

Mangrove destruction for shrimp rearing in Minh Hai, Viet Nam: its damage to natural resources and the environment*

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Characteristics of the Mangrove Ecosystem at Ca Mau Cape Minh Hai

Minh Hai has the widest mangroves in Viet Nam. The mangrove vegetation at Ca Mau Cape develops faster than in other areas in the number of species, tree size, forms of communities, as well as biomass and biological productivity.

The Ca Mau vegetation consists of 32 true mangrove species and 32 associate mangrove species.

The growth rate of the mangrove in Ca Mau is fast (planted *Rhizophora* grow by 0.58-1 m/year in height and 0.7 - 0.8 cm/year in diameter). In a forest belonging to Dat Mui Forestry Enterprise where *Rhizophora apiculata* account for more than 90%, the total biomass is 276.83 kg/ha as mentioned by Hong and Tri, 1984. Compared to the biomass of 286.80 kg of the 28-year old mature forests in Malaysia, the biomass of Ca Mau *Rhizophora* forests is only a little smaller but still larger by 251.28 kg/ha of the *R. mangle* forests south of Florida.

The productivity of mature forests is also high. The 1984 report of the Forest Investigation and Planning Institute showed an annual timber and firewood yield of 349.88 m³ from one hectare of mature *Rhizophora* forests (with 305 stands of the average height of 25 m). Middle-aged *Rhizophora* forests (673 stands/ha average height 22 m) yielded 278.16 m³ of timber and firewood.

Ca Mau mangroves have outstanding characteristics due to favorable local natural conditions: hot, humid climate; low topography,

*A complete list of references may be obtained free of charge upon request.

(regularly inundated with diurnal tide); and the rich soil from the alluvia flowing in from the Mekong River and the detritus produced by trees, algae and animals that accumulate on the forest ground. As a result, the content of humus and total composition are high whereas the contents of exchanging actions harmful for trees' growth like Fe²⁺ and Al³⁺ are usually low. The rich dense system of rivers and canals of Ca Mau Cape rapidly transport tide water and rain water to mangrove forests. Though receiving very little water from upstream (more than 2,400 mm/year), the salinity is not too high and does not vary much due to the high rainfall. Thus, the trees' physico-biological function are not affected much.

These natural conditions are also favorable for the natural regeneration and rehabilitation of the forests.

However, under serious over-exploitation of timber and firewood to build embankments for large shrimp ponds, the soil quality degenerates and the tree growth is stunted due to insufficient entry of tide water into the ponds and forests.

In some areas where evaporation is high due to strong sunshine and high temperature and when tide water exchange is absent, the salinity rises fast, adversely affecting and killing the local fauna and flora.

The Role of Mangroves on Minh Hai's Marine Resources

The humus from fallen mangrove leaves and other plant parts that were decomposed by various micro-organisms, serve as food for

aquatic animals. Moreover, the intricate root system of plants retains alluvia and creates an appropriate environment for many zoobenthos.

Mangroves can serve as a source of organic matter to increase the yield of the coastal area. They are a place for reproduction and growth, and a permanent shelter for many valuable sea products such as fish, shrimps, crabs, and molluscs.

A number of researchers have shown that high-yield fishery is mainly carried out in the rivers, coastal areas and estuaries with mangroves. This is due to the high concentration of nutrients brought by rivers from upstream areas and by tides from the sea. A close relationship between the yields of mangroves and the quantity of sea products caught in the locality exists. In Western Australia, 67% of the total amount of commercially valuable sea products are collected in mangroves. Hamilton and Snedaker in 1984 estimated that 90% of sea organisms, for some periods, or their whole life, live in estuaries with mangroves. For many marine creatures, this relationship is indispensable.

The primary abundant food is plant organic matter, also called "humus". It comes from the decayed plant remains as leaves, branches, buds, and roots from mangrove plants. According to Snedaker in 1978, the dry mass of fallen leaves from mangrove plants in the South of Florida is 10,000 - 14,000 kg/ha/year, among which 79.71% are leaves. Ca Mau *Rhizophora* forests can provide the ecosystem with 8,400 - 12,000 kg of leaves/ha/year (dry mass).

All year round, leaves fall in rivers and channels, on the forest ground, and are then carried away by tides. The decaying process takes place the whole year.

When leaves are still on trees, some fungi live as parasites on them (on the surface or under the epidermis). As they fall into the tidal water, after 24 hours, they begin to undergo the decaying process by micro-organisms: first by *Phytophthora* (in the Phycomyces family), then by *Fusarium* and *Penicillium* in the family of Fungi imperfecti. After 2 or 3 weeks, they are replaced by other microorganisms such as *Zelerion* and *Lulozthia*. Porous tissues are decomposed first and cellulose and lignin are decomposed last. In the decomposition process, the protein content in leaves increases by 2 - 3 times. In analyzing and comparing amino acids in fresh and decayed leaves, a researcher in 1970 found a general increase of amino acids (both with and without protein) on the leaf surface and in the leaf composition, which is considerably larger in decomposed leaves than in the fresh ones.

On high lands, fallen leaves, when not carried away immediately by the tide, are decomposed on the site, mostly by earth creatures on the forest ground. The product of this decomposition process is mainly easily-dissolved organic matters concentrating at the soil surface. After some time, the amount of fallen leaves accumulate and so does the organic compounds. Finally, when the whole area is inundated with tide or rain water, these organic matter flows with the tide to canals, rivulets, and estuaries to enrich the food source for the creatures in the local estuaries and the East Sea.

Mangroves provide food directly (humus) and indirectly (through humus-eating animals as prey) for big fishes and some other species of predators. Therefore, the composition of the fauna in the mangrove areas is abundant and diversified. Preliminary surveys in Minh Hai mangrove area

show 64 fish species in 35 families, 25 shrimp species, 22 reptile species, 67 bird species, and 21 animal species.

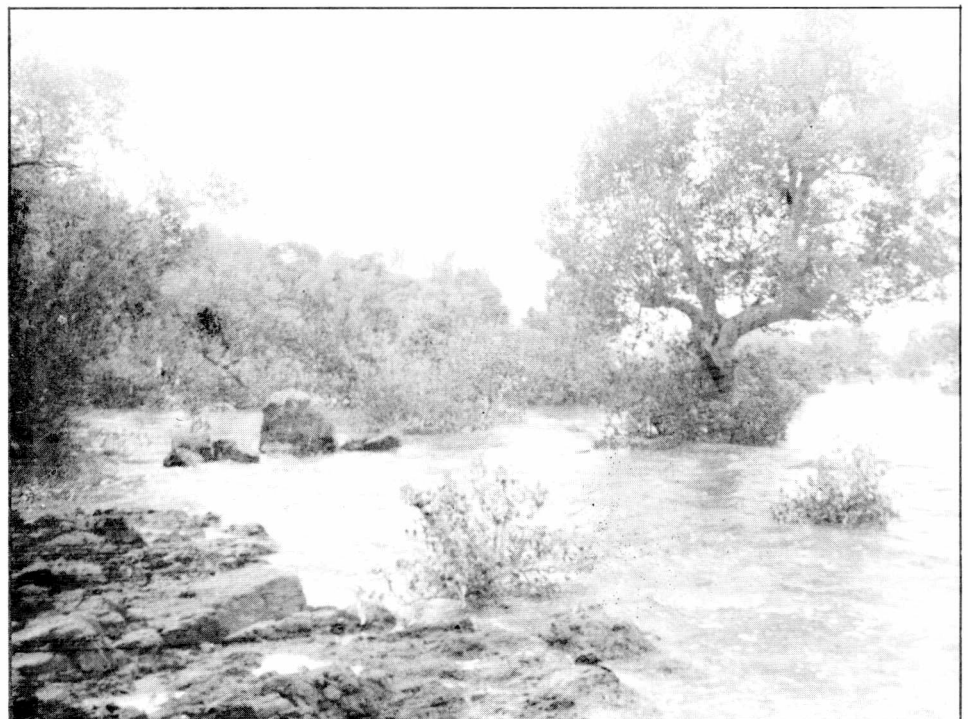
Young shrimps, crabs, and fish in the mangrove areas are very abundant. Comparison of the composition of fishes and shrimps in the mangrove, the sandy coastal and sea grass areas show that mangrove areas had greater quantity of larvae in all seasons of the year. A conclusion can be drawn that mangroves are the main feeding ground of the larvae of shrimps, crabs, and some other species of fish and oysters. Mangroves provide the seed source for aquaculture because the larvae and post-larvae of many cultured species such as banana shrimps, crabs, oysters, and fish live in mangrove areas.

The tidal flats with mangroves are also the habitat of many species of water birds and migrant birds. The main food of these birds are small marine creatures (fish, shrimps, small crabs, shells). Thus, many bird species are attracted to the area to search for food, forming a diversified ecosystem. The

birds produce a considerable amount of feces, which facilitates the trees' growth and increases the amount of organic matter as feed for aquatic creatures and benthos.

Mangroves are also very useful in regulating the climate, protecting the community, reducing riverside erosion, and expanding the mainland seaward. At the west side of Ca Mau Cape where soil accretes rapidly, mangroves also expand fast. Within only 30 years (1964-1994), two islets have been formed at the Ong Trang river mouth. Con Trong has already had nearly all species of the local mangroves and *Avicennia*, and *Kandelia* have covered all of Con Ngoai Islet.

When shrimp breeding had not yet developed, the life of most inhabitants in Ca Mau depended on the mangrove resources. People who had capital used boats for fishing while the poorer ones caught fish by netting along rivers and canals. The poorest people lived by catching crabs, oysters, and shells on the forest ground. The local dwellers did not have to fear starvation because



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the marine creatures were so abundant. But since the forests were destroyed to build shrimp ponds, many aquatic creatures lost their habitat and as a result, the above-mentioned jobs have decreased.

Causes of the Deterioration of Minh Hai Mangrove Resources

Overgrowth of Population. Minh Hai, the province with the largest extent of mangroves in Viet Nam (149,982 ha of mature forests in 1943) and 50,000 ha of non-classified forests) is also the area with the most severe deforestation. In 1994, there are only 65,779 ha of forest left, mainly secondary and newly-planted forests. An important

inhabitants consisted of 4,703 individuals in 505 households and increased to 8,600 individuals in 1,400 households in 1991. From 1991, another sudden increase has been shown owing to the building of embankments, thus, invading the immature accretion west of Ca Mau Cape to build shrimp ponds. Until 1994, thousands of people from various provinces have come to this area. They destroy the forests to build shrimp ponds, cut down the trees for timber to build houses, consolidate the pond embankments to make sluice gates, etc. At the end of 1994, most of the mangrove area of 4,461 ha in Dat Mui Commune were destroyed for shrimp

Cai Nuoc now have no remaining forests.

Poor management and utilization of Mangroves in Minh Hai. In the early 1980's, due to a shortage in export items, marine shrimp farming was encouraged by the State to earn foreign currency. This created a precedent for local inhabitants to destroy the mangroves indiscriminately. Today, the policy has been evaluated to have a lot of loopholes, especially with regards to the allocation of land to army units, police units, provincial committee offices, and district committee offices.

Furthermore, individuals allocated with land who were not able to culture shrimps sold their land to people coming from other parts of the country. Though the Provincial People's Committee had issued legal documents prohibiting the destruction of forests and the attendant planning and utilization guide, they have not been effective.

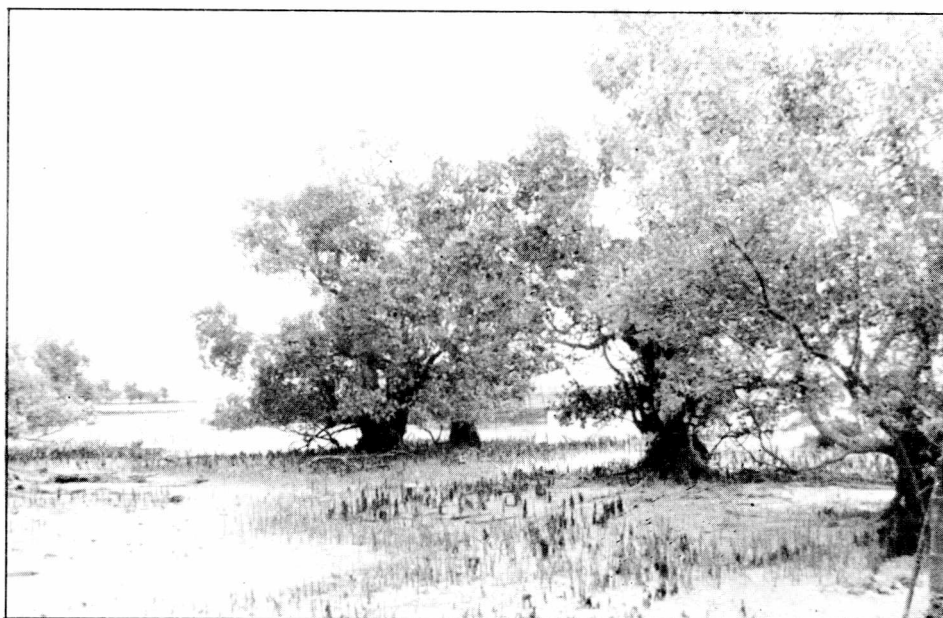
Also during this period, some silvo-fishery enterprises used that chance and destroyed the forests - a typical example is Bong Van Dia Enterprise which cleared nearly 1,000 ha of mangroves to culture shrimps.

The above events have caused massive mangrove deforestation.

Lack of Attention to Propagate and Disseminate Shrimp Farming Techniques. The lack of understanding of mangroves' role in developing and maintaining marine resources have made people destroy mangroves for their own interests, especially the illegal migrants. The absence of control from the authorities and police has led to large-scale deforestation in a very short period to build shrimp ponds in remote areas.

Impact of the deforestation on the resources and environment

Deterioration of the biological resources. During the two wars of resistance, the Minh Hai mangroves protected the people and soldiers against the enemies. All efforts were made to protect and restore these



Mangroves serve as a source of organic matter to increase yield of the coastal area.

cause of this reduction is rapid population growth.

According to the 1982-1990 statistics data of Minh Hai province, the population of Ngoc Hien District increased by 21,610 people, i.e., the average annual growth is 2,700 people. The natural growth rate is 2.93%. But the bigger danger lies in the very rapid mechanical growth of population due to illegal mass migration from many localities in the country to the mangrove areas to destroy the forests and build shrimp ponds. Dat Mui Commune is an example. In 1988, the commune's

pond construction.

The shrimp ponds in Minh Hai have expanded very fast. In 1980 and 1981, shrimp ponds occupied 4,000 ha. They increased by nearly 20 times in 1993. According to T.P. Cuong (1994), the land area with shrimp ponds inside the mangroves has increased from 29,920 ha in 1982; 47,480 ha to 67,072 ha in 1993. Of the 67,072 ha, 45,756 ha were cleared of forests; the remaining 21,316 ha have regenerated forests only recently. The average loss of forests (1988-1992) of Ngoc Hien District is 5,000 ha. Some other districts such as

valuable forests which are now being destroyed for short-term benefits, leaving very serious consequences.

At present, only 25% of the forest land is covered with forests, mostly secondary and newly planted ones. This situation is the result of deforestation and outdated shrimp culture method on a large area, degrading the pond environment. There are very few sluice gates to exchange tide so the pond environment is strongly polluted, adversely affecting the pond creatures.

A 1992 study by P.N. Hong, L.D. An, and collaborators revealed considerable decrease in plankton as feed for shrimps after only two years of shrimp pond operation at the west accretion of Ngoc Hien. Instead, some blue algae develop vigorously. When these algae die, the soil at the pond surface is oxidized forming H_2S and NH_4^+ which are poisonous to living creatures. A survey has shown that there are 22 species of benthos on the mud flat while two species remain in the pond.

If the mangroves are not rehabilitated, the local creatures would not be able to find food and then they leave for other areas.

Waste of shrimp resources. Due to the method of "keeping shrimps in the pond" for only 15-20 days, the shrimps are small when harvested (500-1,000 ind/kg) despite the high value of shrimps of 20-50 ind/kg. In the southwest accretions of Ngoc Hien, hundreds of tons of young shrimps the size of seed shrimps are harvested at each tide cycle. The productivity in other ponds behind the embankments built here has decreased because most of the shrimps were caught at the accretions.

Some shrimp culturists know that early harvest adversely affects the crop, but since the pond environment has been degraded, shrimps either do not grow or die gradually if reared for a longer period. Thus, they would rather harvest a little than nothing.

Decline in the seed source of shrimps and crabs. Indiscriminate forest destruction has greatly reduced the seed source of shrimps and crabs.

These species lay eggs at sea, their larvae and post-larvae move to the river mouths with mangroves and then live there until they become mature and go back to the sea again to lay eggs. When there are no forests, they lose their habitat and leave for other places. Other valuable marine products such as *Mugil cephalus*, *Lates calcarifer*, *Muraenesox talabon*, *Pseudapocryptes serperaster*, *Parapocryptes macrolepsis*, oysters, shells and terrestrial animals such as reptiles and birds have also been deprived of their habitat, breeding ground, and living environment.

A vivid example of the role of mangroves in this aspect is Can Gio District. After the American herbicide war when the forests were destroyed, all fauna resources were degraded. But after the mangroves were rehabilitated, the yield of marine products in the area increased year after year. According to the statistics data of Ho Chi Minh City Aquatic Product Service, in 1977 when there were no forests, the catch yield was 10 tons of fish and no shrimps; in 1980, when the mangroves were young, the yield was 3,172 tons of fish and 150 tons of shrimps; in 1989, when the forest closed canopy provided a lot of humus, fish caught was 15,870 tons and 2,430 tons of shrimps. Of course this increase is also due to other factors such as catching tools and equipment, increased number of laborers involved, etc. From 1993, the number of long-tailed monkeys have increased rapidly at Khe Dinh and Khe Doi. Other animal and bird species have also risen in quantity.

Rise in the extent of fallow lands. The destruction of forests for shrimp pond construction or agricultural production has quickly raised the extent of fallow land. Data of Minh Hai Forestry Service showed a loss of 86,037 ha of forests up to September 1993, of which more than 20,000 ha is now fallow land with only the ditches being used for shrimp breeding.

With strong sunlight and high temperature due to loss of forest

canopy, the soil rich in organic matter and sulfates is oxidized into sulfate acidic, salty soil. Furthermore, the peat layers abounding in carbon are also oxidized, forming a large amount of CO_2 dispersing into the air, heating the atmosphere.

Impact of deforestation on salt intrusion. In recent years, the construction of embankments for shrimp ponds on a large scale along the coast, river mouths, and in coastal areas of Minh Hai has considerably decreased the area of tide distribution, especially at spring tides. In November and December annually, when there are high tides and northeast monsoon, the monsoon would bring salty water deep inland, badly affecting the agricultural land and causing riverside erosion.

Enhancement of mud accumulation and erosion. The destruction of mangroves for construction of shrimp pond embankment or for agricultural land has filled a number of small canals joining large rivers, resulting in alluvia accumulation. On the other hand, some rivers do not receive sufficient accreting soil, and as a result these are strongly eroded by waves.

For many years, the east coast of Ca Mau has been eroded under the influence of the northeast monsoon, and erosion has been accelerated after the mangroves were destroyed. At present, the absence of mangroves has also caused erosion at the tip of the Cape and some other places such as Go Cong Cape, which used to be an accretion inside the Thailand Gulf.

The construction of the chain embankments along the southwest side of Ca Mau Cape, from the tip to Bay Hap river mouth, has hindered the transport of alluvia from the east of the peninsula to the west through the river system. Furthermore, the accreting soil is mainly fine sand (0.002 - 0.01 mm) in the form of wet mud which can be very easily carried away by waves, especially during the period of southwest monsoons when the amount of alluvia is small and the current and

waves are stronger. This situation would remain and the consequences would be imponderable when Ca Mau no longer has forests and pioneer species stabilizing accretion land like *Avicennia alba* has no place to develop seaward any longer.

Water and soil pollution. The disorderly construction of shrimp ponds is such that lower ponds receive waste water from higher ones. On the contrary, the tide usually has to pass lower ponds before flowing into those on higher land at spring tide, facilitating the spread of the dirt between ponds. Poisonous matters like Fe^{2+} , Fe^{3+} , NO_3^- , NH_4^+ blue green algae, organic wastes, disease-causing bacteria from the ponds are brought by the tide to canals and rivulets, severely affecting the coastal and riverside flora and fauna. When an epidemic happens, it spreads very quickly.

In 1994, the shrimp epidemic in the South provinces spread over an area of 84,858 ha resulting in a damage of approximately 294 billion dong (\$1=11,000 dong; Information on Fisheries, Vol. 2 - 1995). The most important reason is deforestation, thus, severely degrading the environment, and facilitating the spread of disease-causing bacteria.

The shrimp epidemic has repercussions on the economy of coastal Minh Hai. Many shrimp culturists went bankrupt causing employment problems while a number of freezing factories did not have the needed materials. To meet immediate needs, people continue to destroy the already exhausted or newly planted mangroves, leading to even more serious deterioration of the resources.

Preliminary results in the rehabilitation and propagation of rational utilization of mangroves

Although the mangroves in Minh Hai have been seriously destroyed, it would be unfair not to mention the rehabilitation and propagation efforts and contribution of the local people, cadres and authorities, and especially the Forestry Branch.

During the second Indochina war, the people contributed hundreds of thousands of man-days to replant 13,000 ha out of the herbicide-sprayed 44,918 ha of mangrove forests.

After the liberation of the South, Minh Hai people succeeded in mangrove rehabilitation, covering most of the bare land with trees. After 18 years (1975 - 1993), under the leadership of the Minh Hai People's Committee and Forestry Service, 56,445 ha of mangroves were replanted.

Unfortunately, the destruction of forests for shrimp culture has become rampant. Many indigenous dwellers who used to work day and night to replant mangroves are now cutting down the trees to build shrimp ponds or make charcoal; or their children are doing so in fear that people from other areas would come and do the same if they did not act fast. This is the consequence of poor management and bad compliance of current law and regulations.

Some research institutions such as the Mangrove Ecosystem Research Center and a number of scientists have, for many years, assisted Minh Hai in planning, doing research for mangrove protection through training courses on silvo-fishery combination, and writing educational materials for peasants, teachers, and schoolchildren. However, the results have been limited due to many problems and difficulties.

The Minh Hai Center for Wetland Forest Research and Technology Application has also compiled the experiences gained, and with some preliminary results of study on silvo-fishery production on mangrove, produced educational materials and video tapes.

Good mangrove protection requires adequate instruments (laws and regulations) and strict enforcement from the state and the local authorities.

Recommendations for a rational utilization of the mangrove ecosystem in aquaculture.

It is urgent and practical to make an overall plan of production on the areas with mangroves, to conduct

investigations and surveys of the exact current status of mangroves, shrimp breeding land, agricultural land, eroded land, accretion land in Ngoc Hien District (and if possible, in some other districts with mangroves) through satellite photos, aerial photos, and field trips done by professional staff. Planning of the irrigation system, clean water supply for the forest ponds, and the sewage system should be given sufficient attention. Adequate investment from the State and the province, and funds borrowed from the World Bank and other projects on the locality should be fully used. A capable and active management system which can operate the projects immediately should be made as another requirement.

An assessment with regards to the economic resources, and environment impact of some models in the silvo-fishery enterprises of 184, Tam Giang 3, should be carried out in order to evaluate achievements to be replicated, and identify problems to be solved. Some shrimp culturists should be organized to apply these models in other places with financial and technical support from the projects.

Research should be done on the relationship between mangroves and marine products through the amount of decomposed vegetative detritus and nutrition cycle in the shrimp breeding area with varying proportions of forests and shrimp ponds in order to work out the economic and environmental impacts. Based on that, a specific appropriate proportion of forest/shrimp ponds will be calculated for each locality in the province.

Regarding the management of soil, mangrove, and pond resources, the local authorities of Minh Hai and the districts with mangroves should work out specific and proper measures to:

- Survey and classify shrimp farmers for appropriate policies.

- Persuade the indigenous inhabitants who have lived in the area for a long time or the legal migrants to narrow their pond area if they have natural extensive fish ponds, and apply the improved extensive culture method

with the technical assistance of the project. State banks should grant them loans to repair their ponds, to build sluiceways, buy feed, and young shrimps. The Forestry sector should provide them with tree seeds for reforestation on the land with a written commitment on long-term land and forest allocation that the people are really the owners of the means of production. The households with shrimp ponds and land for afforestation should be gathered into a production group aimed at using, protecting, and controlling the tide water going in and coming out of the ponds.

- Classify shrimp ponds built by illegal migrants without permission. The poor people who signify willingness to settle should also be allocated with land and forests. This will enable them to implement production in the silvo-fishery combination method according to the common planning and instructions of the local authorities. They can either work on a family scale or in groups supported technically by forestry and fishery sectors and financially by banks through loans granted. The authorities in Minh Hai, especially at the provincial level, should discuss with illegal migrants engaged in deforestation to make their fortune somewhere else or return to their home places.

- The forest lands and accretions which have been invaded illegally or allocated wrongly must be returned. Planning will be done and the lands would then be allocated to the households which can meet the criteria for long-term management and utilization. The State and National Assembly should also pay attention to, give instructions for, and increase investments in the socio-eco-resources-environment problem currently existing in Minh Hai.

- The provinces from which migrants have illegally flowed to Minh Hai should set up an overall plan for the Minh Hai mangroves to stabilize the situation as soon as possible.

Before a new project is implemented and land-to-forest allocation is carried out (according to an overall plan),

training courses for staff of the relevant sector such as forestry, fishery, banking, finance, police, as well as the local population should be conducted on the role of mangroves to the marine products and on the damaging consequences of deforestation using funds from World Bank loans, projects, and local sources. Good trainers are essential for effective training. The Ministry of Fishery and the Ministry of Forestry should cooperate with the Ministry of Education to train students

The mangrove rehabilitation in Minh Hai cannot be done overnight. There should be effective measures for replanting and land distribution.

at the secondary or special purpose colleges, then send them to Minh Hai to participate in the training. Minh Hai Province and its districts should arrange meals and accommodation for the trainers as well as organize the training courses. These courses will concentrate on providing the trainees with the techniques of improved extensive shrimp farming. If the State and the province do not pay attention to this important activity, other activities will be difficult to realize or complete, leading to destruction of forests and devastation of resources.

Part of the funds for experimental purposes of the projects should be spent on widening the number of cultured species such as oysters, crabs, *Lates calcarifer*, etc. on the tidal flats in front of the mangroves and on cages and rafts along the rivers. Later, people should be instructed regarding the breeding method of these species, thus, creating jobs for the unemployed, increasing the local dwellers' income, and reducing human pressure on the mangroves.

Educational activities for the local population on the protection of natural resources and mangrove environment combined with family planning education should be enhanced. Specific activities should include: (1.) dissemination of knowledge on mangrove conservation on the national and local mass media; and (2.) publication and distribution of mangrove books to the coastal teachers, schoolchildren, and dwellers to avoid and limit the increasing damage caused by natural disasters. The Mangrove Ecosystem Research Center has been actively involved in these activities. Initially, 2,000 books for peasants and a number of teachers' books would be given as a gift to Minh Hai Province.

The mangrove rehabilitation in Minh Hai cannot be done overnight. There should be effective measures for replanting and land distribution based on specific natural, economic, and social conditions. These measures should be flexible but safe, to help improve the living standard of the indigenous people. At the same time, the ecological equilibrium would be restored on this potentially rich but fragile land.

In order to rehabilitate the forestry and marine product resources, ensure rational use and arrest their degeneration, there should be support from the state, province and districts, various sectors and branches, as well as close coordination among them so that an overall plan can be drawn up and implemented while learning from the process.