

# Viet Nam: Mangrove-friendly aquaculture

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## Overview of aquaculture

In 1995, the Ministry of Fisheries and the Institute for Fishery Economic and Planning estimated that aquaculture covers 590,000 ha, of which 250,000 ha are brackishwater shrimp ponds and 325,000 ha are freshwater fishfarms (lakes, reservoirs, garden ditches, paddies, ponds). Aquaculture contributed about 415,280 tons or more than 30% of total fishery production. Molluscs including clams, blood cockle, abalone, and other gastropods contributed about 100,000 tons. The export earning from aquaculture in 1995 was US\$260 million, accounting for 47% of total fisheries export.

Viet Nam's aquaculture systems can be described as extensive and/or improved extensive. The strategy is to quickly increase production of shrimp, fish and other commodities to serve the local and export markets. The average yield of a traditional extensive shrimp farm is low - 70-80 kg/ha -- which is attributed to the decline in natural shrimp seed supply. For improved extensive farming, it is higher, 200-300 kg/ha in the northern part of Vietnam and 400-500 kg/ha in the south.

### *Aquaculture in tidal areas and brackishwaters*

High-value shrimps (*Penaeus indicus*, *P. merguensis* and *P. monodon*) are cultured in brackishwater ponds. There is also integrated farming of *P. monodon* with one rice crop or *Macrobrachium rosenbergii* with one rice crop. Culture of other species including mud crab (*Scylla serrata*), seaweed, marine fishes and special products are highly developed.

Annual shrimp production is about 50,000 tons, mainly from the four provinces of Ca Mau, Bac Lieu, Soc Trang and Tra Vinh in the Mekong Delta. This is about 84% of total shrimp production. The common practice of stocking ponds is through the natural influx of shrimp seed at flood tide during full and new moon.

In the early 1990s, a yearly yield of 350-400 kg/ha used to be possible for extensive and improved extensive farms (Luu 1991, 1993; Tuan & Phuong 1994). Recently, this has dropped to less than 100 kg/ha/year because the density of natural shrimp seed has decreased due to overexploitation of nearshore breeding grounds and inland water ways; the loss of nursing grounds in mangrove areas; environment deterioration created by too much organic matter available in ponds, alluvium deposition, blue-green algae booming; and disease outbreaks.

In the case of improved extensive shrimp farming, farmers depend on hatchery-produced seeds of *Penaeus monodon* and *P. indicus*, if they can afford it.

Apart from shrimp, mud crab, blood cockle (*Arca granosa*), and clam (*Meretrix meretrix*) are produced mainly in southern Vietnam.

From 1993 to 1995, 43 aquaculture projects with national investment of 149 billion VND were implemented by the Ministry of Fisheries under Decree 773 TTg (former 327 CT). The results included: (1) expansion of 15,790 ha of new farming areas, (2) settlement of 3,847 households, (3) creation of jobs for 9,449 persons, and (4) harvest of 18,991 tons of aquatic products of which shrimps make up 1,063 tons.

#### *Mariculture*

Some provinces carry out small-scale marine farming operations with the following species: lobster (*Panulirus ornatus*, *P. longipes*), red grouper (*Epinephelus akaara*), Dumeril's amberjack (*Seriola dumerili*), sea bass (*Lates calcarifer*), pearl oyster (*Pteria margaritifera*), clam, and abalone (*Haliotis diversicolor*).

#### *Aquaculture in reservoirs, rivers and streams*

The use of floating cages and pens was promoted in the country as a whole. Up until 1995, there were 16,000 cages and pens used for fish farming. The main species cultured are grass carp (*Ctenopharyngodon idellus*) and marble sleepy goby (*Oxyleotris marmoratus*). Other species farmed in cages and pens include: hybrid walking catfish (*Clarias* spp), snakehead (*Ophicephalus micropeltes*, *O. striatus*), common carp (*Cyprinus carpio*), giant gouramy (*Osphronemus gorami*), and river catfish (*Pangasius bocourti*).

Viet Nam has a long tradition of culturing special species such as trionychid turtle (*Palea steindachnen*), swamp eel (*Fluta alba*), and tiger frog (*Rana tigrina*) based on semi-intensive and intensive farming systems in small ponds.

#### *Fish and shrimp hatcheries*

By 1995, a total of 840 hatcheries (559 shrimp and 281 fish hatcheries) produced more than 1 billion juveniles of *P. monodon*, *P. indicus*, *M. rosenbergii* and 6 billion fish fry. The country's central coast is by far the largest producer of postlarval shrimp where over 76% of the country's hatcheries are located. In 1994, approximately 1.7 billion shrimp postlarvae were produced from 570 hatcheries.

## **Mangrove areas**

#### *Existing mangrove area*

Viet Nam had about 400,000 ha of mangrove forests in the 1940s (Mauran 1943) which was mainly distributed in the southern part of the country (250,000 ha). By the 1950s, this forest was reduced to 290,000 (Rollet 1956) because of overexploitation for wood, charcoal and firewood. By 1962, this was further reduced to 286,000 ha (Ross 1975). The 1962-1971 war with the US further destroyed 104,939 ha, of which 52% are located in Ca Mau Cape (Hong 1993). After the war, the reduction of mangrove areas was caused by its conversion to agriculture and shrimp farming. Up to the end of 1991, the area of mangrove forest in Minh Hai province had decreased to 47,840 ha (Hong 1993).

#### *Distribution of mangrove forest*

More than 50 mangrove trees have been identified (Hong 1993a,b; 1995; 1997) with the following distribution (Figure 1):

**Region 1**

The northeast coastal region from Mong Cai (Quang Ninh province) to Do Son (Hai Phong City): Mangrove forest expanded because a shelter island existed outside of the mangrove forest band. The main mangrove trees are *Rhizophora stylosa*, *Bruguiera gymnorrhiza*, *Aegiceras comiculatum*, *Kandlia candel*, *Avicennia marina*. The height of mangrove trees is limited at 1.5-7.0 m due to the cold weather/winter season.

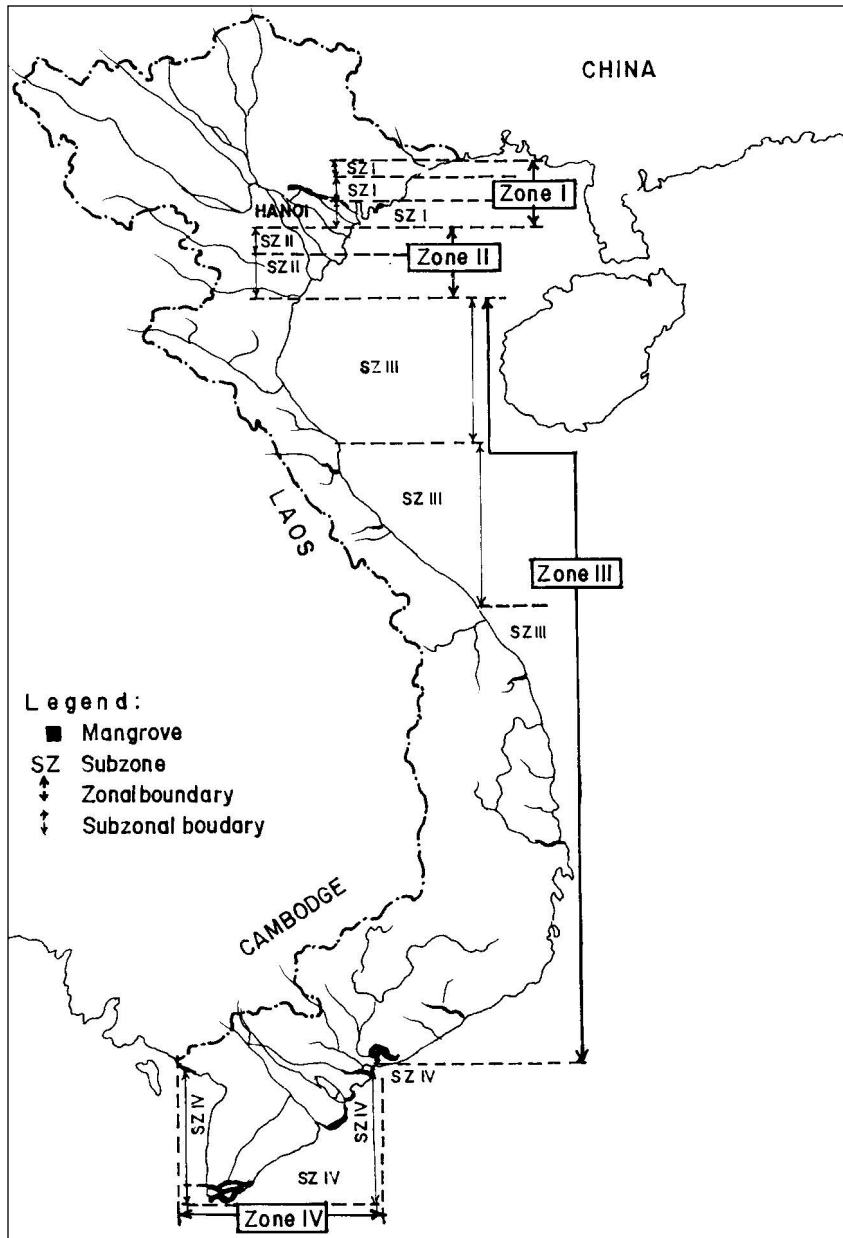


Figure 1. Distribution of mangrove forest in Vietnam (Hong 1993)

- Region II** *Coastal region from Do Son to Lach Truong river mouth (Thanh Hoa province):* Due to the lack of shelter islands, the mangrove forest is not so developed as other typical brackishwater trees such as *Sonneratia caseolaris*, *Kandelia candel*, *Aegiceras comculatum*, and *Acanthus ilicifolius*.
- Region III** *Central coastal region from Lach Truong river mouth to Vung Tau:* Because of the narrow tidal flat, slope coast and typhoons, mangrove trees consisting of *Rhizophora apiculata*, *R. stylosa*, *Aegiceras comiculatum*, *Bruguiera gymnorrhiza*, *Avicennia alba* are located at the river mouth.
- Region IV** *Southern coastal region from Vung Tau to Ha Tien:* Due to suitable conditions -- wide tidal flat, rich alluvia from Dong Nai and Mekong rivers, rare typhoon -- the mangrove forest is highly developed with many trees such as *Rhizophora apiculata*, *R. mucronata*, *Bruguiera sexangula*, *B. parviflora*, *Avicennia alba*, *A. officinalis*, *Nypa fruticans*, *Ceriops decandra*, and *C. tagal*.

#### *Value of mangrove resource*

Generally speaking, mangrove forests play a very important role in coastal protection and land reclamation. Along the coast, they buffer the impact of wave action and slow down erosion. They also provide natural protection of sea dikes. Along those stretches of the coast where accretion takes place, mangroves colonize the newly formed mud flats, and trap and stabilize sediment.

Mangrove trees provide a variety of valuable products such as timber, fuelwood, charcoal, tannin, among others. The leaves of the *Nypa* palm are highly valued as roofing material. The total biomass of mature *Rhizophora apiculata* in Viet Nam's forests was measured to be 276,829 kg/ha of which 57% or 158,034.02 kg are timber (Tri 1986).

The high amount of leaf litter produced by the mangrove trees provides the base of natural food chains in the estuarine and coastal waters. During decomposition, the leaves are enriched by proteins from microorganisms that break down the leaves. This protein-enriched plant detritus provide the main food for juveniles of commercially important penaeid shrimps that spend part of their life cycle in brackish tidal swamps. Plant detritus are transported by the current seaward and the nutrients released from the mineralization process support primarily productivity in estuarine and coastal waters. Besides, many estuarine organisms feed directly on detritus.

Mangrove swamps are nursery areas for a large number of marine species (eg., penaeid shrimps, mud crab, fish and molluscs).

#### *Zonation and succession*

The following description of mangrove species zonation and distribution is mainly based on data provided by Dr. Phan Nguyen Hong (Hong *et al.* 1993; Hong 1997). The main factors determining zonation are salinity and soil properties. Along the coastline, on newly accreted land with a substrate of deep, soft mud affected by low tide, pure stands of *Avicennia alba* are found. Scattered stands of *A. officinalis* and *Bruguiera sexangula* also occur. Mixed communities of *Rhizophora apiculata* - *B. parviflora* or *A. alba* - *R. apiculata* occupy areas flooded by the tide.

On high land flooded only during spring tide and with loamy substrate, a community of *Lumnitzera racemosa*-*Ceriop tagal* is found. On high land near the sea, a pure community of *Exoecaria agallocha*

is anchored on firm mud and a secondary forest of the palm *Phoenix paludosa* can be found.

The rhizomatous palm *Nypa fruticas* is characteristic of areas which are slightly brackish though regularly flooded. In parts of the mangrove forest that are rarely flooded and where trees have been cut, the giant fern *Acrostichum aureum* can be seen. On the severely eroded sandy flats of the east coast of Ca Mau peninsular, from Bo De to Dat Mui, an almost pure stand of *Avicennia manina* is found. In rapidly accreting areas, *Avicennia alba* has not been replaced by *Rhizophora apiculata*, but instead the mangrove has developed into a mixed community of *A. alba* - *A. officinalis*.

The zonation and succession of mangrove vegetation at Ca Mau Cape is illustrated on Figure 2.

*Wildlife*

Reptiles, birds and mammals originally made up the terrestrial wildlife fauna of the southern mangrove forests (Hong & San 1993). Some surveys on wildlife trade have been carried out, showing a huge number of reptiles and amphibians traded on the local market for consumption or for export. Tigers, deers, wild pigs and crocodiles existed in mangrove forests long ago, but have disappeared because of overhunting and destruction of mangrove areas. Rehabilitation of mangrove forests can increase population of such animals as wild pigs, crocodiles, monkeys, water birds, fishes and shrimps like in the case of Can Gio District, Ho Chi Minh City when 20,000 ha of new mangrove trees were replanted.

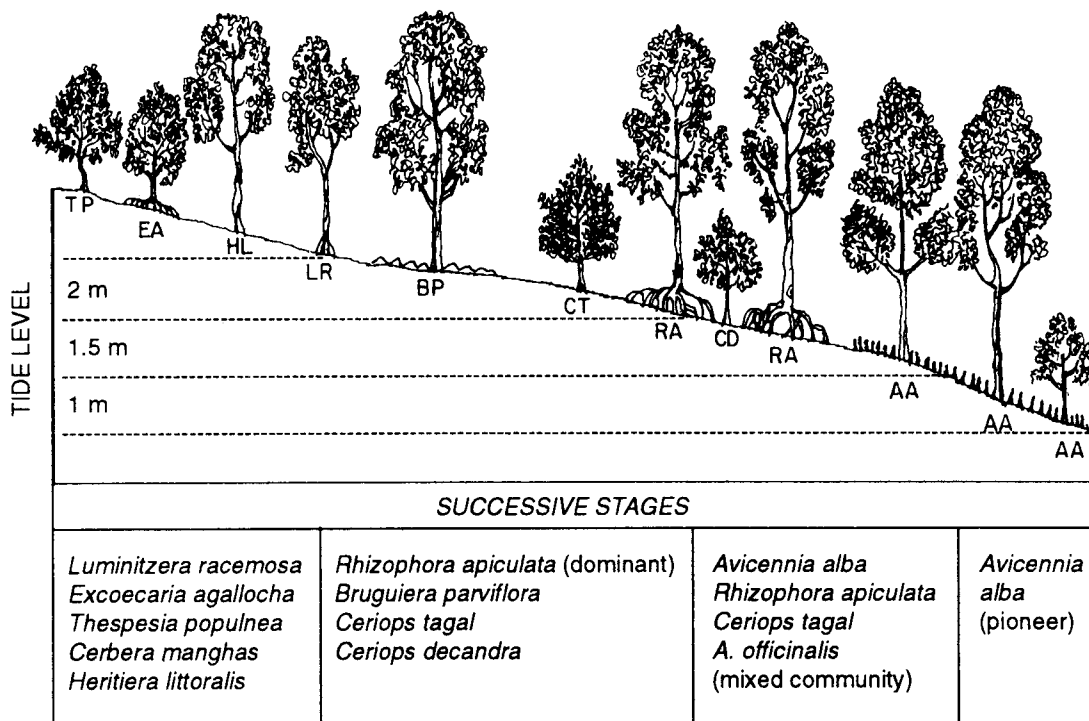


Figure 2. Zonation and succession of mangrove vegetation at Ca Mau Cape (Hong & San 1993)

The mangrove forest is a good habitat for some stages of the life of fishes, shrimps, crabs, clams, oysters and so on. Humus is a very important food source.

Mangroves in Vietnam have very abundant aquatic life. For example, 80 species of crustaceans, 160 species of molluscs and 250 fish species were identified by Vietnamese scientists. Recently, 106 species of algae, 102 of zooplankton, 113 of zoobenthos, 50 of marine and brackish fishes and 17 of shrimps were recorded in an area of 4,000 ha mangrove forest located in Ben Tre province (Xuan *et al.* 1998).

### **Some causes of mangrove destruction**

#### *Chemical war carried out by the US*

About 159,000 ha mangrove area in southern Vietnam were destroyed by defoliant sprays during the American-Vietnam war, with loss of timber calculated at 21,928,611 m<sup>3</sup> (Hong 1997).

#### *Overexploitation*

The mangrove forest has been overexploited by local communities for poles, charcoal/fuelwood, woodchips, medicines, and food in times of famine.

#### *Conversion to shrimp ponds, agricultural land*

Thousands of hectares of mangrove forest have been converted into shrimp ponds in the last decade. But yields of shrimp and crab are low even after 2-3 years of operation because of the degradation of the pond environment. Pond design is part of the problem, as it allows very limited water exchange (pond is either too big or too small, and there's only one sluice gate). The locals usually abandon the old ponds, and clear cut the mangroves to build new ones. Thousands of hectares of protected coastal mangroves from Quang Ninh to Ninh Binh provinces have been destroyed in this manner. From 1983 to 1995 alone, about 66,253 ha of mangrove forest in Minh Hai province have been converted into shrimp ponds (Cuong 1996).

Due to the lack of agriculture land, some mangrove forest areas have been destroyed and converted into ricefields and subsidiary land although these lands are not suitable for agriculture. Crop yield is very low because of freshwater shortage and acidification. In the case of Quang Ninh and Hai Phong provinces, about 50,000 ha coastal areas have been fallowed (Hong *et al.* 1995).

#### *Other causes*

Some mangrove areas have been destroyed to build residential areas, industrial areas, roads, fishing and coal ports. Mangrove forests near industrial areas could not regenerate normally due to waste waters with high concentration of toxicants.

### **Consequences of mangrove destruction**

#### *Decline of biological resources*

Mangrove destruction not only decreased timber sources but also lowered species composition and population of aquatic organisms and other animals (eg., mammals, birds, reptiles and amphibians). For example, the densities of wild shrimps *Penaeus indicus* and *Metapenaeus* spp in the Mekong Delta decreased to only 1 shrimp/260 m<sup>3</sup> and 1 shrimp/45 m<sup>3</sup>, respectively (RMFP 1998).

*Increasing fallowed land and CO<sub>2</sub> concentration*

Mangrove soils have chemical (salt and acid) and physical features unsuitable for agriculture. Insufficient freshwater causes soil degradation as had happened so often in the past. Besides, a huge amount of organic matter from the mangrove is decomposed; hence, adding to higher atmospheric carbon dioxide (CO<sub>2</sub>) concentrations and contributing to global warming.

*Salinity intrusion, silt accumulation, soil and water pollution*

Shrimp ponds significantly decrease the areas for receiving marine and brackishwaters. So, during the dry season, seawater goes further inland through the canal and river systems, affecting rice fields and eroding the banks of canals and rivers.

Silt can not be transported but builds up because shrimp dikes and rice paddies bisect some small rivers and tributaries. Some of these tributaries may also become eroded.

The concentration of toxicants such as H<sub>2</sub>S, FeO, NH<sub>4</sub>, chemical fertilizers, pesticides, and oils tends to increase in some mangrove areas which have been converted into shrimp ponds and agriculture lands.

## **Legislation, policies and regulations**

*Legislation and policies*

The government has issued in 1991 a law protecting and developing forestry in which mangrove forest preservation in national coastal areas are included. The government has also developed a number of policy measures.

To attract local people to take part in mangrove preservation and reforestation, an area of 5-10 ha is allocated to households based on Government Decision No. 202 dated 2 May 1994. A Contract of Leased Forest Land which is signed by the Director of SFE and household head and registered at the People's Committee of Commune defines the rights and obligations of contracting parties.

The forestry policy towards the year 2010 aims to:

- conserve natural resources (e.g., watersheds, biodiversity)
- make forest development and land use ecologically and socially sustainable
- give long-term benefits to rural population and country economy (i.e., improve living standards, develop the mountainous and coastal areas)

Viet Nam also became a contracting party to the RAMSAR Convention on January 20, 1989 and had designated the mangrove islands of Xuan Thuy district in Nam Ha province for inclusion in the RAMSAR list (Duc 1990).

*Regulations*

Some regulations have been issued and implemented, as follows: (1) densities of planted mangrove must be 10,000-20,000 trees/ha; (2) the first to be thinned will be stands 9-10 years old, next will be stands 18-20 years old; and (3) for shrimp farming, 70% of the farm area must be reserved for mangrove planting.

Under Decision 327 dated 15 September 1992, some Provincial Forest Development Plans were prepared. The objectives of these plans are reforestation and rehabilitation of coastal and estuarine mangrove ecosystems; specifically, protection of coast against erosion, reclamation and stabilization of newly accreted mud flats, rehabilitation of nursing areas for economically important fish and shrimp species, sustainable forest production, improvement of income levels and the standard of living of local people.

At regional level, the Mekong Delta Master Plan has identified 10 forestry projects since 1993. Four of these projects are located in the coastal zone and much emphasis was put on re-establishing mangrove protection belt, protection of nature reserves, and creating new ones in mangrove areas.

Between 1965-1974 after liberation, about 2,783 ha of mangrove trees were replanted in Minh Hai province to protect guerrillas, and from 1975 to 1990s about 63,323 ha have been replanted to mangrove trees (Hong 1997)

## **Organizations to support mangrove-friendly aquaculture**

### *National level*

The Ministry of Agriculture and Rural Development (MARD) has assigned the tasks of mangrove preservation and mangroves development to the Department of Forest Management and Control (DFMC) and Department of Forest Development (DFD), respectively.

### *Provincial level*

Under the leadership of MARD and the Provincial People's Committee (PPC), a Sub-Department of Forest Management and Control (SDFMC) has been established in all coastal provinces. The SDFMC manages the Boards of Mangrove/Melaleuca Special Use Forest or Mangrove Forest Reserve. The Sub-Department of Forest Development (SDFD) belonging to the Provincial Department of Agriculture and Rural Development (PDARD) supplies concrete guidance in mangrove rehabilitation and protection to local Forestry-Fishery Enterprises (FFE).

## **Land-use options in mangrove areas**

### *Ecological considerations*

Shrimp culture can be considered destructive to mangroves, however, it is the best way to increase the value of the mangrove ecosystem to support the poor. The problem is building mangrove-friendly aquaculture models to ensure sustainable development. The coastal areas of the Mekong Delta practice these models:

- **Mixed shrimp farming-mangrove forest**

About 3 ha (300 x 1,000 m) are reallocated to each household for mangrove planting and for canal excavation to culture shrimp. FFE gives capital for the household to plant *Rhizophora* at a rate of 1,000-2,000 trees/ha. The household invests money and labor in excavating canals and in building embankments that are 5 m wide with one outlet and one inlet sluice gate. The ratios of pond size including embankments and mangrove forest are 32% and 68%, respectively (Binh 1994). At neap tide, the seawater just wets the ground, so the trees grow well. The low tree density prevents too



much shading in canals and gives enough light for phytoplankton and enough surface and dissolved oxygen for aquatic organisms. The fanning method is traditional extensive without additional supply of food and shrimp seed, and the highest yield is estimated at 200-250 kg/ha/year. The soil in this model is not degenerated due to good water exchange; it is also usable for a long time (about 7 years now).

- **Mixed mangrove forest-shrimp farming**

FFE invests in felling miscellaneous trees, replants mangrove, divides the area into 5-ha squares on an average, and allocates it to households for forest protection and shrimp farming. The household invests in digging canals and building embankments on 30% of allocated land. Besides a surrounding canal system in the *Rhizophora* planting area, there are 2 canals of the same size separated by a 6-m bank in order to increase the area of unshaded water surface suitable for primary production by phytoplankton. *Rhizophora* are planted at a density of 10,000 trees/ha.

#### *Socioeconomic considerations*

In principle, no economic activities such as aquaculture, farming, and settlement are permitted in the Protection Belt and Full Protection Zone (FPZ) except controlled thinning, collection of dead forest products and protection of breeding and nursing grounds. But in practice, relocation and resettlement of all existing farms and people living in these zones would be costly and could lead to social problems.

To wisely use the inland mangrove forest and to reduce the pressure from the human population on the FPZ or Core Area, some conditional human activities — e.g., traditional extensive shrimp farming mixed with mangrove forest, cage and pen aquaculture — in the BP are allowed, aimed at sustainable use of natural resources, creation of jobs and increasing income of the poor.

In the Economic Zone, human activities are concentrated on settlement, development of a long-term mangrove forest (main product) in combination with short-term aquaculture (additional product for daily life).

Other farming models may be explored to diversify products, reduce risks from one crop (shrimp), increase household income, and provide locally produced food. This could include culture of crabs and fishes in ponds and subsidiary crop production such as vegetables, banana, cassava, cherry in the raised beds and land near the house.

### **Existing programs on sound utilization of mangrove areas**

In the Mekong Delta, some projects and studies relating to aquaculture in mangrove areas are being done:

#### *MILIEV - Rehabilitation of Mangrove Forest Project*

This Netherlands Government 3-year technical assistance project started in March 1996. It aims to achieve three main goals: providing natural protection of the coast, contribution to sustainable aquaculture, and restoring biodiversity. It has an aquaculture component which includes some experimental farming systems such as improved extensive shrimp fanning, sea bass cage culture, mud crab cage culture, and fish-and-pig farming carried out in 184 FFE, Tam Giang I FEE and Dam Doi FFE (Ngoc Hien District, Ca Mau province).

#### *Semi-Intensive Shrimp Culture Project*

Under the Mekong Delta Master Plan, a feasibility study was undertaken for shrimp culture-cum-mangrove reforestation on two pilot areas nearly 3,000 ha located at Ba Tri (Ben Tre province) and Ganh Hao (Ca Mau province).

#### *Mixed Shrimp Farming-Mangrove Forest Models in the Mekong Delta*

A pilot program to improve extensive shrimp farming mixed with mangrove forest was carried out in 1995-1998 by the Ministry of Fisheries/RA2-ACIAR/AIMS in cooperation with The Centre for Mangrove Forest Research. The pilot farm was on 12,000 ha located at Tam Giang III FFE and 184 FFE, Ngoc Hien District, Ca Mau province. Specific objectives of the project were to investigate factors controlling shrimp yields and wood production from existing shrimp farming-mangrove forest systems and to evaluate different culture options for shrimp and mangrove forest management. During the first phase, recommendations with respect to pond design, management, water quality and shrimp/crab seeds supply were detailed.

#### *Integrated Management of Coastal Resources in the Mekong Delta*

The project is jointly proposed by Can Tho University and Wageningen Agricultural University (Netherlands). The 3-year project has strong training and research components that focus on socio-economic aspects of water management in coastal farming systems, remote sensing, land use planning, ecology and environmental impact assessment. The study site (about 10,000 ha) will be located in Vinh Loi District, Bac Lieu province.

## **Strategic plans for improving mangrove areas**

#### *Strategic plans*

- Zoning of coastal mangrove areas (Protection Belt, Full Protection Zone, Buffer Zone, Economic Zone, Protected Area, Core Areas, Conservation Areas, Bird Sanctuaries)
- Establishment of management measures for each zone and area
- Community development (extension and education, transfer of technology, upgrading of infrastructure)
- Economic policy (land allocation and making contract with farmers to protect mangrove forest for long periods)
- Improvement of credit system serving the poor (low interest and long borrowing period)
- Controlling human population in mangrove forest areas (limitation of human habitation)
- Management of mangrove areas (based on a combination of some sectors such as agriculture, forestry, fisheries and aquaculture, environment, and land management)

#### *Development programs*

##### • **Integrated Provincial Master Plans/Projects**

A feasibility study was undertaken for the South Mang Thit Integrated Irrigation and Drainage Project under the MDMP study. This area includes Tra Vinh province. Project interventions are water control and regulatory works, mangrove forestry, fisheries and aquaculture, drinking water supply, and public health and sanitation

##### • **Coastal Wetlands Protection and Development, Southern Mekong Delta**

This Euroconsult-supported technical assistance project was carried in the coastal areas belonging to the provinces of Minh Hai, Soc Trang and Tra Vinh in 1995 to 1996.

One of the main objectives is providing of nurturing functions for fisheries and provision of support services for the mangrove forestry and aquaculture in protected wetlands and key surroundings areas

- **Mangrove/wetland management project in Thanh Phu, Ben Tre Province**

This 3-year project (1998-2000) is supported by the Mekong River Commission for the purposes of mangrove forest resources inventory and management strategy for coastal mangrove wetland reserve

- **National project of planting 5 million ha of forestry up to the year 2010**

## **Recommendations (national and regional levels)**

### *Creating awareness through education and training*

To ensure sustainable development of mangrove ecosystems and resources, the awareness of local people should be increased through education and training courses. Likewise, the participation of the local community in the protection and conservation of mangroves should be encouraged.

Topics that discuss the value of mangrove forest, mangrove forest planting and management, sustainable mixed aquaculture farming-mangrove forests systems can be taught to farmers, women, children and FFE management staff.

### *Promoting research on critical areas, sustainable management plans*

Research on mangrove ecosystems and biodiversity in some zones such as Accreting Areas, Protection Belt, Full Protection Zone, Core Areas, Special-Use Mangrove Forest should be carried out. It could cover classification of mangrove functions and mangrove valuation, zoning and management, strategies of economy and occupations which mitigate the devastation brought by people, and improvement of mixed aquaculture-mangrove forest farming systems.

Some specific studies are suggested:

#### **Assessment studies**

- determining the value of mangrove resources including natural shrimp seed stock
- possibility of natural mangrove regeneration in different areas located on high land or fallow land
- pollution levels in mangrove and river mouth areas created by oil, fertilizers, pesticides and heavy metals

#### **Impact research**

- on agriculture and aquaculture development in mangrove forest along the coast of the Mekong Delta and vice versa

#### **Socio-economic studies**

- on mixed aquaculture farming-mangrove forest systems which provide households with reasonable income and benefit

#### **Mangrove-related fisheries**

- quantitative study on the processes of energy flow, nutrient exchange and exchange of aquatic organisms between mangrove swamps, estuaries and coastal waters

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