THE ROLE OF MANGROVE ECOSYSTEMS AND COASTAL AQUACULTURE IN THE LIFE OF PEOPLE IN COASTAL MANGROVE AREAS

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I. Introduction

Mangroves, the important ecosystems with high productivity in the tropical coastal zone, are very sensitive to both human and natural impacts. Mangroves provide not only valuable forestry products such as timber, firewood, charcoal, tannin, food, medicines, but also serve as the breeding ground for many species of marine organisms, water birds, migrating birds, and other economically valuable terrestrial species like monkeys, wild boars, boas, etc. Mangroves have important role in protecting the coastlines and the riversides, regulating the climate, limiting erosion, expanding mainland areas, restricting saline intrusion, and in protecting dikes, fields and coastal inhabitants' residence from the damages of monsoons, typhoons, and sea level surge.

Reports have indicated that mangrove resources in Vietnam are seriously deteriorating. The American chemical warfare (1962 - 1971) destroyed a big area of mangroves in South Vietnam, where mangroves had the best growth and of the best species. After the war and under the pressure of economy and population growth, mangrove areas continued to decline in structure as well as in quality.

The indiscriminate exploitation and clearance of forests for land to convert into urban cities and towns, ports, to practice agriculture and salt making, and especially the destruction of forests including the protected ones for conversion into natural extensive shrimp ponds have currently been the great threats to the natural resources and the environment. Consequently, soil degeneration has increased, the climate has obviously been changing for the worse, saline water has intruded farther and farther inland, the natural stocks of shrimps and fishes have decreased, many marine species have been deprived of their habitat and certain fish species of their breeding grounds, and riverside and coastal erosion occurs daily owing to the loss of the forests, menacing the lives of the poor coastal dwellers.

The above-mentioned situation is happening because of inadequate and insufficient understanding among the coastal inhabitants and local authorities of the multi-sided and great benefits that the mangrove ecosystem brings for people. In order therefore to remedy the situation, the role and potential of this essential ecosystem should be assessed, the causes leading to the deterioration of mangrove areas and quality should be analyzed, and the damaging impacts of the loss of forests on the biodiversity resources, coastal environment and life, should be appraised. Based on the results, policies and strategies suitable to the Vietnamese situation should be drawn up in order to improve the knowledge and the lives of coastal dwellers, and at the same time protect and promote sustainability of the natural resources and the environment.

II. Mangrove Areas

Before the war, there was about 400,000 ha of mangroves in Vietnam (Maurand 1943), mainly in the South (250,000 ha). There were two areas with large mangrove forests: the Ca Mau peninsula (200,000 ha of which 150,000 ha was virgin forests and 5,000 ha of mixed ones) and Rung Sat (Bien Hoa and Ho Chi Minh City) with 40,000 ha of mangroves (Cuong, 1964).

Owing to the over exploitation of the forests for timber, firewood and charcoal, the mangrove extent has rapidly decreased. In 1950, there was only 290,000 ha left (Rollet, 1956), and in 1962, only 286,000 ha remained (Ross, 1975). From 1962 to 1971, the chemical warfare of the American Army destroyed 104,939 ha of mangrove areas, of which 52% was in Ca Mau Cape, 41% in Rung Sat and the remaining in some western provinces of the South. Since 1983 when only 252.000 ha of mangroves existed, the forest extent has continued to diminish due to deforestation, use of coastal land for agricultural production, and for extensive shrimp farming.

According to an incomplete investigation data, the present mangrove extent in Vietnam accounts for only one fourth of the pre-war extent, now consisting mainly of secondary forests. Only over 300 ha of virgin forests remained in Minh Hai and about 2000 ha of natural mangroves at Tien Yen District, Quang Ninh Province. At the end of 1998, there were only 65,799 ha of mangroves left in Minh Hai, the province which used to have the largest area of mangroves in Vietnam (Coung, 1994). Since then, the forests have been continuously diminishing because of migrants who destroyed them indiscriminately in order to convert to shrimp culture areas.

After the war, when the coastal people return to their native places and the mass migration from other provinces to the mangrove areas in the South, have led to the increased demand for building timber, firewood and charcoal. In addition, the increasing exploitation of the Forestry Agencies on the decreasing resources also exhausted the forests. Moreover, the people in the communes of Vien An Dong and Dat Mui, Ngoc Hien district produced charcoal on commercial scale for sale to the other provinces. This industry destroyed many valuable forests including those that were newly-planted after the war.

The coastal area of Quang Ninh province used to have thick natural forests in which *Bruguiera gymnorhiza* were 7-8 m high, *Kandelia candel* 4-6 m high and *Rhizophora stylosa* 5-7 m high. At the river mouths, there were *Sonneratia caseolaris* 8-12 m high such as in Uong Bi (Quang Ninh), Thuy Nguyen, Kien Thuy, Tien Lang (Hai Phong), Nghi Loc (Nge An), Nghi Xuan, Can Loc (Ha Tinh), Quang Trach (Quang Binh). But owing to the absence of proper management, these forests were destroyed and in some places no traces of mangroves were left.

III. Role and Potential of Mangroves in the Economy and in Nature

In discussing the benefits from forests, usually only the direct products such as timber or other forestry products are counted. Little attention is made on indirect benefits such as climate regulation, erosion prevention, flood restriction, etc., which are of great importance because mangrove forests grow at tidal and riverside areas where winds and waves are usually strong. In this paper, the direct products and indirect benefits from mangrove forests are discussed.

A. *Direct products*

1. Forestry products

The composition of mangrove forests is much less varied than that of inland tropical forests because only certain species of trees can adapt to the saline, muddy and tide flooding conditions. Chapman (1975) produced a list of the world's mangrove flora comprising 68 species. In Vietnam, researchers on mangroves have listed 51 species (Hong and San, 1984), of which 49 species are very popular.

These species have various uses and the percentage of species which are useful over the total number of species is very high. They have for long met the daily needs of the local inhabitants such as timber for construction, leaves for roof-thatching, food, fuel, livestock feeds, etc.

Among the 51 mangrove species listed in Vietnam, only some species are of little value, the rest can be grouped in the categories of their utilization (Hong & San, 1984). These are the species giving timber, firewood, charcoal; species giving tannin; species providing materials for green fertilizer used in, improving or maintaining soil productivity; species providing herbal medicines; species providing honey or bee raising facility; and species providing sap for producing soft drinks, sugar, alcohol

There are also species which are used in minor industries, such as those that are utilized to produce lie for cork making, hard hat frame making, and those that provide fibers. Other uses include providing materials for producing paper and pressed planks, new emerging industries that need attention in the near future.

Of the species providing timber, only 5-6 popular species could give high productivity such as *Rhizophora, Bruguiera, Lumnitzera,* etc. Even with these species the uses vary in different localities depending on the ecological conditions and the size of the trees.

In Ngoc Hien (Minh Hai), *Rhizophora apiculata* are 25-30 m in height and 39-40 cm or more in diameter providing a valuable source of timber. The reserve in the natural *Rhizophora* forests at Ngoc Hien at ages 30 is 210 m^3/ha, but it could reach 450-600 m^3/ha in some areas (Forest Planing and Investigation Institute, 1985).

According to some preliminary works, the average growth rate of *Rhizophora* spp. in Ca Mau is 0.6-0.7 cm/year in diameter and 0.6-0.8 m/year in height with a volume of 0.2 m^3/year. *Avicennia* in natural forests are about 20-30 years old with an annual growth of 4 gm^3/ha/year. On the other hand, *Bruguiera parviflora* grows more slowly: 45-year-old trees are still 21 m high with an average diameter of 25 cm. The average growth rate is 0.48 cm/year in diameter and 0.64 m/year in height (FIPI, 1985). In general, in the natural forest lands with high tree density, the annual growth rate can reach 15-20 m^3/ha/year.

If the forests are properly managed, mangroves will provide a significant amount of timber for use in various ways, such as, poles, planks, and common tools for use in the localities. They are also used in many countries as railway sleepers, as supporting poles in furnaces, in making paper, etc.

Charcoal from *Rhizophora* and *Bruguiera* is very popular because it produces little smoke with high heat energy. One kg of *Rhizophora* charcoal can provide 6.675 Kcal and it is 6.375 Kcal with *Bruguiera* charcoal. At present, *Rhizophora* charcoal is used in the metallurgical industry. Charcoal from *Lumnitzera racemosa* was used to run steam ships during the Second World War (Hong et al. 1988). Trees in mangrove forests are also important sources of firewood, many of which give good quality firewood with little smoke and high energy. In the past, the coastal dwellers in Quang Ninh, Hai Phong and Ha Nam Ninh used firewood from mangroves. In Hai Phong in 1960, 18,000 mt of firewood was exploited from the mangrove forests on Dinh Vu Island and its neighboring areas. Afforestation in the coastal muddy salty land therefore, provided a considerable source of firewood.

Since 1978, the Ho Chi Minh City Forestry Department has planted nearly 20,000 ha of *Rhizophora* on the areas sprayed with chemicals during the war. This project has not only improved the local environment but also supplied a large amount of firewood for the City's dwellers. From each hectare of forests at the age of 8-10 years old, 6-7 steres of firewood on the average, can be exploited through thinning.

Another important product from mangroves is tannin. Compared to other vegetative species, the amount of tannin in the bark of many mangrove species is high. The percentage of tannin varies between 4.6-35.5 % from the different species and the quality of the tannin from mangroves is good. Tannin is used in the industries for curing leather, dying cloths and fishing nets, making glues, and other uses in the pharmaceutical and printing industries. Although a good number of species provide tannin, only 56 species give high yields and are usually exploited. Moreover, different kinds of barks are used in different areas. In Quang Ninh, Hai Phong, the bark of *Bruguiera gymnorhiza, Kandelia candel,* and *Rhizophora stylosa* is mainly used while in the South, *Rhizophora apiculata* and *Ceriops tagal* are often exploited. The older the tree is, the thicker is the bark. The bark of *Rhizophora apiculata,* 25 cm in diameter is 1 cm thick. The thick-barked *Ceriops* can provide 7,740.47 kg of bark/ha and 3,956.91 kg of branch bark/ha (calculated in dry weight, Hong and Tri, 1986).

In addition to the main species which provide timber, firewood, and tannin, *Nypa fruiticans* is worth mentioning. *Nypa fruiticans* grow naturally in estuarine areas and along brackishwater rivers, sometimes 60 km from the sea (as at Tien River, Hau River). It is not difficult to plant *Nypa fruiticans* and its abundance is not harmful to agriculture.

For many generations, coastal and estuarine dwellers have been using *Nypa fruiticans* leaves to thatch the roof and make walls for their houses, and also to make other home implements like brooms, water scoops, baskets, hats, etc. Young leaves are used to wrap a kind of delicious coconut cake, the leaf stems used as buoys of fishing nets, while the outside cover of the stems is a good electricity-insulator. The fibers in the stems of nipa leaves are woven into strong ropes which can tolerate salty water. The people at Binh Dai District (Ben Tre) weave mature leaf ribs together and use as the bottom of sluicegates in shrimp ponds instead of wood which can last for 5-6 years.

The young meat of nipa fruit which is sweet and fatty, is either eaten fresh or used to cook sweet soup or to make soft drinks or ice cream. The mature shell is used to make buttons and fine art articles. Some countries in Southeast Asia use the young buds, leaves, stems, and roots of *Nypa fruiticans* as medicines for boils, toothache, headache (Burkill, 1935). Recently, the South Sub-Institute of Forestry Research was successful in making planks from *Nypa fruiticans* leaf ribs.

The percentage of sugar in nipa sap is high, ranging from 13 to 17%. Results of the study by P.N. Hong and H.T. San (1993) showed that one hectare of *Nypa fruiticans* in Thanh Phu Ben Tre produced a considerable amount of sap which can be made into 8-10 mt of sugar or 720-730 liters of wine. The process of making sugar from *Nypa fruiticans* is simpler and has more advantages than the sugar from sugarcane. The soil for planting sugarcane must be ploughed thoroughly, in many cases it is also necessary to make sugarcane beds. Sugarcane has to be re-planted every year, while machines are needed for pressing sugarcane and treating its residues.

Nypa fruiticans are planted only once and can be harvested continuously after the fifth year. The tools used for collecting sap are simple comprising mainly bamboo tube to contain the sap which will then be boiled into sugar or into other products like soft drinks, wine and alcohol preparations. *Nypa fruiticans* are also very effective in retaining accreted soil, protecting the banks of rivers and canals, and preventing erosion due to the tide's influence. *Nypa fruiticans*, when planted inside the embankments of brackishwater shrimp ponds, will help retain soil, shade the pond water and provide shelter for shrimps when it is hot and sunny.

2. Terrestrial animals

Although the mangrove environment is not as favorable for terrestrial animals as the inland forests due to lack of freshwater and the muddy soil, there are still a number of rare animal species in mangroves because of the availability of food. The mangrove forest at Ca Mau, was once a habitat for tigers, leopards, crocodiles, and monkeys. Snakes and varans are also abundant in mangroves because of their favorite food which includes bird eggs and young birds, *Presbytis cristata* in Thailand or *Macaca* sp. in Vietnam. The *Macaca fascicularis* live in large herds in mangroves, searching for food in swamps at ebb tide and living on the trees or in high dunes at flow tide. In Can Gio Forest Park, which has a good protection, there are now hundreds of *Macaca fascicularis* which are producing at a fast pace.

Mangroves are the habitat, nesting place or food source of more than 200 bird species including some rare ones like *Mycteria cinerea*, *Pseudibis davisoni*, *Leptoptilos*, and *Guis antigone sharpi*. These species used to be popular in Southeast Asia but now only few remain in the Mekong Delta area, Cambodia, and South Thailand (Quy, 1984).

Several migrating bird species are also found in mangrove forests. In the breeding season from April to February, the birds gather and build their nests in huge flocks in certain mangrove forests or "bird sanctuaries". There are 10 bird and bat sanctuaries in Minh Hai (Thuy, 1994), six of the bat sanctuaries are privately owned. The Tan Khanh Sanctuary (Cai Nuoc District) with an area of approximately 130 ha is considered the biggest natural bird sanctuary in Southeast Asia (Quy, 1984).

The terrestrial animals living in mangrove forests excrete a large amount of feces everyday. This is a source of nutrition for the forest trees and also food for various creatures, small invertebrate animals, shrimps, and fishes in canals and rivulets. With forest destruction, and the over-hunting and trapping of mangrove animals, the natural resources have greatly declined. Some species are in danger of extinction due to the loss of their habitat while for some species, very few individuals remain in protected forests. However, the situation has improved recently in Minh Hai where many birds and bat sanctuaries owned by households have been formed and more animals have come to these sanctuaries to settle.

B. *Agricultural products*

The agricultural products provided by mangroves are not rice or food plants but livestock feed and honey. Although mangrove leaves are tart, they are rich in protein and are good feed for livestock especially the *Avicennia* leaves.

If rationally exploited and well processed, this can be an abundant and nutritious source of dry feed for livestock as well as fishes raised in cages or in rafts. Mangrove leaves have high salt contents and iodine because mangroves grow in the muddy, salty environment flooded with sea tide giving big advantage over the leaves of other inland tree species.

Of the many agricultural products provided by mangroves, honey is considered of great economic value. Raising bees in mangrove forests is not complicated and does not harm the environment. On the contrary, the productivity of mangroves is increased because of the process of pollination. In mangrove forests, since there are many species which bear flowers with honey such as *Avicennia*, *Excoeccaria*, *Ceriops*, *Bruguiera*, *Rhizophora*, *Kandelia candel*, *Aegiceras*, bees can be raised in small or medium scale levels.

There are various simple techniques of raising bees in mangrove forests. The most popular way is to search for natural beehives but this method does not give good yield because it is dependent on luck. For better control of the yields, studies are done to build wooden bee hives with fresh water container for the bees' daily use. With simple techniques and small investment, raising bees in mangrove forests can bring about a valuable product for the economy of any country.

The most difficult problem in raising bees in mangroves is the high content of salt. Some species, usually those with a lot of flowers with honey like *Avicennia* and *Aegiceras*, can excrete their surplus salt to the leaf surface through their salt glands. The salt is then dried into small grains on the leaf surface which bees, while searching for food, can bring with them to their hives. Bees can only tolerate a low content of salt in their blood and will die when the salt content in their body reaches 0.125%. However, this is not a very serious problem because some species of bees do not bring salt to their hives. Furthermore, the bee species living in mangrove forests for many generations have already adapted to this environment, especially those that build their hives on poles installed in mangrove forests by local inhabitants.

The leaves of some mangrove species are also used to make green fertilizers for agriculture production, especially *Avicennia* leaves which have high contents of salt and are very good green fertilizer for certain kinds of plant species. The coastal inhabitants of Quang Ninh use *Avicennia* leaves through fermentation, into other kinds of green fertilizer which when applied, the cultivated plants are less attacked by pests or fungi.

IV. Role of Mangroves in Marine Resources

In mangroves, the fallen leaves and other plant parts which are decomposed by various micro-organisms, form "humus' which serves as food for many aquatic animals. On the other hand, the intricate root systems of the plants retain alluvia and create an appropriate living environment for many zoo benthos.

Mangroves play an important role in the nutritional cycles and serve as source of organic matters to increase the yield from the coastal areas. Mangroves also play an important role in the reproduction, growth and as a permanent shelter for many valuable sea products such as fish, shrimps, crabs, molluscs, etc.

A number of reports indicated that high fishery yield is mainly obtained from rivers, coastal areas, and estuaries with mangroves. This is because of the high concentration of nutrients brought by rivers from upstream areas and by tides from the sea. Reports also showed that there is a close relationship between the yields of mangroves and the quantity of sea products caught in a locality. In Western Australia, 67% of the total amount of commercially valuable sea products are collected from mangrove areas. Hamilton and Snedaker (1984) estimated that 90% of sea organisms for some periods of their whole life, live in estuaries with mangroves. For many marine creatures, this relationship is indispensable.

The first food, abundant and diverse in sea products, is plant organic matters, also called "humus". It comes from the decayed plant remains such as leaves, branches, buds, and roots from mangrove plants. According to Snedaker (1978), the dry mass of fallen leaves from mangrove plants in the South of Florida (U.S.A.) is 10,000-14,000 kg/ha/year of which 79.71% are leaves. Ca Mau *Rhizophora* forests on the other hand, can provide the ecosystem with 8,400-12,000 kg of leaves/ha/year (dry mass) (Hong, Tri, 1986).

All year round, leaves fall in rivers and channels or on the forest grounds and are carried away by tides. The decaying process takes place throughout the year. When the leaves are still on the trees, some fungi live on them as parasites (on the surface or under the epidermis). When fallen into the tidal water, after 24 hours, they begin to undergo a decaying process facilitated by the micro-organisms; first by *Phytophora* (in the *Phycomycetes* family), then by *Fusarium* and *Penicillium* in the family of *Fungi imperfecti*. After 2 or 3 weeks, they are replaced by other micro-organisms such as *Zelerion* and *Lulozthia*. Porous tissues are decomposed first, followed by cellulose and lignin last. In the decomposition process, the protein content in the leaves increased by 2-3 times (Kaushik and Hynes, 1971). Analyzing and comparing the amino acids (both with and without protein) of the leaf surface and the leaf composition, these are considerably larger in decomposed leaves than in fresh ones.

On high lands, fallen leaves, when not carried away immediately by tide, are decomposed mostly by some earth creatures on the forest grounds. The products of this decomposition process are mainly easily-dissolved organic matters concentrating at the surface soil layers. After some time, the amount of fallen leaves augments and so does the organic matters. These are carried with rain to canals, rivulets and estuaries to enrich the food source for the creatures in the estuaries and in the seas.

Mangroves provide food both directly (humus, fallen leaves and fruits) and indirectly (through humus eating animals as preys) for big fishes and some other species of predators. Therefore, the composition of the fauna in the mangrove areas, although diversified is very abundant. Preliminary surveys in Minh Hai mangroves showed 64 fish species in 35 families (Yen, 1986), 25 shrimp species (Thoung, 1990), 22 reptile species (Sang and Cuc, 1978), 67 bird species, and 21 animal species (Duc, 1989).

Young shrimps, crabs, and fish in the mangroves areas are also always in abundance. A comparison of the composition of fishes and shrimps in the mangrove areas, the sandy coastal areas and the areas with sea grass, showed a far higher quantity of larvae in the first type of land in all seasons of the year. From that, one can say that mangroves are the main breeding ground for 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 species such as banana shrimp, crabs, oysters, and fish inhabit the 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 certain small marine creatures (fish, shrimps, small crabs, shells). The birds excrete a considerable amount of feces, which facilitates the trees' growth and increases the amount of organic matters as feed for aquatic creatures and benthos, attracting many species to the area to search for food, thus forming a diversified ecosystem which is rich in species.

V. Role of Mangroves in the Climate, Accretion Expansion, and Erosion Limitation

A. *Climate*

Mangroves can help regulate the local climate where they grow. Laco (1975) who studied climate and forest micro-climate commented that mangrove communities contribute to the cooling of the climate and in decreasing the temperature and heat amplitude to the minimum. There have been many typical examples of mangrove losses that lead to changes in the micro-climate of a region. After the vegetation has been cleared, evaporation increases, resulting in the increase of water and soil salinity. In some places, after mangroves are destroyed, the regional wind velocity could suddenly soar, causing desertion due to moving sand which fill up canals and fields. The increased wind velocity also causes big waves breaking dikes, dams, and eroding the coastline. Thus, the loss of mangroves adversely affects the rainfall of an area.

A huge area of mangrove forests in the Bay of Fort de France in the Martinque archipelago (France), for example, were cleared due to industrial wastes. Soon afterwards the rainfall in that locality changed, the wind velocity in the coastal area increased, pollution and noise together with epidemics spread (Blasco, 1975).

In the last tens of years, a considerable area of mangroves in Minh Hai has been destroyed to be converted into extensive shrimp ponds. Consequently, the beautiful sight has disappeared and tens of thousands of hectares of land has become fallow. Many canals and rivulets which used to provide food and shelter for fish and shrimp larvae have now been filled with sand, while hot, harsh climate and pollution spread over a large area.

A very typical example of the devastating effect of the American warfare herbicides on the mangroves was experienced in South Vietnam. Tens of hectares of mangroves were cleared up, the soil was exposed to sunlight, the salinity in the surface soil layer at Can Gio, Ho Chi Minh City reached to 35-40‰ in some places. The loss of the vegetation has adversely influenced the whole ecosystem, including the local natural conditions and climate. After the forests have now been restored, the view and climate have changed for the better and the forests have now been considered "the lungs of the City."

B *Accretion expansion and erosion limitation*

The development of mangroves and expansion of accretion are two processes which always go hand in hand except in some special cases. Mangroves are generally found on all the accretions with suitable climate, with availability of seeds and in areas that are protected. Mangrove stretches can be found on soft mud, sandy clay, sand and even on coral reefs (Snedaker, 1978, 1982). On newly-accreted land, pioneer mangroves belonging to the *Avicennia*, *Sonneratia ovata* genera are found in the coastal areas with high or relatively high salinity. *Sonneratia cascolaris* often grows at the estuarine areas with lower salinity

Mangrove roots especially the vegetative communities that grow thickly help sediments to accumulate more rapidly. The roots prevent the waves' damaging activities effectively and promote sediment accumulation. Thus, the presence of mangroves increases the speed of sediment accumulation, expands the area of accreted lands, and at the same time limits the coastal erosion processes. The afforestation and preservation are aimed not only at exploiting the resources but also at protecting the coastline, expanding accretions and regulating the climate. In natural conditions, mangroves follow closely new accretion and regulate the climate.

In only 30 years (1964-1994), two small islets named Con Trong and Con Ngoai have been formed at Ong Trang Mouth (Ca Mau Cape). Con Trong has many typical species of mangroves, and Con Ngoai has been fully covered with the pioneer *Avicennia alba*. In the estuarine areas of the Red River, many islets with mangroves have also been formed like Con Den, Con Vanh (Thai Binh), Con Thoi, Con Ngan (Nam Ha). Many valuable marine species and birds have come and live in those islets.

VI. Reasons for the Deterioration of Mangroves

A. *Conversion into shrimp ponds*

Due to the alleged huge benefit from shrimp export while the marine catch yield has been decreasing, shrimp farming has been encouraged by the government and many local authorities. Therefore, both the indigenous people and state bodies have felled down lush mangrove forests (at Thai Binh, Nam Ha, Ninh Binh) to be converted into extensive shrimp ponds. In some provinces such as in Minh Hai, the forest clearance for shrimp farming has been carried out not only by the indigenous inhabitants but also by people migrating either legally or illegally from other areas. Since 1991, thousands of people from Ca Mau town have constructed embankments on the new accretion southwest of Ca Mau tip for shrimp ponds and also houses for long-term residence.

According to the statistics of Searprodex Company (1987), brackishwater shrimp ponds which was 50,000 ha in 1981, increased to 120,000 ha in 1987. Minh Hai, the province with the largest area of mangroves in Vietnam, is also the place where most forests were destroyed to give way to shrimp aquaculture. The extent for shrimp farming from 1980 to 1981 was only 4000 ha. This has increased 230 times in 1992 to 80,000 ha (Minh, 1993). Each year Ngoc Hien district loses an average of 5000 ha of forests to shrimp aquaculture.

From 1982 to 1986, the Thai Thuy district (Thai Binh) destroyed 668 ha of planted and protected *Kandelia candel* forests for conversion to shrimp ponds. Most of the protected forests in Tien Hai district (Thai Binh) and many dike-protecting *Sonneratia caseolaris* and *Aegiceras* forests in Hai Phong, Ninh Binh were also cleared to give way to shrimp aquaculture.

B. *Conversion to agricultural areas*

The rapid population growth and its consequence, such as the need for food, led many people from the localities to cut mangroves and build dikes to encroach the sea. A great deal of money and effort was spent, but in most cases the effort was a failure because of insufficient freshwater supply. The yield was very low and in some worse cases no harvest could be made.

For instance, 6039 ha of tidal flats, mostly those with mangroves, in Hai Phong, Quang Yen was used for rice cultivation for 38 years (1954-1992). Owing to the lack of freshwater, the soil became acid sulfate and 1154 ha was left fallow. In Minh Khai, Minh Thanh, Dong Mai (Yen Hung Quang Ninh), after 30 years of forest destruction to give way to agricultural production, the land is now completely wasted (Cu, 1993). In some other places, although a part of the land may still be arable, the productivity is very low.

Salt production has also been practiced for a long time in the coastal areas with sandy soil and brackish salty water. Due to the rapid growth of population and the lack of available jobs, people in some localities such as in Thuy, Nguyen, Kien Thuy (Hai Phong), Vinh Chau (Soc Trang) cleared the mangrove forests, including the protected ones, in order to make salt pans. Of the 9067 ha of salt ponds spreading on the 59 km of the coast in Minh Hai province, a considerable area was once coastal *Avicennia* protected forests.

C. *Mining activities*

Some open mines such as those in Ha Tu, Cam Pha, Mong Duong in Quang Ninh province are near the coast and salty rivers which support the mangroves. During the exploitation, workers discharge waste into the rivers or the sea and into the mudflats affecting the growth of the mangroves. The construction of some coal ports in this province such as in Uong Bi. Cua Ong, has also led to the destruction of many mangrove forests.

D. *Urbanization*

In recent years, the conversion of mangrove areas into towns, industrial zones, and ports also contributed to the narrowing of the mangrove forest areas. For example in Nam Can town in Minh Hai province, after ten years of the mangrove conservation, the town had increased its population by 10 times. Furthermore, houses and enterprise buildings gradually replaced the areas which once supported dense forests of *Rhizophora* or *Avicennia*. In Quang Ninh, the urbanization of Ha Long City also affected all the mangrove forests at Coc 3, Coc 5, and Coc 8.

E. *Infrastructure development*

In line with the economic development of the coastal areas, some localities have constructed dams and roads such as the dam at Cam river, the road joining Dinh Vu and Phu Long islands in Hai Phong, and the road to Hoang Tan island in Yen Hung, Quang Ninh. Although road transportation has been facilitated, this caused adverse effects on the environment.

VII. Impacts of Deforestation on Shrimp Pond Construction

A. *Deterioration of the biological resources*

The deterioration of mangroves has been most serious in Minh Hai, the province with the largest and most luxuriant mangrove forests in Vietnam. During the two resistant wars, many mangrove forests served as protection for the people and soldiers against the enemies' bombs and attacks. Sweats, tears and even blood were shed to protect and restore these valuable forests which are now being destroyed for some short-term benefits, leaving very serious consequences. At present, only 1/4 of the forest land is covered with mangroves, mostly secondary and newly-planted ones.

A worse situation has resulted from the deforestation and the shrimp culture method using a large area which caused degradation of the pond environment. Most of the shrimp ponds have very few sluicegates for water tide exchange so that the pond environment is polluted, adversely affecting the shrimps in the ponds.

A study of P.N. Hong, L.D. An and collaborators (1992) revealed a considerable decrease in plankton as feed for shrimps after only two years from the construction of the shrimp ponds, at the west accretion of Ca Mau Cape. On the contrary, some blue algae such as *Oscillatoria* species are developing 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 in the pond.

On the tidal flats are the typical tidal micro-organism species adaptable to the substrate exposed to the sun at ebb tide and flooded at flow tide, particularly the crabs species of two families, namely *Grapsidae* and *Ocypodidae*. Unicellular silica algae are important food source for shrimps, fish and their larvae, and these are found in rivers and canals. Other species of algae, such as blue-green algae (which are adapted to stagnant waters) and green algae, are present in smaller quantities in the ponds. The species of blue-green algae *Oscillatoria subbrevis*, *O. princeps*, *O. lemusa*, *O. chaiyeta*, *O. salina*, *O. geitleriana* and *O. planetonica* which are commonly present in culture ponds in South Vietnam (Canh et al., 1993), caused the foul smell in the water.

In ponds with a great quantity of organic matter, an alga mat may be formed at the bottom, harming the activities of shrimps and consuming oxygen during the night. When the algae die, they are anaerobically decomposed releasing H_2S and causing serious pollution in the pond. The research results of the Research Institute of Aquaculture No. 2 (1992) showed that in the extensive culture ponds of the Ben Tre province, the pond environment decays during the first year of use changing the community structure of the organisms. Water temperature in shrimp culture ponds is high (sometimes reaching 36-37°C) mainly due to lack of forest cover. The alluvium sediment silts up the canal (0.3-0.5 cm) and water turbidity is high (5-15 cm), restricting the growth development of the aquatic organisms and algae (Luu, 1993).

The shrimp ponds which occupy an extensive area have reduced or replaced the habitats of many benthos and plankton species originally abounding the muddy tidal flats. Furthermore, this has also destroyed the nurseries of shrimps and crab larvae, affecting the livelihood of poor people catching crabs and picking shells on the tidal flats. A survey showed that there are 22 species of benthos on the mud flat whereas there are only two species remaining in the ponds, which serve as important source of food. In some cases, there were ponds where shrimps could not even survive (Hong and An, 1992) for lack of natural food in the ponds.

Destruction of the natural and planted mangroves along the coast of Thai Binh, Quang Ninh, Hai Phong has decreased the quantity and quality of marine life which often live the whole or part of their life cycle in mangrove forests. If mangroves are not rehabilitated, these creatures would not be able to find food and have to leave for the other more conducive areas.

B. *Waste of shrimp resources*

The practice of "keeping shrimps in the pond" in too short period of 15-20 days, resulted in harvest of small-sized shrimps (500-1,000 ind/kg), of which only shrimps of the size of 20-50 ind/kg are of high value. In the southwest accretions of Ngoc Hien (Minh Hai Province), hundreds of mt of young shrimps at juvenile sizes were harvested at each tide cycle. The productivity in other ponds behind the embankments has also largely decreased because most of the shrimp source are caught at the accretions.

Some shrimp culturists know that early harvest will adversely affect the crop, but since the pond environment has been degraded, the shrimps would either not grow or die gradually if culture is continued for a longer period. Therefore, farmers would rather harvest a little than harvest nothing at all.

C. *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 live until they become mature and go to sea again to lay eggs. When mangrove forests are no longer there, they also lose their habitat and have to leave for other places. Many economically valuable marine products such as *Mugil cephalus, Lates calcarifer, Muraenesox talabon, Pseudapocryptes serperaster, Parapocryptes macrolepis*, oyster, shells, terrestrial animals such as reptiles and birds are also deprived of their habitat, breeding ground and living environment.

A vivid example on the role of mangroves in this aspect is in Can Gio District. After the American herbicide war, the forests were destroyed, all fauna resources also declined. But after the mangroves were rehabilitated, the yield of marine products in the area has increased year after year. According to the statistics data of Ho Chi Minh City Aquatic Product Service 1990, in 1977, when there were no forests, the catch yield was 10 mt of fish and no shrimps. In 1989, when mangroves were young, the yield was 3172 mt of fish and 150 mt of shrimps. In 1989, the forests closed canopy and provided a lot of humus and the quantity of fish caught was 15,870 mt, while shrimps was 2430 mt. Although this could also be due to other factors such as improved catching tools and equipment, and increased number of laborers involved. On the other hand, from 1993, the number of long tailed monkeys have increased rapidly to approximately 300 individuals at Khe Dinh, Khe Doi. Other animal and bird species have also increased in quantity.

VIII. Impacts of the Construction of Shrimp Ponds

A. *Salt intrusion*

In the plains of Bac Bo, saline intrusion extends rapidly in the dry season when river flows are reduced from December until May, a minimum flow of which occurs in March. In the Thai Binh river system, saline intrusion is worse than in the Red River system, mainly due to the smaller water flow in the Thai Binh river during dry season, and also because the Hai Binh river is located on the lower land and the tidal amplitude is higher. A maximum of 1‰ salinity may intrude more than 20 km in the Kinh Thay river, Lach Tray river and about 10 km in the Red River (Thanh et al, 1990).

During the last few years, the construction of a series of large shrimp ponds along the coast, estuaries and riverbanks has considerably decreased the area of tidal water distribution, particularly during high tides. When high tides coincide with the north-eastern monsoon, saline water may intrude farther inland and produce saline pollution not just in the land outside the dike, but also in the plain inside the dike.

Under dry, low humidity weather patterns, saline pollution may emerge at the surface and affect plant life. Saline pollution disrupts the ecological balance in estuarine areas causing some brackishwater organisms (among them species of crab, *Uca*, *Sesarma* and some species of molluscs) to invade farther inland. Freshwater organisms either die because they cannot adapt to the salinity or they migrate farther inland. Some riverside freshwater plant species such as *Paspalum scrobiculatum, Hemarthria compressa* and *Digitaria violasceus*, which are important food sources for cultured animals die or become sterile as a result of the expansion of saline-adapted weed species, such as *Cynodon dactylon, Sporobolus virginicus, Paspalum vaginatum* and *Cyperrus stoloniferus* (Hong, 1995 A).

Saline intrusion during the monsoon period also causes erosion along the riverside, destroying the habitats of some land organisms, such as the freshwater crabs and earthworms. In some locations, the dike boundaries are extended for rice farming purposes but, due to the soil acidity and salinity, the yield remains low. In some parts of the land area transformed into ponds to culture brackishwater shrimp and crabs inside the dike boundary, as in Uong Bi Town and Yen Hung District (Quang Ninh), Kien Thuy and Tien Lang Districts (Hai Phong), the yields usually decrease due to restricted water exchange. Some organisms, especially nitrogen-fixing micro-organisms also die causing the restriction or obstruction of the mineralisation process of organic fertilizers used for rice cultivation.

The salinisation of agricultural land due to shrimp culture creates antagonism between rice and shrimp farmers. This happened not only in some parts of Vietnam but also in many other countries. Macintosh and Phillips (1992) recorded that 16 - 22% of agricultural land in Thailand has been affected by saline pollution as a result of the construction of shrimp ponds.

B. *Enhancement of mud accumulation and erosion*

Apart from the extension of the dike boundary to increase land area for rice cultivation purposes, the embanking of dikes to enlarge some shrimp culture ponds has filled up some smaller rivers flowing into the sea or into larger rivers. This has resulted in the alluvium and sediment concentration in the great estuaries of the Red River system or accumulating inside the dike. In the smaller estuaries, erosion occurs due to lack of accumulated alluvium. One representative case is a part of the seashore from Gia Hai to Van Ly (Nam Ha Province), which is 20 km long and since it has no tidal mud marshlands, serious erosion has occurred.

For nearly a century ago, one branch of the Red River used to flow across this area, but what is left now is a small branch called the So River with weak water flow (Thanh et al., 1990). Many other branches of Bach Dang river in Uong Bi, Yen Hung (Quang Ninh) have also been reclaimed for land to rear shrimps and cultivate rice. Consequently, the topography has changed for the worse and the abundant source of biodiversity resources at tidal flats, including many marine species of high economic value, has been destroyed.

In some areas, namely Thai Thuy, Tien Hai, Xuan Thuy, Kim Son, south Hoang Hoa, south Lach Ghep Estuary and especially the southwest of Ca Mau Cape, shrimp ponds are built on loose accretions which are in the process of forming tidal flats with mangrove forests. Under the impacts of monsoons, particularly at spring tide and during typhoons many ponds break or erode because the substrate is soft mud.

The composition is usually powder sand or fine sand, poor in nutrition and lacking in glue substances. This led to wastage of a great deal of money and labor. On the other hand, the above-mentioned activity has harmed the environment and natural resources, devastating the habitats of many benthos species, and preventing the shrimp/crab seeds from entering rivers and canals. Furthermore, due to the building of the embankments preventing the accumulation of mudflats, a number of pioneer sea-encroaching species such as *Sonneratia caseolaris*, *Acanthus ilicifolius*, *Avicennia alba*, and *Sonneratia alba* cannot grow (Hong 1995).

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. 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 southwest monsoons when the amount of alluvia is small and the current and waves are strong. This situation will remain and the consequences will become imponderable when Ca Mau no longer has forests and the pioneer species stabilizing the accretion of land like *Avicennia alba*, has no more place to develop seaward.

C. *Water pollution*

Due to the holding of shrimps in the ponds for a longer period and weak water exchange, however, the pond medium may become strongly polluted by the formation of H_2S and NH_4 originating from the decomposition of the saline flooded plant debris. This is a common phenomenon in extensive pond culture in North Vietnam as well as in the South where there is presence of oscillating algae. These algae often develop into green, mucus stratum and die, rendering the pond water obnoxious with low dissolved oxygen and rapidly deteriorating the pond water quality. During the harvest of shrimps and fish, the effluent flow carries toxic metabolites along rivers and canals, and pollutes the surrounding environment. In some cases after heavy rainfall, the saline concentration abruptly decreases which leads to massive death of shrimp in the pond, as anaerobic decomposition will form into toxicants. During pond drainage, these toxicants will be released to the marshland environment and affect other organisms, including seed sources of many high value fishes (Hong 1995).

The inadequately planned construction of shrimp ponds has led to lower ponds receiving waste water from the higher ones. On the contrary, the tide passing the lower ponds before flowing into the ponds on higher land at spring tide, facilitates the spread of the dirt into the ponds. Poisonous matters like Fe^{2+}, Fe^{3+}, NO_3, NH_4, blue algae, organic wastes and disease-carrying bacteria from the ponds are brought by the tide to canals and rivulets, severely affecting the coastal and riverside flora and fauna.

D. *Spread of diseases and epidemics*

In some culture ponds, due to poor water quality, diseases and pests caused by bacteria or fungi begin to appear. Due to lack of preventative measures and pathological and nutritional methods for shrimp culture, the prevalence of the diseases occurs. This greatly affects the culture yields and in many cases, the disease spread throughout the whole area, where effective measures to counteract them are not adequate.

In some locations, especially in the coastal areas of south Vietnam, farmers adopt methods of killing fish in the culture ponds using a killing agent which is mainly the plant *Derris sp.* or waste of tea seeds. The liquid killing agent is poured into the pond to kill the fishes, while the rotting fish serves as food for the shrimps. The pond water would therefore, be seriously polluted affecting adjacent ponds and surrounding rivers and canals destroying many organisms in the area. Moreover, the obnoxious smell affects the human health.

The forest clearance for shrimp farming has also created a breeding place for the anopheles mosquitoes. After the forest are destroyed, the water becomes stagnant and a species of *Cyanophyta*, a food for the anophele larvae, receives enough light to develop and thus facilitates the quick growth of the anopheles mosquitoes. In the last few years, malaria has spread to some coastal areas with mangroves such as Can Gio-Ho Chi Minh City, Binh Dai-Ben Tre and Ngoc Hien-Minh Hai, threatening the lives of local people, workers in manufacturing and industries, and many members of research teams (Hong, 1994).

In 1994, the shrimp culture band wagon in the South provinces spread over an area of 84,858 ha, resulting in a loss of approximately 294 billion Dong (Information on Fisheries, No. 2-19095). There are many reasons for such loses, but an important reason is deforestation which degenerates the environment, and the wide spread of the shrimp culture using low technology. This has left a terribly bad impact on the economy of coastal Minh Hai.

Many shrimp farmers went bankrupt, the working people encountered many problems while a number of freezing factories stopped operating for lack of materials, and workers became unemployed. In order to meet their immediate needs, the people continue to destroy the already exhausted or newly-planted mangroves, leading to even more serious deterioration of the resources.

IX. Impacts of the Conversion of Mangrove Areas

A. *Agricultural land*

1. Soil degeneration

The destruction of mangrove forests for agricultural production when there is a shortage of freshwater to wash away the acid and salt cause degeneration of the soil. Gradually, oxidation, salt endosmosis and acidification turn the soil into complete fallow.

In the coast where soil has no vegetative cover, the content of sulfur is high, oxidization and sulfatation take place from the surface to the gray sediment underneath. Therefore, the soil becomes salty and acidic and poisonous ions Al^{3+}, Fe^{3+}, Fe^{2+}, SO_4 are released. The coastal salinity goes up (Table 1) while the pH becomes low, resulting in the death of the animals in the water. Meanwhile, in the environment which is regularly flooded by tide, in spite of the oxidization and sulfatation, the average pH and the rate of poisonous ions are low because there is no free Al^{3+}.

It has been confirmed that the construction of dike to reclaim the sea for agricultural production in areas lacking water such as in Quang Ninh, Hai Phong and some other localities, is a very serious mistake. It is a waste of labor and money while the environment is ravaged, turning vast areas of land fallow; destroying the habitats and breeding ground of many tidal animals and creatures living in the shallow sea; and depriving coastal poor people of their livelihood which is dependent on the animals living on tidal flats within mangrove forests (Hong, 1994).

The construction of salt-preventing dikes has also hindered the flow of freshwater from the mainland, destroying the adjacent areas with mangroves. Furthermore, the use of chemical manure and pesticides also leave bad effects on the creatures in the ecosystem (Aksornkoae, 1993).

Table 1: Changes in soil chemical features of oxidized sediments in the surface layer (0-20 cm) of coastal tidal flats reclaimed for agricultural production

(N.D. Cu, 1993)

Location	Free Ions (ppm)			Salinity (‰)				Environmental factors		
	Al^{3+}	Fe^{3+}	Fe^{2+}	Cl	SO_4	Cl/SO_4	pH	$\%Fe^{3+}$	$\%Fe^{2+}$	Fe^{3+}/Fe^{2+}
Minh Khai	1,524	289	189	0.920	1.824	0.51	2.0	1.12	0.50	2.24
Minh Thanh	1,428	262	202	0.890	1.762	0.50	2.4	1.38	0.60	2.30
Dong Mai	1,287	256	211	0.792	1.420	0.56	2.6	1.16	0.52	2.23
Ha An	875	304	248	0.820	1.418	0.58	2.8	0.94	0.48	1.96
Song Khoai	776	323	237	0.893	1.382	0.65	2.8	1.08	0.58	1.86
Gia Minh	632	176	156	0.682	0.652	1.05	3.2	1.42	0.83	1.72
Tan Vu	520	147	122	0.641	0.587	1.09	4.0	0.86	0.65	1.32

2. Rise in the extent of fallow lands

The destruction of forests for shrimp pond construction or agricultural production has increased the extent of follow land. Data from the Minh Hai Forestry Service showed a loss of 86,037 ha of forests until September 1993, of which more than 20,000 ha is now fallow land where only the ditches can be used for shrimp culture.

Due to the large-sized ponds with too few sluicegates, the water tide exchange between the ponds and the outside environment is irregular and hence the environment has degenerated. In some coastal areas, especially in Quang Ninh Province, a 5000 ha of mangrove forests was bounded by dikes to bar saline water, and the area was used for agricultural production. Due to the lack of freshwater in these areas, the soil became degraded and unsuitable for rice cultivation.

A large part of this land was abandoned and afterwards part of the land was used for shrimp and fish culture ponds, as in Ha Dong - Ha Thu (Tien Yen district), Ha An, Gia Ninh. In some other provinces, such as in Hai Phong, Thai Binh, Nam Ha, Ninh Binh and Thanh Hoa, many mangrove areas have been destroyed for the construction of extensive shrimp culture ponds. In these areas were *Somneratia caseolaris* natural forests in the riverside marshlands for protection against storms and floods, and *Kandelia candel* forests planted some decades ago to protect the coastal dikes. During construction, the pond bottom was dried, which resulted in soil oxidation and the transformation of decayed materials. The pyrite stratum (FeS_2) in the soil layers (having saline plant debris, lack of water and also being exposed to solar radiation) become oxidized. The ratio of Fe_2O_3/FeO in the substrate increased rapidly, especially in the surface layer. A comparison of the content of solvable Fe_2O_3 and FeO in the marshland soils with saline water plants to that of the culture pond after deforestation and soil decay, showed that the Fe_2O_3 content in pond is 7-10 times higher and the Fe_2O_3/FeO ratio 4-5 times higher (Cu and Hoa, 1990). In addition, there is an increase in the SO_4^{2-} in the surface layer.

In the bottom layer, a great deal of precipitated Fe^{2-} and Mn^{2-} could accumulate resulting in the transformation of the neutral, nutrient-rich, mangrove forest soil into the acid-sulfate soil, unsuitable for breeding aquatic animals (crab, fish, shrimp) and other organisms. The seaweed *Gracilaria sp.* transplanted in Ha Dong pond died after one month mainly due to the adhesion of iron hydroxide to the algae, restricting photosynthesis and nutrient exchange, and destroying the algae cells. The oxidation process also hardened the pond bottom making it unsuitable for zoobenthic and shrimp life. In some ponds, where the soil and water quality is good enough and the dike surface and sides are not covered by weeds and vegetation, oxidation transforms the soil into acid-sulfate soils. Rainfall causes erosion of the dikes and sweeps acid soil from the adjacent hills and dike sides into the ponds. In ponds where water exchange is poor, the pH of the water decreases, where many organisms in the pond could not adapt, leading to shock and death of the organisms. The acidity of water in the pond also affects the development of organisms, including protozoa which serves as food for cultured species. The lower pH levels also destroys the carbonate equilibrium, releasing heavy metals, which are toxic to aquatic organisms and immobilizing the phosphate ions necessary for algal growth (Hamilton and Snedaker, 1984).

Owing to the loss of the forest canopy covering the land, under the impacts of strong sunlight and high temperature, the soil rich in organic matters and sulfate is oxidized into sulfate acidic and salty soil. Furthermore, the peat layers abounding in carbon are also oxidized, forming a large amount of CO_2 dispersed into the air and heating the atmosphere.

B. *Salt pans*

The conversion of mangrove areas into salt pans has also proved uneconomical. Only on coarse sandy soil will water evaporation take place easily and where the salt yield is high. Mangrove land is very fine mechanic soil with 50-70% clay grains 0.062 mm in size, hence the capacities of endomensis and evaporation are weak. Besides, the content of sulfa in the sediments is high, usually 1.5-2.0% in the surface layer and 2.5-3.5% in the underneath greenish gray layer, hindering the formation of salt. The sulfates Fe, Al, Mn released from the sediments together with salinity come to the surface of the pans and make the salt very salty (N.D. Cu, 1993).

This explains why many salt producers in Yen Hung-Quang Ninh, Can Gio- Ho Chi Minh City have failed, leaving the land fallow. The salt pans at some areas have now been converted to agricultural land or aquaculture land, but was almost equally ineffective.

C. *Development of infrastructures*

1. Construction of towns, ports and factories

The construction of towns, ports and factories have devastating effects on the rich natural resources of the mangrove ecosystems and also bad effects on the environment because of the solid domestic and industrial wastes discarded into the water. Ships and motor boats which discharge oil and other substances, pollute the mangrove environment as well as the adjacent areas and killing many animals or forcing them to move farther away. Further more, this also results in the erosion of river banks due to the plying of large motor boats (like in Ca Mau) or due to change of the water flow. A typical example is the change of the flow near the river bank after the construction of Cua Lo port, which caused strong erosion at Cua Hoi. More than half of Xuan Hoi commune and a part of Xuan Truong commune where there used to be green *Sonneratia* and *Aegiceras* forests had been washed away.

2. Construction of dams and reservoirs on rivers

The construction of dams and reservoirs on rivers also destroyed the natural breeding grounds and migration routes of some species of freshwater animals as well as marine water fishes at the river mouths. The nutrients which used to be transported through the river mouths, coastal areas and on the freshwater bodies into the mangrove areas, have been redirected somewhere thus, strongly affecting the physical activities of the flora and fauna especially during the breeding season. The change of the river flow together with the monsoon's effect has brought salt water mainland, resulting in intrusion and changes of the accumulation-accretion process. The physio-chemical environment in the estuarine and coastal area is disturbed, leading to the changes in the habitats, distribution, and life of the marine species (V.T. Tang, 1994). The construction of the dam at Cam river and of the road to Dinh Vu island (Hai Phong) obstructed the Cam river mouth where water is now redirected to the Nam Trieu mouth. This change has resulted in the erosion of the tidal flat with mangrove forests in Dinh Vu, replacing the floury muddy sediments at the edge of the island by sandy sediments and moving a whole large sand dune from road No 14 near Lach Tray river mouth to Doc mountain (N.D. Cu, 1993).

3. Development and expansion of the transport system in mangrove areas

When large systems of transportation and roads were built through mangrove areas, the consequence is the forests could not receive (enough) tidal water. After a short period of time, the mangrove forests near the mainland at some communes of Can Gio district, Ho Chi Minh City have gradually degenerated and the trees grow very slowly. Some wild species such as *Phoenix padulosa* and *Acrostichum* replaced the mangrove species like *Avicennia*. In some other places such as in Long Phu, Vinh Chau, Soc Trang, Can Gio, Ho Chi Minh City, *Avicennia lanata* regenerated in the form of stunted bushes.

The expansion of waterways also changes the sedimentary environment in tidal flats as can be seen clearly with the opening of a new river way joining Thai Binh river and Van Uc river. This caused the salt intrusion of Thai Binh river and Van Uc river, and in the gradual narrowing of the Thai Binh river and the water flowing into Van Uc river, and then to the sea. This is also the reason for the salt intrusion of Thai Binh river deep into the mainland as far as Do Dang, Do Han (Hai Phong) in the dry season with salinity 2-4‰ (N.D. Cu, 1993).

X. Sustainable Use of Mangrove Ecosystem

While waiting for the State to issue mangrove management policies and strategies, managing bodies at the central and local levels in coastal areas should coordinate closely with each other for the sustainable utilization and development of mangrove resources and development. The following measures are therefore recommended:

1. It is urgent and practical to make an overall production plan of the areas with mangroves; and to conduct investigations and surveys of the exact current status of mangroves, shrimp breeding land, agricultural land, eroded land, accretion land in Minh Hai Province (and if possible, in some other coastal provinces with mangroves) through satellite photos, aerial photos and field trips done by professional staff. Afterwards, planning of the irrigation system, clean water supply for the forest ponds and sewage system should be given sufficient concern. Adequate investment from the State and the provinces would also be essential. Funds borrowed from the World Bank and other projects on the locality should be made full use of. Another requirement would be a capable and active management system which can build up the projects within a short period of time.

2. Temporary stoppage of the exploitation of timber, charcoal and firewood in mangrove areas. Encourage the implementation of mangrove reforestation and re-plantation programs.

3. Assessment with regards to the economic, resources and environment impacts of some models in the silvo-fishery enterprises of 184, Tam Giang 3 (Minh Hai Province) should be carried out in order to evaluate achievements to be replicated in other areas and problems to be solved. Some shrimp culturists should be organized to apply appropriate models in other places with the financial and technical support from the projects.

4. Researches should be done on the relationship between mangroves and marine products through the amount of decomposed vegetative detritus and nutrition cycle in the shrimp farming areas with different proportion of the extent of forest shrimp ponds in order to work out the economic and environment impacts. Based on the results, a specific appropriate proportion of the extent of forests shrimp ponds will be calculated for each locality in the province.

5. 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 in order to implement the following action plans:

a) Survey and classification of shrimp culturists for documentation purposes.

b) The natives who have lived in the area for a long time and legal migrant households whose stay has been allowed by the local authorities should be persuaded to reduce their extensive shrimp pond area, 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 sluicegates, buy feed and young shrimps. The Forestry sector should provide them with tree seeds for reforestation of the land for forest based on long-term land and forest allocation with written commitment that they are really the owners of the production areas. The households with shrimp ponds and land for afforestation should be organized into a production group.

c) Illegal migrants who destroyed the forests to build shrimp ponds without any permission, should be classified. The poor people who would like to settle should be allocated with land and forests. This will enable them to implement proper production method applying the silvo-fishery combination in accordance with the common planning and instruction of the local authorities. They can either work on a family scale or in groups supported technically by the forestry and fishery sectors and financed by banks through loans. The central authorities should discuss with the provincial localities regarding deforestation by illegal migrants who make their fortune out of destroying the natural resources. They may be required to return to their home places.

d) The forest lands and accretions which have been invaded illegally or allocated to the wrong people must be returned to the government. Planning will be done afterwards and the lands will then be re-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 coastal areas.

e) The provinces from which migrants have illegally flowed to mangrove areas should cooperate and support local administration in setting up an overall plan of the mangrove ecosystem as well as in stabilizing the situation, as soon as possible.

6. Before a new project is implemented and landforest allocation according to an overall plan is carried out, training courses for staff of the relevant sector such as forestry, fishery, banking, finance, police, army as well as the local population and culturists should be conducted on the role of mangroves to the marine products and on the damaging consequences of deforestation with funds from the World Bank's loans, or from projects and from the localities.

Since good trainers are essential for effective training, the Ministry of Fishery and Ministry of Agriculture and Rural Development should cooperate with the Ministry of Education and Training to provide trainers for students at the secondary/special purpose colleges, then send them to the coastal Districts to participate in the training. The provincial administrations and their districts should arrange meals and accommodation for the trainees as well as organize the training courses. The course shall include the techniques of improved extensive shrimp culture. If the State and the provinces do not pay proper attention to this important activity, other activities will be difficult to realize or complete and finally the forest will continue to be destroyed, and resources continually devastated.

7. Part of the funds for experimental purposes of the projects should be spent on exploring the culture of other species such as oysters, crabs, *Lates calcarifer*, on the tidal flats fronting the mangroves, and in cages and rafts along the rivers. The techniques will be introduced to the local people later thus creating more jobs for the unemployed, increasing the local dwellers' income, and reducing human impacts on the mangroves which are now in serious deterioration.

8. Educational activities for the local population, on the protection of the natural resources and mangrove environment combined with family planning education should be enhanced. The specific activities include dissemination of information through the national and local mass media, and publication and distribution of mangrove books for the coastal teachers, schoolchildren and dwellers in order to avoid and limit the increasing damage caused by natural disasters. The Mangrove Ecosystem Research Center, Vietnam National University, Hanoi has been actively involved in these activities and is now ready to supply the necessary mangrove books and organize the training courses where and when required.

9. The mangrove rehabilitation in Vietnam cannot be done overnight. There should be effective measures for replanning the production and land distribution based on specific natural economic and social conditions. These measures should be flexible but safe, helping to the betterment of the living standard of the indigenous people. At the same time, the ecological equilibrium needs to be restored on this potentially rich but fragile land.

Lack of measures and means of education and lack of information dissemination to the communities and agencies with great role of mangroves forest in the coastal area as mentioned above, have been considered part of the major constraints. Consequently, since the knowledge of the local leaders as well as the inhabitants on this issue is very limited, they could only think of immediate benefits rather than long-term advantages.

In conclusion, in order to rehabilitate the mangrove forest and marine product resources, to use them rationally and to protect this degenerating environment, there should be concerns from the State, the provinces and districts, various sectors and the people as well as a close coordination among these groups. This is in order that an overall plan can be drawn up and implemented. While experience is learned during the process, the effectiveness will be increased gradually.

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