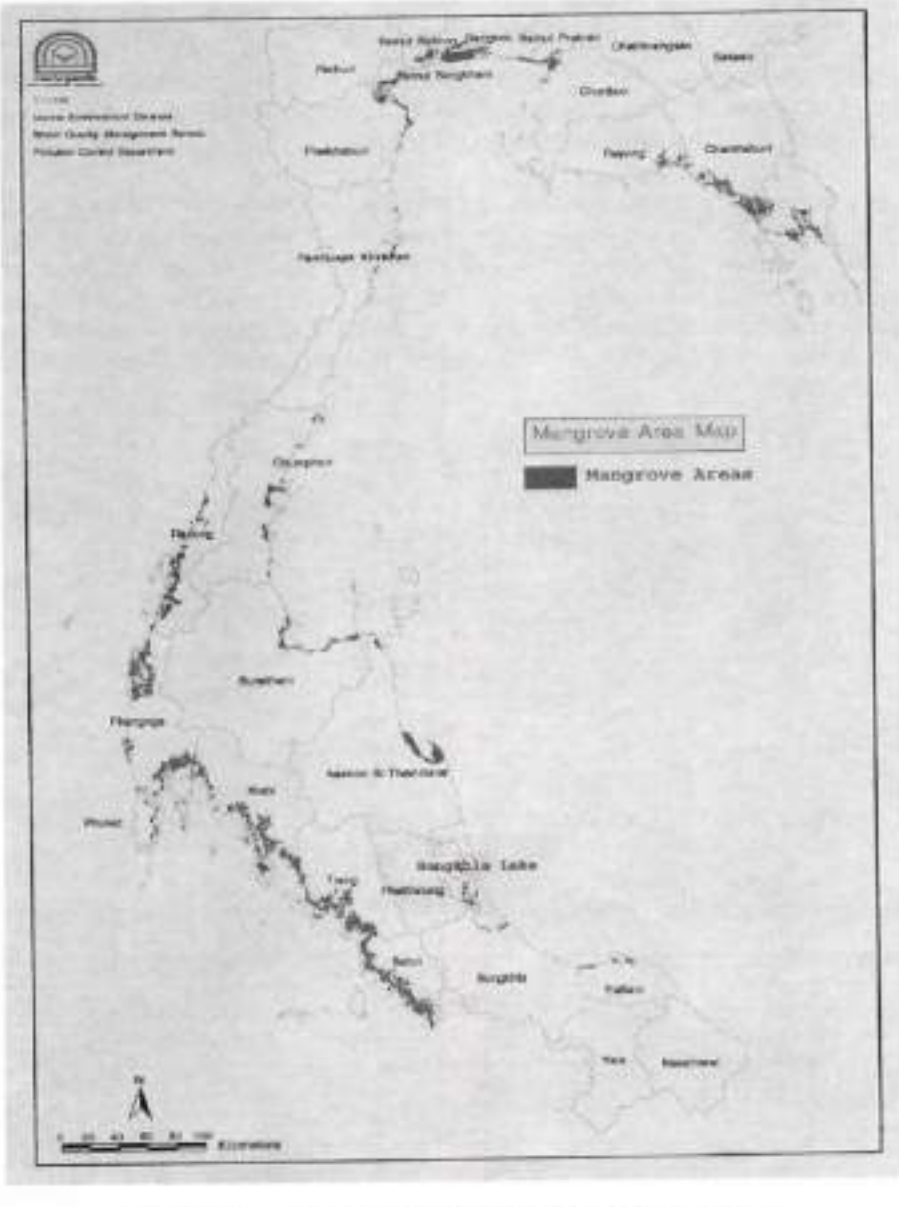


Figure 1 Locations of Mangrove Areas in Thailand.

1.2 Distribution Areas

Mangrove forests in the Gulf of Thailand are located on the sheltered muddy shores and low lying areas in the estuaries of rivers and streams which enter the Gulf. Geographically, mangroves in the Gulf of Thailand can be divided into three distinct groups (FAO, 1985): a group in the Eastern region, a Central group, and a group distributed along the Eastern coast of the Southern Thai Peninsular (Figure 1).

1) Eastern region: The Eastern region consists of the provinces located on eastern coast of the Gulf of Thailand – Trat, Chantaburi, Rayong and Chonburi. The coastline of this region is approximately 502km long.

2) Central region: The Central region is located around the upper part of the Gulf of Thailand, to the south of the Chao Phraya central plain. Provinces with coastline within this region are Chachoengsao, Samut Prakan, Bangkok, Samut Sakhon, Samut Songkhram, Petchaburi and Prachuab Khiri Khan. The total length of coastline in this region is about 439km.

3) Southern Thai Peninsular: This region runs south from the province of Chumporn along the eastern coastline of Surat Thani, Nakhon Si Thammarat, Songkhla and Pattani provinces. The total length of this coastline is about 932km.

Figure 2 shows a breakdown of the total area of mangroves in the Gulf of Thailand into both Regions and Provinces in 1996. Significantly larger areas of mangroves are found on the Western side of the Peninsular in the provinces of Ranong, Phangnga, Phuket, Krabi, Trang and Satun, bordering the Andaman Sea. These mangrove forests are not discussed in this report as they are not in the South China Sea region and are thus beyond the scope of the GEF project for which the report has been prepared. Table 1 shows the distribution of mangroves (ha) in Thailand by region and province, from the period of 1961-2003.

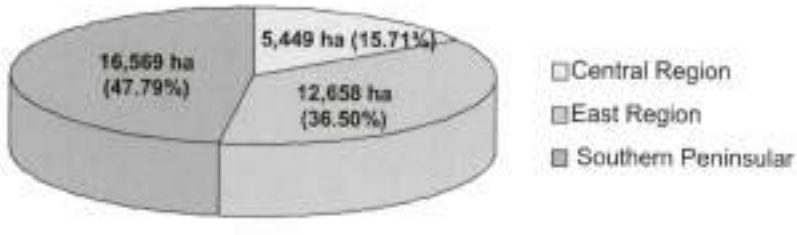


Figure 2 Areas of Mangroves in the Gulf of Thailand in 1996.

Table 1 Mangrove Areas (ha) Distribution in Thailand by Region and Province, 1961-2003.

Province	1961	1975	1979	1986	1989	1991	1993	1996	2000	2003
Central Region										
Samut Prakan	12,616.9	60	1,04	103.0			31	298.8	319.8	519.8
Bangkok	1,90						20	197.7		1,154.5
Samut Sakhon	28,243.8	18,50	14,41	141.9			1,819.0	1,696.3	3,393.0	3,080.4
Samut Songkhram	10,934.0	8,20	7,64	46.9			92	1,144.9	2,456.1	2,553.1
Petchaburi	11,88	8,80	7,79	576.9	488.9	33	2,06	2,069.7	5,747.0	3,058.5
Prachuab Khiri Khan	1,30	40	33	144.9	107.0	70.0	4	43.0	147.5	499.5
Subtotal	**66,890.0**	**36,50**	**31,23**	**1,015.8**	**59**	**406.0**	**5,363.0**	**5,450.7**	**12,053.6**	**10,874.0**
Eastern Region										
Trat	14,506.0	10,60	9,84	8,817.9	8,637.9	7,750.0	7,66	7,533.9	9,245.9	9,517.1
Chanthabun	28,188.9	26,10	24,06	14,506.6	8,69	2,663.0	4,07	3,893.1	9,977.6	12,572.8
Rayong	4,42	5,50	4,60	2,417.9	1,757.9	154.0	68	656.4	1,331.5	1,882.2
Chonburi	3,824.9	3,80	3,31	1,497.9	1,04	150.0	9	9	1,043.0	713.7
Chachoengsao	3,900.9	3,00	2,32	74	568.9	367.0	535.6	482.4	1,142.8	1,746.8
Subtotal	**54,844.9**	**49,00**	**44,14**	**27,980.6**	**20,708.8**	**11,084.3**	**13,047.6**	**12,657.9**	**22,740.9**	**26,40**

Table 1 *cont.* Mangrove Areas (ha) Distribution in Thailand by Region and Province, 1961-2003.

Province	1961	1975	1979	1986	1989	1991	1993	1996	2000	2003
Region of Eastern Coast of Peninsula										
Chumporn	10,63	7,40	68	3625.9	2,264.9	1,818.0	3,293.4	3,151.8	8,003.8	7,246.7
Surat Thani	11,803.0	3,70	5,80	4,283.8	3,767.0	2,20	3,16	3,133.7	3,532.4	9,300.3
Nakhon Sri Thammarat	21,616.9	15,485.6	12,83	8,835.8	8,520.9	8,024.9	7,96	8,416.1	9,874.8	9,580.1
Phatthalung	2,531.0	1,90	1,63	104.9	8	6	12	140.9	3,159.5	216.6
Songkhla	6,079.2	5,90	5,18	964.9	68	228.9	54	623.5	4,664.4	3,488.8
Pattani	3,787.0	1,10	1,39	1,82	1,759.0	1,64	1,295.2	1,105.1	3,573.2	4,230.4
Subtotal	**56,449.1**	**35,50**	**33,77**	**19,643.5**	**17,08**	**13,973.6**	**16,424.6**	**16,571.3**	**32,808.4**	**34,063.0**
Region of Western Coast of Peninsula										
Ranong	27,034.0	24,20	22,59	21,613.9	21,230.0	19,470.0	19,30	19,236.6	25,271.6	27,253.6
Phang-nga	43,979.0	51,10	48,71	36,42	35,626.0	33,510.0	30,716.1	30,442.4	39,696.0	42,037.9
Phuket	2,770.0	3,10	2,84	1,935.0	1,786.0	1,554.0	1,54	1,511.6	1,918.4	1,87
Krabi	39,918.0	33,00	31,76	30,31	29,643.0	31,915.0	28,526.7	28,273.4	34,996.3	35,094.0
Trang	39,892.9	34,00	32,86	26,27	25,04	30,848.9	24,32	24,095.5	33,50	35,788.3
Satoon	40,578.2	46,30	55,37	31,23	28,936.1	31,053.4	29,420.3	19,344.3	35,342.4	39,331.5
Subtotal	**194,172.3**	**191,70**	**194,15**	**147,795.8**	**142,218.2**	**148,351.6**	**133,847.2**	**132,90**	**170,726.8**	**181,381.4**
Total area of country	**372,356.4**	**312,700.0**	**303,308.0**	**196,435.8**	**180,607.0**	**173,822.0**	**168,682.5**	**167,584.0**	**238,329.9**	**252,751.3**

Source: Royal Forest Department, 2005.

Large areas of mangroves in the Gulf of Thailand have been destroyed as a result of human settlement, industrialisation, and shrimp farming, and mangrove forests along the Gulf coast distribute mainly as isolated narrow strips. However, substantial mangrove areas remain at the following Gulf coast locations:

- Trat and Mu Koh Chang National Park, Trat province (11°45' – 12°10'N and 102°15' – 31'E).
- Welu River estuary, Chantaburi province (10°16' – 17'N and 100°08' – 22'E).
- Khung Kraben Bay, Chantaburi province (12°32' – 41'N and 101°52' – 57'E)
- Don Hoi Lot mudflats and Klong Yeesan and Klong Kone estuaries, Samut Songkhram province (13°17 – 25' N and 99° 55' – 100' E).
- Petchaburi River mouth, Petchaburi province (10° 6' N and 99°7' E)
- Khao Sam Roi Yot National Park, Prachuab Khiri Khan province (12°05' – 20' N and 99°52' – 100°02' E).
- Thung Kha Bay and Savi Bay, Chumporn province (10°20' – 25' N and 99°05' – 15' E).
- Ban Don Bay, Surat Thani province (9°11' – 24' N and 99°13' – 41' E).
- Pak Phanang Bay, Nakhon Si Thammarat province (8°21' – 34' N and 95°58' – 100°15' E).
- Pattani Bay, Pattani province (6°51' – 58' N and 95°58' – 100°16' E).

2. SPECIES DISTRIBUTION AND FORMATION

2.1 Species Distribution

According to Santisuk (1983) 71 species of trees and shrubs have been recorded from the mangrove forests of the Gulf of Thailand (Table 2). These species include 27 species which have been classified as "true mangroves" (species that are bound to saline or brackish water) and 44 species classified as "mangrove associates" (species of littoral vegetation that regularly occur in the rear, landward zone of mangrove forests). The most common mangrove species is *Rhizophora apiculata* while other common species belong to the families Verbenaceae (*Avicennia* spp.), Rhizophoraceae (*Rhizophora* spp., *Bruguiera* spp., *Ceriops* spp.) and Sonneratiaceae (*Sonneratia* spp.).

Distribution of mangrove species across the Gulf of Thailand is quite uniformed in nature with only minor differences in species distribution apparent between the groups from the East, the Central region, and the Southern peninsular (Table 2).

Table 2 Distribution and Characteristics of Mangrove Trees and Mangrove Shrubs found in the Gulf of Thailand.

No.	Scientific Name	Vernacular Name	Family	Habit	Distribution	
					C& S	E
1	*Acanthus ebracteatus*	Ngueak Plaamo	Acanthaceae	S	+	+
2	*A. ilicifolius*	Ee kreng	Acanthaceae	S	+	+
3	*Acrostichum aureum*	Prong thale	Pteridaceae	S	+	+
4	*A. speciosum*	Prong nuu	Pteridaceae	S	+	-
5	*Aglaia cuculatta*[xx]	Daeng nam	Meliaceae	T	+	+
6	*Aegiceras corniculatum*	Lep mue naang	Myrsinaceae	S	+	+
7	*Allophyllus cobbe*	Tosai	Sapindaceae	S	+	+
8	*Ardisia elliptica*	Raamyai	Myrsinaceae	S/ST	+	+
9	*Avicennia alba*	Samae khao	Avicenniaceae	T	+	+
10	*A. marina*	Samae thale	Avicenniaceae	T	+	+
11	*A. officinalis*	Samae dam	Avicenniaceae	T	+	+
12	*Barringtonia asiatica*	Chik le	Barringtoniaceae	T	+	+
13	*B. racemosa*	Chik suan	Barringtoniaceae	ST	+	+
14	*Brownlowia tersa*[xx]	Nam Nong	Tiliaceae	S	+	+
15	*Bruguiera cylindrica*	Thua Khao	Rhizophoraceae	T	+	+
16	*B. gymnorrhiza*	Kongkaanghua sum	Rhizophoraceae	T	+	+
17	*B. hainesii*[xx]	-	Rhizophoraceae	T	+	+
18	*B. parviflora*	Thua dam	Rhizophoraceae	T	+	+
19	*B. sexangula*	Prasak dok khao	Rhizophoraceae	T	+	+
20	*Calophyllum inophyllum*	Saraphee thale	Guttiferae	T	+	+
21	*Cerbera manghas*	Teepet saai	Apocynaceae	ST	+	+
22	*C. odollam*	Teenpet thale	Apocynaceae	T	+	+
23	*Ceriops decandra*	Prong khao	Rhizophoraceae	S/ST	+	+
24	*C. tagal*	Prong daeng	Rhizophoraceae	T	+	+
25	*Clerodendrum inerme*	Sammangaa	Verbenaceae	S	+	+
26	*Cynometra iripa*	Kaa tong	Leguminosae	S	+	-
27	*C. ramiflora*	Maang kha	Leguminosae	T	+	+
28	*Cycas rumphii*	Prong thale	Cycadaceae	ST	+	+
29	*Dendrolobium umbellatum*	Chamaep	Leguminosae	S	+	+
30	*Derris indica*	Yee nam	Leguminosae	T	+	+
31	*Diospyros ferrea*	Lambit thale	Ebenaceae	S	+	+
32	*D. areolata*	Maa plab	Ebenaceae	T	-	+
33	*Dolichandrone spathacea*	Khae Thale	Bignoniaceae	T	+	+
34	*Excoecaria agallocha*	Taatum thale	Euphorbiaceae	ST/T	+	+
35	*Ficus microcarpa*	Sai Yoi bai thuu	Moraceae	T	+	+
36	*Glochidion littorale*	-	Euphorbiaceae	ST	+	+
37	*Guettarda speciosa*	Kangkaang huuchang	Rubiaceae	ST	+	+
38	*Heritiera littoralis*	Ngonkai thale	Sterculiaceae	T	+	+
39	*Hibiscus tiliaceus*	Po thale	Malvaceae	T	+	+
40	*Horsfieldia irya*	Knuai	Myristicaceae	T	+	+
41	*Intsia bijuga*	Lumpho thale	Leguminosa	T	+	+
42	*Kandelia candel*	Rang ka thae	Rhizophoraceae	T	+	+
43	*Lumnitzera littorea*	Faat daeng	Combretaceae	ST/T	+	+
44	*L. racemosa*	Faat Khao	Combretaceae	S/ST	+	+
45	*Melaleuca cajuputi*	Samet	Myrtaceae	T	+	+
46	*Melastoma villosum*	Khlongkhleng khom	Melastomaceae	S	+	-
47	*Myrisine porteriana*	Phrong nok	Myrsinaceae	S	+	+
48	*Nypa fruticans*	Chaak	Palmae	ST	+	+
49	*Oncosperma tigillaria*	Laao cha on	Plamae	T	-	+
50	*Pandanus odoratissimus*	Toei thale	Pandanaceae	ST	+	+
51	*Peltophorum pterocarpum*	Non see	Legumminosae	T	+	+
52	*Pemphis acidula*	Thian le	Lythraceae	S	+	+
53	*Phoenix paludosa*	Peng thale	Palmae	T	+	+
54	*Planchonella obovata*	Ngaa saai	Sapotaceae	T	+	+
55	*Pluchea indica*	Khluu	Compositae	S	+	+
56	*Premna obtusifolia*	Chaa lueat	Verbenaceae	S	+	+
57	*Rhizophora apiculata*	Kongkaang bailek	Rhizophoraceae	T	+	+
58	*R. mucronata*	Kongkaang baiyai	Rhizophoraceae	T	+	+
59	*Sapium indicum*	Samo thale	Euphorbiaceae	ST/T	+	+
60	*Scaevola taccada*	Rak Thale	Goodeniaceae	ST	+	+
61	*Scolopia macrophylla*	Takhob Thale	Flacourtiaceae	ST	-	+
62	*Scyphiphora hydrophyllacea*	Chee ngam	Rubiaceae	ST	+	+
63	*Sonneratia alba*	Paat	Sonneratiaceae	T	+	+
64	*S. caseolaris*	Lam phu	Sonneratiaceae	T	+	+

Table 2 *cont.* Distribution and Characteristics of Mangrove Trees and Mangrove Shrubs found in the Gulf of Thailand.

No.	Scientific Name	Vernacular Name	Family	Habit	Distribution	
					C& S	E
64	*S. griffithii*	Lam phaen hin	Sonneratiaceae	T	+	-
65	*S. ovata*	Lam phaen hin	Sonneratiaceae	T	+	+
66	*Sueda maritima*	Cha khraam	Chenopodiaceae	US	+	+
67	*Terminalia catappa*	Huu kwaang	Combretaceae	T	+	+
68	*Thespesia populnea*	Pho thale	Malvaceae	T	+	+
69	*Xylocarpus granatum*	Ta buun khao	Meliaceae	T	+	+
70	*X. rumphii*	Ta buun	Meliaceae	T	+	-
71	*X. moluccensis*	Ta buun dam	Meliaceae	T	+	+

Source: Modified from Santisuk, 1983.

Notes to Table 2: T = tree, S = shrub, ST = shrubby tree, US = under-shrub, C = Central area, S = Southern peninsular area, E = Eastern area, '' = classified in the IUCN Red Book as endangered. Shading indicates that the species is classified as a "true mangrove" bound to saline or brackish water. Unshaded species are mangrove associates, species of littoral vegetation that regularly occur in the landward zone of mangrove forests.

2.2 Formation

The distribution of mangrove species within mangrove forests across the Gulf of Thailand occurs in distinct zonation patterns with different species or combinations of species dominating different zones, resulting from the competitive advantages each species has along the gradient from mean sea level to above the high water line (corresponding to frequency of inundation) as well as the influence of other environmental factors at the site including soil type and soil salinity (Santisuk, 1983; Aksornkoae, 1985).

Aksornkoae (1975) studied the dominant species associations of mangrove forests in Eastern Thailand and summarised the zonation patterns from the river edge to inland sites as follows: "*Rhizophora apiculata* and *Rhizophora mucronata* are the dominant species along river and channel banks. *Avicennia* and *Bruguiera* are associated with *Rhizophora* along the channels, but form a distinct zone further inland. *Xylocarpus* and *Excoecaria* dominate on sites adjacent to the *Avicennia* and *Bruguiera* zone that have drier soils and are less subject to tidal inundation; *Ceriops* and *Lumnitzera* are also found within this zone. *Melaleuca* reaches its greatest dominance further inland on even drier and more elevated sites that are still less subject to tidal flooding".

Eastern Region

In the Eastern region province of Chantaburi, the mangrove forests can be divided into three principal classes (National Research Council and Royal Forest Department, 1985).

Central region

In Samut Sakhon province the important species have been recorded as *Rhizophora* spp., *Avicennia* spp., *Sonneratia* spp., *Xylocarpus* spp., *Lumnitzera* spp. and *Nypa fruticans*. Currently only a few species are found within the mangrove forests along the Tha Chin estuary and the dominant species are *Avicennia marina* and *A. alba*. A greater number of species were observed in mangrove forests on the river banks, and common species recorded included *Avicennia alba, Sonneratia caseolaris, Xylocarpus granatum, Cerbera odollam* and *Nypa fruticans* (Aksornkoae and Eiumnoh, 1988).

Southern Peninsular

At Khanom district in Nakhon Si Thammarat province, where a high species diversity is found, the most common species are *R. apiculata, R. mucronata, X. moluccensis, A. alba, C. tagal, Lumnitzera* sp., *E. agallocha, Bruguiera gymnorrhiza, B. cylindrica, Heritiera littoralis, Acrostichum aureum, S. alba* and *Phoenix paludosa* (Aksornkoae and Eiumnoh, 1988).

3. ENVIRONMENTAL STATE

3.1 Physical

3.1.1 Climate

Thailand's climate is dominated by the influence of the powerful South and Southeast Asian monsoons which result from the seasonal differences in temperatures between land masses and the oceanic body, alternately blowing south-westerly and north-easterly over the country. The surrounding waters and the physiographic terrain contribute much to modifying the monsoon effects on various localities of the country. Characteristics of the climate in each of the three mangrove forest zones of the Gulf of Thailand are shown in Table 3.

Table 3 Summary of Climatic Conditions in Each of the Three Mangrove Forest Regions of the Gulf of Thailand.

Region	Climatic type	Rainfall	Temperature	Humidity
Eastern	Rayong-Trat: Tropical monsoon climate. Rayong-Chonburi: Tropical savanna climate.	Average annual rainfall is 2,663.7mm. Maximum monthly rainfall in September (505.5mm), minimum in December (6.1mm).	Average annual temperature is 27.6 C. Highest in April (29.4 C) and lowest in December (26.1 C).	Annual average relative humidity is 78.5%. Highest in September (84.7%) and lowest in January (69.8%).
Central	Tropical savanna climate.	Average annual rainfall is 1,555.9mm. Maximum monthly rainfall in September (378.3mm), minimum in December (4.6mm).	Average annual temperature is 27.7 C. Highest in April (29.9 C) and lowest in January (25.3 C).	Annual average relative humidity is 76.1%. Highest in October (81.4%) and lowest in January (70.0%).
Southern Peninsula	Petchaburi – Prachuab Khiri Khan: Tropical savanna climate. Prachaub Khiri Khan – Surat Thani: Tropical monsoon climate. Surat Thani – Narathiwat: Tropical rainforest climate.	Average annual rainfall is 2,003.3mm. Maximum monthly rainfall in November (409.9 mm), minimum in March (52.5mm). This coastline receives the full impact of the northeast monsoon. Provinces located along the seashore, especially Narathiwat, have a maximum annual rainfall of 2,585.3mm.	Average annual temperature is 27.6 C. Highest in May (28.6 C) and lowest in December (25.5 C).	Annual average relative humidity is 80.7%. Highest in November (84.6%) and lowest in April (77.9%).

Source: Meteorological Department, 1987.
Notes to Table 3:
- *Tropical savannah climate: Little rainfall and severe drought during winter and summer, but forests nevertheless present.*
- *Tropical monsoon climate: High rainfall throughout the year and a short dry period.*
- *Tropical rainforest climate: High humidity and rainfall throughout the year.*

3.2 Biological

3.2.1 Aquatic Fauna

Phytoplankton

Many efforts have been made to study the composition and distribution of phytoplankton in the mangroves of the Gulf of Thailand (Boonrang, 1985, and Marumo *et al.*, 1985). Suvapepun *et al.* (1979) reported on the species composition and distribution of zooplankton communities in the mangrove forest at Laem Phak Bia in Petchaburi province. Copepod and decapod larvae were the dominant groups. Marumo *et al.* (1985) also found that copepods dominated in the epipelagic zooplankton community at Khung Kraben, Chanthaburi province.

Macrofauna

Mangrove macrofauna have been intensively studied emphasizing the distribution, abundance and biomass of major species or groups such as crustaceans, molluscs, and polychaetes, and many reports have been published studying the macrobenthos of mangrove areas in the Gulf of Thailand. It was described the benthic communities in the mangrove forests at Khlung district, Chantaburi province, recording thirty-five species of macrofauna, mostly crustaceans and polychaetes annelids. Total organic content, tidal inundation and salinity were the three factors controlling animal distribution and species composition and richness. Distribution of mangrove organisms was also related to soil characteristics. More recently several studies have been completed on the impact of mangrove reforestation on benthic communities and production (Piyakarnchana, 1988; Paphavasit *et al.*, 1996; Suzuki *et al.*, 1997 (a) Suzuki *et al.*, 1997 (b)). It was found 116 species of benthic fauna in a long-term study of a mangrove area in Samut Songkhram.

Crabs

A survey of crabs in mangroves and adjacent areas at Laem Phak Bia, Petchaburi province, was carried out by Naiyanetr (1979). Seven families with 54 species were recorded. The majority of these mangrove crabs belonged to the families Grapsidae and Ocypodidae. The genera commonly found from the Grapsidae family were *Sesarma, Parasesarma, Chiromentos, Sarmatium* and *Metaplax*. Those from the family Ocypodidae consisted mostly of the genera *Macrophthalmus, Ilyoplax* and *Uca*. A few species were found belonging to the families Portunidae, Gecarcinidae, Paguridae, Coenobitidae and Xiphosuridae.

Molluscs

Mangrove molluscs in Thailand, both gastropods and pelecypods (bivalves), have been studied by Isarankura (1976). Molluscs were observed to be either attached to stems, roots and leaves of mangroves or living on the mangrove soil (floor). The predominant snail species included those from the genera *Littorina, Cerithidae, Telescopium, Terebralis* and *Nerita*, with the latter being the most abundant. There were 10 species of gastropods and three species of bivalves living on trees and eight species of gastropods and two species of bivalves living on mangrove soils. Two species of gastropods (*Cassidula aurisfelis* and *Onchidium* sp.) were found at both habitats investigated but only one species of bivalve (*Isognomon ephippium*) was observed. Bivalves such as oysters and cockles are found buried in the mud or attached to the roots and stems of plants. Boring bivalves (*Teredo* spp.) live on rotten stems of dead trees. Four species of bivalves are found in mangrove forests, and of these *Crassotrea commercialis* is of particular commercial importance.

Shrimps

Chaitiamvong (1983) reported on species of shrimps found in the mangroves in Thailand and observed that these species mainly belong to the genera *Metapenaeopsis, Metapenaeus*, and *Parapenaeopsis*. About 16 species of shrimps migrate from marine waters to brackish water mangrove areas and the main genera which do so are *Metapenaeus, Penaeus* and *Acetes*. The species of shrimps most commonly found in the mangrove forests are *Macrobrachium equidens, Palaesnder* sp. and *Palaemonetes* sp. Chaitiamvong recorded few species of shrimp migrating from freshwater to brackish water mangrove areas but those most commonly doing so were *Macrobrachium rosenbergii* and *Leptocarpus potamiseus*.

Fish

The shallow waterways characteristic of mangrove forests are of immense and traditional importance for fisheries as they provide food and shelter for many species and serve as nursery areas for juvenile fish and shrimps. Several studies of mangrove-associated fish populations in Thailand provide evidence that Thai mangrove forests are used by fish as: (a) nursery grounds; (b) permanent habitats; or (c) breeding grounds in the case of some coastal species (Paphavasit, 1995). Numerous studies have been undertaken to assess the diversity of fish species and the results of some of these studies are summarised in Table 4.

Table 4 Fish Diversity in the Mangrove Forests of Thailand.

Location	Total species recorded
Laem Phak Bia, Petchaburi	More than 30 families of fish larvae of Economic importance such as snappers, Milkfish, groupers and mullets.
Klong Wan, Prachaub Khiri Khan	31 species of fish larvae with tarpon, lady fish, milkfish, and snappers as dominant groups.
Klong Klone, Samut Songkhram	55 species in 32 families with *Ambassidae, Clupeidae* and *Engraulidae* as dominant groups.
Trat Bay, Trat	111 species of fish from 47 families, with *Cypridinae, Gobiidae, Sigainindae* and *Engraulidae* as dominant groups.

Sources: Vatanachai, 1979 and Singkran and Sudara, 1999.

3.2.2 Terrestrial Wildlife Species

Terrestrial fauna inhabiting the mangrove forests in Thailand include birds, amphibians, reptiles and mammals. Surveys of mangrove vertebrates (excepting fishes) were reported a total of 106 species of mangrove mammals. Two groups of mammals are found: true mangrove species and other terrestrial species found at the forest margin. Among the former group are species found in large numbers which are well adapted to mangrove life, such as rats, squirrels and bats. The latter group consists of species that enter the forests in search for food, including bandicoot rats, spotted cats, civets, wild boars, crab-eating macaques, and otters. Nabhitabhata (1982) reported that six amphibian species are known to occur in mangroves, including the crab-eating frog (*Rana cancrivora*), but only two of these species are true residents. Nabhitabhata (1982) in his ecological studies of birds in Songkhla Lake, Southern Thailand noted that there were 25 families with 90 species of birds in the area. Of these, 70% and 20% respectively were residents and seasonal migrants. Kongsangchai and Prayoonsit (1990) found that vertebrates visited mangroves in search of food and/or for residence, with a total number of 278 species (not including fish) recorded. These included 36 mammals, 204 birds, 32 reptiles and 6 amphibians.

3.2.3 Threatened Species

A number of the species observed in the mangrove forests of the Gulf of Thailand are designated as endangered species either nationally or globally. Endangered species which have been recorded during survey work are listed in Table 5.

Table 5 Bird and Fish Species at Risk which have been Recorded in Mangrove Areas in the Gulf of Thailand.

Scientific name	Common name	Status	Location
		Birds	
Aquila clanga	Greater spotted eagle	Globally threatened	Khao Sam Roi Yot National Park
Aythya baeri	Baer's pochard	Globally threatened	Khao Sam Roi Yot National Park
Charadrius peronii	Malaysian plover	Globally threatened	Khao Sam Roi Yot National Park Ban Don Bay, Pattani Bay
Columba punicea	Pale-capped pigeon	Globally threatened	Khao Sam Roi Yot National Park
Eurynorhynchus pygmaeus	Spoon-billed sandpiper	Globally threatened	Khao Sam Roi Yot National Park
Heliopais personata	Masked finfoot	Globally threatened	Ban Don Bay, Pattani Bay
Leptoptilos dubius	Greater adjutant	Globally threatened	Khao Sam Roi Yot National Park
Limnodromus semipalmatus	Asian dowitcher	Globally threatened	Khao Sam Roi Yot National Park Pak Phanang Bay
Pelecanus philippensis	Spot-billed pelican	Globally threatened	Khao Sam Roi Yot National Park
Tringa guttifer	Spotted greenshank	Globally threatened	Khao Sam Roi Yot National Park
Anous stolodus	Brown noddy	Critically endangered	Mu Koh Chang National Park
Bubo coromandus	Dusky eagle-owl	Critically endangered	Khao Sam Roi Yot National Park
Leptopilos javanicus	Lesser adjutant	Critically endangered	Klong Kone and Klong Yeesan Pak Phanang Bay
Acrocephalus tangolum	Manchurian reed warbler	Endangered	Khao Sam Roi Yot National Park
Aquila heliaca	Imperial eagle	Endangered	Khao Sam Roi Yot National Park
Ardea cinerea	Grey heron	Endangered	Khao Sam Roi Yot National Park Thung Kha Bay/Savi Bay, Don Hoi Lot
A. purpurea	Purple heron	Endangered	Khao Sam Roi Yot National Park Thung Kha Bay/Savi Bay
Ciconea nigra	Black stork	Endangered	Khao Sam Roi Yot National Park
Egretta eulophotes	Chinese egret	Endangered	Klong Kone and Klong Yeesan
Milvus migrans	Black kite	Endangered	Khao Sam Roi Yot National Park
Myeteria leucocephala	Painted stork	Endangered	Klong Kone and Klong Yeesan Khao Sam Roi Yot National Park
Phalacrocorlax carbo	Great cormorant	Endangered	Klong Kone and Klong Yeesan Khao Sam Roi Yot National Park
Sterna bergii	Great crested tern	Endangered	Mu Koh Chang National Park Khao Sam Roi Yot National Park
Threskionis melanocephalus	Black-head ibis	Endangered	Khao Sam Roi Yot National Park
Aerodramus fuciphagus	Edible-nest swiftlet	Near-threatened	Mu Koh Chang National Park Khao Sam Roi Yot National Park Pak Phanang Bay, Don Hoi Lot
Amandava amandava	Red avadavat	Near-threatened	Khao Sam Roi Yot National Park
Aquila nipalensis	Steppe eagle	Near-threatened	Khao Sam Roi Yot National Park
Boteurus stellaris	Great bittern	Near-threatened	Khao Sam Roi Yot National Park
Buceros bicornis	Great hornbill	Near-threatened	Mu Koh Chang National Park
Burhinus oedicnemus	Eurasian thick-knee	Near-threatened	Khao Sam Roi Yot National Park
Coturnix chinensis	Blue-breasted quail	Near-threatened	Khao Sam Roi Yot National Park
Ducula bicolour	Pied imperial pigeon	Near-threatened	Mu Koh Chang National Park Khao Sam Roi Yot National Park
Emberiza aureola	Yellow-breasted bunting	Near threatened	Khao Sam Roi Yot National Park
Falco severus	Oriental hobby	Near-threatened	Khao Sam Roi Yot National Park Thung Kha Bay/Savi Bay
Fiecdula narcissina	Narcissus flycatcher	Near-threatened	Khao Sam Roi Yot National Park
Gallicrex cinerea	Watercock	Near-threatened	Khao Sam Roi Yot National Park
Gallinago megala	Swinhoe's snipe	Near-threatened	Khao Sam Roi Yot National Park
Gorsachius melanolophus	Malayan night-egret	Near-threatened	Thung Kha Bay/Savi Bay
Haliaeestrus leucogaster	White bellied sea eagle	Near-threatened	Mu Koh Chang National Park Khao Sam Roi Yot National Park Thung Kha Bay/Savi Bay, Ban Don Bay, Pattani Bay
Haliastur indus	Brahminy kite	Near-threatened	Welu River Estuary, Mu Koh Chang National Park Khao Sam Roi Yot National Park Ban Don Bay, Pattani Bay Don Hoi Lot

Table 5 *cont.* Bird and Fish Species at Risk which have been Recorded in Mangrove Areas in the Gulf of Thailand.

Scientific name	Common name	Status	Location
Ixobrychus eurhythmus	Schrenck's bittern	Near-threatened	Khao Sam Roi Yot National Park
Nettapus coromandelianus	Cotton pygmy-goose	Near-threatened	Khao Sam Roi Yot National Park
Numenius madagascariensis	Eastern curlew	Near-threatened	Khao Sam Roi Yot National Park
Ploceas philipinus	Baya weaver	Near-threatened	Khao Sam Roi Yot National Park
Rhyticeros subruficollis	Plain-pouched hornbill	Near-threatened	Mu Koh Chang National Park
Sterna albifons	Little tern	Near-threatened	Khao Sam Roi Yot National Park Pak Phanang Bay, Don Hoi Lot
Treron bicincta	Orange breasted pigeon	Near-threatened	Khao Sam Roi Yot National Park
Vanellus cinereus	Grey-headed lapwing	Near-threatened	Khao Sam Roi Yot National Park
Aythya nyroca	Ferruginous pochard	Vulnerable	Khao Sam Roi Yot National Park
Garrulax merulinus	Spot-breasted laughing thrush	Vulnerable	Mu Koh Chang National Park
Ploceas manyar	Streaked weaver	Vulnerable	Khao Sam Roi Yot National Park
Terpsiphone atrocaudata	Japanese paradise-flycatcher	Vulnerable	Khao Sam Roi Yot National Park
		Fish	
Hippocampus kuda	Seahorse	Endangered	Welu River Estuary
Anodontostoma chacunda	Chawnda gizzard-shad	Vulnerable	Welu River Estuary
Chiloscyllium burgeri	Bamboo shark	Vulnerable	Welu River Estuary
C. indicum	Slender bamboo shark	Vulnerable	Welu River Estuary
Clarius batrachus	Walking catfish	Vulnerable	Khao Sam Roi Yot National Park
Pampus argenteus	Silver pomfret	Vulnerable	Welu River Estuary
P. chinensis	Chinese pomfret	Vulnerable	Welu River Estuary

Source: Critically Endangered/Endangered = designated as an critically endangered or endangered species in Thailand.

4. SOCIAL USE AND OWNERSHIP

4.1 Ownership

4.1.1 Reserve Forests

The great majority of Thailand's mangrove forests are owned by the Thai government and reserved as National Reserve Forests. Until recently mangrove forests were the responsibility of the Royal Forest Department and were used for logging for the production of charcoal, but since 2002 the management and conservation of mangroves has been carried out by the Department of Marine and Coastal Resources, part of the new Ministry of Natural Resources and the Environment.

4.1.2 Private Mangrove Plantation

Mangrove plantations have been established in some coastal areas by private individuals as well as the Royal Forest Department. *Rhizophora apiculata* and *Rhizophora mucronata* are the two species most commonly planted on a large scale. Trees are grown for 10 years, after which time they are harvested and the wood used for production of charcoal (90%) or as posts or firewood (10%). There are approximately 17,500 rai (2,800ha) of private mangrove plantations (Havanond, 1994) predominantly located in the Central region provinces of Samut Sakhon, Samut Songkhram, and Samut Prakan. Small plantations also exist in the Southern provinces of Chumporn and Pattani, focusing principally on the production of *Bruguiera* spp. and *Ceriops tagal* for stakes used in culturing mussels. In the past assistance in the establishment and operation of private plantations has been provided by the Royal Forest Department, particularly in planting, maintenance, and harvesting techniques.

4.1.3 Community Mangrove Forests

In recent years villages and community groups living inside and adjacent to the mangrove forests of the Gulf of Thailand have become involved in the planning and implementation of mangrove rehabilitation projects and the management of mangrove forests close to their villages. These activities are usually initiated by local NGOs, often with external donor funding and technical support from academic institutes. Community mangrove forests have proved successful in some areas in reducing illegal encroachment into these areas for economic activities such as shrimp farming, and in improving the success of mangrove rehabilitation efforts. Some internationally recognised examples of community mangrove forestry projects have been associated with the Yadfon Association, a

non-governmental organization which has assisted villages in establishing community forests to conserve the mangroves of Trang on the Andaman Sea and also in the provinces of Surat Thani, Nakhon Si Thammarat, Songkhla, and Pattani (Charnsnoh, 1999; Erftemeijer and Bualang, 1998). In the Central region examples of community involvement in the management of mangrove forests can be seen in Samut Songkhram Province, where local communities at Klong Kone have now successfully rehabilitated a very large area of mangroves in the vicinity of their village. Key factors leading to the success of this community forest are a high level of public participation and awareness, strong community organisation, and support from provincial government officers, academics and non-governmental organizations (Paphavasit, 1999).

The emergence of community forestry in Thailand has led to the drafting of a Community Forestry Bill, which has been under consideration by the Thai government for several years. Once the Bill is approved the trend towards community management and ownership of mangrove forests in Thailand is likely to accelerate.

4.2 Present Uses

Significant numbers of people depend on the wide range of products and services that mangroves of the Gulf of Thailand provide. Most mangrove dwellers live in houses clustered in small village communities at the edge of forests or along channels within mangrove estuaries (Aksornkoae, 1985).

4.2.1 Food Items

Mangrove forests in the Gulf of Thailand have traditionally provided a source of food for villagers, especially in the monsoon season when fishing activity has to be reduced. Food from the mangrove forests comes in various forms, which are summarised in Table 6.

Table 6 Food Items Obtained from Different Mangrove Species.

Species	Local name	Products	Uses
Avicennia spp.	*Samae*	Fruits	Food
Bruguiera spp.	*Thoa*	Fruits	Food
Nypa fruticans	*Jaak*	Leaves, flowers, fruits	Sugar Production, vineger alcohol production, foods
Phoenix paludosa	*Pang*	Young leaves	Food
Sonneratia spp.	*Lume-Paan*	Young flowers, fruits	Food

Source: Bamroongrugsa and Koaesinaul, 1995.

Villagers living close to mangrove areas typically use these areas to collect seaweed. In Pattani Bay, for example, there is an abundance of *sarai-pomnang* seaweed which villagers collect in February-April (Bamroongrugsa and Koaesinaul, 1995).

4.2.2 Medicine

Mangrove vegetation with healing properties has been used traditionally by villagers as a source of medicine. Known medicinal properties of mangrove vegetation are summarised in Table 7.

Table 7 Medicinal Properties of Some Common Mangrove Species.

Species	Local name	Medicinal parts	Medicinal use
Acrostichum spp.	*Prong-talae*	Rhizomes	Extract from rhizomes is an antiseptic.
Acanthus ebracteatus *A. ilicifolius*	*Ngueak-Plaamo-Dokkaw* *Ngueak-Plaamo-Dokmuang*	All parts of the plant	Cures skin allergies, treats malaria (mixed with ginger), treats abscesses. Extract of boiled barks and roots helps to reduce cold symptoms.
Avicennia alba *A. officinalis*	*Samae-Kaw* *Samae-Dum*	Fruits, heart wood, seeds, bark, roots	Extract from fruits is an antiseptic and extract from fresh heart wood sooths stomach pains, has tonic properties, and treats abscesses.
Barringtonia racemosa	Chick-Suan	Roots, fruits	Anti-diarrhoeal.
Bruguiera sexangula *B. parviflora*	*Phangka-Huasum-Dokkaw* *Thua-Dum*	Bark	Anti-inflammatory.
Cerbera manghas	*Teen-Peed*	Seeds	Treats heart problems.
Ceriops decandra *C. tagal*	*Prong-Kaw* *Prong-Dang*	Shoots, bark	Anti-diarrhoeal, anti-inflammatory, treats malaria.
Excoecaria agallocha	*Taatum-Talae*	Roots, latex	Extract from roots treats skin Allergies. Latex used for treating sea cat fish stings.

Table 7 *cont.* Medicinal Properties of Some Common Mangrove Species.

Species	Local name	Medicinal parts	Medicinal use
Hibiscus tiliaceus	*Po-Talae*	Roots, leaves, flowers	Laxative. Fresh flowers boiled with fresh milk can treat ear infections.
Heritiera littoralis	*Ngonkai-Talae*	Seeds	Anti-diarrhoeal.
Phoenix paludosa	*Khluu*	Leaves	Antiseptic.
Phoenix paludosa	*Parig*	Shoots	Sooths stomach pains.
Rhizophora apiculata R. mucronata	*Kong-Kang*	Barks, roots	Extract from bark is anti-diarrhoeal and extract from roots is provides nourishment.
Scaevola taccada	*Rak-Talae*	Leaves	Treats colds and headaches.
Xylocarpus granatum, Moluccensis	*Taboon-Kaw, Taboon-Oum*	Seeds, bark	Extract from seeds is an antiseptic and extract from bark is anti-diarrhoeal.

Source: Aksornkoae, 1993.

4.2.3 Wood Products

The traditional uses of mangrove wood in Thailand are for charcoal burning, firewood, use as poles and construction materials, production of fishing gear, and tannin collection (Aksornkoae, 1985).

Charcoal

The harvest of mangrove wood for the production of charcoal has traditionally been a major industry in the mangrove forests of the Gulf of Thailand, with 90% of the wood harvested used for this purpose (Aksornkoae, 1995). The depletion of forest resources and a recent change in government policy banning the harvesting of mangroves for this purpose has reduced charcoal production greatly (Havanond, 1994). At the present time only limited production of charcoal occurs using wood from private mangrove plantations.

Firewood

Wood from Thai mangrove forests is widely used as firewood by local villagers. Species commonly used are *Avicennia, Xylocarpus, Excoecaria, Bruguiera and Lumnitzera* (Aksornkoae, 1995).

Building/fishing materials

Wood from mangrove harvesting is commonly used as foundation pilings during construction work. The species most commonly used to make poles are *Rhizophora apiculata, R. mucronata, Ceriops* sp., *Bruguiera* sp., *Excoecaria agallocha* and *Rhizophora* spp. (Aksornkoae, 1993). Nypa palm is also important as a source of roof shingles and is an important source of income for many coastal villagers (Bamroongrugsa and Koaesinaul, 1995).

Various types of fishing gear are used by mangrove dwellers, and some of this equipment is constructed from mangrove wood. Most of the mangrove poles from *Rhizophora* spp. are used for crab traps. Other types of fishing gear made from mangrove posts are drift gill-nets and the winged set-bag (Aksornkoae, 1985).

Tannin

In former times the bark of *Rhizophora* spp., *Ceriops* spp., *Bruguiera* spp., and *Xylocarpus* spp. was important as a source of tannin and dyes. These products were used in the manufacture of leather and ink used for dyeing fish nets, ropes, sails and textiles (Aksornkoae, 1993). At the present time tannin is rarely used for dyeing because the introduction of nylon net fishing equipment has made this use redundant (Aksornkoae, 1993).

4.2.4 Artisanal Fisheries

The mangroves of the Gulf of Thailand support large numbers of small-scale or subsistence capture fishermen who use the mangrove forests on a daily basis. Subsistence fishermen take many different species of fish and invertebrates using numerous fishing techniques such as push nets, barrier nets, crab net traps, gill nets, winged set-bag nets, hooks and lines, stake nets, cast nets, and hand picking. 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 commonly caught species of shrimp are *Penaeus merguiensis, P. monodon* and *Metapenaeus* spp. There is only one important species of crab in the catch – *Scylla serrata* – while important molluscs are *Nerita* sp., *Anadara* sp. and *Crassostrea*

commercialis. Villagers also catch a number of invertebrate species such as bivalve molluscs, gastropods and brachiopods by hand (Aksornkoae, 1993).

4.2.5 Mariculture

In addition to capture fisheries, the mangrove forests in the Gulf of Thailand are used by local people as a location for aquaculture facilities, particularly shrimp farm ponds but also aquaculture cages. Species typically cultured include shrimp, shellfish and various fish species.

Shrimp culture
Intensive shrimp farming is the main form of coastal aquaculture in the Gulf of Thailand. Shrimp farms are common in the Central region provinces bordering the Inner Gulf, the Eastern coastal provinces of Chonburi, Chantaburi, and Trat, and the Southern provinces of Surat Thani, Nakhon Si Thammarat, and Songkhla. The majority of farms culture the black tiger shrimp (*Penaeus monodon*), which are purchased as young post-larval shrimp and stocked in shrimp ponds for a period of four to five months (Rungreungwudhikrai and Tongdee, 1999). The culture period depends on a variety of factors, including market price, growth rate, pond water quality, and the prevalence of disease. Shrimp are fed several times daily with artificial food pellets, and the ponds are usually aerated using paddle wheel aerators. Lime and dolomite may be added to improve water quality. Issues and threats to mangroves posed by intensive shrimp farming are discussed in further in section 7.

Shellfish culture
Shellfish, particularly mussels, are often cultured on poles or ropes suspended from rafts floating on canals within and adjacent to mangrove forests, with the mangroves providing an important source of dissolved and suspended nutrients for the shellfish (Rungreungwudhikrai and Tongdee, 1999). The occurrence of shellfish culture is quite limited, being restricted to Rayong, Chantaburi and Chumporn provinces. The most important species of shellfish cultured in the Gulf of Thailand are the horse mussel (*Modiota senhausenii*), green mussel (*Perna veridis*), blood cockle (*Anadara granosa*) and oyster (*Crassostrea commercialis*).

Fish culture
Groupers (*Epinephelus* spp.) are the principal species of fish cultured in the Gulf of Thailand mangrove areas. Fish are raised in floating cages along the canals of the mangrove areas, with work usually being done by family members rather than hired workers. The fish are harvested when they reach a marketable size and many live groupers are exported for sale in Hong Kong (Rungreungwudhikrai and Tongdee, 1999).

4.3 Potential Uses

4.3.1 Eco-tourism

The Gulf of Thailand's mangrove forests have the potential to be utilised as locations for eco-tourism activities. Eco-tourism activities are commonplace in the mangrove forests of Trang, Krabi, Phangnga and Phuket on the Andaman sea coast and lessons learnt from experiences in these provinces could be applied to the mangrove forests of the Gulf of Thailand. Activities could possibly include canoeing, bird watching tours, fishing, and visits to villages located in mangrove forests to observe traditional lifestyles. Eco-tourism activities could provide benefits to local communities from enhanced employment opportunities and opportunities to sell local produce and could serve as an incentive for these communities to protect forest resources.

4.3.2 Sustainable Forestry

Although the Thai experience with mangrove forestry for charcoal and wood production has not proved sustainable, many examples of mangrove based charcoal/wood production industries exist around the world which is able to operate successfully on a sustainable basis. In Matang, Malaysia, a large mangrove forest area has been continuously harvested for the last 30 years with minimal impacts on the environment and is lauded as an example of how it is possible to combine economic harvesting of mangrove timber alongside maintenance of the environmental services that mangrove forests provide (Chan, 1996). Lessons learnt from Matang and similar experiences from around the world could be applied by local community leaders with the assistance of Thai government agencies to develop sustainable mangrove forestry in Thailand.

4.4 Current Management Regime

4.4.1 Institutional Structure

Department of Marine and Coastal Resources, Ministry of Natural Resources and Environment
The principal responsibility for management of mangroves in Thailand lies with the Department of Marine and Coastal Resources, part of the newly formed Ministry of Natural Resources and Environment. Prior to October, 2002, when the Ministry was formed, responsibility for the management of Thailand's mangroves was with the Royal Forest Department. The Department of Marine and Coastal Resources is charged with co-operating with other relevant government departments which have an interest in mangrove management. These departments include the Royal Forest Department, the National Parks Department, the Office of Environmental Policy and Planning, and the Fisheries Department.

The management of Thailand's mangrove forests by the Department of Marine and Coastal Resources is based on the following principles:

1. To manage mangroves as a renewable resource on a sustainable use basis for production of direct and indirect products.
2. In terms of direct products, to manage mangroves as an important and potentially sustainable source of wood and charcoal to meet increasing needs for domestic use and export.
3. In terms of indirect products, to manage mangroves as an important primary food source for aquatic organisms in estuaries, a habitat for various important fishery species, spawning grounds and nurseries for marine animals, and a means of protection against coastal erosion.
4. To manage mangroves as an integral part of the coastal zone ecosystem rather than as an isolated ecosystem. Management of mangroves will therefore be conducted on the bases of sustainable use and maintenance of the ecological balance of coastal resources.

Department of National Parks, Ministry of Natural Resources and Environment
The management of mangrove areas lying within Marine National Parks in Thailand is the responsibility of the Department of National Parks. Along the coast of the Gulf of Thailand, the only Marine National Parks containing mangrove areas are Mu Koh Chang National Park, an island off Trat Province, and Khao Sam Roi Yot National Park in Prachuab Khiri Khan Province.

Office of Environmental Policy and Planning (OEPP), Ministry of Natural Resources and Environment
The Office of Environmental Policy and Planning (OEPP) is responsible for establishing environmental policies and plans for Thailand in accordance with the Enhancement and Conservation of National Environmental Quality Act 1992. In undertaking this role, OEPP also co-ordinates the work of various other environmental agencies, and provides a secretariat to the National Environment Board. OEPP is responsible for the development of national resource management policies and plans relating to mangrove forests.

Office of the National Environmental Board (ONEB), Ministry of Natural Resources and Environment
A further government agency playing an important role in mangrove conservation and development in Thailand is the Office of the National Environment Board (ONEB). ONEB has a direct responsibility for examining the directly or indirect affects of development activities on environmental quality along the coastal zone, including mangrove areas. In the past ONEB has co-operated with the Royal Forest Department, the Fisheries Department, the Royal Thai Navy, and Provincial Administration Organisations to develop and implement mangrove conservation initiatives and introduce mangrove ecology into the educational curriculum at the primary, elementary, and pre-university school levels and at universities across Thailand.

National Committee on Mangrove Resources (NATMANCOM)
In 1977, the Thai Cabinet adopted a resolution to establish the National Committee on Mangrove Resources (NATMANCOM) with a membership of 19 organisations with an interest in mangroves, including non-governmental organizations. The committee was assigned the following roles:

1. Co-ordinate with the National Committee on Marine Science on matters pertaining to mangrove resources.
2. Advise the office of the National Research Council of Thailand (NRCT) on the programming of mangrove research projects.
3. Provide advice on the planning and implementation of development projects in mangrove areas and the identification of any problems which might result from such projects.
4. Identify problems relating to mangrove conservation.
5. Co-ordinate with other national and international organisations with an interest in mangrove resources.

Office of the National Economic and Social Development Board (NESDB)
The Office of the National Economic and Social Development Board (NESDB), part of the Office of the Prime Minister, is responsible for overall national development planning as well as the formulation national economic and social development policy. NESDB is responsible for setting the direction and framework of natural resource and environmental policies in Thailand. The framework sets criteria for budget allocation and investment in all development projects in Thailand.

4.4.2 Legislation and Regulations Relevant to Management of Mangroves

Enhancement and Conservation of National Environmental Quality Act (NEQA, 1992)
The NEQA provides a foundation for the legal framework governing environmental protection and management in Thailand.

Forestry Act 1960
This Acts regulates the use of timber and forest products in national forests. It provides guidelines for the Royal Forest Department in supervising the exploitation of forests as well as in supervising various activities concerning timber forest products, from the time of harvesting to the sale of the final products. The scope of the act covers mangrove forests, for which a principal use has traditionally been the harvesting of wood for charcoal production and timber.

National Reserve Forest Act 1964 and predecessor Acts
All mangrove forests are designated as reserve forest areas under this Act (article 6) or earlier Reserve Forest Acts. The act controls all activities carried out in mangrove forests and other reserve forests.

National Parks Act 1961
Mangrove forests lying with the boundaries of National Parks are protected by the National Parks Act, under which all natural resources in park areas are to be strictly conserved.

Regulations and Cabinet Resolutions relevant to mangrove forests
The Thai government has taken steps to address the degradation of mangroves in Thailand through issuance of a series of Cabinet resolutions (Table 8). These resolutions must be followed by Government agencies when carrying out their activities.

Table 8 Summary of Thai Government Cabinet Resolutions relating to Mangrove Conservation and Management.

Date	Summary of Resolution
27 July 1978	Establishment of the National Mangrove Committee (NATMANCOM), with a duty to screen development projects planned for mangrove areas and to propose policy on mangrove issues to the government. NATMANCOM and the National Environment Board have the role of reviewing and screening all development projects proposed by government agencies which relate to mangrove areas so as to maintain optimum sustainable productivity without degrading the integrity of ecosystems.
19 August 1980	All development projects planned for mangrove areas must undergo an environmental impact assessment. Private land holding and the issue of secure land titles in mangrove areas no longer allowed.
1 May 1984	Mangrove zonation to be clearly implemented following study of the ecosystems involved. Rehabilitation of degraded mangrove forest by government agencies and private sector to be encouraged.
15 December 1987	Implementation of a Zonation system for Thailand's mangroves classifying mangroves either as a conservation Zone, economic zone (type A), or economic zone (type B).

Table 8 *cont.* Summary of Thai Government Cabinet Resolutions relating to Mangrove Conservation and Management.

Date	Summary of Resolution
1 August 1969	Cabinet approved proposals presented by the Ministry of Science, Technology, and Environment to undertake rehabilitation and protection of all remaining mangrove areas in Surat Thani and Nakhon Si Thammarat provinces, with financial support provided for the establishment of additional mangrove management and protection units.
6 February 1990	In an attempt to curtail problems associated with shrimp farming in mangrove areas, the Cabinet declared that no further shrimp farming would be permitted within economic zone A of mangrove forests.
4 June 1991	Five-year action plan approved for recovery and establishment of mangrove areas, together with a 750 million baht (US$30 million) budget. Actions included: • Provincial mangrove management plans to be drawn up. Plans to take local conditions and requirements into account. • Mangrove areas to be defined and marked. • Remote sensing techniques to be applied. • Ground surveys and marking to be conducted every two years. • Mangrove propagation to be encouraged through replanting. • Degraded forests to be restored and replanted. • Privately owned mangrove plantations to be supported. • Seed source areas to be developed in conservation forests and plantations. • Encroachment into mangrove areas to be reduced. • Patrolling to be intensified and public awareness increased. • Support to be requested from the Navy and Navy officers designated as additional forestry officers according to the Forestry Act. • Intensive aquaculture to be promoted away from mangrove areas. • Programme evaluations to be conducted by inspectors from the Prime Minister's Office. • Budget needed for plan implementation to be allocated by the Budget Bureau.
23 July 1991	Permission to convert mangrove forest land into other uses to be no longer given. Committees of officials from all departments concerned established at provincial level to prevent illegal encroachment and address mangrove use problems.
2 September 1997	Provincial Mangrove Management Units ordered to: • Monitor whether mangrove concessionaires follow conditions of their concessions. • Monitor the licensing of land use in mangrove areas granted after 1991. • Monitor the licensing of shrimp farm operators in mangrove areas. • Persuade concessionaires to surrender their concessions after the expiry date.
10 March 1998	Logging and charcoal concessions in mangrove areas to be permitted to continue only until concessions expire.
22 August 2000	Cabinet approved recommendations presented by the Ministry of Science, Technology and Environment and the Ministry of Agriculture and Co-operatives to commit to mangrove conservation by confirming the cabinet resolution of 23 July 1991. Logging and mining in mangrove forest areas to continue only until the termination of concessions, with contracts to be strictly enforced. Remaining forest to be reclassified for conservation or development-related activities. Aquaculture to be permitted only in areas behind mangrove forests. Department of Fisheries, Royal Forest Department and Department of Pollution Control to co-operate in promoting sustainable management of aquaculture operations without detriment to surrounding ecosystems or mangroves.

4.4.3 Thai Government Policy

Ninth National Economic and Social Development Plan

The Ninth National Economic and Social Development Plan for the period 2002-2006 (NESDB, 2002) sets the following goals for mangrove conservation in Thailand: Conserve and restore conservation forests, so that at least 30% of the country is covered by forest, with mangrove forests covering an area of at least 1.25 million rai (2,000km^2).Protect and restore marine resources and coastal ecosystems. Preserve, conserve and protect biodiversity in highly diverse areas.

In terms of environmental and natural resource management, the plan sets the following objectives: Improve the process of strategic environmental and natural resources management, with emphasis on participation from all parties. Strengthen enforcement and take actions to ensure compliance, including prescribing legislative measures for the protection of flora and fauna. Preserve the ecological balance while supporting the basic socio-economic profile of the area. Support a reduction in waste quantities, support the reuse of waste, and develop technology for pollution management.

National Environmental Quality Enhancement and Conservation Policy and Plan for 1997 to 2016

In 1997 the Office of Environmental Policy and Planning (OEPP) published its National Environmental Quality Enhancement and Conservation Policy and Plan for 1997 to 2016. This plan was prepared under section 13 of NEQA 1992 and includes policies and guidelines on environmental management looking forward over a 20 year period. The purpose of the plan is the "integration of the management and enhancement of natural resources and the conservation of national environmental quality with sustainable economic and social development to maintain the quality of life".

Policies included in the document (and strategies) aim to accelerate the rehabilitation of renewable resources and address water pollution, air pollution, noise and waste problems. Of particular relevance to mangroves are policies on natural resources, natural and cultural environments, and communities and the environment. For each of these policies, the plan lists goals, specific policy measures, and guidelines for their implementation.

The plan lists the following national targets relating specifically to mangrove management:

1) Preserve at least 1 million rai (160,000 hectares) of mangrove forest.
2) Conserve and rehabilitate all type of coastal resources in order to maintain the natural balance of this ecosystem.

Policies on the protection of mangrove ecosystems

The December 1987 Cabinet Resolution classified mangrove areas into two classes: conservation zones and economic zones. Economic zones are divided into 2 sub-zones: economic zone A and economic zone B.

In **conservation zones** all human utilisation and disturbance are prohibited. Conservation zones include:

- Areas for preservation of economic plants and animals.
- Nursing grounds for plant and animals.
- Areas susceptible to damage and erosion.
- Historic areas.
- Area with unique local characteristics.
- National parks, tourist areas, wildlife sanctuaries, and non-hunting areas.
- Wind shield areas.
- Area with significant research importance.
- Area with significant importance for environmental and ecological preservation.
- Areas within 20 metres of natural rivers or streams or within 70 metres of the sea coast.

In **economic zone A** only sustainable uses of mangrove trees are permitted. This includes:

- Concession areas.
- Community forests.
- Mangrove plantations.

Economic zone B consists of degraded mangrove areas in which other land uses and development are allowed, although the environmental implications of these uses must be considered. Such activities include:

- Agriculture (cash crops, husbandry, fisheries, salt farms).
- Industry (mining, factories).
- Urban areas.
- Trading and commercial areas.
- Piers and harbours.
- Other uses.

Policies on mangrove rehabilitation

In June 1991 the Thai Cabinet resolved to allocate a budget of approximately 450 million baht to rehabilitate 40,000 hectares of Thailand's mangrove forest area over the period 1992-1996. During this period 13,569 hectares of mangrove forest were successfully planted. Mangrove restoration activities have been largely concentrated on the direct planting of nursery grown or elongate propagules of *Rhizophora* species on unvegetated mudflats or degraded forest areas. The species most commonly planted are *Rhizophora apiculata* and *R. mucronata*, with some planting of species of *Ceriops* and *Bruguiera*. Mangroves are typically planted at higher levels within forests.

Coastal areas on the Gulf of Thailand which are suitable for mangrove planting consist of the landward strip behind tidal mudflat areas, degraded mangrove forest areas, and abandoned shrimp farms. Efforts to rehabilitate mangroves in Thailand have only been partially successful, with the exception of cases where a community management approach has been applied. This has largely been a result of centralised, top-down planning which has failed to recognise local environmental factors or practical issues at sites selected for replanting. Some of the causes of unsuccessful replanting schemes are inappropriate choice of species for planting, inappropriate choice of sites, use of unsuitable planting techniques, monoculture planting, and lack of maintenance and aftercare at replanting areas. Community based projects which recognise the rights of communities to use forest projects sustainably provide an important incentive for local people to become involved not just in replanting but also in maintenance and follow-up schemes.

Policies on education and training

One of the root causes of mangrove depletion and degradation in the Gulf of Thailand is a general lack of understanding at all levels in society about the importance of mangrove resources. Recognising this, the Thai government has started encouraging the public to participate in mangrove restoration programmes and has organised numerous seminars and prepared a wide range of articles, films, and educational materials to raise awareness about the value of mangroves. Policies for mangrove area protection and conservation and public awareness campaigns aim to present an overall positive picture regarding mangroves. In the long-term, it is hoped that such initiatives will contribute to the restoration and sustainable development of mangrove ecosystems.

Policies on mangrove research

Various agencies such as the National Research Council of Thailand, the National Environment Board, the Royal Forest Department, the Fisheries Department, and Thai universities receive support by the government to conduct research into mangrove ecosystems and management. A considerable number of international organisations, including CIDA, AIDAB, USAID, JSPA, RECOFTC, UNDP, UNESCO and FAO have sponsored research programmes on mangrove management and conservation. Information obtained from these research programmes has been instrumental in the formulation of the government policies outlined above.

5. ECONOMIC VALUATION OF MANGROVE FORESTS IN THE GULF OF THAILAND

The economic valuation of mangroves has been the subject of a number of studies. For mangrove forests in Thailand, Sathirathai (1998) has carried out a valuation study of mangroves in Surat Thani province on the Southern Thai peninsula, which estimated the total economic use value provided by mangroves to be in the range of 13,339 to 17,122 baht per rai per year (US$2,084 to 2,675 per hectare). Kantangkul (1997) has calculated the economic values of some aspects of mangrove use in Trang province on the Andaman sea coast.

5.1 Use Values

5.1.1 Direct Use Value

Direct use values of mangroves relate to the direct benefits that local communities derive from mangrove forests, for example through collection of timber and mangrove products, gathering of food, or recreational use. Kantangkul (1997) estimated the value of mangroves in supporting livelihoods of coastal dwellers as 1,710 baht per rai/year at 1990 prices (US$267 per hectare/year).

5.1.2 Indirect Use Value

Indirect use values of mangrove forests represent the indirect contribution mangroves make in support of a broader range of economically beneficial activities, including the provision of environmental services. Examples include the role mangroves play in supporting offshore fisheries, providing coastal protection and flood control, enhancing water quality, and contributing to carbon sequestration.

Offshore fisheries

The use value estimated for the role of mangroves in supporting offshore fisheries productivity has been estimated by Sathirathai (1998) as ranging from 33.5 baht to 187 baht per rai/year (US$5.2-29.2 per hectare/year). Kantangkul (1997) gave a higher figure for the fishery value of mangroves, estimating the value as 1,782 baht per rai/year at 1990 prices (US$278/hectare).

Coastal protection
The value of mangroves in acting as a wind break and contributing to erosion control has been estimated by Sathirathai (1998) by reviewing expenditure by the Thai Harbour Department in constructing replacement breakwaters in areas where mangroves have been destroyed. The estimated value provided by mangroves for this purpose was 12,444 baht per rai/year (US$1,944 per hectare/year).

Carbon sequestration
To estimate the monetary value of carbon sequestered by a mangrove forest, Sathirathai (1998) applied a price of 141.7 baht per tonne of carbon. This figure combined with an estimate of the amount of carbon sequestered by mangroves each year allows calculation of the indirect value provided by mangroves through carbon fixation as 342 baht per rai/year (US$53 per hectare/year).

Nutrient release
Kantangkul (1997) calculated the value of nutrient release from mangrove forests as 798 baht per rai/year (US$125 per hectare/year).

5.2 Non-use Values

Non-use values relate to the essential nature of a mangrove forest and the value that is placed on it for qualities such as its biodiversity, cultural and heritage importance, or social significance. The authors are not aware of any comprehensive studies which have been carried out to date reporting non-use values for mangrove forests in Thailand.

6. THREATS, PRESENT AND FUTURE

6.1 Threats

6.1.1 Human Pressure

The mangrove forests of the Gulf of Thailand have been degraded significantly over recent decades by a number of different human activities, with 86,000 hectares lost since 1975, representing more than 70% of the original area. As can be seen from Figure 3, the greatest degree of mangrove clearance occurred over the period 1979 - 1986, when 60,600 hectares (more than 50% of the original area) were cleared. Comparison of the degree of loss of mangrove areas across different provinces and regions shows that in some provinces, particularly provinces close to Bangkok and some of the Eastern provinces, the mangrove area was almost completely lost, while other provinces have managed to retain a large proportion of their original mangrove area (Figure 4).

Since 1991 the area of mangroves in the Gulf of Thailand has begun to increase as a result of restoration programmes in the Central region of the Gulf of Thailand, greater Government efforts to control mangrove clearance, and migration of shrimp farmers away from the Gulf of Thailand towards provinces on the Andaman sea coast.

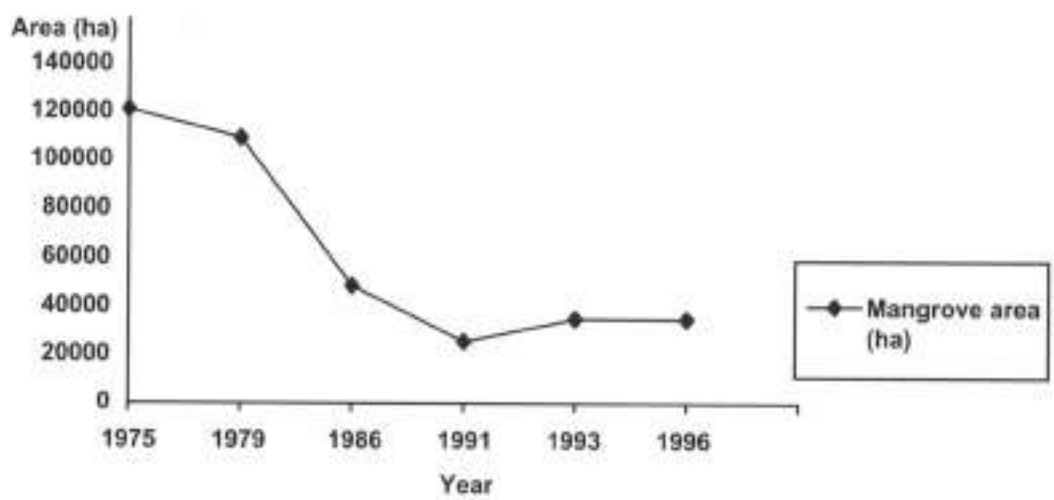


Figure 3 Change in Mangrove Areas in the Gulf of Thailand from 1975-1996.

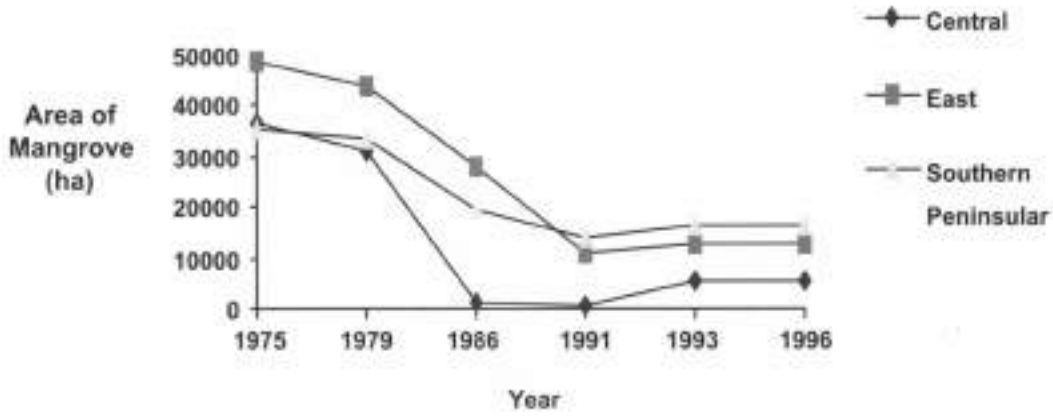


Figure 4 Change in Mangrove Areas around the Gulf of Thailand Coast from 1975-1996.

Activities which have resulted in the loss of mangroves include logging for the production of charcoal, the conversion of mangrove land to shrimp aquaculture ponds, agriculture, salt production, urban development, and industrial development. The proportion of the total mangrove area cleared for each of these activities is difficult to estimate, but a study by Charuppat and Charuppat (1997) gives an indication of the main activities that have led to significant loss of mangrove forest area in the Gulf of Thailand (Table 9). This chapter discusses the nature of each of these threats and the extent of mangroves lost through each activity.

Table 9 Land Uses in Areas which were originally Mangrove Areas in the Gulf of Thailand.

Land use type	Region			Total (ha)
	1. Central	2. Eastern	3. Southern Peninsula	
1. Mangrove	5449	12,658	16,570	34,677
2. Shrimp Farm	15,629	24,295	21,920	61,844
3. Urbanisation	3,100	4,957	1,001	9058
4. Others	42,803	13,935	16,957	73,695
Total	**66,981**	**55,845**	**56,448**	**179,274**

Source: Adapted from Charuppat and Charuppat, 1997.

6.1.1.1 Mangrove Forestry

One of the major causes of the degradation of mangroves along the Gulf of Thailand has been harvesting for the production of charcoal. In the past, up to ninety percent of the mangrove wood harvested in Thailand was used for charcoal production (Aksornkoae, 1993), an activity which continued from the 1960s until 2001 when the Thai government introduced new regulations revoking charcoal concessions. To support this industry, areas of mangrove were leased to concessionaires for fifteen year periods under the condition that concessionaires would rehabilitate the forest at their own expense following specified silviculture management practices. Significant problems arose as a result of poor practices by concession holders, who seldom operated according to the regulations or conditions of their concession and often carried out logging in areas outside the concession areas. As a result of this over-harvesting, former concession areas were often left in a degraded state, depleted of large trees and dominated by weed species (Tragulkumjai, 1993).

6.1.1.2 Conversion for Shrimp Farming

Significant areas of mangrove forest in the Gulf of Thailand have been lost as a result of conversion for shrimp aquaculture. Destruction is caused by clear cutting during preparation of land for shrimp farms, embankment construction, or from the modification of water flows which block saline and fresh water from reaching the mangrove forests (Aksornkoae, 1993).

Extensive culture of shrimp has been practiced for over 50 years in the Central Region provinces of Samut Songkhram, Samut Sakhon, and Samut Prakan, all close to Bangkok, while further loss of mangrove area in these provinces resulted from the adoption of semi-intensive and intensive farming techniques from the mid-1970s onwards (Jitsanguan *et al.*, 1993). A characteristic of the shrimp farming industry in the Gulf of Thailand has been its boom and bust nature and transience. In 1990, for example, shrimp farming in the Central Region suffered a crash in production caused by disease

and other production problems related to acid sulphate soils and water pollution, forcing migration of the industry from the Inner Gulf area to the Eastern provinces of Chonburi, Chantaburi and Trat and the Southern provinces of Nakhon Sri Thammarat, Surat Thani and Songkhla (Flegel, 1998; Funge-Smith, 1997). Likewise, disease and production problems in these newly established areas has subsequently resulted in further movement of the shrimp aquaculture industry from the Gulf of Thailand to the provinces bordering the Andaman Sea (Plathong and Sitthirach, 1998; Jitsanguan *et al.*, 1993). In the Gulf provinces where shrimp farming was formerly prevalent, large areas of land which was until recently covered by mangrove forests lie abandoned as wasteland.

Estimates of the area of mangroves in the Gulf of Thailand lost as a result of shrimp farming vary significantly. Studies for the whole of Thailand using satellite imaging (Landsat, TM5, 1:50,000) in 1993 concluded that only 17.25% of mangrove areas had been invaded for marine shrimp farming (Budget Bureau, 1990; Kongsangchai (1993); Charuppat and Ongsomwang (1995); Research Council of Thailand, 1995) while other studies (Platong, 1998) claim that a much greater area has been cleared for this activity. The controversy over the exact area of mangroves in the Gulf of Thailand that has been cleared for construction of shrimp ponds stems from the fact that in many cases shrimp farms were developed from areas already cleared for other purposes, e.g., salt farms and rice paddies.

A study by Charuppat and Ongsomwang (1995) has identified that large areas of shrimp farms still remain in the conservation and economic zone A areas despite the 1987 Cabinet resolution prohibiting shrimp farming in these zones (Table 10).

Table 10 Areas and Percentage of Total Numbers of Shrimp Farms Occupying Conservation and Economic Zone A Areas along the Gulf of Thailand Coast.

Region	Identifiable shrimp farms (ha) in conservation and economic zone A areas	Percentage of identifiable shrimp farms in zones where shrimp farming prohibited
Central	927	19
Eastern Coast	18,952	52
Southern Peninsula	3,882	15
Gulf of Thailand Total	23,761	37

Source: Charuppat and Ongsomwang, 1995.

6.1.1.3 Urbanisation and Coastal Development

Loss of mangrove forests in the Gulf of Thailand has resulted from urban expansion and infrastructure development including the construction of fishing ports, solid waste disposal schemes, industrial power plant development, road construction, and dredging. Human settlements in the mangrove areas of the Gulf of Thailand are widespread, covering many provinces but particularly prevalent in Chonburi, Rayong, and Surat Thani. Human habitation in these areas consists mainly of permanent fishery villages varying in size from a few houses built on platforms raised on stilts of mangrove wood to highly urbanised settlements and industrialised cities.

As well as urban development, mangrove areas in the Gulf of Thailand, by virtue of their strategic coastal location and general reputation as wasteland areas, have also been an easy target for satisfying the shortage of relatively cheap land for industrial estates and ports. The mangrove forests of provinces in the Central region such as Samut Prakan, Samut Songkhram, and Samut Sakhon, and the Eastern region provinces of Chacheongsao, Chonburi, and Rayong have been particularly impacted by industrial development. In Samut Prakan province, for example, mangrove land was claimed for the development of various industries such as textiles, chemicals and battery manufacturing. There are no appropriate waste treatment systems serving the industrial areas and waste is discharged directly into the mangroves, eventually discharging as a result of tidal action into the upper Gulf (Piyakarnchana, 1979).

Once such development centres have been constructed, migration of a large rural population soon follows, resulting in an acute shortage of houses and other urban amenities. This, in turn, creates additional pressure on the adjacent mangrove areas.

6.1.1.4 Agriculture

Some mangrove areas in the Gulf of Thailand have been converted for agricultural use, including the cultivation of coconuts, oil palms, and rice, although this is not a common practice because of the

presence of acidic soils which result in low productivity. No estimate of the total area of mangroves converted to agricultural land is available. In the provinces of Samut Songkhram and Samut Sakhon construction of salt pans has resulted in widespread mangrove destruction.

6.1.1.5 Major Infrastructure Projects

The Thai government and private developers are currently considering a number of major infrastructure development programmes which may have implications for coastal zones or river water quality. These include:

- Further expansion of the Eastern Seaboard industrial zone in the coastal area of Rayong province.
- Construction of a major North – South highway through the country.
- A coast-to-coast 'landbridge' across the Southern Thai peninsular.
- Schemes to divert water from the Mae Klong and Tha Chin catchment basins into the Chao Phraya basin to meet agricultural and urban needs in the Chao Phraya basin.

Thailand's Prime Minister has promised that no damage will be caused to mangrove areas as a result of such projects, but as yet no details have been provided as to how impacts will be avoided.

6.1.2 Natural Phenomena

As well as the impacts that humans have on mangrove forests in the Gulf of Thailand, these areas are also subject to impacts associated with natural phenomena such as cyclones and severe storms. In recent years, the provinces of Nakhon Sri Thammarat, Surat Thani and Chumporn have been hit by major tropical depressions resulting in significant damage to mangrove forests in these provinces. Deforestation in catchment areas has increased the risk of fluvial flooding in recent years, as well as contributing to higher rates of soil erosion and sedimentation.

Sea level rises caused by global climate change are predicted to have an impact on mangrove forests in the Gulf of Thailand in the future, pushing the inner and outer margins towards the land, and shifting mangroves inland. Most mangrove forests in Thailand are now bordered by developed land on their landward side, and so a rise in sea level will reduce or completely destroy many mangrove areas.

Severe coastal erosion occurs along major stretches of the coastline in the Inner Gulf of Thailand. Erosion is in some cases exacerbated by construction work on the shoreline. One of the areas where erosion is most serious is to the west of the Chao Phraya river mouth, where a length of over 30km of coastline and an area of 700 hectares of coastal land was lost as a result of erosion over the period 1967-1987, with a maximum eroded distance of 500m. Severe erosion has also been recorded at the area of Ban Bang Kaew in Petchaburi province, where over 135 hectares of land was lost to erosion with a maximum eroded distance of about 200 metres.

7. PRESENT AND FUTURE STATUS OF MANGROVE ACTION PLANNING

7.1 Present Situation

Thailand's policies on mangrove forests currently prioritise three main areas for action: rehabilitation, conservation and sustainable management. Policies on sustainable management emphasise non-timber productive uses and environmental protection. Wood from mangrove forests can only be used by communities, and not by industry as previously. In order to meet national objectives on mangroves, action is planned in the following areas:

Area 1: Conservation and Sustainable Management

1. Revision of classification of mangrove land use;
2. Assessment of existing silvicultural systems;
3. Assessment of mangrove rehabilitation in different areas: success and failure; and
4. Experimentation with eco-friendly management systems: mangrove conservation and aquaculture.

Area 2: Mangrove Information and Awareness

1. Gathering existing mangrove information and establish a database;
2. Review of research work for dissemination and application of knowledge to sustainable mangrove management; and
3. Establishment of a range of effective educational tools and programmes for public awareness campaigning on mangrove importance.

Area 3: Socio-Economic Aspects

1. Experimentation on community management of mangrove forests;
2. Assessment of local participation in conserving and utilising mangrove forest resources; and
3. Experimentation on mangrove plantation management.

Area 4: Mangrove Ecosystem Function and Health

1. Establishment of a demonstration site for mangrove biodiversity conservation; and
2. Establishment of demonstration sites to assess or monitor specific aspects of mangrove management, e.g., eco-tourism.

Area 5: Co-operation and Capacity Building

1. National training on strategies for conservation and sustainable management of mangrove ecosystems; and
2. Review of national co-operation on mangrove ecosystems.

Area 6: Policies and Legislation

1. Review of institutions, laws, and regulations related to conservation and management of mangrove ecosystems; and
2. Assessment of policies and political initiatives concerning conservation and sustainable management of mangrove ecosystems: success and failure.

7.2 Future Perspectives

It is envisioned that in future mangrove forests will be managed sustainably and utilised for the production of non-timber products, with environmental protection as a high priority. Only local communities will be permitted to use wood from mangrove forests. Community management of mangrove forests will be expanded, with increased participation of local people in decision-making and implementation of conservation and management initiatives. Mangrove rehabilitation programmes will be the highest priority for future action.

REFERENCES

Aksornkoae, S., and Euimnoh, 1988. Evaluation of Mangrove Development Potential of Phangnga and Ban Don Bays for Coastal Zone Management. Final report to ASEAS-US Cooperative Programme on Marine Science Coastal Resources Management Project.

Aksornkoae, S. 1975. Structure, Regeneration and Productivity of Mangroves in Thailand. Ph. D. Thesis Michigan State University, USA.

Aksornkoae, S. 1985. 'Traditional uses of the mangrove in Thailand'. In: 'Mangrove ecosystems of Asia and the Pacific', ed. C.D. Field and A.J. Dartnall. Proceedings of the Research for Development Seminar, Australian Committee for Mangrove Research, 18-25 May 1985, Townsville, Australia.

Aksornkoae, S. 1993. 'Ecology and Management of Mangroves'. The IUCN Wetlands Programme. IUCN Press, IUCN Southeast Asia Regional Office, AIT, Bangkok, Thailand.

Aksornkoae, S. 1995. 'Problems of Mangrove Degradation' in 'Ecology and Management of Mangrove Restoration and Regeneration in East and Southern Asia'. Proceedings of the UNESCO/MAB Ecotone IV Conference, 18-22 January 1995, Surat Thani, Thailand.

Bamroongrugsa, N. and Koaesrinaul, N. 1995. 'The utilisation of Nypa in Pak Pha Nang Basin, Nakorn Sri Thammarat province.' Paper presented at the Ninth National Seminar on Mangrove Ecology – Mangrove Conservation for Thai Society in the Next Decade, 6-9 September 1995, Phuket, Thailand. National Research Council of Thailand, Bangkok (in Thai).

Boonruang, P. 1985. Preliminary Study of Phytoplankton Composition in Phangnga Bay and the East Coast of Phuket Island. Paper presented at the Symposium on Fisheries, Department of

Fisheries, Bangkok, Thailand, September 1985 (in Thai)1985 [Page 15 – Phytoplankton] should be Boonruang?

Chaitiamvong, S. 1983. 'Shrimps in mangroves and adjacent areas.' Paper presented at the UNDP/UNESCO Regional Training Course 'Introduction to Mangrove Ecosystems'. National Research Council of Thailand, Bangkok, Thailand.

Chan, H.T. 1996. 'Mangrove restoration in Peninsular Malaysia: a case study of Matang'. In: Field, C. (ed), 'Restoration of Mangrove Ecosystems'. Publication of the International Society for Mangrove Ecosystems (ISME), Okinawa, Japan.

Charnsnoh, P. 1999. 'Promoting a productive coastal marine ecosystem through community management: Yadfon Association's experience in Trang, Thailand.' In: 'Enhancing Coastal Ecosystem Restoration for the 21st Century'. Proceedings of Regional Seminar for East and Southeast Asian Countries: Ecotone VIII. Ranong and Phuket provinces, Thailand, 23-28 May 1999. P. 236-240.

Charuppat, T. and Ongsomwang, S. 1995. 'Standard data and map of mangrove forests'. Paper presented at the Ninth National Seminar on Mangrove Ecology – Mangrove Conservation for Thai Society in the Next Decade, 6-9 September 1995, Phuket, Thailand. Part 2, Volume 10. National Research Council of Thailand, Bangkok (in Thai).

Charuppat, T. and Charuppat, J. 1997. 'Application of LANDSAT-5 (TM) for monitoring the changes of mangrove forest area in Thailand'. In: Proceedings of the Tenth Thai National Seminar on Mangrove Ecology, 25-28 August 1997, Had Yai, Thailand. Part 1 Volume 9. National Research Council of Thailand, Bangkok (in Thai).

Erftemeijer, P.L.A and Bualuang, A. 1998. 'Participation of local communities in mangrove forest rehabilitation in Pattani Bay, Thailand: Learning from successes and failures'. Paper presented at the 2nd International Conference on Wetlands and Development, Dakkar, Senegal, 8-14 November, 1998.

FAO, 1985. Mangrove Management in Thailand, Malaysia and Indonesia. FAO. Environment Paper No. 4. Rome.

Flegel, T.W. 1998. Virus Diseases in Asian Shrimp. In: Biotechnology in Shrimp Culture, Thailand, SCRD and FRC . (in press)

Funge-Smith, S. 1997. 'Thailand. World Shrimp Farming 1997.' In: Rosenberry, B., ed., Shrimp News International, 142-154.

Havanond, S. 1994. 'Charcoal production from mangroves in Thailand.' Paper presented at the Workshop on ITTO Project 'Development and Dissemination of Re-afforestation Techniques of Mangrove Forests'. Bangkok, 18-20 April 1994.

Isarankura, K. 1976. Status Report on Faunatistic Aspects of Mangrove Forest in Thailand. Paper presented at the First National Seminar on Mangrove Ecosystem held from 10-15 January 1976 at Phuket Marine Biological Centre, Thailand (in Thai).

Jitsanguan, T., Mungkin, N. and Claithong, W. 1993. 'Sustainable coastal resource management in Thailand: the case study of shrimp cultivation at Pak Panang Bay'. Research paper submitted to Asia Fisheries Social Science Research Network (AFSSRN), Thailand, 106 p.

Kantangkul, P. 1997. An Economic and Environmental Analysis at Southern Thailand's Coastal Resource Use: A Case Study of Unsustainable Shrimp Mariculture. Paper presented at 10th National Seminar on Mangrove Ecosystem. Had Yai, Songkhla Province, 25-28 August 1997.

Kongsangchai, J. 1993. 'Suitability and policy of mangroves'. Forestry Technology Office, Royal Forestry Department, Thailand. 24p.

Kongsangchai, J., and Prayoonsit. 1990. Vertebrate Species in the Mangrove Forests of Thailand (Excluding Fish). Royal Forest Department, Thailand. 37 p.

Marumo, R., S. Laoprasert and C. Kanjanagesorn. 1985. Plankton and Near Bottom (Communities fo the mangrove Regions in Ao Khung Kraben and the Chantaburi River, Final Report, NRCT, Bangkok.

Meteorological Department. 1987. Statistics on the Climate of Thailand in Period 30 year (1956-1985). Ministry of Communication. Bangkok, Thailand.

Nabhitabhata, J. 1982. Ecological Studies of Birds in Mangrove Forests, Songkhla Lake. Paper presented at the Fourth National Seminar on Mangrove Ecosystems held from 7-11 July 1982 at Surat Thani, Thailand (in Thai).

Naiyanetr, P. 1979. 'Fiddler crabs in Thailand'. In: 'Report of the Sixth National Seminar on Mangrove Ecosystems. National Research Council of Thailand, Bangkok. p. 263-271 (in Thai).

National Research Council and Royal Forest Department. 1985. Remote Sensing and Mangroves, Thailand. Progress reported submitted to International Development Research Centre, 60 Queen Street, P.O. Box 8500, Ohawa, Conada K 16 3 H 9. 89 p.

Paphavasit, N, C. Sudtongkong, and D.J. Macintosh. 1996. 'Mangrove macrofauna in different mangrove plantations at Klong Ngao mangrove forests, Ranong Province, Southern Thailand.' In: 'Tropical Forestry in the 21st Century'. Proceedings of the FORTROP'96 International Conference, 25-28 November 1996, Kasetsart University, Bangkok, Thailand. Volume 10: 'Mangrove Ecosystems' p. 104-117.

Paphavasit, N. 1995. 'Factors maintaining biodiversity of mangrove forest in Thailand.' In 'Ecology and Management of Mangrove Restoration and Regeneration in East and Southern Asia'. Proceedings of the UNESCO/MAB Ecotone IV Conference, 18-22 January 1995, Surat Thani, Thailand.

Paphavasit, N. 1999. 'Mangrove restoration and coastal fishery productivity: Thailand's experience'. In: 'Enhancing Coastal Ecosystem Restoration for the 21st Century'. Proceedings of Regional Seminar for East and Southeast Asian Countries: Ecotone VIII. Ranong and Phuket provinces, Thailand, 23-28 May 1999. p. 110-119.

Piyakarnchana, T. 1979. The Impacts from Development Activities in Mangrove Ecosystem. Paper presented at National Seminar on Mangrove Ecosystems held from April 8-12, 1976 at Prince Songkhla University, Had Yai, Thailand. (in Thai).

Piyakarnchana, T. 1998. Some ecological factors limiting the crab and gastropod mollusc population living on abandoned tin mines and mangrove reforestation soils. Proceedings of the Symposium on New Perspectives in Research and Management of Mangrove Ecosystems, Colombo, Sri Lanka. 105-120.

Plathong, J., and N. Sitthirach. 1998. 'Traditional and Current Uses of Mangrove Forests in Southern Thailand.' Wetlands International Thailand Project Publication No. 3, Had Yai, Thailand.

Platong, J. 1998. 'Status of Mangrove Forests in Southern Thailand.' Wetlands International Thailand Project Publication No. 5. Had Yai, Thailand.

Royal Forest Department, 1997. Forestry statistics of Thailand'. Natural Forest Analysis Section, Royal Forest Department, Bangkok, Thailand (in Thai).

Rungreungwudhikrai, E., and Tongdee, N. 1999. 'Community issues in mangrove aquaculture management and awareness building: lessons from the Ranong mangrove ecosystem, Thailand'. In: 'Enhancing Coastal Ecosystem Restoration for the 21st Century'. Proceedings of Regional Seminar for East and Southeast Asian Countries: Ecotone VIII. Ranong and Phuket provinces, Thailand, 23-28 May 1999. p. 315-319.

Santisuk, T. 1983. Taxonomy and Distribution of Terrestrial Tress and Shrubs in the Mangrove Formations in Thailand. Natural History Bulletin of the Siam Society, 31:1, p. 63-91.

Satirathai, S. 1998. Economic Valuation of Mangroves and the Roles of Local Communities in the Conservation of Natural Resources: Case Study of Surat Thani Southern Thailand. Economy and Environment Program for Southeast Asia Report Series. 51 p.

Singkran, N., and S. Sudara. 1999. 'Species composition of fish in mangrove canals as reflected from coastal land use at Trat Bay.' In: 'Enhancing Coastal Ecosystem Restoration for the 21st Century'. Proceedings of Regional Seminar for East and Southeast Asian Countries: Ecotone VIII. Ranong and Phuket provinces, Thailand, 23-28 May 1999. p. 133-139.

Suvapepun, S., P. Sribayatta, and V. Vichaengvorakul. 1979. 'Zooplankton in mangroves'. Technical Report No. 3/1979. Marine Fisheries Division, Department of Fisheries, Thailand (in Thai).

Suzuki, T., M. Nishihira, N. Paphavasit, S. Shikano, A. Piumsomboon, and E. Aumnuch. 1997a. 'Ecological distribution and community structure of benthic animals in Samut Songkhram mangrove swamps, Thailand'. In: 'Benthic Communities and Biodiversity in Thai Mangrove Swamps (ed. M. Nishihira). Biological Instituto, Tohoku University, Sendai. p 41-78.

Suzuki, T., S. Shikano, Y. Nakasone, N. Paphavasit, A. Piumsomboon, and M. Nishihira. 1997b. 'Effect of deforestation on the benthic communities in Samut Songkhram mangrove swamps, Thailand. In: 'Benthic Communities and Biodiversity in Thai Mangrove Swamps (ed. M. Nishihira). Biological Institute, Tohoku University, Sendai. p. 79-98.

Tragulkumjai, K. 1993. 'Comparison of mangrove management by government and local communities in Sikao, Trang province.' Masters thesis, Faculty of Environmental Management, Prince of Songkla University, Thailand (in Thai).

Vatanachai, S. 1979. Species and abundance of fish eggs and fish larvae of the mangrove swamp at Laem Pak Bia, Petchburi, 1978-1979. In: 'Report of the Third National Seminar on Mangrove.

United Nations Environment Programme

UNEP/GEF South China Sea Project

Global Environment Facility

NATIONAL REPORT

on

Mangroves in the South China Sea

VIET NAM

Mr. Vu Tan Phuong
Focal Point for Mangroves
Research Centre for Forest Ecology and Environment (RCFEE)
Dong Ngac, Tu Liem, Hanoi,
VIET NAM

Table of Contents

List of Tables and Figures

1. GEOGRAPHICAL DISTRIBUTION OF MANGROVE FOREST IN VIET NAM

1.1 Maps

The Forest Inventory and Planning Institute is a governmental agency responsible for monitoring and updating the forest resources inventory for Viet Nam. All maps relevant to forest state and distribution of forest types are also carried out by Forest Inventory and Planning Institute. The information and data sources for map production are based on satellite, arial photos and a network of stable sample plots. Every 5 to 10 years the process of surveying and updating the forest inventory is implemented nation wide.

The maps of current land use and land use planning were produced in 1997 by the Forest Inventory and Planning Institute for a number of provinces in the Mekong River Delta such as Tra Vinh, Soc Trang, Bac Lieu and Ca Mau provinces. These maps were produced at the scale of 1/100,000 based on SPOT photos taken in 1995 and topographical maps with scale of 1/100,000 and 1/50,000.

During the year 2000 the Forest Inventory and Planning Institute as part of the national forest inventory programme followed by decree No. 286/TTg dated 2nd May 1997 produced up-to-date mangrove state and distribution maps for 12 coastal provinces. Paper and GIS maps were produced for the following provinces Quang Ninh, Thai Binh, Nam Dinh, Hai Phong, Ninh Binh, Tien Giang, Long An, Kien Giang, Dong Thap, Ca Mau, Bac Lieu and Ben Tre provinces. All maps are digitised and produced at a original scale of 1/100,000.

1.2 Geographical Distribution of Mangrove Areas

1.2.1 Classification of Mangrove Areas

According to researches of Phan Nguyen Hong (1991, 1999) mangrove forest of Viet Nam is classified into 4 main regions and sub-divisions as follow:

Region I: North-East coastal area, from Ngoc cape to Do Son cape. In this area 3 sub-divisions of mangrove distribution are identified:

- **Sub-division 1:** From Mong Cai to Cua Ong
- **Sub-division 2:** From Cua Ong to Cua Luc
- **Sub-division 3:** From Cua Luc to Do Son cape

Region II: Coastal area of Red River Delta, from Lach Truong cape to Vung Tau cape. This area is divided into following sub-division:

- **Sub-division 1:** From Do Son cape to Van Uc estuary
- **Sub-division 2:** From Van Uc estuary to Lach Truong estuary

Region III: Central coastal area, from Lach Truong cape to Vung Tau cape. This area is divided into 3 sub-divisions as below:

- **Sub-division 1:** From Lach Truong cape to Ron cape
- **Sub-division 2:** From Ron cape to Hai Van pass
- **Sub-division 3:** From Hai Van pass to Vung Tau cape

Region IV: Coastal area of the South, from Vung Tau cape to Nai cape. In this area 4 sub-divisions for distribution of mangrove forest are identified as follow:

- **Sub-division 1:** From Vung Tau to estuary of Soai Rap River (Coast of South-East area)
- **Sub-division 2:** From Soai Rap estuary to My Thanh estuary (Coast of Mekong River Delta area)
- **Sub-division 3:** From My Thanh estuary to Bay Hap estuary (South-West area of Ca Mau Peninsular)
- **Sub-division 4:** From Bay Hap estuary to Nai cape (Coast of West area of Ca Mau Peninsular)

However as researches of Forest Science Institute of Viet Nam and Forest Inventory and Planning Institute on classification of distribution of mangrove forest have identified 6 geographical regions for mangrove distribution corresponding to guidelines on evaluation and inventory of forest resources that are North-East, Red River Delta, North Central, South Central, South East South and Mekong River Delta regions.

1.2.2 Geographical Distribution of Mangrove Areas

Viet Nam has a total inland natural area of 32,894,398ha, with a 3,260km length of coastline, starting from the North (Mong Cai of Quang Ninh province) from 22°5 North latitude, to the South (Ha Tien of Kien Giang province) to 8°33' North latitude. From 102°10' East Longitude to 109°26' East Longitude.

According to the national forest inventory results as of 31/12/1999, Viet Nam has a total forest area of 10,915,592ha, of which natural forest is 9,444,198ha and plantation forest is 1,471,394ha. Present forest cover is 33.2%.

Also according to the national forest inventory results conducted by the Forest Inventory and Planning Institute and Decision No. 03/2001 QD/TTg signed by the Prime Minister of the Government of Viet Nam on 5/1/2001 and promulgated in July 2001, then, the total mangrove area of Viet Nam as of 21/12/1999 is 156,608ha. Of which the natural mangrove area is 59,732ha accounting for 38.1% and mangrove plantation forest area is 96,876ha accounting for 61.95%.

Out of the total mangrove plantation forest area in Viet Nam, the *Rhizophora apiculata* plantation forest accounts for 80,000ha (accounting for 82.6%) and the remaining area of 16,876ha is plantation forest with species such as: *Kandelia obovata*, *Sonneratia coseolaris* and other mangrove species (accounting for 17.4%) (Forest Inventory and Planning Institute, 1995).

However, according to the data recorded by coastal provinces in December 2000, Viet Nam possess a total mangrove area of 155,290ha, a reduction of 1,318ha (0.84%) from the data issued in December 1999. Of the 155,290ha, natural mangrove covers only 32,402ha (accounting for 21%) whilst plantation mangrove area is 122.892ha, accounting for 79% (Forest Science Institute of Viet Nam, 2001).

The total coastal wetland area of Viet Nam in 1982 was 494,000ha (General Department of Land Management – frequently salted land). While in 2000, frequently salted land along the coastal area of Viet Nam remains at 446,991ha, a reduction of 47,009ha, due to a large salted area along the coastal line having been converted to brackish water shrimp farming areas.

At present, along coastal areas of Viet Nam where the development of blackish water shrimp farming is being promoted, in many localities of Viet Nam where salted water has been introduced into waterlogged rice fields for blackish water shrimp farming activities.

According to statistical data compiled by the coastal provinces and Ministry of Fisheries 1999-2000 as well as Forest Science Institute – 2000, If the coastal brackish water shrimp farming areas included into coastal wetland (Salic fluvisols) along the coast (permanently salted land affected by high-tidal inundation), then, total area will be 606,782ha (increased as compared with wetland area in 1982 is 11,2792ha), of which:

- 155,290ha are coastal mangrove area;
- 225,394ha are coastal wetland (Salic fluvisols) area without mangrove forest; and
- 226,075ha are coastal brackish water shrimp farming area with dykes and water gates.

The map shows the distribution of mangrove forest in the coastal areas in Viet Nam (Figure 1). The detailed data relevant to mangrove areas and distribution in coastal provinces and regions of Viet Nam is synthesised in Table 1.

Figure 1 Map of mangrove distribution in Viet Nam.

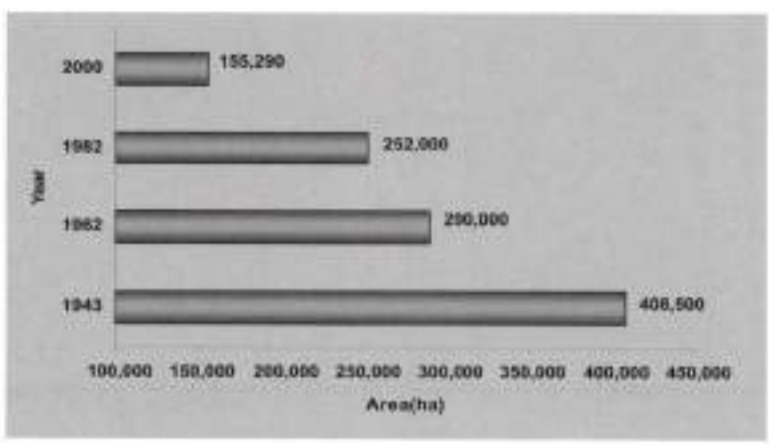
Table 1 Distribution of coastal wetland and mangrove areas by provinces and ties along the coastal zone of Viet Nam.

No.	Province	Area with mangrove forest		Area without mangrove forest		Brackish water shrimp farming area	
		Area (ha)	%	Area (ha)	%	Area (ha)	%
Total		**155,290**	**100**	**225,394**	**100**	**226,075**	**100**
1	Quang Ninh	22,969	14.8	27,194	12.1	14,837	6.6
2	Hai Phong	11,000	7.1	1,000	0.4	5,000	2.2
3	Thai Binh	6,297	4.0	14,526	6.4	2,852	1.3
4	Nam Dinh	3,012	1.9	6,031	2.7	5,800	2.6
5	Ninh Binh	533	0.3	1,084	0.5	200	0.1
6	Thanh Hoa	1,000	0.6	15,848	7.0	1,152	0.5
7	Nghe An	800	0.5	2,137	0.9	1,035	0.4
8	Ha Tinh	500	0.3	8,182	3.6	318	0.1
9 + 19	Remaining 10 provinces and cities in the Central part	700	0.4			12,368	5.5
20	Ba Ria – Vung Tau	1,500	1.0	34,360	15.2	1,240	0.5
21	Ho Chi Minh	24,592	15.8	3,180	1.4	2,228	1.0
22	Long An	400	0.2	300	0.1	1,050	0.5
23	Ben Tre	7,153	4.6	9,023	4.0	20,100	8.9
24	Tien Giang	560	0.4	120	0.05	2,148	0.9
25	Tra Vinh	8,582	5.5	22,007	9.8	8,481	3.7
26	Soc Trang	2,943	1.9	6,423	2.8	25,468	11.3
27	Bac Lieu	4,142	2.7	1,411	0.6	20,533	9.1
28	Ca Mau	58,285	37.5	71,718	31.8	92,000	40.7
29	Kien Giang	322	0.2	850	0.4	9,265	4.1

Source: Ministry of Agriculture and Rural Development, 2001.

1.3 Change in Mangrove Areas

The mangrove area of Viet Nam is recorded in 1943, 1962, 1982 and 2000. During the past 57 years, the mangrove area of Viet Nam has reduced 253,210ha accounting for 61% of mangrove area in 1943 (Figure 2). The latest data in the year of 2000 shows that the existing mangrove area of Viet Nam is about 38% compared to mangrove area in 1943. The deforestation of mangrove forest in Viet Nam is very high. From the recorded data it can be said that average loss of mangrove area during past 57 years is about 4,400ha per year. The chart below shows the changes in mangrove area of Viet Nam.



Source: Forest Inventory and Planning Institute, 1995; Forest Science Institute of Viet Nam, 2001.

Figure 2 Chart of changes in mangrove area of Viet Nam, 1943-2000.

2. SPECIES DISTRIBUTION AND FORMATION

2.1 Species Distribution

In a study conducted by Phan Nguyen Hong (1999) on mangrove ecosystems of Viet Nam, 109 mangrove species have been identified belonging to 2 groups:

- "True" mangrove species group: This group has 37 mangrove species belonging to 20 genuses of 14 families (in 1999, one species added).
- "Associate" mangrove tree group: This group has 72 species, belonging to 36 genuses of 28 families.

Out of 77 mangrove tree species, "True" mangrove species with wooded stems belonging to *Rhizophoraceae*, including 4 genuses: *Rhizophora, Buguiera, Ceriops and Kandelia.*

For Rhizophora genera, there are 6 tree species in the world, of which 3 species have been found in Viet Nam:

- *Rhizophora apiculata* Bl is widely and naturally distributed in the Southern part, scattered in south central region, but not naturally distributed in the Northern part of the Central Region, Red River Delta and North Eastern Part of Viet Nam. *Rhizophora apiculata* plays a very important economic and environmental role along the coastal area of the Southern Deltas. Out of the total mangrove plantation forest area of 96,876ha presently in Viet Nam, then, *Rhizophora apiculata* plantation forest occupies 80,000ha (82.6%).
- *Rhizophora mucronata* Poir in Lamk only distributed on a limited and scattered area in South of Viet Nam and not naturally distributed in the North (from 16° North Latitude to 22°30 North Latitude).
- *Rhizophora stylosa* Griff most commonly distributed in the North of Viet Nam, but not naturally distributed or if yes, individual trees are very rarely seen.

For genus of *Bruguiera,* out of 6 species of *Bruguiera* found in the world, 4 species existed in Viet Nam including *Bruguiera gymnorrhiza* (Lam) distributed widely from the North to the South. There are 3 species of *Bruguiera* genera include:

- *Bruguiera cylindrica* (L)
- *Bruguiera sexangula* (Lour) Poir in lamk
- *Bruguiera parviflora* (Roxb) W. and Am. ex Griff

These three species of *Bruguiera* are rather commonly distributed in South of Viet Nam, especially along the coastal areas of Ca Mau Peninsular (Mekong River Delta) but not naturally distributed in the North of Viet Nam.

For genera of *Ceriops,* 3 *species* have been found in the world, of which 2 species are present in Viet Nam and include:

- *Ceriops decandra* (Griff)
- *Ceriops tagal* (Pers) C.B.Rob. Ding Hou

These species are naturally distributed in a large area along the coastal area of the Delta in the South and are naturally scattered in the Central Southern part of Viet Nam and not found naturally distributed in the North of Viet Nam.

For *Kandelia* genera, there is only one species *of Kandelia,* i.e., *Kandelia obovata* (L) Druce. This species is very commonly and widely distributed in the North of Viet Nam, especially in the North.

The Eastern part of Viet Nam and the Northern Delta, but vary rarely distributed naturally in the coastal area of the Southern Delta.

For *Avicenniaceae,* there is only one genus of *Avicennia* distributed worldwide, consisting of 8 species of *Avicennia,* of which 4 species are found in mangrove ecosystems of Viet Nam. They play a crucial role in mangrove ecosystems of Viet Nam after *Rhizophoraceae.* There are 2 species of *Avicennia* which play an important role in sea encroachment, fixing newly built up mud flats along the coastal area, where deeply inundated with tide and with low tide, i.e.:

- *Avicennia marina* (Forsk) Vierh in the North
- *Avicennia abba* Bl extensively distributed in the South and in some places where *Avicennia marina* exists. This species also contributes to fixation of alluvial sediment and is deeply inundated during low tide, on the accumulated soil mixed with clay mud.

Besides the two above-mentioned species, there existed species of *Avicennia lanata* Ridl distributed scatteredly from the South to the North, but not creating into a clear population or association in which *Avicennia lanata Ridl* dominated.

Lastly is *Avicennia officinalis* L. This species is most commonly distributed along the southern coastal regions in Viet Nam, especially along the Ca Mau Peninsular. In addition *A. officinalis* L has a limited and scattered distribution within the southern part of the central region. This species is not naturally distributed in the North of Viet Nam.

Sonneratiaceae has one genera of *Sonneratia*. There are 6 different genus of *Sonneratia* in the world, while 3 of them are present in Viet Nam including:

Sonneratia caseolaris O.K Niedenzu. This species is rather common and widely distributed in the South, North and Central regions. It grows in bed of alluvial sediment in the estuaries, rich in mud and clay. This species prefers condition of low salinity, i.e. brackish water whereby the salt level does not more exceed 20% and survive in conditions where there is a large annual water salinity variation. For example salinity in rainy seasons below 5% and dry seasons up to 20%.

Sonneratia alba J.Sm in Rees is naturally distributed in the coastal area of the South and South of the Central region, deposited *alluvial* bed consisting of rich mud and clay within the estuaries. Water salinity in these locations has been found to be higher as compared with the distribution of *Sonneratia caseolaris* (salinity from 7-27%).

Sonneratia ovata Backer or Sonneratia acida has a natural distribution scattered along the coastal areas of the Southern Delta and it is not distributed naturally in the central and the Northern regions. *Myrsinaceae* with genera of *Aegiceras*, of which there are two species of *Aegiceras*:

- *Aegiceras comiculation (L)* Bleo is wooded tree in shrub form, usually not exceeding 3m high. This species is naturally distributed throughout the North of Viet Nam, especially in the North East of Viet Nam and in the coastal area of the Red River Delta. According to Le Cong Khanh (Ministry of Forestry, 1965) *Aegiceras comiculation* accounts for 54% of the total coastal mangrove area in the North while in the South it only occupies 2.5% of the total regional mangrove area.
- *Aegiceras floridum* Roem. et. Schult has highly restrictly natural distribution within Viet Nam. Recently (1993) Phan Nguyen Hong found a population growing within gravel and sand at Con Dao in South of Viet Nam.

Finally, there are two genera of mangrove trees belonging to *Palmeae* or *Arecaceae*, consisting of 2 genera. Of which *Nypa* genus has only two species in the world that are Wurmb and *Phoenix paludosa*. These two species are also naturally distributed in Viet Nam and have a variety of economic activities: leaves for house roofing, coconut fruit, and milk for drinking or its liquid for alcohol production. In addition these species are highly effective at soil erosion and protecting river banks and canals.

The distribution of *Nypa fruticans* is concentrated mainly in the Southern Delta with scattered populations along the southern part of the central region. *N. fruiticans* is not naturally distributed in the North of Viet Nam. Details of distribution of "True" mangrove species are shown in Table 2.

Table 2 Distribution of "True" Mangroves by Regions.

No.	True mangroves species	Northern Region		Central Region		Southern Region	
	Scientific name Family *Species*	Zone I North East	Zone II Northern Delta	Zone III North Central	Zone IV South Central	Zone V East South	Zone VI Mekong River Delta
Total "True" Mangrove species		**16**	**14**	**18**	**23**	**32**	**33**
	Sonneratiaceae						
1	*Sonneratia alba* J. Sm in Rees	0	0	0	x	x x	x x
2	*S. caseolaris* O.K. Niedenzu	x	x x x	x x	x x	x x	x x x
3	*S. ovata* Backer	0	0	0	0	X	x
	Avicenniaceae						
4	*Avicennia alba* Bl.	0	0	0	x	x x	x x x
5	*A. officinalis* L.	0	0	0	x	x x	x x x
6	*A. marina* (Forsk.) Vierh	x x x	0	x x	x	X	x
7	*A. lanata* Ridl	0	X	x	x	X	x
	Rhizophoraceae						
8	*Rhizophora apiculata* Bl.	0	0	0	x	x x	x x x

Table 2 *cont.* Distribution of "True" Mangroves by Regions.

No.	True mangroves species Scientific name Family *Species*	Northern Region		Central Region		Southern Region	
		Zone I North East	Zone II Northern Delta	Zone III North Central	Zone IV South Central	Zone V East South	Zone VI Mekong River Delta
9	*R. mucronata* Poir. In Lamk	0	0	0	x	X	x
10	*R. stylosa* Griff	x x x	0	x x	0	X	0
11	*Bruguiera gymnorrhiza* Lam.	x x x	0	x	x	X	x x
12	*B. parviflora* (Roxb) W. and Arn. Ex Griff	0	0	0	0	X	x x
13	*B. cylindrica* (L.) Bl.	0	0	0	0	X	x
14	*B. sexangula* (Lour.) Poir. in Lamk						
15	*Ceriops decandra* (Griff.)	0	0	0	x	X	x x
16	*C. tagal* (Pers) C.B Rob. Ding Hou	0	0	0	0	x	x x
17	*Kandelia obovata* Sheue, Liu and Yong	x x x	x x x	x x x	x	0	x
18	*Kandelia candel* (L.) Druce	0	0	0	x	x	x
	Myrsinaceae						
19	*Aegiceras corniculatum* L. Blco	x x x	x x x	x x	x	X	x
20	*A. floridum* Roem.et.Schult	0	0	0	0	0	x
	Combretaceae						
21	*Lumnitzera littorea* (Jack.) Voigt.	0	0	0	0	X	x
22	*L. racemosa* Willd	x x	X	x	x	X	x
23	*L. rosea*	0	0	x	0	0	0
	Euphorbiaceae	TG					
24	*Excoecaria agallocha* L.	x x	x x x	x x	x x	x x	x x x
	Meliaceae						
25	*Xylocarpus granatum* Koenig	x	X	x	x	X	x x
26	*X. mekongensis* (Lam) Pierre	0	0	0	0	X	x
27	*X. moluccensis* (Lamk) Roem	0	0	0	0	X	x
	Arecaceae/Palmeae						
28	*Nypa fruticans* Wurmb.	0	0	0	x	x x x	x x x
29	*Phoenix paludosa* Roxb.	0	0	0	x	x x	x x x
	Acanthaceae						
30	*Acanthus ilicifolius* L.	x x x	x x x	x x	x x	x x x	x x x
31	*A. ebracteatus* Vahl.	x x	x x	x x	x x	x x x	x x
	Sterculiaceae						
32	*Heritiera littoralis* Dry and Exh. Ait	x	X	x	x	X	x
	Rubiaceae						
33	*Scyphiphora hydrophyllacea* Gaertn	x x	X	x	x	X	x
	Aizoaceae						
34	*Seasuvium portulacastrum* L.	x	X	x	x	X	x
	Araceae						
35	*Cryptocoryne ciliata* (Roxb.) Scott	0	0	0	0	X	x
	Pteridaceae						
36	*Acrostichum aureum* L.	xxx	Xx	x	xx	Xx	xxx
37	*Acrostichum speciosum*	x	X	x	x	X	x

Source: Phan Nguyen Hong, 1999; Dang Trung Tan, 2001.
Remarks: 0: Not distributed; x: Distributed; xx: Widely distributed; xxx: Very widely distributed.

However it must be noted that the experts of UNEP/GEF of project *"Reversing Environmental Degradation Trends in the South China Sea and Gulf of Thailand"* supposed that *Xylocarpus mekongensis* was named as *Xylocarpus rumphii* (Kostel) Mabb and was considered as associate species.

There are also 2 opinions for *Dolichandrone spathacea* (L.f) K. Schum belongs to *Bignoniacea*. According to Phan Nguyen Hong (1999) this species is considered as true mangrove species. But this species is considered as associate mangrove species.

For *Cynometa ramiflora*, Dang Trung Tan (2001) considered as true mangrove species, but in the second meeting of regional working group on mangroves has agreed that this species is associate species, therefore *Cynometa ramiflora* is put into associate species. *Acrostichum speciosum* is amended to list of true mangrove species in Viet Nam as research results of Dang Trung Tan (2001).

In addition, according to Phan Nguyen Hong *Kandelia obovata* Sheue, Liu and Yong, Gn has been found recently in North Central region. As this consequence the total true mangrove species will be 37.

In 1993, Phan Nguyen Hong has made in public a list of "Associate" mangrove species that includes 42 species belonging to 28 families but in recent years, the author and some botanists have added plant species involving in mangrove forest up to 70 species belonging to 32 families (Phan Nguyen Hong, 1999).

It has been identified that the development of a set of standard criteria for the addition of new "Associate" mangrove species should be explored further. Table 3 below shows the list of "Associate" mangrove species, in which 2 new species are added to.

Table 3 List of "Associate" Mangrove Species and Distribution by Regions.

No.	Scientific name family species	Distribution area		
		Northern region	Central region	Southern region
Total "Associate" mangrove species		**36**	**41**	**68**
	Amaryllidaceae			
1	*Crinum asiaticum* L.	xx	x	x
	Annonaceae			
2	*Annona glabra* L.	xx	x	xx
	Apocynaceae			
3	*Cerbera manghas* L.	x	x	xx
4	*C. odollam* Gaertn.	x	x	xx
	Araceae			
5	*Aglaodora griffithii* (Schott) Schott	0	0	x
6	*Lasia spinosa* (L.) Thu.	x	0	x
	Asclepiadaceae			
7	*Gymnanthera nitida* Wall.	0	0	xx
8	*Finlaysonia obovata* R. Br	0	0	xx
9	*Sarcobolus globosus* Wall.	0	x	xx
	Asteraceae			
10	*Pluchea indica* (L.) Less	xxx	xxx	xxx
11	*P. pteropoda* Hemsl	x	x	x
12	*Wedelia biflora* (L.) DC	xxx	xxx	xxx
13	*Tridax procumbens* L.	0	0	x
	Boraginaceae			
14	*Cordia cochinchinensis* Gaertn	0	0	x
	Bignoniacea			
15	*Dolichandrone spathacea*	x	x	xx
	Ceasalpiniacea			
16	*Cynometra ramiflora*	0	0	x
	Chenopodiaceae			
17	*Suaeda maritima*	xxx	xxx	xxx
	Combretaceae			
18	*Combretum quadrangulare* Kurz	x	x	xx
19	*Terminalia catappa* L.	x	x	xx
	Convalvulaceae			
20	*Ipomea pes -caprae* (L.) Sw subsp. Brasiliense (L.) Ooststr.	xxx	xxx	xxx
	Cyperaceae			
21	*Cyperus elatus* L.	0	0	x
22	*C. malaccensis* Lam.	xxx	xxx	xx
23	*C. stoloniferus* Vahl.	xx	xx	x
24	*C. tageliformis* Roxb	x	x	x
25	*Fimbrystylis ferruginea* (L.) Vahl.	0	x	x
26	*F. littoralis*	0	0	x
27	*F. miliacea* Vahl.	xxx	0	0
28	*Scirpus kimsonensis* K. Khoi	x	0	0
	Euphorbiaceae			
29	*Glochidion littorale* Bl.	x	x	x
	Flacourtiaceae			
30	*Scolopia macrophylla* (W.et.A.) Clos.	0	0	x
	Flagellariaceae			
31	*Flagellaria indica* L.	xx	xx	xxx
	Goodenicaeae			
32	*Scaevola taccada* (Gaertn.) Roxb	xx	x	xx

Table 3 *cont.* List of "Associate" Mangrove Species and Distribution by Regions.

No.	Scientific name family species	Distribution area		
		Northern region	Central region	Southern region
33	*S. hainanense* Hance	x	0	0
	Guttiferae			
34	Calophyllum inophyllum L.	0	0	x
	Lauraceae			
35	*Cassytha filiformis* L.	xx	x	x
	Lecythidaceae			
36	*Barringtonia acutangula* (L.) Gaertn.	0	0	x
37	*B. asiatica* (L.) Kurz.	0	0	x
38	*B. macrostachya* (Jack.) Kurz.	0	0	x
39	*B. racemosa* (L.) Spreng.	0	0	x
	Leguminosae			
40	*Caesalpinia bonduc* (L.) Roxb.	xx	x	xx
41	*Instsia bijuga* (Colebl.) O. Ktze	0	0	x
42	*Canavalia cathartica* Du Petit. Thouars	xx	x	x
43	*Dalbergia candenatensis* (Dennst) Prain.	x	x	x
44	*Derris trifoliata* Lour.	xxx	xx	xxx
45	*Derris heptaphylla* (L.) Merr	0	x	x
46	*Pongamia pinnata* (L.) Pierre	xx	x	x
47	*Canavalia lineata* (Thunb.) A.P. de Cand	x	x	x
48	*Canavalia maritima* (Aubl.) Piper	xx	x	xx
	Loranthaceae			
49	*Dendrophtoe pentandra* (L.) Miq.	0	x	x
50	*Viscum orientale* Willd	0	x	x
	Malvaceae			
51	*Hibiscus tiliaceus* L.	xxx	xx	xxx
52	*Thespesia populnea* (L.) Soland.ex. Correa	xx	x	xx
	Myoporaceae			
53	*Myoporum bontioides* A. Grey.	x	0	0
	Myrtaceae			
54	*Eugenia jambolana*	0	0	x
55	*Melaleuca cajuputi* Powell	0	x	x
	Pandanaceae			
56	*Pandanus odoratissimus* L.	xx	xx	xx
	Poaceae/Gramineae			
57	*Cynodon dactylon* L.	xxx	x	xx
58	*Leptochloe fusca* (L.) Kunth	x	x	x
59	*Paspalum vaginicum* Swort	xx	x	x
60	*Phramites vallatoria* (L.) Vedk.	x	x	x
61	*Sporobolus virginicus* (L.) Kunth	xxx	xx	xxx
	Rubiaceae			
62	*Guettarda speciosa* L.	0	0	x
63	*Gardenia lucida* Roxb.	0	x	x
64	*Psychotria serpens* L.	0	x	x
	Rutaceae			
65	*Limnocitrus littorale* (Miq.) Sw.	0	0	x
66	*Acronychia pedunculata* (L.) Miq.	0	0	x
	Salvadoraceae			
67	*Azima sarmentosa* (Bl.) Benth. & Hook.	0	0	x
	Sterculiaceae			
68	*Kleinhovia hospita* L.	0	0	x
	Styracaceae			
69	*Styrax agrestis* (Lour.) G. Don.	0	0	x
	Verbenaceae			
70	*Clerodendron inerme* (L.) Gaertn.	xxx	xxx	xxx
71	*Premma integrifolia* L.	xx	xx	xx
	Xyridaceae			
72	*Cayratia trifolia* (L.) Domino	0	x	xx

Source: Phan Nguyen Hong, 1991; Phan Nguyen Hong, 1999; Dang Trung Tan, 1998 and 2001.
Remark: 0: Not distributed; x: Distributed; xx: Widely distributed; xxx: Very widely distributed.

Research results show that in the North of Viet Nam, there are 17 species of "True" mangrove tree species out of total 36 "True" mangrove tree species in Viet Nam representing 47% of total "True" species. While in the South, there are 33 "True" mangrove tree species out of 36 "True" mangrove tree species in Viet Nam estimating at 92% of total "True" species in Viet Nam.

In the North Eastern coastal area (Quang Ninh province) there are 16 species over 36 species of "True" mangrove species, accounting for 41.6%, including commonly and very commonly wooded stem species with important economic value in the region and country such as *Rhizophora stylosa, Bruguiera gymnorrhiza, Kandelia candel.* In addition, also there are *Aegicennia marina and Aegiceras comiculatum.*

In the coastal area of the Northern Delta there are 14 "True" mangrove tree species out of 36 in total, representing 36% of total true species, of which there exist wooded stem species which are widely distributed and of importance in the region and the whole country, i.e.: *Sonneratia caseolaris, Kandelia candel.* Besides, there is *Aegiceras comiculatum.*

In the coastal area of the Northern part of the Central region there are 18 "True" mangrove tree species out of total 36 species, accounting for 47% of total species, but distributed scatteredly into small and narrow areas, along river sides, streams, channels along coastal area.

In central South Coastal Region there are 23 "True" mangrove tree species out of total 36 species, occupying 61% of total species. Although more species are found than three above-mentioned regions, but scarily distributed in small and narrow areas, along rivers or streams, canals inside.

seashores. Here, in some places, the rainfall is very low, less than 1,000mm/year, unsuitable for distribution and growth of "True" mangrove tree species (Ninh Thuan and Binh Thuan provinces).

In the coastal area of Ba Ria – Vung Tau (belonging to the Eastern part of the South), due to favourable climatic conditions, without winter and alluvial grounds are rather large, therefore, number of "True" mangrove tree species increases considerably up to 32 species out of 36 species in total, representing 86%, of which there are wooded stem tree species of large diameter which are of value for the region and the whole country, i.e., *Rhizophora apiculata, Sonneratia caseolaris, Avicennia alba, Avicennia officinalis* and *Nypa fruticans* .

Attention should be finally given to the coastal area of the Mekong River Delta where existed the largest mangrove land area of Viet Nam, about 373,305ha, accounting for 61,5% of the total mangrove land area of Viet Nam with total 82,387ha of existing mangrove area, estimating at 53% of the total mangrove area in Viet Nam. The climate is warm all year round, no winter, relatively high rainfall ranging from 1,500mm to 2,500mm/year, with large alluvial grounds and fertile accumulated alluvium. Here, it is found that number of "True" mangrove tree species is 33 species, representing nearly 89% of total "True" mangrove tree species of the country. Of which there are wooded stem tree species, commonly and very commonly distributed, playing an important role in terms of economy and environment in the Region, such as *Rhizophora apiculata, Sonneratia caseolaris, Avicennia alba, Avicennia officinalis, Avicennia alba, Bruguiera gymnorrhiza, Bruguiera parviflora, Ceriops tagal, Ceriops decanda, Nypa fruticans, etc.*

Regarding respectively to "Associate" mangrove species in Viet Nam up to 72 species belonging to 34 families are found. Their distribution becomes richer and diversified from the North to the South, i.e.:

- In the Northern region there are 36 species out of 72 species, accounting for 50%;
- In the Central region there are 41 species out of 72 species, accounting for 56%; and
- In the Southern region there are 68 species out of 72 species, accounting for 94%.

2.2 Formation

In Viet Nam, Phan Nguyen Hong was recognised as the first person to conduct research on formations of mangrove communities and his research studies were published in 1970, 1975, 1991 and 1996. Within Viet Nam there is a rich diversity of mangrove communities, of which there are 45 identified communities and 6 distinctive populations. Their regional distributions follow:

2.2.1 North East Coastal Region (Quang Ninh Province)

The main mangrove communities include:

- *Avicennia marina* community – pioneer, fixed alluvial flats, deeply inundated when high tide appears, rich in sand grain, together with grasses of *Cynodon deotylon and Suaeda maritima.*
- *Aegiceras corniculatum* Community – mixed with other species like *A. marina* and *Cyperus stoloniferus.*
- *Bruguiera gymnorrhiza* community – dominated by *Bruguiera gymnorrhiza* mixing with other species i.e., *Rhizophora stylosa, Kandelia candel* and *Aegiceras corniculatum.* They all grow on the tidally flooded areas when high or medium tides occur.
- Mixed community – codominated species including *Rhizophora sylosa, Kandelia candel, Bruguiera gymnorrhiza*, combined with *Aegiceras corniculatum.* These species naturally distributed on inundated tidal areas when the tide is at medium level.
- *Excoecaria agallocha* community, *Lumnitzera racemosa* and dominant *Xylocarpus grasatum*, combined with *Scyphiphora hydrophyllacea, Ilenitiera littoralis and Hibiscus tiliaceus, Scaevola taccada, Cebera odolans, Clerodendrom inerm* developed on inundated alluvial areas when the tidal is high and extremely high within the year, on relatively well developed or fully developed land.

In addition to the above-mentioned naturally distributed mangrove communities, a number of man-made communities have been established during recent years along the coastal area of Viet Nam that include *Kandelia candel* and *Bruguiera gymnorrhiza* plantation forest.

2.2.2 Coastal Area of the Northern Delta (Red River Delta)

Main mangrove tree communities include:

- *Sonneratia caseslaris* Community – dominated in high layer combining with *Acanthus* sp., *Cyperus malaensis and Aegiceras corniculatum* at lower layer. These species distributed on rich mud and clay alluvial flats, deeply inundated with high tides raised at estuaries.
- Shrubs community – *Aegiceras corniculatum* developed and distributed on alluvial flats rich in sand and mud.
- From estuary of Van Uc (Hai Phong) along the southern coastal line where existed a lot of tidal mud flats flooded when tide rises, only salt-resisted grasses such as *Cyperus stoloniferus, Cyperus deotylon* and *Scirpus kimsonensis* grow naturally and well develop attracting many species of water.
- Birds like gooses, wild duck, spoon-beaked storks visiting this area for food such as in nature reserves of Giao Thuy (Nam Dinh province) and Kim Son (Ninh Binh province).

In addition to the above-mentioned naturally distributed mangrove tree communities, in recent years, in the coastal area of the Northern part of Viet Nam, efforts have been made to establish mangrove forest in order to protect and prevent from salt water along the coastal area; fix alluvial plains and encroach further to the South China Sea, i.e.: Man-made *Kandelia candel* community; Man-made *Sonneratia caseolaris* community; Man-made *Sonneratia caseolaris* community in high layer and *Kandelia candel* community in low layer.

2.2.3 Coastal Area of the Central North Region

This region is still affected by the North East monsoon, which carries cold wind from the North. Along the coastal area where sand dunes are found without mangrove forest distributed. Inundated communities in the region are only developed along the river banks, near estuaries or inland canals, streams near the seashores.

Avicennia marina Community combined with salt-resisted grasses like *Cyperus stoloniferus, Cynodon deotylon* and distributed naturally on deeply flooded alluvial plains when high tides, along both river banks near estuaries. This is a permanent and pioneer mangrove tree community on the alluvial plains with rich sand grains mixed with mud and sand.

Rhizophora stylosa and *Kandelia candel* codominant community and mixed with some species of *Bruguiera gymnorrihiza and Aegiceras corniculatum on* alluvial plains flooded by medium tides.

Aegiceras corniculatum dominant community developed on alluvial plains flooded by medium tides.

Aegiceras corniculatum dominated community mixed with some *Bruguiera gymnorrhiza and Avicennia marina* distributed on flooded alluvial plains when high tides occur and with less flat topography.

Rhizophora stylosa community distributed on alluvial plains along streams, canals, far from river mouths, inundated when medium tides take place, and salinity is rather high, less changes in the year (10-25%) along the coastal area of Quynh Luu district of Nghe An province).

Sonneratia caseolaris community occupies dominantly on high tree layer while at low layer *Acanthus* sp. *and Cyperus malaensis* are seen. Community of *Sonneratia Caseolaris* is in most cases distributed naturally on alluvial plains, flooded blackish water, near estuaries, even going further to mainland up to 30-40km.

2.2.4 Central South Coastal Region

This region extends from the South direction of Hai Van pass up to Ba Ria – Vung Tau belonging to South of Viet Nam.

This region almost has no winter season, the climate is warm all year round, therefore, number of mangrove plant species is more abundant than other regions except 2 provinces of Ninh Thuan and Binh Thuan, and where rainfall is too low, less than 1,200mm, unsuitable for distribution of many mangrove tree species, in the coastal of the Central Southern Part, main communities of mangrove species are as follows:

- Population of *Rhizophora mucronata* is a pioneer population with fixed alluvial plains, deeply flooded when high tides and situated in the West of some islands.
- Community of *Rhizophora mucronata and R. apiculata* is dominant, combined with other species like *Bruguiera gymnorrhiza, Bruguiera parviflora and Xylocarpus granatum,* distributed on alluvial areas along the rivers, canals, streams, pretty steep and not flat topography.
- Community of *Avicennia lanata* and *Avicennia officinalis* developed dominantly mixed with some secondary species like *Scyphiphora hydrophyllaceae, Lumnitzera littoralis, and Ceriops decandra* on alluvial plains flooded when high tides arrive.
- Community of *Excoecaria agollocha, Xylocarpus* sp. and *Hibiscus tiliaceus, Cerbera manghas* mixed with *Scaevola taccada, Heritiera littorallis* and *Phoenis paludosa,* distributed on alluvial plains to be only inundated by high tides and irregularly high tides in the year.
- Community of *Sonneratia caseolaris* occupies dominantly on high tree layer mixed with *Acanthus* sp. *and Cyperus malaensis, Derris trifoliata, Flagellaria indica* on lower layer.

2.2.5 The Coastal Area of Ba Ria – Vung Tau – Ho Chi Minh City

This area has been built up by sediments of the system of Dong Nai and Sai Gon rivers, with fairly large alluvial flats, alluvium with rich mud and clay, warm climate all year round, no winter season, no typhoons, rather favourable for mangrove trees growing. In this area, the mangrove communities and populations are identified as follows:

- Population of *Sonneratia alba* is population of pioneer mangrove trees, fixed on new alluvial grounds, deeply submerged, when high tides, in some places mixed with some trees of *Rhizophora mucronata* like along Soai Rap River.
- Community of *Rhizophora apiculata* and *Sonneratia alba* distributed on alluvial grounds flooded by tides and with rather sustainable land sources.
- Community of *Rhrizophora apiculata, Ceriops tegal* and *Avicennia alba* distributed on alluvial grounds flooded with medium water level when tide rising.
- Community of *Rhrizophora apiculata, Ceriops tagal* and *Aegiceras officinalis, Ceriops decandra.* In addition, it is found that *Xylocarpus granatum* and *Xylocarpus moluccensis* distributed on alluvial grounds to be flooded when high tides arrive.
- Community of *Excoecaria agollocha* and *Phoenis paludosa,* mixed with *Xylocarpus moluccensis, Heritiera littorallis,* distributed on alluvial plains to be only inundated by high tides and irregularly high tides in the year.

In the brackish water area of the estuaries in this region where main mangrove tree communities and populations are seen as follows:

- Population of *Sonneratia caseolaris* is a population of pioneer and permanent mangrove trees in the alluvial grounds of blackish water estuaries and deeply inundated areas.
- Community of *Nypa fruticans* and *Cryptocoryne ciliata, Acanthus* sp. *and Cyperus malaensis* distributed on the alluvial grounds of blackish water estuaries and flooded when tides rise at medium height.
- Community of *Dalbergia candenatensis, Hibiscus tiliaceus* and *Thespesia populnea* and *Clerodedron inerme, Pluchea indica* distributed on high alluvial plains to be only inundated by high tides and irregularly high tides in the year.

According to Vien Ngoc Nam (2002), apart from this, in the region, in recent years, many populations of mangrove trees have been established, especially in the World Biosphere Reserve in Can Gio belonging to Ho Chi Minh City recognised by UNESCO. Additional plantation forest has also been established including:

- Population of *Rhrizophora apiculata* planted on an area of 21,000ha;
- Population of *Rhizophora* with area of 68ha;
- Population of *Rhizophora candel* with area of 3ha;
- Population of *Nypa fruticans* with area of 28ha;
- Population of *Avicennia* sp. with area of 18ha; and
- Population of *Xylocarpus granatum* with area of 19ha.

2.2.6 Coastal Area of Mekong River Delta

This area has been created by sediments of Mekong River system, which has the highest water current and content of alluvium in Viet Nam. Large and fertile alluvial plains, very favourable climate for the growth and distribution of mangrove trees. In the region there are 33 "True" mangrove tree species, accounting for 89% of total "True" mangrove tree species of Viet Nam. The followings refer to the mangrove communities and populations in main estuaries and the Ca Mau Peninsular in the southern region.

In in estuary of Tien River (Ba Lai) there are the following populations and communities:

- Population of *Sonneratia alba,* dominated on alluvial, salty, narrow and mud areas, outside of the estuaries.
- Community of *Avicennia alba, Sonneratia alba* together with other species like *Rhizophora mucronata, Bruguiera parviflora* growing scatteredly. This Community is distributed inside pioneer population of *Sonneratia alba* developed on alluvial ground to be flooded when medium tides arriving.
- Community of *Lumnitzera racemosa, Xylocarpus granatum occupied* dominantly, mixed with *Ceriops tagal, Ceriops decandra, Avicennia lanata* and distributed on alluvial flats to be flooded only when having high tides.
- Community of *Excoecaria agollocha, Hibiscus tiliaceus*, occupied dominantly, mixed with some species like *Thespessia populnea, Phoenis paludosa* and *Sesuvium portulasstrum* distributed on high alluvial grounds and less flooded by tides.
- Mangrove trees populations and communities in estuaries of Cua Dai, Cua Tieu and Ham Luong belonging to Tien River (Cuu Long River).
- Mangrove trees populations and communities in estuaries of Co Chien River.

The following populations and communities have been identified as bellows:

- Population of *Avicennia alba* develops strongly on weak alluvial ground, with relatively high salinity and not many changes in the year.
- Community of *A. alba* and *A. officinalis*
- Population of *Sonneratia alba* as pioneers on alluvial ground with a wide range in salinity between the dry season and the rainy season.
- Community of *Rhizophora mucronata* mixed with *R. apiculata and Ceriops decanda* distributed on alluvial ground, inundated by medium tides.
- Mangrove tree populations and communities in coastal area of Ca Mau Peninsular.

This is a sediment area, which operates vigorously in the Mekong River system, with low and large alluvial flats, rich in mud, clay and nutrients. Salinity of the water is suitable for mangrove trees to be distributed and growing and salinity has little change in the year. In this region, there are communities and populations of main mangrove trees as follows:

- Population of *Avicennia alba* as pioneer on permanent alluvial soils with rich mud and clay.
- Community of *A. alba and Rhrizophora apiculata* distributed on alluvial soils flooded by low tides.
- Population of *Rhrizophora apiculata* distributed on alluvial flats and be inundated by medium tides.
- Community of *Rhrizophora apiculata, Bruguiera parviflora* distributed on alluvial soils and be flooded by medium and high tides.
- Population of *Bruguiera parviflora* distributed on alluvial grounds that are flooded when medium and high tides occur.
- Community of *Rhrizophora apiculata* and *Ceripos decanda* in low layer, on fairly well developed alluvial plains and is flooded during having high tides.
- Community of *Rhrizophora apiculata* and *Rhizophora mucronata* distributed on alluvial flats along the rivers, deeply flooded with water (not large area).
- Community of *Lumnitzera racemosa* and *Ceriops tagal* usually grow on high alluvial flats, with rather tight soil and irregularly flooded by tides.
- Community of *Excoecaria agollocha* mixed with *Acanthus ilicifolius*, grow on high and well developed soil and being less flooded by tides.

Besides, there is a community of *Avicennia marina* mixed with *A. officinalis* and *Excoecaria agollocha*, distributed on alluvial flats with abundant sand and mud, be flooded when tides are high and medium.

Community of *Nypa fruticans* mixed with *Acanthus ilicifolius* at lower layer, distributed naturally along the rivers, canals, channels and interior fields.

In addition to the above natural communities and populations, in Ca Mau Peninsular area and Mekong River *Delta* where population of mangrove trees have been established by people such as population of *Rhizophora apiculata*, population of *Sonneratia caseolaris* and man made secondary communities, i.e., community of *Phoenix paludosa* mixed with *Acanthus ilicifolius* after exploitation of mangrove forest.

3. ENVIRONMENTAL AND BIOLOGICAL STATES

3.1 Physical Factors

3.1.1 Climatic Conditions

Temperature regime

The coastline of Viet Nam has a length of 3,260km, extending from Ca Mau (South Viet Nam) at 8°25' North Latitude to Mong Cai (North Viet Nam) at 25°50' North Latitude, a length of over 14 latitudes. Generally, the entire coastal area of Viet Nam lies within the tropical belt with annual average temperature ranging from 22.7°C (in Mong Cai) to 27.6°C (in Rach Gia – Kien Giang). The climate within coastal Viet Nam exhibits tropical humid characteristics with two relatively distinctive climatic zones.

Northern Viet Nam

From the latitude of16° North (North of Hai Van pass) to 22,050' North (Mong Cai). This area locates in the transitional location of two climatic belts, i.e., tropical and sub-tropical, and heavily influenced by monsoonal regime belonging to the South East Asia where a complicated rotation of atmospheric pressure from the equator, tropics and North Pole converges. Therefore, there are two distinct seasons for this area. Summer season is hot with much rain, from May to October. Winter season is cold with less rain. However, in winter, usually no hoarfrost appears and not seriously lacking of water for crops) lasting from November to April. Every year, North East wind occurs 20 up to 25 times which carries cold wind from the North. Averagely in one month of winter, there are 3 up to 5 turns of appearance of North East moonsoon. When the North East wind arrives that makes the temperature suddenly drop to about 4° to 5°C and sometimes down to 10°C.

The North Easterly winds blow along the country from the North to the South and significantly influences the temperature along the coastal areas at different latitudes. This type of weather pattern differs from that experienced by neighboring tropical countries located on the same latitudes.

South of Viet Nam

Between Hai Van Pass (16° North latitude) to Ca Mau Peninsular (8°25' North latitude). The climate is less influenced by the North East monsoon. To the southern Delta the influence of this monsoon is minimal and is characterised by monsoon tropics, near equator with total annual average temperature of 9,000-10,000°C and annual average temperature is relatively high, between 26-27°C.

In the South, there are two distinct seasons: rainy season and dry season. The rainy season begin in May and last until October whereas dry season commences in November and last until the end of April. The temperature variation between months is very low ranging from 3°C to 5°C and the daily temperature difference is only about 1°C. Table 4 shows Annual changes in temperature regime by Regions in Viet Nam.

Table 4 Annual changes in temperature regime by Regions in Viet Nam.

Part	Regions	Number of months in the year have temperatures		
		<20°C	20-25°C	>25°C
North Viet Nam	North East Region (Quang Ninh province)	5 months	2 months	5 months
	Northern Delta	4 months	2 months	6 months
	Central North Region	2-3 months	2-3 months	9-10 months
South Viet Nam	Central South	0 month	3-5 months	7-9 months
	Ba Ria – Vung Tau (South Eastern part of the South) Ho Chi Minh City	0 month	0 month	12 months
	Mekong River Delta	0 month	0 month	12 months

Source: General Department of Hydrology and Meteorology, 2000.

Scientists who research on physiology if mangrove trees all have assumed that atmospheric temperature from 25°C to 28°C are very suitable for the growth of mangrove trees. Therefore, the temperature regime in the South of Viet Nam remains through the year round (12 months); it is very suitable for the growth and distribution of coastal mangrove trees.

Rainfall

Viet Nam is situated along the eastern seaboard of the Asian continent, adjacent to the Eastern Sea and falling within the tropical belt. The long 3,260km coastline forms a type of ocean influenced climate where there is high annual rainfall and humidity. Generally, the coastal areas of Viet Nam have rather high annual average rainfall ranging from 1,800mm to 2,500mm/year (see Table 5). However, there are also some localities with low rainfall of below 1,500 mm/year like Vung Tau (1,357mm/year) or with very low rainfall, i.e., under 1,200mm/year, e.g., Ninh Thuan and Binh Thuan provinces (total annual rainfall is 794mm/year) and Phan Thiet province (total annual rainfall is 1,152mm/year). The low rainfall influences significantly the distribution of mangrove forest.

Table 5 Changes in annual rainfall between coastal areas.

No.	Region	Annual rainfall (mm/year)
1	North East (Quang Ninh province)	2016-1749
2	Northern Delta	1757-1865
3	Central North	1944-2867
4	Central South	1152-2290
5	Ba Ria – Vung Tau (South East South) and Ho Chi Minh City	1357-1684 (Vung Tau), (Can Tho)
6	Mekong River Delta	1473-2366

Source: General Department of Hydrology and Meteorology, 2000.

Mangrove trees distributed in the Northern hemisphere develop well in the locations having relatively high rainfall, from 1,800 to 3,000mm/year. In Viet Nam, there are 3 regions: North East, Northern Delta and North central where annual rainfall range from 1,757 to 1,867mm which is very favourable for the growth of mangrove trees. In addition, the Ca Mau Peninsular has annual rainfall varying from 1,800 to 2,366mm also very suitable for the growth and distribution of mangrove trees. Especially, this region with a very suitable temperature, fertile and large coastal wetland area, therefore, it becomes a good

place where many types of mangrove trees distribute and provide a high production of timer i.e., *Rhrizophora apiculata* growing in natural *Rhizophora* forest, at the age of 60, it can reach a diameter of 1.3m and height of 28m. The timber productivity of *Rhizophora apiculata* plantation forest averages between $8m^3$ – $12m^3$/year and occasionally as high as $13,5m^3$/year. On contrary, in the localities where the annual rainfall is under 1,200mm. the mangrove forest seem not to be appeared or if any the forest are in poor growth.

3.1.2 Water Temperature

Coastal North East Region(Quang Ninh)
Water temperature is affected by the cold winter climate. During the winter, the temperature may drop down to 10°C, however along the coast of Quang Ninh, the water surface temperature ranges from 15 to 18°C. Seawater temperature e.g., Luc estuary as low as 12°C on some days. Seawater temperature gradually increases from the water surface to deeper water varying between 1 and 2°C. In summer, average temperature of the surface water ranges from 28-30°C and the temperature gradually reduces from the surface water to deep water level. Its difference is from 2-3°C. This justification resulted from pilot planting of *Rhizophora apiculata* trees in this area, *Rhizophora apiculata* trees died after 1 to 2 cold winter seasons.

The Red River Delta
The influence of the above mentioned North East monsoonal wind is less profound at the Red River Delta, however, a cold winter wind continues to blow for the three months of December to February.

During this time the average monthly seawater temperature close to the shore is under 20°C, varying between 17.9°C and 19.5°C. From the March to November (Remaining nine months) the average seawater temperature is always higher than 20°C and varies between 21.4 and 28.6°C. The coldest average seawater temperature of about 17.9°C is in the month of January and conversely, the warmest average seawater temperature is in June, about 28.6°C.

Central North Region
Influence of the North East monsoonal wind becomes minimal and in this region it is not very cold during the winter. About 1 or 2 months in the year, normally during December and January, seawater temperature is lower than 20°C.

The Central South Region
There is no distinctive winter climate within this region and the influence of the North East monsoonal wind is negligible. The average seawater temperature throughout the year is higher than 20°C, which provides ideal conditions for *Rhizophora* trees to grow naturally along the coastal mangrove land.

The Ba Ria – Vung Tau and the Mekong River Delta Region
This region is characterized by a typical tropical equatorial climate where the mean monthly temperature in all months of the year is higher than 25°C, thus, the average seawater temperature is always higher than 25°C, varying from 26.5°C (in September) as the lowest water temperature in the year, to 30.7°C (in March) which has the highest water temperature in the year. Here, different mangrove types are abundant and grow very well in Viet Nam.

3.1.3 Hydrological Characteristics

River system
The total average annual water rainfall volume of Viet Nam is approximately $630km^3$. The network of rivers and streams is quite dense and if drainage lines whose length has more than 10km were considered, Viet Nam would have almost 2,500 streams and rivers. Density of river network varies from 0.5 to $2km/km^2$.

The rivers and streams annually discharge between 800-$900km^3$ of water into the South China Sea. If outside water volume discharges into Viet Nam is not included, then water volume derived from territory of Viet Nam is about $300km^3$ of water (Nguyen Viet Pho, 1984).

The two largest rivers in Viet Nam are Mekong and Red Rivers. They discharge approximately 70% of the country's total water volume from their catchment systems.

Tide

The driving force and highly important element in formation of mangrove ecosystem is tide. Along the coast of the South China Sea of Viet Nam, there are 4 different types of tides i.e., diurnal tide, semi-diurnal tide, irregular diurnal tide and irregular semi-diurnal tide. Irregular diurnal tide and irregular semi-diurnal tide is produced by a mixture of diurnal and semi-diurnal tide where either on variety exits more dominance than other at that location.

Pure diurnal tide area may be clearly observed along the coast from Mong Cai (Quang Ninh province) to Do Son (Hai Phong). In this area, tide range is the greatest in Viet Nam ranging from 4.0-4.5m. In one day and night, there appears one time of leap tide and one time of ebb tide.

In addition, Northern Delta area experiences a diurnal tide regime, however tide range gradually reduces from Do Son to Ninh Binh, with tide ranging from 3.2 to 3.6m. Within one year there are more than 165 days where high tide exceeds 3m. In this region the tide is most active yearly in December, January, June and July.

In the Central North area tidal patterns are rather complicated. From Thanh Hoa to Ha Tinh an irregular diurnal tide regime occurs and from Ha Tinh to Hue an irregular semi-diurnal tide regime appears. From Thanh Hoa to Hue, tide range gradually reduces in height, from 3.0m to Thuan An (the lowest tide range in Viet Nam) where there is only 0.5-0.7m range.

In Central South Area, the tidal regime changes from irregular semi-diurnal tide (Quang Nam – Da Nang) to irregular diurnal tide (Nghia Binh-Phu Khanh) and then from Phu Thanh to Thuan Hai returns to irregular semi-diurnal tide with a gradually increased tide range of 0,7-2,5m.

In the South East South (Ba Ria-Vung Tau) and Can Gio (Ho Chi Minh City), tidal regime is semi-diurnal and has a relatively high tide range, from 3.6-4.0m. In one day and one night, there are 2 times of leap tides, one incomplete tide and one main tide is higher. In the year the highest tide range appears in September, October, November and December and the lowest tide range occurs in May and June.

The Mekong River Delta coastal area experiences semi-diurnal tidal regime where tide ranges from 2.0-3.0m. The speed of tide during leap tide is 6.9m/s. Especially in the Western part of Ca Mau Peninsular, from Bay Hap estuary (Ca Mau province) to Ha Tien (Kien Giang province) the tidal regime changes its partern to diurnal tide regime with low tide range varying between 0.7 and 1.0m. In addition, from Dat Mui area to Bay Hap estuary of Ca Mau province where experiences a mixture of semi-diurnal tide and diurnal tide (transitional area).

The influence of rivers within the North Eastern coastal area (Quang Ninh province) is minimal. During the rainy season, the volume of water pouring into the sea contributes between 20-40% of the total volume of water near the shore and during the dry season this drops to between 5-10%. Sediments derived from river water is low, therefore, the dominant driving force behind the formation of tidal flats is the daily rise and fall of tides. This process creates the formation of tidal flats with very dense branched canals perpendicular to the coastline. The influence of the tide has increased 40,000ha of high tidal flats where mangrove forest have colonised and over 27,000ha of low tidal flats which are ideal environment for the development of fishery products (i.e., brackish and salty water fishery farming) of high economic value.

Sea waves

Estuaries and tidal flats along the coastal areas of Viet Nam are strongly affected by coastal sea waves. Coastal sea waves in Viet Nam tend to be influenced by two seasons in the year: Rainy season from April to September dominated by North East waves and during the dry season from October to March dominated by South East waves. Waves from the Sea traveling to the seashore usually have an average height of 1.5 to 2.5m. During the days of the formidable seas and strong North East monsoonal wind, the sea waves may reach between 3.0-4.0m. During the typhoons take place the sea waves along the coastline vary greatly rising between 4 to 6m and even higher than 7m.

In Viet Nam, there are on average between 4-6 storms which more towards the mainland, with wind speed of 20-40m/s. Storms cause great impact on the existence of coastal mangrove forest and destroy sea dyke system where no mangrove protection forest exist. Only along the coastal area of Southern Delta area where storms rarely occur.

A notable exception to the above mentioned process is the coastal area of Quang Ninh (North East of Viet Nam) with a coastal length of more than 250km. 2,077 islands and limestone mountains rise out of the sea near the seashore and create a closed bay. As a result, the waves arriving on the shoreline become rather calm while wave height averages at 0.5m. 85.4% of the time the sea conditions are calm. Table 6 represents Wind Direction and Speed and Seawave Range in the Red River Delta (Hon Dau Observation Station); and Table 7 shows Prevail seawave Direction and Ranges in the Western Part of Ca Mau Peninsular.

Table 6 Wind Direction and Speed and Seawave Range in the Red River Delta (Hon Dau Observation Station).

Month	Wind			Ranges of seawave (m)	
	Prevail direction	Speed (m/s)		Average	Max
		Average	Max		
JAN	North East - East	4.5	24	0.66	1.9
FEB	East	4.8	20	0.68	2.2
MAR	East – South East	4.1	28	0.65	2.2
APR	East – South East	4.9	28	0.72	2.8
MAY	East – South East	5.7	40	0.83	2.4
JUN	South – South East	5.9	34	0.80	2.2
JUL	South – South East	6.1	40	0.92	5.6
AUG	South – South East	4.8	45	0.70	5.0
SEP	North East – East	4.8	45	0.66	4.2
OCT	North East – East	5.1	28	0.75	2.3
NOV	North East – East	4.9	24	0.69	2.0
DEC	North East – East	4.8	30	0.65	2.0

Table 7 Prevail seawave Direction and Ranges in the Western Part of Ca Mau Peninsular.

Month	Prevail seawave direction	Seawave rangs (m)	
		Average	Max
JAN	East – North East	0.80	1.80
FEB	East – North East	0.95	2.00
MAR	North East	1.10	2.30
APR	East – South East	0.80	2.00
MAY	West – South West	0.85	3.00
JUN	West – South West	0.95	4.00
JUL	West – South West	0.95	4.00
AUG	West – South West	0.90	3.50
SEP	West – South West	0.90	3.50
OCT	West – South West	0.85	3.00
NOV	North East	0.92	2.50
DEC	East – North East	0.92	2.50
Anunual average		**0.91**	**4.00**

Oceanic water current

Currents of water in the Ocean also have a great impact in distribution of mangrove tree species along the coastal area of Viet Nam.

The South West monsoon brings water currents from Indian Ocean through Indonesia and Malaysia to the coastal area of South Viet Nam, therefore, the composition of mangrove trees within the Mekong River *Delta* is similar to mangrove tree species in South East Asian countries, e.g., *Rhizophora apiculata, Rhizophora mucrosata, Bruguiera parviflora, Bruguiera cylindrica, etc.*

The water current along the coast flowing from the South to the North of Viet Nam, up to 12° North latitude then to the Sea. While in the North where the coastal water current runs from the North to the South or from the North East to South West and down to 12° North latitude. Therefore, the difference of the composition of mangrove plant species between two parts of Viet Nam is clearly seen. In addition to climatic conditions, there is impact of coastal oceanic water current.

3.1.4 Salinity of Coastal Seawater

The North East region (Quang Ninh province)
Salinity of coastal seawater is rather high and varies slightly in the year. Salinity of seawater in rainy season is about 20% and in dry season about 30%. In the locations close to the estuaries, the salinity may reduce and varies widely, about 10% in rainy season and 25% in dry season. However, this fluctuation occurs in small area.

The Red River Delta Region
Salinity of water in the river mouth areas has a small change. In Van Uc estuary, the salinity varies between 1.0% in rainy season and 11% in dry season. In Ba Lat estuary it ranges between 1.1% in rainy season and 13.8% in dry season.

Salinity of water in coastal alluvial flats varies rather clearly. In Do Son, the salinity changes from 16.4% in rainy season to 27.5% in dry season. In Thuy Anh it fluctuates between 10.5% in rainy season and 20.7% in dry season. In Van Ly water salinity is between 20% in rainy season and 30% in dry season.

The Central Coastal Region
Salinity of seawater differs relatively greatly between seasons. Salinity of seawater in Lach Truong (Thanh Hoa province) ranges from 10.3% in rainy season to 20.4% in dry season. In Thuong estuary of Thua Thien – Hue province it is 13.23% in rainy season and 20.5% in dry season. In Cau Hai lagoon (Hue) the salinity differs between 5-23% in rainy season and 20-33% in dry season.

The Ba Ria – Vung Tau – Can Gio Region
Coastal seawater has a relatively high salinity and fewer changes throughout the year. In rainy season, water salinity ranges from 12 to 18% and in dry season, water salinity varies from some 20 to 30%.

The Mekong River Delta Region
Salinity of water has a big difference between seasons. Water salinity in Tien estuary in rainy season is between 1-4% and in dry season it is 18-20%. In the place far from estuary (forest enterprise of Thanh Phu, Ben Tre province) water salinity is from 7 to 12% in rainy season and from 20 to 24% in dry season. In Ca Mau Peninsular (Ca Mau province) salinity of coastal seawater is fairly high and has a small fluctuation throughout the year. In rainy season, water salinity ranges between 19% and 23% and between 26% and 31% in dry season.

3.1.5 Suspended Solid Particles

North East Region (Quang Ninh province)
All estuaries in this region have low water flow and there are approximately 30 rivers and streams whose length is over 10km. The annual water flow of these rivers is very low, ranging from 3.07-23.5m^3/s. The distribution of rivers along the coastline is highly dense, in some places a river mouth may be found every 4 to 5km along the coastline. However the total volumetric discharge into the sea within the Quang Ninh province is small, with approximately 6.56 billion m^3 of fresh water/year.

During the dry season, the suspended solid particle content is measured at 3.5g/m^3 and hence the water is rather clear. Where as during the rainy season, this content only increases to a maximum of 189g/m^3.

The suspended mud and sand content in water at Ha Coi (Tien Yen – Quang Ninh) ranges from 5-10g/m^3 in dry season to 10-50g/m^3 in rainy season. At Sa Bach Dang this content is higher with 10-30g/m^3 in dry season and between 50-120g/m^3 in rainy season.

The Red River Delta Coastal Region
Water turbidity in Red River estuary varies greatly from that within the North East region. The suspended solid content in the water at Ba Lat estuary is 44.3g/m^3 in dry season and 1,400g/m^3 in rainy season. In the Tra Ly estuary is 30.67g/m^3 in dry season and 1,050g/m^3 in rainy season. Finally in the Van Uc estuary this content is 359g/m^3 in dry season and 876g/m^3 in rainy season.

Generally, the suspended solid content along the coastal area of Red River Delta Region in dry season is between 50-100g/m^3 and during the rainy season, this content increases to 200 or sometimes to as high as 500g/m^3.

The Central Coastal Region

Within this region, the suspended solid particle content in the water during the dry season is very low, about 5-10g/m^3. During the rainy season, this content increases to between 20-100g/m^3. As a result, coastal seawater in Central Region is clear all year round.

The Ba Ria – Vung Tau – Can Gio Region (South Eastern Part of the South)

At Dong Nai River mouth, suspended solid particle content in the water ranges from 10-20g/m^3 during dry season and about 40-100g/m^3 in the rainy season. Generally, the suspended solid particle content at Dong Nai River mouth is not high.

The Mekong River Delta Coastal Region

Within the Mekong estuaries the suspended solid particle content in the water is between 10-50g/m^3 during the dry season and increases to around 80-150g/m^3 in the rainy season. At the Ca Mau Peninsular area (observation at 11 different localities throughout over the region), during dry season (measured in April 2001), the suspended solid particle content in the water ranges from 200g/m^3 (Genh Hao) to 423g/m^3 (Bay Hap estuary). During the rainy season, from July to October, this content at Genh Hao River is 25.6-447g/m^3 and at the Cua Lon River is between 342-550g/m^3.

So, within the Ca Mau Peninsular region, sea water near the seashore is always muddy, the content of alluvial material in the water is rather high and there is very little difference between the dry season and the rainy season.

3.1.6 Particle Composition of High Tidal Flats

Other than the Ca Mau Peninsular which has the highest clay content of 56-60% in its deposited sediment. The clay content found in the deposited sediments of the Thai Binh River and the Bach Dang estuary is about 15-30%. This content is between 15-25% in the Dong Nai estuary, in the Cuu Long River is 12-22%, in the Red Rriver mouth is10-15% and the lowest clay content found in the estuaries of Central coastal region, less than 1%.

The rivers of the Central region of Viet Nam have the highest sand content deposited within its sediments, with between 80-95%, this is followed by the rivers of North East region (Quang Ninh province), about 12-15%; the Red River, about 6-10/%; the Mekong River, between 5-10%; and the lowest being the Dong Nai River, about 2.5-10% and the Thai Binh river (Bach Dang estuary) at between 3-12%. Table 8 shows Particle composition of surface sediments of high tidal flats of estuaries in Viet Nam.

Table 8 Particle composition of surface sediments of high tidal flats of estuaries in Viet Nam (Mean value calculated).

Areas of estuaries	Particle class, mm (%)				
	>0.05 (sand)	0.05-0.01 (fine sand)	0.01-0.005 (silt)	0.005-0.001 (fine silt)	<0.001 (clay)
Tien Yen – Ha Coi	12-18	15-25	15-28	20-30	10-25
Bach Dang (Thai Binh River)	3-12	10-22	20-30	25-32	15-30
Red River	6-10	15-25	15-25	20-25	10-15
Central rivers of Viet Nam	80-95	5-10	1-3	<1	<1
Dong Nai River	2.5-10	12-20	25-30	25-35	15-25
Cuu Long River	5-10	12-25	15-30	20-28	12-22

Source: State Sea Programme KT03, 1995.

3.2 Chemical Factors

3.2.1 Chemical Characteristics and Nutrient Contents (N, P)

pH value of water
Generally, water has neutral reaction or almost neutral reaction during the rainy season whereas in the dry season, pH value of water may increase up to 7 and in some places the pH of water may be lightly alkaline of pH = 8.04 (Red river estuary). Seawater along the coastal area of the Central region usually has pH higher than other regions, although not much.

Dissolved N (mg/liter)
The location with the highest content of dissolved N is along the coast of Ba Ria – Vung Tau – Can Gio where there is about 0.585-1.170mg/litre. The most likely explanation for this may be wastewater flowing downstream from Ho Chia Minh City. Following is the Red River estuary and the lowest content of dissolved N found along the coast of the Mekong River *Delta*, ranging between 0.108-0.284mg/litre.

Dissolved P (mg/liter)
Generally, the content of P dissolved in water is quite low and there is small variation between regions.

The data from the study of pH, N and P along the coastal region of Viet Nam is described in the Table 9.

Table 9 Chemical characteristics and content of the nutrients of N, P dissolved in water along the tidal flats of the coastal regions of Viet Nam.

No.	Regions	pH	Dissolved N (mg/litre)	Dissolved P (mg/litre)
1	North East (Quang Ninh)	6.85-7.33	0.121-0.514	0.008-0.010
2	Red River Delta	7.68-8.04	0.225-0.268	0.001-0.009
3	Central Coastal	6.90-7.90	0.100-0.320	0.001-0.005
4	Ba Ria – Vung Tau – Can Gio	6.62-7.48	0.585-1.170	0.032-0.073
5	Mekong River Delta	6.80-7.30	0.108-0.284	0.002-0.005

Source: Forest Science Institute of Viet Nam, 2001; State Sea Programme, 1995.

3.2.2 Percentage of Nutrient Contents (N, P, C ,S)

Content C,% (organic)
It is generally low, some localities in the North West of Viet Nam and Ba Ria – Vung Tau record a medium value of 2.8-3.0%.

Content N,% (total)
Generally, deposited materials along the coast of Viet Nam all have a medium level of N content. Some localities in the Ba Ria – Vung Tau and North East of Quang Ninh province have a higher content of Nitrogen, about 0.25%.

Content P_2O_5, %(total)
Sediments of the Red River have P_2O_5 total content (%) of highest, followed by those of the Mekong River. The poorest in P_2O_5 total content is sediments along the cost of the Ba Ria-Vung Tau and North East of Viet Nam as the sediments in these regions formed by humid tropical weathered products.

Content Sulfur, %
The percentage content of Sulfur contained within deposited sediment materials of the tidal flats varies distinctively between regions. The tidal flats in North Eastern Viet Nam and the Ba Ria-Vung Tau have the highest sulfur content. In these regions the weathered sediments are rich in Fe_2O_3 and Al_2O_3 and accumulated sulfur at levels between 1.0 and 4.5%. Comparatively, the Mekong River Delta and the Red River Delta have sulfur content between 0.20-1.0%. This characteristic has explained rather clearly about the forces of formation of potential sulfate mangrove land in the coastal area of Viet Nam.

3.3 Mangrove Biodiversity in Viet Nam

Viet Nam has so far no systematic researches on biodiversity of mangrove ecosystems, therefore, the below summary only derive from separate research documents carried out in individual region or coastal ecological areas by many authors. As non-identical research methodology used in different researches, thus, the collected data should be regarded as for references. Table 10 lists out biodiversity by geographical distribution areas in Viet Nam.

Table 10 Biodiversity at different ecological regions along the coastal area of Viet Nam.

Regions	Total species*	Mangrove trees		Plankton		Zoobenthos		Fish	Birds	Amphibians	Reptiles	Animals
		True	Associate	Phytoplankton	Zooplankton	Mollusca	Crustacea					
North East (Quang Ninh)	651	52		355		400		194	57	-	-	-
		16	36	185	170	113	65					
Red River Delta	428	50		245		136		130	113	10	16	6
		14	36	64	181	55	65					
Central Coastal	378	64		204		150		150	15	5	3	10
		23	41	171	33	16	20					
Ba Ria – Vung Tau – Can Gio	388	98		82		116		127	130	9	31	19
		32	66	63	19	32	52					
Mekong River Delta	364	101		198		82		69	171	6	34	28
		33	68	119	79	52	30					

Source: Vu Trung Tang, 1997; Dang Trung Tan, 2001; State Sea Programme, 1995.
*Note: *: Total species is calculated for important species groups only that include Mangrove trees: Zoobenthos, Fish and Birds.*

Data synthesized from the resaerches on biodiversity of mangrove ecosystem revealed that biodiversity of mangrove ecosystem is very abundant. The detailed statistical on biodiversity of mangroves ecosystem is described as follows:

- ***Phytoplankton:***

To date 537 species of Phytoplankton have been identified, in which:

  - Bacillariophyta has a largest number of species with 348 species, accounting for 71,5%.
  - Seaweed: 662 species are found, in which there are some species that play an important role in economic value and are being commonly grown: *Gracilaria verrucosa, Gracilaria arucata, Gracilaria temtstipitata* which belong to Rhodophyta with about 309 species.
  - Seagrass: There are 15 species of 9 genus and 3 family.

- ***Zooplankton:*** It has identified 468 species

- ***Zoobenthos:*** 450 species are found, which include the main groups as bellows:
  - Crustacea and Mollusca: For shrimp only there are 101 species of 11 different families found. In the family of Penaenidae there are 75 species found, in which some important species for economic values for coastal area that are *Penacus merguiensis, Penacus semisulcatus, Penacus indicus, Penacus erguiensis, Penacus monodon, and Metapenacus ensis.*
  - Crab: It has known about 60 species of crab, of which some crab species with high economic values are *Scylla serrata, Portunus trituberculatus.*
  - Mollusca: In class of Bivalvia there are 35common species and the high economic values species are *Arca antiguata, Arca granosa, Arca subcrenata, Mactra luconica, Meretrix meretrix, and Meretrix lusoria.*

- ***Fish:***

There are about 516 species of 97 families found in coastal areas in Viet Nam (Vu Trung Tang, 1997). Of those there are many species with high economic value, for xample *Epinephelus*

maculatus, Epinephelus awoara, Monodactylus argenteus, Psenopsis anomala, Pangasius polyuranodon and some endemic species having close relation with mangroves that are:

- Mugilidea (11 species)
- Lates calcarifer
- Eleotridae
- Plotosus anguillaris

Panagasus polyuranodon (The fish eats directly ripe fruit of Avicennia and is very famous for Ca Mau Peninsular).

- ***Birds:***

In Viet Nam, there are about 386 species found, in which 77 species are migrant and some of those are rare and endangered species according to IUCN criteria such as: *Tringa gutlifer, Limnodromus semipalmatus, Eurynohynchus pygmeus, Platea minor, Pelecanus philippinensis, Mycteria leucocephala, Egretta eulophotes.*

Tidal flats in estuaries like Red River estuary where provide good and vailable food sources is the place which attracts about 120,000 waterbirds to live in this area.

- ***Mammals:***

With in coastal mangrove ecosystem in Viet Nam, 28 species of mammal have been found, in which 7 species are recorded in Red book of Viet Nam and IUCN.

- ***Reptile:***

There are 54 species, in which 11 species are recorded in Red book of Viet Nam and IUCN.

- ***Ambiphian:***

It has been identified 10 species of ambiphian related to mangrove ecosystem in Viet Nam.

4. SOCIAL USE AND TENURE INFORMATION

4.1 Tenure

Viet Nam has promulgated a number of laws relating to land-use rights, forest resources and protection and development of natural resources, including forest resources. Main laws are:

- Land Law issued in 1993, revised and added in 1998 and 2000 and revised in 2003.
- Law on Forest Protection and Development in 1991, revised in 2004.
- Law on Environment Protection in 1994.

Under-law documents include important degrees and decisions of the Government such as:

- Decision No. 01/CP promulgated in 1995 on the allocation of forest and agriculture land and aquaculture land within State enterprises.
- Degree No. 163/1999/ND-CP of the Government on land allocation and leasing forest land to organisations, households and individuals for a long-term and sustainable use for forestry purposes.
- Decision No. 661/QD-TTg in 1998 of the Prime Minister on the objectives, tasks, policies and organisation for the implementation of 5 Million Hectare Reforestation Programme.
- Decision No. 08/2001/QD-TTg by the Prime Minister on Regulation of the management of three natural forest types: Special use forest, Protection forest and Production forest.
- Decision No. 178/2001/QD-TTg of the Prime Minister on beneficiaries, obligations of households and individuals who are permitted to allocate, lease, receive forest contracting and forest land.

The local authorities with mangrove forest should be flexible in applying legal documents, regulations issued by the Government and Prime Minister. The main contents of the laws, decrees and decisions of the Government in relation to management, protection and development of forest can be summarised as follows:

Constitution and Land Law states that land belongs in the people's ownership whilst the State manages land according to the plans and laws to ensure effective use and for the correct purposes. Land ownership is clearly defined in the Land Law, which has been revised and amended in 1998,

2000 and being revised in 2003. Land is allocated to organisations, households and individuals for duration of 50 years to use for a long-term and correct purposes. After 50 years has elapsed and the landusers have efficiently used the land according to the terms of the contracts, they may wish to continue their landuse rights. Their application for further use will be considered and the decision will be made and. The allocated area depending on the allocated objects and land availability within the localities. Forestland to be allocated to households and individuals completely depends on local land availability. The maximum area of forestland allocated to households and individuals is 30ha. Land users (mainly households and individuals) have 6 rights as stipulated in current Land Law, they include: (i) Right to change; (ii) Right to transfer; (iii) Right to inherit; (iv) Right to mortgage; (v) Right to lease and use; and (vi) Right to use the land as a part of contribution to business funds.

At present, the Law on Forest Protection and Development is being revised and focusing on forest ownership by communities, usually it is called village forest.

Forest are classified into three forest types: production forest, protection forest including watershed protection forest, sand-breaking protection forest, sea wave protection forest..., and special-use forest including national parks and nature reserves. Ownership and management of three forest types are also different.

Natural forest is generally managed by the State through State agencies like forest enterprises or forest management boards, commune people's committees, etc. Presently, discussion on policy is underway to consider whether natural forest can be allocated to communities or households to manage.

For protection forest and special use forest (national parks, nature reserves) forest management boards will be established for management and protection. Certain forest areas, especially protection forest, will be allocated to households to protect on contractual basis.

For production forest as natural forest will be mainly managed by forest enterprises as forest owners.

In case of plantation forest, if funding has been provided by the state, then tending and protection will be provided by the state, i.e., state enterprises. In addition, plantation forest may be allocated to either individuals or households who are responsible for protection through contracts and/or benefit sharing.

If the establishment of plantation forest is funded by households or individuals on their allocated land, then, its ownership will belong fully to those households and individuals. They have the right to decide the time of harvesting and sell the products freely on the market.

Forest policy pays much attention to the benefits of the people involved in forest resources protection and development. Those who sign forest protection contracts receive payment from the State (through forest enterprises, forest management boards) as stipulated: 50,000 VND/ha/year (about US$3.4 as of current rate: US$1 = 15,000 VND). In addition, they are allowed to collect fuelwood, minor forest products, thinning products when necessary for protection forest. Upon exploitation of production forest, benefits will be shared depending on the increase in forest volume. Each locality ha sits own regulation and depending on the status of the forest, households and individuals may receive 70-100% of forest products.

The State concentrates its National budget on protection and rehabilitation of protection and special use forest, while production forest depends on preferential rate floating capital and credit policy.

People are encouraged to apply the integrated Agriculture-Forestry-Fisheries measures on their land and enjoy the benefits of these products from these combined agriculture-forestry and fishery activities.

Statistical data on the area of wetland and mangrove land allocated and contracted during the period from 1998-2000 (according to degree 02/CP) was 128,741ha, with 32,077 households and 62 organisations involved. Details are given in Table 11.

Table 11 Contracted area of land and mangrove forest in provinces of West – South region.

Unit:ha

No.	Provinces	Land and mangrove areas contracted	No. of contracted households	No. of contracted organisations
	Total	**128,741**	**32,077**	**62**
1	Ca Mau	88,990	18,232	35
2	Tra Vinh	17,053	7,102	1
3	Bac Lieu	2,100	428	16
4	Ben Tre	11,200	7,780	5
5	Soc Trang	6,127	2,067	3
6	Kien Giang	3,271	870	2

In the Northern coastal provinces mangrove forest are mainly designated for coastal protection and managed by the State. The protection of mangrove forest is undertaken through forest management boards, local authorities and contracts with households.

4.2 Present Use

Mangrove forest in Viet Nam are used mainly for:

Providing timber and fuelwood, this is especially the case for mangrove forest of the Mekong River Delta where there is large volume of timber. Whereas, in the North, mangrove forest are poorly developed and hence timbered. Their main role therefore is of protective function. Timber is mainly used for house construction and fuelwood for basic survival needs of the local people. *Rhizophora* timber is used for charcoal production, as *Rhizophora* charcoal created is very effective. The bark of *Rhizophora apiculata* and *R. stylosa* is used for tannin production.

All above-mentioned values of mangrove forest occupy a small property compared to indirect values through mangrove forest. Fishery sources are of great sources of mangrove forest. Mangrove forest play a great role in protection of environment and development of eco-tourism, especially, mangrove area of Can Gio (Ho Chi Minh City) which has been recognised by UNESCO as a biosphere reserve and an ecological area of Ho Chi Minh City.

Mangrove forest in Viet Nam are mainly concentrated within Mekong River Delta, mainly in the Ca Mau province where the largest area of mangrove forest exist and are well developed. The following data demonstrates the utility of mangrove forest during the period from 1975 to 2000 in Ca Mau province. Table 12 shows the Utilisation of mangrove forest in period from 1975 to 2000.

Table 12 Utilisation of mangrove forest in period from 1975 to 2000.

Year	Utilisation		
	Timber (m^3)	Fuelwood (stere)	Charcoal (tonne)
1975	25,787	35,011	669
1981	20,662	174,026	2,162
1983	10,826	51,909	2,641
1991	30,903	272,610	830
1993	16,207	176,150	343
1995	15,000	100,000	368
1998	15,911	311	–
2000	17,357	–	–

Source: Dang Trung Tan, 2001.

Since 1975 there has generally a decline in timber exploitation due to the plantation forest not being at a suitable age for harvesting. Between 1991 and 1995 volume of fuelwood harvested decreased significantly.

The value of aquaculture products is related to the mangrove forest in Ca Mau means reference only because the data collected based on estimation and deduction. According to the research results of the Forest Science Institute of Viet Nam (Dang Trung Tan, 1998), 1ha of forest drops into the water 13.5 tonnes of dry matter and it is an important food sources for fisheries. The total area of mangrove forest at Ca Mau is approximately 64,000ha (figure of 2000). This forest is estimated to provide the fishery sector with 205,000 tonnes of shrimp and fish (both aquaculture and fishing) with an estimated value of US$265 million. In addition, the mangrove forest act as a nursery and provide large numbers

of baby shrimp. The Ministry of Fisheries estimated in 1990 that the Ca Mau forest area annually produced 8 billions baby shrimps.

The implementation of the silvo-fishery model at Ca Mau province has seen a progressive increase in shrimp production within mangrove forest:

- In 1986, shrimp production in mangrove forest was 6,000 tonnes, productively is 0.19 tonnes/ha.
- In 1990, shrimp production in mangrove forest was 24,450 tonnes, productively is 0.41 tonnes/ha.
- In 1995, shrimp production in mangrove forest was 33,600 tonnes, productively is 0.27 tonnes/ha.
- In 1998, shrimp production in mangrove forest was 42,362 tonnes. In 1999, shrimp production was 46,718 tonnes and in 2000 it was 64,000 tonnes.

However, the increased production of shrimp aquaculture in mangrove forest in some years has resulted in over-exploitation of mangrove forest for shrimp farming. The models on mangrove afforestation combining with shrimp farming regulates that the forest percentage ranges from 50-70% depending on specific conditions.

4.3 Potential Use

In the future, the mangrove forest in Viet Nam will perform the following functions:

- Protect and fix alluvial grounds along the coast and extend the mainland further towards the sea;
- Prevent sea waves from damaging dykes and prevent saline intrusion along the coastal area;
- Protect and safeguard aquatic resources and conserve mangrove forest;
- Develop eco-tourism especially in some province of Mekong River Delta; and
- Establish plantation forest with diversified tree species of high economic value to provide raw materials to paper industry, chips production etc.

With its important functions in protection and development of aquatic sources, therefore, in Mekong River Delta, one project is being implemented entitled "Protection and Development of Coastal Wetland " in Ca Mau, Bac Lieu, Soc Trang and Tra Vinh provinces, funded by the World Bank with a total investment capital of US$65 million, with a duration of 6 years starting from May 2000 to May 2006.

In Ca Mau province, the establishment of a mangrove national park has been proposed at Ca Mau cape. The proposed national park will cover an area of 13,401ha. It is also proposed to protect 14,346ha of mangrove forest to prevent soil erosion of the coast of the South China Sea and to accelerate the deposition process for the area extension towards the western part (Gulf of Thailand).

Eco-tourism in the mangrove areas of the Ca Mau province is also being considered and special attention is now being paid to the development of projects and to existing eco-tourism now conducted in the mangrove area.

4.4 Present Management Structure

4.4.1 Organisational Structure

Presently, the Ministry of Agriculture and Rural Development (MARD) is the agency on behalf of the government takes the responsibility for the protection and development of forest resources. Under the Ministry, there are two professional forestry departments, i.e., Forestry Department (FD) and Forest Protection Department (FDP).

At the provincial level, there is Provincial Department for Agriculture and Rural development (DARD) in which there is Provincial Forestry Department (PFD). In addition, there is a Provincial Forest Protection Department (PFPD) under direct supervision of Provincial People's Committee. At the district level, there is district forest protection unit. PFD and PFPD have a close relationship with Forestry Department and Forest Protection Department at Ministerial level through different projects or issues relating to management and technical aspects. The organisational structure is described in the diagram (Figure 3).

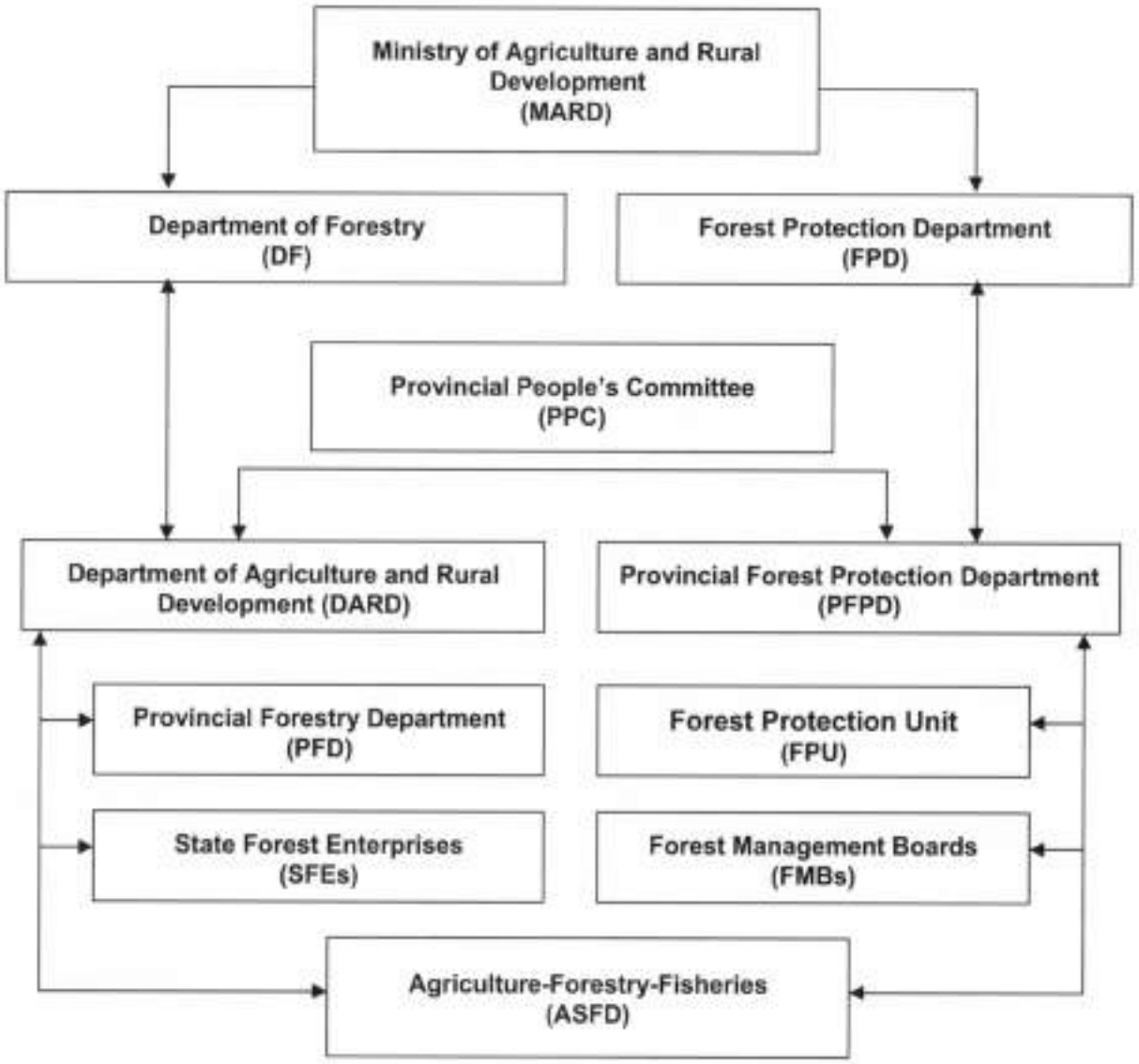


Figure 3 Organisational diagram on the forest management in Viet Nam.

4.4.2 Current Management Regime

According to general classification of forest, the mangrove forest in the North belong to coastal protection forest and nature reserves like RAMSAR Xuan Thuy (Nam Dinh province).

In the Mekong River Delta, the mangrove forest are usually divided into three types of forest (mainly in Ca Mau province), they include Protection forest, nature reserves and production forest.

According to future land use projections in the Ca Mau province, it is expected that by 2005 there will be 13,737ha of protection forest, 15,941ha of Special use forest and 84,833ha of Production forest.

Mangrove areas of Mekong River Delta have been divided into three zones (according to the World Bank project).

Strictly protected zone: is an intended length and adjacent to the coastline, mangrove forest is fully protected. Its width extends hundreds of meters and based on the characteristics of each zone, it will vary from 500 to 1,000m.

Buffer zone: located between the strictly protected zone and economic development zone. The forest cover here is about 70%. The width of this area may potentially reach thousands of metres.

Economic zone: it is situated before the buffer zone in support of sustainable economic and social development. Protection forest and nature reserves as mentioned earlier are the responsibility of the forest management boards and mostly managed by silvo-fishery enterprises, provincial protection forest departments or districts. This area has been allocated to the people for protection on contractual basis.

Some areas of production forest are managed by forest and fishery enterprises. Some are managed by households and individuals, when land has been allocated to them for afforestation combined with aquaculture. Production forest protection contracting and benefit sharing systems are also implemented and based on the above-mentioned general regulations.

The Ca Mau province has concrete regulations as follows: In 1991, Provincial People's Committee of Minh Hai province has issued a Decision No. 64/QD/UB promulgating policy and measures for management, protection and use of land, forest and water resources including the following contents:

- Land allocation of an area of 10ha and forest contacting to people for production purpose;
- People have to reserve 75% of the allocated land for establishing mangrove forest whilst the remaining area is to be reserved for aquaculture activities; and
- Regulate the rights and obligations of individuals and households when receiving land and forest area.

At present, draft forest land planning includes the following regulation details:

- If Individuals and households are allocated more than 5ha, then 70% of the area should be used for forest plantation and 30% of the area for fishery and forestry combination activities;
- If Individuals and households are allocated from 3 to 5ha, then 60% of the area should be used for afforestation and 40% for fishery and agriculture combination; and
- If Individuals and households are allocated less than 3 ha of land, then 50% of the area must be used for afforestation and 50% for fishery and agriculture combination.

Land and benefit sharing policy states clearly that:

- Issuing landuse certificates (Red Book) to households who involve in fishery and forestry production as stipulated by the policy;
- Forest owners of production forest have the right to decide the time of exploitation and are free to sell the products on the market and must reforest within 12 months after exploitation; and
- Households who invest in forest plantation on their allocated land are allowed to benefit 95% of the forestry products from the exploitation.

In brief, management of the three types of mangrove forest has to follow the promulgated laws, decrees and decisions of the Government. In addition, each locality where mangrove forest is found has more specific regulations.

At the present, the constraints and problems in management of mangrove forest are mainly the reclamation of aquaculture development. In some localities where land-use plans for aquaculture development have been prepared but the destruction of mangrove forest for this activity is still not controlled.

In actual management of mangrove forest, the community-based forest management has not yet been formulated. To date only forest are protected by household groups through contracts. Community forest and community-based forest management are being tested in Viet Nam and this kind of management model is being started with mountainous and watershed protection forest areas.

5. ECONOMIC VALUATION OF MANGROVE FOREST

5.1 North East Region

Dong Rui commune, Tien Yen district, Quang Ninh province is selected as a typical mangrove area from the North East region of Viet Nam. The commune has a total area of 5,000ha, of which 4,000ha are tidal flats and where about 3,000ha of mangrove forest exist. These natural forests include *Bruguiera gymnorhiza*, *Rhizophora stylosa*, *Kandelia candel*, *Avicennia marina* and *Aegiceras corniculatum* forest. Mangrove trees in this region are normally not higher than 6m with DBH less than 15cm (Forest Science Institute of Viet Nam, National project on Research on integrated economic and

technical solutions for restoration of mangrove and Melaleuca forest in some distribution area in Viet Nam, 2000-2001).

In term of direct values of mangrove forest, in Dong Rui there are 480 households with 1905 inhabitants (2000-2002). The people in the commune chiefly use the fuelwood collected from the mangrove forest. According to the report by the commune people's committee (2002), annually every person consumes about 1 stere of firewood, therefore about 1,905 steres of firewood per year are consumed within the commune, valued at 228,600,000VND (Based on local price: 120,000VND/1 stere). This is considerable direct benefit from the mangrove forest which plays a crucial role in livelihood of the people in the commune.

In the case of indirect values derived from mangrove forest, the people in the commune collect sea worm in the tidal flats where mangrove forest is present for 5 months of the year. Each month, about 50 tonnes are collected and exported to China with a value of about 3 billions VND per year.

The people also collect clam (Bivalve) all year round such as *Meretri* and *Dodinia*. One person can collect about 8-10kg in one workday, valued at between 48,000-60,000VND/workday. In one year the commune's total income from clam collection is approximately 3.6 billions and a further 1.2 billions VND from squid and octopus. Thus excluding the value of fishery breeding products and fishing production (fish, shrimp, and crab). The people in the commune can earn an annual of about 7.8 billion from only *Mollusca*. This is a great income source compared to the income of 1.5 billion VND derived annually from agricultural production on the commune's 170ha paddy fields. Table 13 analyses economic the economic values of mangrove forest in Quang Ninh province.

Table 13 Analysis of economic values of 1ha of mangrove forest in Quang Ninh.

Unit: VND

Benefit sources				Value	Remarks
Direct value 120,000 (2.6%)		Timber, fuelwood (bole, branches)		120,000	Productivity Timber/ha/year
		Flowers (bee breeding)			Few people
Indirect value 4,590,000 (97.4%)	**Fisheries** 4,510,000	Mollusca	Sea worm	300,000	
			Bivalves	480,000	
			Squid, octopus	130,000	
		Shrimp		3,500,000	Wild shrimps (200kg)
		Crab, fish		100,000	Wild crab, fish (2-3kg)
	Environment services	Mitigation of typhoons, salt water encroachment, dam protection		0	– Quiet sea wave – No dam – Bumpy seashore
		Extension of alluvial grounds		0	Tidal flats eroded
		Conservation		–	–
	Eco-tourism	Visit, eco-tourism		–	–
Total economic values				**4,630,000**	
Investment in plantation		Planting forest		420,000	
		Maintenance, protection		100,000	
Total investment in mangrove plantation *(25 years rotation)*				520,000	Investment value: 20,800/ha/yr

Source: Nguyen Ngoc Binh, 2001.

5.2 Northern Delta Region

The typical mangrove forest selected in this region is RAMSAR Xuan Thuy of Giao Thuy district (Xuan Thuy district in the past), Nam Dinh province.

In this area there are a number of rare and precious species of birds recognised by the world that need to be protected such as *Platalea minor*, *Erynorhynchus pygmeus*. This area is also an eco-tourism and study venue for international and national visitors. Data on the analysis of economic value of mangrove forest is shown in Table 14.

Table 14 Analysis of economic value of 1ha of mangrove forest in Nam Dinh (Coastal area of Red River).

Unit:VND

Benefit source			Value	
			Low price	High price
Direct value 229,653 (1.4% → 0.86%)		Timber, fuelwood (bole, branches)	110,313	110,313
		Flower for honey bee	119,340	119,340
Indirect value 15,362,000 to 26,328,000 (98.6-99.1%)	**Fisheries** 10,703,000 to 21,669,000 (67.1-81.6%)	Shrimp	200,430	266,220
		Crab	801,720	1,604,970
		Fish	361,080	396,270
		Mollusca, bivalve	71,910	143,820
		Breeding of *Dodinia*	9,628,290	19,256,110
	Environment service 3,858,000 (24.2-14.5%)	Mitigation of typhoons, salinity encroachment, dam protection	3,476,160	3,476,160
		Extension of alluvial ground	133,110	133,110
		Conservation	249,390	249,390
	Tourism 801,720 (3-5%)	Visit, tourism	804,720	801,720
Total economic values			**15,953,310**	**26,559,270**
Investment in forest plantation		Planting	1,224,000	1,530,000
		Maintenance, protection	459,000	765,000
Total investment of forest plantation			**1,683,000**	**2,295,000**

*Notes: * Benefit from breeding; Exchange rate: US$1 = 15,300 VND.*

5.3 Southern Delta Region

Three typical mangrove areas in Southern Delta region selected are: (i) Mangrove area of the Ben Tre province, (ii) Mangrove area of Ca Mau, and (iii) Mangrove area of Can Gio, Ho Chi Minh City. Mangrove forest in this region grow very well, with the highest timber productivity in Viet Nam. Excluding the indirect values from fishery production the fishery fishing generates a great benefit within the region. The direct values of mangrove forest in this region are fuelwood and timber. For example, the Thanh Phu forest enterprise of Ben Tre province annually harvests 50ha of *Rhizophora apiculata* plantation at the age of 12 year established in model of *Rhizophora apiculata* plantation in combination with shrimp farming on an area of 700ha (mixture ratio is 70% of the area for *Rhizophora apiculata* plantation and 30% of the area for shrimp farming and canals, water drainage, boundaries) and has gained value of 1 billion and 295 millions VND from selling timber and fuelwood.

In case of the Ca Mau province, *Rhizophora apiculata* plantation aged between 6 up to 35 years annually drops 11-8 tonnes of litterfall (calculated in dry weight), of which the leaves accounts for 38,3-80,9% of the total amount (Dang Trung Tan, 1998). The 80,000ha of *Rhizophora apiculata* plantation annually provides about 712,800 tonnes of dry leaves as an important feed source which is rich in protein to the aquatic species living in coastal areas of the Mekong River Delta.

The Ca Mau province has an estimated area of 2,170ha of mangrove forest harvested annually. The harvesting is mainly operated in *Rhizophora apiculata* plantation. According to Department of Agriculture and Rural development of Ca Mau province (2001), the average forest production between 1991 and 1995 within the Ca Mau province was as follows:

- Timber: 21,844m^3/year with a total value of 8.737 billion VND (mean price is 400,000 VND/m^3).
- Fuelwood:196,990m^3/year valued at 23.638 billion VND (average price is 120,00VND/m^3).
- Charcoal: 488 tonnes/year.

Between 1992 and 1997 the thinning of the mangrove area of Can Gio (Ho Chi Minh City) was annually undertaken. 1,205 to 1,530ha of mangrove forest, mostly *Rhizophora apiculata* plantation was thinned at 14-15 years of age. These plantations produced 12,972-16,863 steres per year of fuelwood at a value of 1.556 to 2.23 billion VND (Vien Ngoc Nam, 2002).

The Mangrove forest of Can Gio plays a vital role in mitigating influence of typhoons, big winds and tsunami. For example, in 1981 there were small areas of mangrove forest and the mangrove

plantations were newly established where the mangrove trees were small. Typhoons, big winds and tsunami damaged approximately 70% of existing houses in the area, causing estimated losses of 10 billion VND. As of 1997, mangrove plantation covered an area of 28,000ha and by this time mangrove trees were quite large. Damages to housing caused by typhoons, big winds and tsunami were estimated at 30% of that during 1981, i.e., 3 billion VND.

Protection forest at Can Gio also plays an important role in fixing sediment and encouraging the deposition of the suspended mud and sand from the water which in turn results in decreasing the turbidity of the river water considerably. For example in 1990 7cm of mud and sand was being deposited on the river bed and passages of Sai gon harbour. Despite there being forest cover of 42%, the annual costs for dredging the passages and the river bed was 21 billion VND. As of 1998 the mangrove cover has increased to 78%, since then the thickness of mud and sand layer deposited in canals, passages and river bed of area of Sai Gon harbour has decreased to 4cm. Consequently the costs of dredging has been greatly reduced 5 billion VND to 16 billion VND per year. Table 15 and Table 16 below show the analysis of the economic values of mangrove forest in Ben Tre in estuary of Cuu Long River and Ca Mau Peninsular.

Table 15 Analysis of economic value of 1ha mangrove forest in the estuary of the Cuu Long River (Ben Tre province).

Unit:VND

Benefit source			Low price	Remarks
Direct value 2,166,700 (19.3%)		Timber	2,041,700	3,500 trees (7,000VND/tree 12 years old)
		Fuelwood	125,000	1,500 trees (30% for fuelwood) (price: 200.000VND/m^3)
Indirect value 9,054,500 (80.7%)	**Fisheries** 9,054,500	Natural shrimp	6,360,000	353kg/ha/year (price: 18.000VND/kg)
		Natural crab	1,200,000	30kg/ha/year (price: 40.000VND/kg)
		Natural fish	200,000	40kg/ha/year (price: 5,000VND/kg)
		Mollusca, bivalve	1,294,500	Meretric: 335,500VND Shell: 959,000VND
	Environment service	Mitigation of typhoons, water rising, salinity encroachment, dam protection	0	– Few typhoons – No dam
		Extension of alluvial ground		Alluvial grounds extended
		Conservation	–	–
	Tourism	Visit, eco-tourism	–	–
Total benefit			11,221,200	
Investment in forest plantation		Seed	375,000	250 kg seed of *R. apiculata*/ 1ha
		Vegetation clearing	300,000	10 workday
		Planting	300,000	10 workday
		Maintenance, protection	360,000	12 workday
Total investment in forest plantation *(12 years rotation)*			1,335,000	Investment level: 112,250 VND/year

Source: Nguyen Ngoc Binh, 2001.

Table 16 Analysis of economic value of 1ha mangrove forest in Ca Mau peninsula.

Unit:VND

Benefit source			Low price	*Remarks*
Direct value 3,060,000 (28.8%)		Timber	2,520,000	6,3m^3/ha/year (price: 40,000VND/m^3)
		Fuelwood	540,000	2,7m^3/ha/year (price: 200,000VND/m^3)
Indirect value 7,567,000 (71.2%)	**Fisheries** 7,492,000 (70.5%)	Natural shrimp	6,330,000	317 kg/ha/year (price: 20,000VND/kg)
		Natural crab	932,000	23,3 kg/ha/year (price: 40,000VND/kg)
		Natural fish	230,000	46 kg/ha/year (price: 5.000VND/kg)
		Mollusca, bivalve	–	–
	Environment service (1.3%)	Mitigation of typhoons, water rising, salinity encroachment, dam protection	–	– Few typhoon – No protection dam
		Extension of alluvial ground	* 75,000	Alluvial ground deposited annually
		Conservation	–	–
	Tourism	Visit, eco-tourism	–	–
Total economic value			10,627,000	
Investment in mangrove plantation		Seed	375,000	250kg seed of *R. apiculata*/1ha
		Vegetation clearing	300,000	10 workday
		Planting	300,000	10 workday
		Maintenance, protection	360,000	12 workday
Total investment in mangrove plantation *(25 years rotation)*			1,335,000	Investment level: 112,250VND/year

Source: Nguyen Ngoc Binh, 1999.

Notes: The price used to calculate the above values are referred to market price at research area.

**: As influence of 1,466ha of Avicennia alba plantation in the West of Ngoc Hien district (Ca Mau province), annually a area extents toward the South China Sea is about 138ha (average data recorded for 60 years) and price for land used for fishery production is 800.000VND/ha.*

6. THREATS TO MANGROVES

6.1 Human Pressure

6.1.1 Effect of Toxic Chemical used during the American War

During 1962-1971, the American military used toxic chemical to destroy an area of 104,939ha of mangrove forest in the Southern region. For example, in the Can Gio mangrove forest, the American military used 665,666 gallons of orange herbicide plus 343,385 gallons of white toxic and 49,200 gallons of blue toxic to destroy more than 10,000ha of mangrove forest. Since 1975, most of mangrove areas damaged by toxic chemicals have been reforested and restored.

6.1.2 Reclamation of Mangrove Forest for Agriculture

During the 38 years, between 1954 and 1992, the coastal areas of Hai Phong province and Quang Yen district – Quang Ninh province approximately 6,039ha of tidal flat areas mainly covered by mangrove forest were converted into paddy fields by dam construction and land reclamation. Some 1,154ha of land has been abandoned due to saline contamination.

From 1976 to 1982 (6 years) Minh Hai province (now split into Cau Mau and Bac Lieu provinces) allocated 26,300ha of mangrove forest land to local people. Many people from Nam Dinh and Ninh Binh provinces who came to Minh Hai province for their new settlement to take advantage of this allocation and to undertake agricultural business. As low terrain and soil with low maturity (very loose mud) thus salty water came out from the center of the field although local people had made a lot of affords to build bordering edges to control salty water. It was costly. Therefore the reclamation areas in mangrove forest for agriculture business after using for a short time had to leave abundant again

(Phan Nguyen Hong, 1999). Obviously now deforestation of mangrove forest for agricultural cultivation no longer happens in Viet Nam.

6.1.3 Over Exploitation of Mangrove Forest

Within the Ca Mau province some silvo-fishery enterprises pay a lot of attention to exploitation of fuelwood and timber to increase economic income. The mangrove forest is therefore significantly declined in quality and quantity and in some areas no forest remain.

6.1.4 Environmental Pollution

The crucial issue at present and particularly for the future is pollution of water source in tidal flat including mangrove forest that are of our concern.

6.1.4.1 Oil pollution

Oil pollution has occurred in tidal flats in river estuaries with presence of harbour, i.e. Hai Phong, Sai Gon, Hon Gai harbors, etc.

At present it has been concluded that in all the coastal areas of river estuaries of Viet Nam there is evidence of oil pollution in both water and soil. If suitable measures for controlling pollution are not implemented properly In the future, the pollution caused by the oil extraction industry and through motor boat transportation will increase.

6.1.4.2 Pollution due to excess pesticide used for agriculture

Viet Nam is an agriculture based country. The production of rice and vegetables is dramatically increasing within the Delta areas along the coast. Results of research conducted in the estuary of the Red River revealed five (5) chemical pesticide residues in the water, sediment and *Zoobenthos* in the tidal flats, they included Lindane, DDT, Endin, DDE and Hepta chlor.

Only two (2) chemical pesticide residues were found within the water of the Red River estuary that are Lindane and DDE. Lindane was found to have a concentration of 0.59mg/litre and DDE of 0.176mg/litre.

In the near future, strict measures need to be implemented for the prevention of pesticide pollution resulting from agricultural cultivation.

6.1.5 Reclamation of Mangrove Forest for Shrimp Farming

In most coastal provinces in Viet Nam (18 provinces) the leaders at all levels, from commune, district and provincial authorities, as well as the people are well aware that strong development of brackish water shrimp farming towards commodity production will create job opportunities and eliminate poverty and hunger.

As calculated only for 8 provinces in the North of Viet Nam, in 1998 production of *Penaeus monodon* reached 838 tonnes, was 1,612 tonnes in 1999, increasing 200% compared to that in 1998 and was 3,090 tonnes in 2000, going up 368,7% in comparison to the production of 1998.

Production value of *Penaeus monodon* in 8 provinces in the North for the year of 2000 is 309 billions VND, although productivity is not high, productivity on average is ranging from 200 to 230kg/ha/year (Sale price of *Penaeus monodon* is 80.000-120.000VND/kg, average is of 100.000VND/kg).

Average interest from shrimp (*Penaeus monodon*) farming fluctuating between 25 millions and 30 millions VND/ha/year. While the real interest for one hectare of salt production in coastal areas is 8 millions VND maximum. One hectare of *Cyperus malaccenisi* plantation is 3-3,5 millions VND/ha/year of interest. And interest for one hectare of high quality rive field (i.e., in Rang Dong enterprise of Ninh Binh province) with 2 crops per year and productivity of 10 tonnes/ha/year, sale price at 1,600VND/kg, is 16 millions VND/ha/year.

In the year of 2000 government board for price of goods has investigated and evaluated cost price of rice production in Northern provinces and the cost price is 1.3 millions VND/tonne of rice. Thus the real interest of one hectare of paddy field with 2 crops per year is only 3 millions VND.

In comparison income of mangrove plantation in Northern coastal provinces is only 1%-2.6% of income of one hectare of fishery production, even fishery farming in this area is extensive farming (breeding source of shrimp, crab and feed is depend on nature).

In the Southern provinces as climatic condition, water environment and soil are more favourable than that of the North in brackish fishery in the coastal area, therefore mangrove area used for fishery development, in particular *Penaeus monodonin* farming, is much bigger than fishery farming in the North. Table 17 shows Area of shrimp pond on mangrove land (salic fluvisols) in Viet Nam from 1994 to 1998; and Table 18 shows Farming area of Penaeus monodon in Viet Nam during 1998-1999.

Table 17 Area of shrimp pond on mangrove land (salic fluvisols) in Viet Nam from 1994 to1998.

Year	Area (ha)	Production (tonne)
1994	230,000	56,000
1995	243,000	60,000
1996	260,000	65,000
1997	290,000	70,000
1998	295,000	70,000

Source: Ministry of Fishery, 2001.

Table 18 Farming area of *Penaeus monodon* in Viet Nam during 1998-1999.

Region	1998		1999	
	Area (ha)	Production (tonne)	Area (ha)	Production (tonne)
The North	6,493	838	9,155	1,612
Central	15,000	9,500	16,000	11,200
The South	184,000	42,000	182,000	40,000
Total	**205,000**	**52,000**	**207,000**	**53,000**

Source: Ministry of Fishery, 2001.

With the high benefits from shrimp farming, there is therefore a tendency in Viet Nam and provinces located along the coast to reclaim spontaneously mangrove areas for brackish shrimp farming and they not follow master planning prepared by the collaboration of forestry, agriculture and fishery departments. The Table 19 shows the damatical changes in mangrove area and shrimp farming area during 1893 and 1999 within the Ca Mau province.

Table 19 Change in mangrove areas and shrimp farming areas in Ca Mau from 1983 to 1999.

Year	Mangrove area (ha)	Shrimp farming area (ha)
1983	117,745	3,000
1988	83,637	28,701
1990	67,550	45,701
1991	58,844	47,480
1992	51,129	67,072
1995	51,492	76,036
1999	64,572	92,000

In case of the Quang Ninh province, during 1995-1996, 14,837 ha of mangrove land area were used for construction of shrimp farming ponds by deforestation of 8,501ha of mangrove forest. And this province planned the area for development of fishery farming in brackish and coastal areas till the year of 2010 is 29,000ha, of which about 13,000ha of mangrove forest will be converted to fishery farming areas.

The Ca Mau province with coastal mangrove area is up to 222,000ha, in 1983 the estimated area of 117,745ha was mangrove forest, but as of 1999 mangrove areas decreased to 64,572ha, reducing 54,8% compared to mangrove area remained in 1983.

In the coming time (from 2003 to 2010) Ca Mau province plans only 114,507ha of mangrove area of the province for forestry, accounting 51,6% of mangrove area of the province where mangrove forest were naturally distributed, reducing 22,863ha compared to that in 2000.

In total coastal mangrove areas planned for management and utilisation by forestry department in Ca Mau province are designated for following functions of forest as follows:

- Protection forest with 13,737ha;
- Special use forest with 15,941ha (Ca Mau cape National park, 2 bird gardens and used for scientific purpose); and
- Production forest with 84,832ha. For this type of forest people are allowed to carry out business on forest land by following silvo-fishery models: 60-70% of the area will be used for mangrove plantation forest (mainly *Rhizophora apiculata*) and a further 30-40% of the area will used for the canals, bordering edges, culverts (mostly semi-intensive shrimp farming). At present 76,000ha of mangrove area within the Ca Mau province is utilised as a combination of shrimp farming and mangrove plantation (Dang Trung Tan, 2001).

At the beginning of August 2002 an interdisciplinary scientific conference was held in Ho Chi Minh City to discuss the development of economics for the Ca Mau Peninsular during the years 2002 to 2005. It was agreed that:

- Fisheries account for 72% of total GDP;
- Agriculture accounts for 22% of total GDP;
- Forestry accounts for 1,9% of total GDP; and
- The remainders are from other economic sectors.

Thus, the forestry sector which produces timber, fuelwood and other non-timber products in coastal areas plays an important role in the local and national economy.

If we do not recognise and understand their importance of mangrove forest in coastal areas, in the future there will be the increasing pressure on mangrove as the results of population growth, decrease of land area for production per capital and increasing need for living.

In summary, the main causes for the destruction of mangrove forest by the human is generalised in order as bellows:

- The fishery farming in is widely developed in the coastal areas;
- The high benefits from fishery farming anddomestic and internaltional markets available for the fishery products;
- Lack of the appropriate and scientific master land use planning for the coastal mangrove land and forest; and
- Inadequacy of policies on utilisation of the coastal mangrove land and forest.

6.2 Natural Phenomena

In Viet Nam there are annually, on average, 4-6 typhoons which travel from the South China Sea to the mainland, with wind speed blowing from 20-40m/second. Typhoons have had a large impact upon coastal mangrove forest and damaged sea protection dam networks where no protective mangrove forest are present. An exception to this is the southern Delta region where typhoons rarely occur.

Erosion is a considerable problem on the Eastern side of the Ca Mau Peninsular i.e., from Rach Goc village to the estuary of the Genh Hao, a length of 30km. Over a duration of 27 years (1964-1991) an area of 7,000ha has been eroded, an annual average of over 259ha of erosion. On average the coast encroaches upon the mainland between 5 to 10m per year and sometimes as high as 15-20m/year.

In the Northern Delta, however, there is a small area along Van Ly coastal area in has not been deposited. During 60 years (1936-1996) an area of 650ha was eroded, annually the coast of Van Ly was eroded towards the mainland over 10ha or 3m/year.

7. CONCLUSION

Based on data and information on mangrove ecosystem collected and analysed, general conclusions can be drawn as follows:

1. Mangrove forest in Viet Nam, although the mangrove area is not so big compared to other countries in the region but it plays a significant role in environment, ecology and socio-economic, in particular in Mekong River Delta. The international and national scientists have indicated the abundance and diversity of mangrove ecosystem with differently distinct communities and about 109 mangrove species. Out of 109 mangrove species there are 37 true mangrove species and 70 associate mangrove species. Direct use value of mangrove species has been known as: 30 species for timber and fuelwood; 14 species for tannin; 21 species for medicine; 21 species for bee farming, etc. Researches have found 516 fish species for brackish water in coastal and estuaries which have high economic value, about 450 zoobenthos species in which many species of shrimp, crab, shell, etc., having a close relation with mangrove ecosystem and contribute greatly to coastal economic development and improvement of local livings.

Bird species in mangrove areas are also diverse and bird grounds have been formed, for example Xuan Thuy, Bac Lieu, Dam Doi. It has presently recorded 386 bird species; 77 species are migrant species, in which many of them are rare species. There are 28 mammals, of which 7 species are recorded in the Red book and there are 54 reptile species found, etc.

Initial economic valuation of mangrove forest showed that indirect use value of mangroves ecosystem occupied 70-90% which is derived from fishery, eco-tourism and environment. Direct use value of timber and fuelwood is not so high, about 10-30%. Obviously the value of mangrove forest is not only the mangrove trees but also diverse mangrove ecosystem and the most abundance is fishery sources. Tow biggest mangrove areas in Viet Nam are Mekong River and Red River Deltas that are also the habitats for many fishery species and oviparous area and maintenance of shrimp larva. Besides, mangrove forest also plays an irreplaceable role in coastal protection such as sea wave, typhoons and floods control. However, to date the research on this value of mangrove forest is still limited.

2. Although the value of mangrove ecosystem is very big but due to inadequate view and understanding of this ecosystem, therefore past pressure on mangrove ecosystem was high and it still shows potential for the coming time. Until 2001, statistical data given by Forest Inventory and Planning Institute showed that mangrove area was 156.608ha. In comparison with 1943, mangrove area was 408.500ha, thus loss of mangrove area was about 62% (In 1982 mangrove area was 252.000ha). It can be seen that mangrove area has been always decreasing even though there has been the affords in protecting and restoring mangrove forest. Major causes for decrease of mangrove area are: Deforestation of mangroves for agriculture production, use of chemical during the war and particularly deforestation of mangroves for fishery farming. The third cause is being the most important. The root cause for that is high benefits from shrimp farming and local people who live in and vicinity of mangrove area are very poor, therefore all people, organisations, enterprise, etc., want to invest in coastal areas, especially mangroves areas, for shrimp farming.

3. Management of mangrove ecosystem is ineffective and lacks of co-ordination and/or incomprehensive co-operation between relevant managing agencies, particularly in local level. Inappropriate management of mangrove ecosystem led to fishery planning approaching mangroves areas in many cases. Mangrove forest is one of important elements of wetland. In national wetland management strategy, it has been indicated the roles of ministries in management of wetland. Mangrove forest is managed by Ministry of Agriculture and Rural Development. Under Ministry of Agriculture and Rural Development are Department of Agriculture and Rural Development, Forest Protection Department, Forest Protection Station, Management Boards for protection and special use forest. Mangrove forest covers small area compared to other forest types of the country, thus less attention is paid to with in forest management system except for the provinces with rather big mangrove area. Knowledge and understanding of managers on mangroves are limited and that cause ineffective management of mangroves.

4. Over the past few years, Viet Nam has paid the affords to protection of mangrove ecosystem. Some national parks have been designated and approved, for example Xuan Thuy and Ca Mau headland national parks, Can Gio protection and nature reserve is approved by UNESCO as biosphere area, Thanh Phu Natural reserve. Non-governmental Organizations also concern the protection and restoration of mangroves, for example Red Cross of Japan, Denmark, Swiss,

United Kingdom, etc. Viet Nam is also implementing a project on reforestation of coastal mangroves forest in 4 provinces in Mekong River Delta including Tra Vinh, Soc Trang, Bac Lieu and Ca Mau. However it must be noted that these affords can not be the force for tendency of decreasing mangrove areas in Viet Nam.

5. To sustainably manage and utilise mangrove ecosystem, there will be three basic aspects need to be considered as below:

Firstly, there will be a need to measure and monitor the changes of mangrove areas to get reliable data on mangrove area for nation wide. Up to date, statistical data on mangrove area is not realistic because the *Melaleuca* forest are also included into mangroves in some places. Furthermore, the classification of natural and planted forest for statistical is also not feasible as it is difficult to differ these two types in reality.

Secondly, strengthen researches, basic inventory to get better and more reliable data on biodiversity of mangrove ecosystem. It is needed to carry out economic valuation for mangrove ecosystem as the basics for sustainable and effective management of mangrove forest.

Thirdly, reinforce management systems of mangroves for different levels, from central down to local, in conjunction with wetland management and inter-sectional relation.

There will also be the need to supplement appropriate policies on management of mangrove ecosystem as the legal foundation for managing agencies and people to take right and responsibilities in mangrove management.

Protection and development of mangrove ecosystem as well as improve livings of local people and communities in mangrove areas are the concern of many countries in the region. That is favourable opportunities for us to co-operate and implement the actions for national and regional objectives.

REFERENCES

Dang Trung Tan, 1998. Effect of tidal flooded regime on Development of Rhizophora plantation, Scientific report presented in Scientific workshop on Mangrove forest in Ca Mau.

Dang Trung Tan, 2001. Mangrove forest of Ca Mau, Scientific report, Forest Science Institute of Viet Nam.

Forest Planning and Inventory Institute, 1995. Planning project on forestry economic development of important ecological regions in Mekong River estuary.

Forest Science Institute of Viet Nam, 2001. Conservation and Management of Intertidal Forest in Viet Nam, Published. FAO – New York.

General Department for Hydrology (2000). Climate of Viet Nam. Hanoi.

Ministry of Agriculture and Rural Development, 2001. Regulation on natural forest management for protection, production and special use forest.

Ministry of Fishery, 2001. Orientation of fishery development in Southern area for period 1995-2010.

Nguyen Ngoc Binh, 1999. Planting mangrove forest, Agriculture Publishing House, Hanoi.

Nguyen Ngoc Binh, 2001. Scientific report on "Characteristics of mangrove soil (salic fluvisols) under different coastal mangrove vegetation in Viet Nam", National research project for period of 2000-2002, Forest Science Institute of Viet Nam.

Nguyen Viet Pho, 1984. Flow of Viet Nam's Rivers, Science and Technique Publishing House, Hanoi.

Phan Nguyen Hong, 1991. Mangrove vegetation of Viet Nam, Ph. D thesis of Biology, Hanoi General University.

Phan Nguyen Hong, 1999. Mangrove forest of Viet Nam, Agriculture Publishing House, Hanoi.

State Sea Programme KT03, 1995. Research project on rationale utilisation of typical ecosystems in coastal areas in Viet Nam"

Vien Ngoc Nam, 2002. Mangrove ecosystem of Can Gio, Scientific report, Forest Science Institute of Viet Nam.

Vu Trung Tang, 1997. South China Sea-Natural resources and environment, Technical and science publishing house, Hanoi 1997.

UNEP/GEF South China Sea Project Co-ordinating Unit
United Nations Building
Rajdamnern Nok
Bangkok 10200
Thailand

Department of Nature Conservation and Protection
Ministry of Environment
48 Samdech Preah Sihanouk
Tonle Bassac, Chamkarmon
Phnom Penh
Cambodia

Guangxi Mangrove Research Centre
92 East Changqing Road
Beihai City 536000
Guangxi Zhuang Autonomous Region
People's Republic of China

Indonesian of Institute Mangrove Research and Development
Multi Piranti Graha It 3 JL. Radin Inten II No. 2
Jakarta 13440
Indonesia

Coastal and Marine Management Office
Department of Environment and Natural Resources (CMMO-DENR)
DENR Compound Visayas Avenue
Diliman
Quezon City 1101
Philippines

Department of Marine and Coastal Resources
92 Pollution Control Building
Phaholyothin 7 (Soi Aree)
Phayathai, Bangkok 10400
Thailand

Research Centre for Forest Ecology and Environment (RCFEE)
Dong Ngac, Tu Liem
Hanoi
Viet Nam

UNEP GEF

"Reversing Environmental Degradation Trends in the South China Sea and Gulf of Thailand"
National Reports on Mangroves in the South China Sea