2008 The International Cosmos Prize

Commemorative Lecture

Prizewinner Dr. Phan Nguyen Hong

“Mangroves and Coastal Dwellers in Vietnam
A Long and Hard Journey Back to Harmony”

Sunday 2 Nov, 2008
Kyoto University

Friday 7 Nov, 2008
Tokyo University of Agriculture

Commemorative Lecture at Kyoto University, 2nd November 2008
and Tokyo University of Agriculture, 7th November 2008

MANGROVES AND COASTAL DWELLERS IN VIETNAM - A LONG AND HARD JOURNEY BACK TO HARMONY

Professor Phan Nguyen Hong

INTRODUCTION

Mangroves are amongst the most important and productive of ecosystems and are found along coastal areas and offshore islands. They provide food and nursery grounds for many commercially important aquatic and terrestrial animals. In addition, mangrove ecosystems stabilize coastlines, in many cases promote coastal accretion, and provide a natural barrier against storms, cyclones, and other potentially damaging natural forces. Mangroves have also been traditionally exploited for building materials, herbal medicines and many other forest products. For centuries, coastal dwellers have lived in harmony with mangrove forests in Vietnam.

However, that harmony has been severely broken in the last decades of the 20th century due to the chemical warfare of the US Army, and then population and economic pressures. The over-exploitation of natural resources, conversion of mangrove areas to shrimp and mud crab ponds, agricultural fields, salt pans and human settlements, as well as the environmental impacts of coal exploitation, have contributed to the steady decline and degradation of the once rich mangrove resources.

Once people have disregarded nature, nature will take its revenge. Where mangroves have been destroyed, coastal dwellers have had to suffer heavy damage. Realising this problem, the Government and people of Vietnam as well as Vietnamese and foreign scientists, mangrove research organisations and non-governmental organisations have all tried their best to replant mangrove forests. After 20 years of tireless efforts, coastal dwellers and mangroves in certain areas of Vietnam have started to restore their harmonious co-existence. People have now begun to realise that they should live with, not against, nature, and that they cannot just take away what they want without returning anything to the environment.

BACKGROUND OF THE MANGROVES OF VIETNAM

The area of mangroves in Vietnam

Vietnam, with its 3260 km long coast and dense river system rich in alluvia, has the potential to support a substantial area of mangroves.

Before the revolution (1945), it was estimated that mangrove forests in Vietnam covered an area of 408,500 ha (Maurand, 1943). B.Rollet (1956) using aerial photographs taken in 1952 and 1953 estimated 725,000 acres (290,000 ha) of mangrove forests in the South. The densest mangroves concentrated in Ca Mau Peninsula with a total area of 149,982 ha (Moquillon, 1950). The extent of mangroves depends upon the natural conditions of coastal areas as well as on human impacts, and has changed greatly since then (1945).

According to the Forest Inventory and Planning Institute (FIPI) (2001), as at the end of 1999, Vietnam had an estimate of 156,608 ha of mangroves, of which 96,876 ha were planted and 59,732 ha were natural ones.

Geographical Distribution

Various climatic, hydrographic and topographic factors of the coastal area have strongly influenced the distribution of the mangrove vegetation in Vietnam. The four mangrove zones outlined also represent four distinct coastal zones (Hong, 1991) (Fig.1).

a. **The northeast zone** (Quang Ninh Province) has physical conditions which are suitable for the growth of mangroves. The northeast monsoon in winter creates a sudden drop in temperature, which affects general tree growth and especially certain species which cannot adapt to it. A list of 34 species has been recorded, including 16 species of true mangroves and 18 species of associate mangroves (Hong and San, 1993).

b. **The northern delta zone** (Red River Delta) is accreted by Thai Binh River and Red River. Though the mud flats are large and rich in alluvium and fresh water, this zone is subject to strong winds, storms and waves. In winter, the temperature is rather low so the mangrove stands are not extensive and the trees are relatively small. The local mangrove communities consist of brackish water species, dominated by *Sonneratia caseolaris, Kandelia obovata* and *Aegiceras corniculatum.*

c. **The central zone:** The main factor controlling the distribution of mangroves in the central Vietnam is the physical condition. The seacoast is parallel to the Truong Son Range. Most of the rivers rise from the mountains, thus limiting the supply of fresh water and suspended matters. In addition, the coastline here is rocky, surrounded by deep sea and influenced by strong water actions. Due to the above reasons, there are no mangroves along the seashore. Narrow strips of brackish water mangroves can be seen along riverbanks, river mouths and the west of small peninsulas. 26 species of true mangroves and 24 associate mangrove species have been recorded.

Fig.1 Map of mangrove distribution

d. **The coast of southern Vietnam:** This zone is created by two river systems: Dong Nai River and Mekong River. The ecological conditions are favourable for extensive development of mangroves. Moreover, this zone is located near the Indonesian and Malaysian archipelagos, the places of origin for mangroves species. Due to the warm

streams and the southwest wind which carry seeds and propagules to this zone, the composition is rich, comprising 34 species of true mangroves and 42 species of associate mangroves, and the tree sizes are the largest in the country.

TRADITIONAL HARMONIOUS CO-EXISTENCE OF MANGROVES AND COASTAL DWELLERS

Mangrove forests of Vietnam have been widely used by coastal dwellers who live in or close to them for thousands of years. The forests provide resources for the livelihood and fishery industry of the coastal communities. Commercial and traditional products of mangroves are diverse and include commodities such as timber, charcoal, fuel wood, thatching materials, herbal medicine, forage, and honey (Hong and San, 1993). The greater part of the inhabitants here has been dependent on the wealth of fishery resources within mangrove waterways and mudflats, which include many species of fish, crustacean and shellfish.

Firewood - In most coastal communes, there are no inland forests. As such, mangroves remain the main source of domestic fuel. Recently, coal has been used. Only some richer households use gas in cooking.

Charcoal - *Rhizophora apiculata* and *Bruguiera parviflora* woods are made into charcoal. Under the French domination and the old Sai Gon Government, the charcoal industry was dominated by private entrepreneurs. Since 1975, State-owned forestry enterprises have managed charcoal kilns. In recent years, there has been a sharp drop in charcoal production due to poor forests.

Tannin - Tannin from mangrove barks was used in the last century for the manufacture of leather, ink for dying fishnet, ropes, sails and textiles. In recent years, synthetic tannin has replaced this material.

Nipa palm products - Nipa palm is a very popular plant in the coastal area of southern Vietnam. Nipa shingles are used to make roofs for houses, and henhouses and pigsties (fig.2). The fronds are used as wrapping for a type of sticky rice coconut cake; the leaf stalks are utilized for floats of fishing nets and the ribs are used for making brooms. The soft endosperm of mature seeds is edible (Hong & San 1993).

Fig. 2. Roof thatching by nipa palm shingles

Medicine - The sanitary conditions of dwellers in mangrove areas are often poor, so diseases are common. The traditional medicinal plants have not been studied scientifically or have been subject to experimentation (Aksornkoae, 1993). Field investigations show that there are 33 species of true and associate mangrove species that have been used for treating about 44 diseases (Hong, ed. 1999).

Bee honey - Along the north coast of Vietnam, beekeeping is popular. When the *Kandelia obovata*, and *Aegiceras corniculatum* are in

Fig. 3. Bee hives are placed near mangrove area when mangroves are in bloom

bloom, the hives are placed in temporary holes along the seadykes or on the floor of *Casuarina* forests to avoid sunlight and heat and to enable the bees to feed on the blossoms (Fig. 3). When the blossoms finish, the hives are brought inland where there are many trees and vegetables that have nectariferous flowers (Hong & San, 1993). Several tens of metric tons of honey are produced per year.

Forage and food - Mangrove foliage can be used safely as forage and food since it contains significant quantities of all necessary minerals, vitamins, amino acid, protein, fat and crude fiber necessary for the growth and nourishment of livestock (Hamilton & Snedaker, 1984). In coastal areas, many domestic animals graze on mangrove foliage. Some parts of mangroves can be consumed by human such as *Avicennia* seeds, *Kandelia obovata* propagules, and young leaves of *Acrostichum aureum, Premma integrifolia,* which are used as vegetables.

Other minor products - Pneumatophores of *Sonneratia* species and *Excoecaria agallocha* are made into bottle stoppers, net floats, and frames for sunhats. The *Xylocarpus* species with fine-textured, deep-brown wood has been used in statue carving... (Hong (ed.), 1999).

Fig. 4. Mollucs collected from mangrove forest

Aquatic resources - There is evidence that mangrove forests are used as shelters and nursery grounds, as permanent habitats for some species and breeding grounds for some coastal species (Aksornkoae, 1993). The livelihood of tens of millions of poor people in the estuarine and coastal areas of Vietnam has depended on the aquatic resources in and around mangroves (Fig. 4). Aquaculture is also widely practiced in mangroves.

THE BROKEN HARMONY

In the last century, the harmonious relationship between people and mangroves in Vietnam has changed for the worse. The two most important reasons are the American chemical war and the conversion of mangrove forests area to shrimp ponds, agricultural fields or for other economic purposes.

The American chemical war

During the Vietnam War, Southern mangrove forests served as revolutionary bases for the resistance forces and the reception points of weapons transported from the North. As a result, the American Army used bombs and high–content herbicide and defoliant agents to destroy them.

Areas of mangroves sprayed with herbicides

- Rung Sat

The Rung Sat tidal swamps belonging to Ho Chi Minh City and Dong Nai province had been covered by mangroves. From 1962 to 1970, 65.42% of the Rung Sat mangroves (NAS, 1974) (equivalent to

Fig. 5. A mangrove forest in Ca Mau Cape totally destroyed by defoliation operation (Photo: P.N.Hong, 1977)

35,275.5 ha) was sprayed with herbicides (Hong, 2004c).

- Ca Mau Cape

Ca Mau Cape used to be home to the largest natural healthy mangrove forests of Viet Nam. According to N.M.Cuong (2006), 49.3 % of the mangrove area in Ca Mau (equivalent to 73,942 ha) was sprayed with herbicides (Fig. 5).

- Coastal areas of the Mekong Delta

According to the statistics of the Forest Inventory and Planning Institute (FIPI, 1980) and the data of provincial forestry agencies (checked against sprayed/spread traces on the Vietnam war by Smith and Watkins (1981)), the areas sprayed with herbicides in 6 coastal provinces of the Mekong Delta were 95,435 ha in aggregate.

Impacts on fauna resources

The disruption of the vegetative cover following warring herbicide attacks badly affected the highly diverse mangrove fauna, including aquatic and terrestrial fauna as well as avifauna, which depend on the vegetative cover for food and shelter.

Soil degradation

After the loss of forests, the local soil went through tremendous changes. The strong impacts of sunlight, high temperature and the lack of rainwater in the dry season sped up the formation of pyrite (FeS_2), changing the soil into acid sulphate soil and making it impossible for plants to grow (Hong 1983, Hong 2004c).

In order to address the food shortage during the post-war period, many localities set up agricultural enterprises on the land previously covered by mangroves for cultivating rice, maize, coconut, sugarcane, cashew nuts, soya beans and pineapples; yet, they all failed due to the acid sulphate soil, wasting a great deal of money and labour. Afterwards, the government had to invest a large amount in reforestation on these areas.

Coastal and riverside erosions and salt intrusion

The East coast of Southern Vietnam is influenced by a semi-diurnal tide regime with high amplitude (3-4m). In the past, the mangrove vegetation with a dense system of roots above the ground together with nipa palm population reduced the impacts of strong waves, thus restricting the erosion of river banks and the coastal line. The dense mangrove canopy played a great role in reducing wind intensity. After the loss of these forests, the soil was no longer protected, especially in the dry season with high tides and the strong northeast monsoon. Consequently, erosion has become more and more serious (Hong and San 1993).

Analysis of aerial photos shows that the water surface area has increased. The percentage of water surface in Can Gio River system was 22.70 percent of the total area in 1958 (NAS 1974), but increased to 30.56 percent in 1978 (Department of Statistics, Ho Chi Minh City, 1979). According to FIPI (1980), the erosion speed in the river and canal systems of the South was twice as much as that of the forested area.

Over-exploitation

Rapid population growth in coastal areas has resulted in great demand for firewood, charcoal and housing materials. This situation has led to the indiscriminate exploitation of forest resources.

Shrimp culture

Loss of mangroves due to conversion to shrimp culture ponds

Shrimp culture is one of the major economic sectors in the Vietnamese economy.

Nevertheless, the rapid development of shrimp farming has had a very serious impact on mangrove forests. Over the last 50 years, Vietnam has lost at least 220,000 ha of mangrove forests (Vietnam News, 2001) to this activity.

The mangrove area in Ca Mau Province, the largest in the country, has dropped from over 150,000 ha prior to 1962 to 64,572 ha in 1999, almost solely due to shrimp culture (Tan, 2001).

In Quang Ninh Province, in the 2 years 1995 and 1996 only, 14,837 ha of mangrove land were converted to shrimp ponds, and 8,500 ha of mangroves were devastated. The province planned to have 29,000 ha of shrimp ponds by the year 2010, with 13,000 ha of which built on the land of existing mangroves (Hung, 2003).

In many localities, previously natural mangroves developed very well, such as in Cam Ranh Peninsula and Ninh Hoa District of Khanh Hoa Province (Fig. 6). However, the development of shrimp farms and hatcheries has led to destruction of mangroves for tiger shrimp farming purpose.

Fig. 6. Mangrove destruction for shrimp farming in Ninh Hoa – Khanh Hoa Province

The situation is the same in other coastal provinces. According to the statistics of the Ministry of Fishery, as at the end of the 20th century, 226,075 ha of mangroves had been converted to shrimp ponds (Binh, 2003).

Deterioration of biological resources

The loss of mangroves means the loss of habitats and food sources for a variety of marine species, and a decrease in fish catches.

A survey on the abandoned shrimp ponds in Nam Trieu Estuary (Hai Phong City) where mangroves were destroyed shows that there was a sharp decrease in benthos biomass due to the degradation of substrates. The biomass in this area is 9 times less than that in adjacent areas (Trong and Hong, 2001).

After a series of shrimp ponds were built, many economically valuable marine products and terrestrial animals such as reptiles, varans, and birds were deprived of their habitat, breeding ground and living environment.

Indiscriminate mangrove destruction for shrimp farming has tremendously reduced the seed sources of marine shrimps and mud crabs. These species lay eggs at sea, and then their larvae and post larvae move to river mouths and coastal areas with mangroves to live there until they become mature and go to the sea again to lay eggs. When there were no more forests, they lost their habitat and had to move to other places and can be easily eaten by carnivores.

Fig. 7. Mangrove destruction & water pollution after a period of shrimp farming

Water pollution

The disordered construction of shrimp ponds has led to the consequence that lower ponds receive waste from higher ones. On the other hand, the tide usually has to pass lower ponds before flowing into the ponds on higher land at spring tide, facilitating the spread of pollution in the ponds. Toxic matters like Fe^{2+}, Fe^{3+}, NO_3, NH_4, blue algae, organic wastes, disease-carrying bacteria from these ponds are brought by the tide to canals and rivulets, severely affecting the coastal and riverside flora and fauna (Fig. 7).

Though the Bureau of Fishery Resource Protection and Bureau of Environment Protection have issued a number of warnings on the severe consequences caused by persistent pollutants in aquatic environment and wetland degradation, illegal shrimp farming development in areas of ecological importance is still continuing at a rapid rate (Hong, 2004a).

Spread of diseases and epidemics

In some extensive culture ponds, due to bad water quality, disease and pests caused by bacteria or fungi began to appear. Due to the lack of preventative measures and pathological and nutrition knowledge for shrimp culture, the prevalence of shrimp diseases gradually grew. This has affected culture yields to a large extent. In many cases, diseases spread to the whole region, but no effective measures were applied to counteract them.

In 1994, a shrimp epidemic in Southern provinces spread over an area of 84,858 ha, resulting in damage of approximately 294 billion dong (Seaprodex, 1995) (equivalent to US$2.9 million). There were many reasons for this, but an important reason is deforestation, which degenerated the environment strongly, thus facilitating the wide spread of epidemics.

This shrimp epidemic left a severe impact on the economy of many coastal areas of Vietnam. Many shrimp breeders went bankrupt, working people encountered a lot of problems, a number of freezing factories lacked raw materials and their workers became redundant.

In recent years, due to the spread of epidemics, the area of abandoned shrimp ponds has been on an increase; yet, such abandoned ponds cannot be used for mangrove planting as the long-term land use contracts for them are still valid. Therefore, shrimp pond owners have kept these ponds just for harvesting natural aquatic resources.

Forest clearance for shrimp farming has also resulted in the development of anopheles. After forests were destroyed, the water became stagnant. A species of Cyanophyta, a type of food for anophele larvae, had enough light to develop and thus facilitated the quick growth of these mosquitoes. In the last few years, malaria has spread to some coastal areas with mangroves such as Binh Dai - Ben Tre and Ngoc Hien - Ca Mau.

Urbanization

In recent years, there has been increased urban development in and around the cities, towns and other urban zones along the coast. New large scale industries (especially sea product processing factories), port development and housing complexes are being planned.

The daily movement of large ships has affected river banks. Many small houses and shops on river banks have been knocked down by waves created in the wake of the ships. Only the areas which are fully covered by nipa palm or mangrove trees have been protected from erosion.

THE LONG AND HARD JOURNEY TO RE-ESTABLISH THE MANGROVE – PEOPLE HARMONY

Mangrove rehabilitation – the first step

To re-establish the once-harmonious relationship with mangroves, people first need to restore the mangroves they have destroyed.

Mangrove rehabilitation in the post-war period

After the unification of the country (1975), the Central Government and many coastal localities have paid a lot of attention to mangrove rehabilitation on the land previously sprayed with herbicides in Southern Vietnam.

The total area of mangrove rehabilitated from 1975 to 1980 on the land sprayed with warring herbicides in the South was 52,450 ha.

Mangrove planting has also been implemented in other localities. However, this activity has not been effective and even failed in several places due to poor techniques.

From 1981 to 1990, many localities in the Mekong Delta invested huge funds in replanting forests. However, the management and protection of these planted forests were ineffective. When the trees had grown to a certain age, they were cut down by poor people for firewood, charcoal production or for use in the construction of shrimp ponds for richer people, including local officials. Besides, many poor farmers from other provinces illegally migrated to coastal areas to convert mangroves into traditional extensive shrimp ponds.

Mangrove rehabilitation under State programs

Facing the above situation, on 15 September 1992, the Prime Minister of Vietnam signed Decision No. 327-CT on reforestation of bare land and hills and coastal areas. Such efforts helped increase the mangrove areas in some localities. More than 52,000 ha of mangroves have been replanted.

Higher results have recently been achieved in mangrove reforestation compared to the period after the wars (1975-1980) as some experience has been drawn by coastal localities from previous failures.

Mangrove rehabilitation projects supported by foreign non-governmental organisations (NGO) and the World Bank (WB)

Fully aware of the damage caused by storms and floods to the lives of coastal people and their properties, and of the resulting saline intrusion of agricultural land commonly found in coastal areas of Vietnam, many NGOs have assisted coastal communities in the control of such calamities. Thanks to the financial support of NGOs and technical consultancy from the Mangrove Ecosystem Research Centre (MERC), a considerable area of mangroves has been rehabilitated. From 1991 to 2005, about 24,200 ha of mangroves have been replanted in many coastal provinces (Table 1).

Table 1. Mangrove plantation funded by NGOs and WB

No.	Province/City	Sponsor	Planting time	Total area (ha)
1	Quang Ninh	JRC	1997-2005	1757
		ACTMANG	1999-2000	231
		SCF UK	1994-1996	18
2	Hai Phong	JRC	1997-2005	1616
		ACTMANG	1994-2005	1202
3	Ninh Binh	JRC	1997-2005	790
4	Thanh Hoa	JRC	1997-2005	1245
		ACTMANG	1999-2000	147
		SCF UK	1994-1996	275
5	Nghe An	JRC	1997-2005	1096
		SCF UK	1991-1996	184
6	Ha Tinh	JRC	1998-2005	650
		SCF UK	1991-1993	240
		OXFAM UK&I	1991-1996	377
7	Thai Binh	DRC	1994-2005	3919
		ACTMANG	1996-2005	431
		TEPCO	2005-2006	50
8	Nam Dinh	DRC	1997-2005	2331
		TEPCO	2004-2005	40
9	Binh Dinh	ACTMANG	2004-2006	65
10	Ninh Thuan	ACTMANG	2002-2004	52
11	Soc Trang	ACTMANG	2004-2005	51
		MILIEV	1996-1999	95
12	Ben Tre	ACTMANG	1997	44
13	Ca Mau	MILIEV	1996-1999	3647
14	Ca Mau, Soc Trang, Ben Tre, Tra Vinh	WB	2000-2005	3648
Total				**24201**

Sources: Kogo (2004), Hong (2002), Vietnam Red Cross (2005)

Notes: ACTMANG: Action for Mangrove Reforestation, Japan

DRC: Danish Red Cross

JRC: Japanese Red Cross

MILIEV: A mangrove planting project funded by the Netherlands

OXFAM UK&I: Poverty Prevention Organization of England and Ireland

SCF UK: Save the Children Fund UK

TEPCO: Tokyo Electric Power Company

The responses of nature to people's efforts

Once people has initiated the first step in the 'reconciliation process', nature will also contribute its part.

Enhancement of biodiversity

It is envisioned that with mangrove restoration, the present species could regenerate naturally. Even one-species replanted forests such as *Rhizophora apiculata* forests in Can Gio Biosphere Reserve (Ho Chi Minh City) and Ca Mau National Park (NP) or *Kandelia obovata* forests in Xuan Thuy Ramsar site (Nam Dinh Province) have played an important role in vegetation restoration. The development of their root systems helps improve the soil environment. Wild seeds and propagules of other true and associate mangrove species are trapped on the soil by prop roots; at the same time, organic detritus from litter fall create favourable conditions for new species to grow among the replanted population (Hong, 2004b) (Fig. 8a, 8b).

Fig 8. Replanted mangrove forests in (a) Can Gio District, Ho Chi Minh City and (b) Giao Lac District, Nam Dinh Province.

The rehabilitation of mangrove forests has brought about certain changes in the environment and ecological processes. The organic debris produced by the mangrove vegetation, together with the shelter it provides and local environmental conditions, promotes the enrichment of the food chains and spawning and nursery grounds for many vertebrates and fish species (Hong, 2004b). The biodiversity in replanted mangroves has increased year after year in Can Gio Mangrove Biosphere Reserve (table 2) and in Ca Mau NP.

Table 2. Flora and fauna found in Can Gio replanted mangrove ecosystem of Ho Chi Minh City

Phylum/Class	No. of species	No. of families	Class	No. of species	No. of families
Mangroves			*Vertebrates*		
True mangroves	30	14	Fish	133	40
Associate mangroves	42	24	Amphibia	9	4
Invertebrates			*Reptiles*	31	15
Polychaeta	32	18	Birds	130	41
Crustacea	53	11	Mammals	19	13
Mollusca	32	15	Sources: Hong et al., 1996; Dat, 1997; Mien et al., 1992.		

After mangrove replanting, fishermen in Thai Binh and Nam Dinh have occasionally caught the fish species *Sciaena* sp. This is a high value, precious and rare demersal fish that searches for food in estuarine areas with mangroves. The fish's air bladder is used to make special self-released surgery threads. Depending on its weight, the fish's bladder can be sold for US$ 10,000 – 25,000 each (Fig. 9).

Fig. 9. *Sciaena* sp. caught by fishermen in Thai Binh Province

According to P. Ronnback (1999), the catch from one hectare of mangroves can be 13 to 756 kg of banana shrimp, valued at US$ 91 to 5,292; 13 to 64 kg of crabs valued at US$ 39-352, 257 to 900 kg of fish valued at US$ 415-713, and 500-979 kg of shellfish valued at US$ 140-274.

F.Talbot and C.Wilkenson (2004) demonstrated that an area of 40,000 ha of well-managed mangroves in Western Malaysia brings US$ 100 million each year to the sea product industry sector, or US$ 2,500 per hectare. Each kilometer of the greenbelt of mangroves along the coast of Panama Bay brings US$ 85,000 from shrimp, fish, and other shellfish species. In Thailand, each year a hectare of mangrove provides US$ 1,000 from fishery and other mangrove products (Midas 1995).

Mangroves help protect offshore coral reefs and sea grass beds because their roots filter out the mud and wastes from water that runs off from the land.

Mangrove microorganisms – a valuable gift

Although there have been several studies around the world focusing on microorganisms of mangroves, this field of research is still new in Vietnam.

From 2001 to 2004, microorganism researchers in our research group had several interesting findings.

First, the number of microorganisms in mangrove detritus and in the soil is high. The number of microorganisms changes by locations and the seasons during the year. This number is lowest in spring and highest in autumn.

Microorganisms in soil include bacteria, filamentous fungi, yeast, and actinomycetes. All have the ability to decompose compounds in the topsoil such as starch, cellulose, pectin, gelatin, casein, and chitin as well as complex compositions that are retained in dead bodies of both fauna and flora species such as CMC (carbocine methyl cellulose), lignocelluloses, and help mineralizes these substances, producing strong enzymes such as cellulase, amylase, protease, and chitinase.

Some filamentous fungi can even degrade some long-lasting phosphorous compounds. The decomposing process provides food for other living creatures in mangroves, and in canals and shallow sea areas.

Solid wastes from domestic, clinical, industrial, and agricultural sources as well as residual chemicals from inland water are decayed in mangroves, creating a food source and cleaning sea water. Mangroves thus have been considered as a giant kidney for the coastal environment (Ha et al., 2004; Hang and Hoa, 2004).

The following genera of bacteria, yeast, and especially filamentous fungus, have strong anti-biotic producing activities: *Trichoderma, Penicillium, Cephloporium,* and *Paecilomyces*. These microorganisms also prevent the development of bad microorganisms, protecting animals and plants against diseases and cleaning the polluted coastal environment.

In addition, our research shows that mangrove microorganisms are highly capable of treating wastes from shrimp ponds effectively (Ha et al., 2004). They can decompose wastes such as residual food, excrement, dead shrimps, and shrimp shells, and can even kill the photogenic bacteria (*Vibrio* sp.), which causes massive shrimp deaths (Pitodo et al., 1998).

Protection of coastal areas and seadykes

Planted mangroves are green walls which effectively protect seadykes and coasts against waves and winds. The research results of Y.Mazda et al. (1997) show that waves 1m in height at the open sea, after going through 6 year old *Kandelia obovata* forests 1.5 km in width in Thuy Hai Commune, Thai Binh Province, were reduced to 0.05m in height at the crab dyke. Without these mangroves, the waves would have arrived at the dyke at the height of 0.75m.

- During Storm No 2 which hit Thai Binh Province in 1996, shrimp and crab pond embankments in Thai Thuy District were well protected by mangroves growing outside; meanwhile, those in the nearby district of Tien Hai where mangroves had been destroyed were strongly eroded or broken. Thanks to the stretches of *Rhizophora stylosa* and *Kandelia obovata* planted in 1992 under the financial support of SCF UK, Dong Mon Seadyke in Ha Tinh's provincial town was protected from being broken during a typhoon in 1999.
- The most obvious impact of protective mangrove stretches on many estuaries and sea dykes was demonstrated during the big storms in 2005. In August and September, three storms, named Waley, Vincente and Damrey, struck the coast from Ha Tinh to Quang Ninh with winds at 102 – 133km/hour. Many national dykes made of concrete but not protected by mangroves in these coastal provinces were either broken or seriously damaged (Fig. 10). At the same time, all dykes which were protected by 5 to 9 year old mangrove stretches (300 – 1,000 m in width), though made from soil only, remained intact or were only minimally eroded (Fig. 11). As such, there was no damage to people and property in these areas (Hong et al., 2006).

Fig. 10. Concrete sea dykes in Do Son Town (Hai Phong Prov.) were broken by heavy storms

Fig. 11. Soil sea dykes protected by mangrove stretches remained intact

Expansion of alluvial soils and restriction of soil erosion

Except for some special cases, the growth of mangroves and the expansion of alluvial soil always happen concurrently. In general, mangrove species could grow in mud flats with favourable edaphic features and climate, and good seed sources.

Mangroves in coastal areas and river mouths play a vital role in protecting and expanding mud flats, minimizing erosion, and decreasing wind power, strength of waves and currents on coastal seadykes and at river mouths.

Mangrove roots, especially pioneer populations, are able to assist sediment deposition. They not only effectively disperse the strength of waves toward the seashore, but also speed up the process of sedimentation. In addition, mangroves are really useful in terms of restricting erosion and seashore intrusion (Fig. 12).

Fig. 12. Newly mud flat protected by pioneer *Avicennia* population

Downstream and at the mouths of such rivers as the Red River and Mekong River, alluvial deposits are often gathered on the river bed and outside the river mouths, which leads to the creation of floating islands. Under favourable conditions, after a period of time, pioneer mangrove species will colonize there, making an environment for subsequent species and gradually raising alluvial soils. Con Ngan and Con Lu in Ramsar site of Nam Dinh Province, Con Trong and Con Ngoai islets in the southwest of Ca Mau cape are some examples.

Ben Tre Province is a very typical case. Almost all the land there used to be floating islands created by cumulative alluvial deposits of Mekong River's branches. These areas have slowly become land for farming and residential purposes thanks to mangroves' significant role in protecting and raising land.

Hindering salt intrusion

When mangroves were not yet destroyed on a large scale, salt intrusion took place slowly and in a very narrow scope. The reason was that although high tides inundated large mangroves; however, the tidal water was then weakened by systems of dense roots and tree trunks and the wind power was hampered by canopies of leaves.

Improvement of poor people's living condition

Poor coastal dwellers - direct beneficiaries of mangrove planting programs

With the support of several NGOs through the Vietnam Red Cross, more than 16,000 ha of mangroves have been re-planted in 8 Northern provinces (from Ha Tinh Province to Quang Ninh Province). Project beneficiaries included many of the most disadvantaged households. For example, in 2003, 1,575 households in 63 communes participated in mangrove replanting programmes that contributed to the reduction of the number of poor coastal households.

The annual forest planting and rotational thinning of planted forests in the South have created employment for many poor locals, and at the same time, provided firewood and building materials for the communes having the forests.

Income from collecting and harvesting sea products in newly planted mangrove areas

Mangroves provide the livelihood for many people.

Research conducted by MERC on household incomes in 4 communes of the districts of Da Loc (Thanh Hoa Province), Dai Hop and Ha An (Hai Phong City) showed that the income from sea product collecting and harvesting in replanted mangrove areas accounted for a high proportion of the local households' incomes. Income from this source ranks the second in the distribution of household incomes, following off-shore fishery. Other incomes come from traditional agriculture and salt making practices.

Benefits from collecting baby crabs in planted mangroves

Sea crabs are highly profitable and have a close relationship with mangroves. Most periods of their life cycle depend on mangroves (from larva to pre-adult). Only when they reach adulthood do they go to the open sea for laying eggs.

There have been many changes in the life of coastal communities in the Red River Delta and Soc Trang Province during the period from 1996 to 2003. Of those changes, the increase of income from baby crab collecting is the most significant (Fig. 13).

Fig. 13. Crab catching on the mud flat near mangrove forests

August to November is the period when crab larvae move from the sea into mangroves. The tiny crabs live under fallen leaves (called "louse crabs"), with larger individuals hiding at the base of the mangrove trees.

In 2002, a survey was conducted by MERC on incomes from baby crabs in mangrove areas of 26 communes in 4 districts of Thai Binh and Nam Dinh Provinces where a mangrove planting project had been implemented by the Danish Red Cross. In each commune, 30 households were randomly selected. The results indicated that during 1999 and 2002, each household on average earned US$150 – 200 per year. This reveals that the income from crab collecting accounted for 16.1% - 22.8% of the total household income. (Tho et al., 2004). The income from crab collecting still accounts for a significant part in the total household income at present.

The income from crab collecting in mangrove areas has helped to solve the financial difficulty for many households. For instance: in one hamlet of Thai Do Commune, Thai Binh Province, with this income, 30 households bought piglets and chicken, 12 households improved their homes, 7 households bought TV and radio cassettes, 4 families bought motorcycles, and many bought other home appliances and furniture, as well as paying for children's school fees, buying clothes, buying rice seeds and fertilizers, etc. (Hong & Dao, 2006).

As their life has been improved, some previously poor households have been able to afford their children's secondary school fee. There has been an increase in spending on school textbooks and reference books. Many poor students have had chances to get involved in local cultural activities.

Ecotourism

Eco-tourism is an economically efficient activity in the reforested mangrove area of biosphere reserves and national parks. Since the recognition of Can Gio as a Biosphere Reserve in January 2000 by UNESCO and the City's investment in its infrastructure, the number of

tourists has increased rapidly. In 2005 alone, 185,618 tourists, of whom 3.6% were foreigners (Fig. 14), visited Can Gio. The area's attractive features include high biodiversity as well as historical and cultural sites such as its Heritage House and Rung Sac Revolutionary Base. In order to protect the restored mangrove ecosystem, only 1,014 hectares were allocated to eco-tourism. The supporting services for this activity (supply of food and drinks, boat trips, sale of handicraft items, etc.) have also provided employment opportunities for a number of local people (Tuan, 2001).

Fig. 14. Ecotourism in Can Gio Mangrove Biosphere Reserve

Scientific research and training

During the mangrove forest restoration, professors from many Vietnamese and foreign universities such as Japanese, German, French… have visited Can Gio and mangroves in the north coast together with their postgraduate students (Fig. 15). Their researches on the ecology, soil, flows as well as socio-economic conditions have been published on many regional and international journals, making mangroves in Viet Nam well-known to many NGOs and international agencies. Fifteen PhD theses in biology relating to these forests have been completed. The Mangrove Ecosystem Research Station in Giao Thuy, Nam Dinh Province has attracted many post-graduate students from various universities in the North of Viet Nam, serving as a good field station for research on ecology and socio-economics in adjacent communes.

Fig. 15. Japanese and Vietnamese scientists studying mangrove soil in Can Gio

Public education of mangrove protection – the next step

- For the effective and sustainable protection of replanted forests, MERC has created many methods to educate various target groups, including local officers, mass organizations, schools and local inhabitants. Our experience shows that educational materials should be simple and attractive, containing many cartoons without too much written information. Also, educational information on mangroves should be disseminated in the form of games, quizzes and in combination with singing and dancing to attract people. With careful preparation, one evening in each location should be enough.
- With funding from a number of NGOs, MERC has compiled and widely distributed many educational materials on the role of mangroves, planting and caring techniques, mangrove protection and consequences of the conversion of mangroves for economic purposes (especially shrimp farming). The target groups include teachers, students, peasants, fishermen and shrimp farmers. Another efficient method is to organize training courses and mobile exhibitions to reach hamlets and villages in areas with mangrove projects. This method has raised the awareness of the benefits from

mangroves for local communities, and helped peasants learn mangrove planting and caring techniques (Fig. 16, 17). Local inhabitants have also realized the fact that in replanted mangrove areas, marine creatures, especially baby crabs, have increased rapidly, thus improving the living standards of poor people. The poor dwellers in some coastal areas in Thai Binh and Nam Dinh strongly objected to their provincial authorities' plan to let shrimp farming companies destroy mangroves. As a result, in some communes, shrimp ponds are now located in previous salt fields instead.

Fig. 16. Training course on "the role of mangroves" for the district and commune managers and leaders

Fig. 17. Audiences participating in the contest on mangrove benefits in Nam Dinh Province

A lot more to be done: the development of future mangrove programs in Vietnam

The huge damage caused by recent storms to sea dykes and local property has raised the awareness of authorities at both central and local levels as well as of local inhabitants of the necessity to protect and restore mangroves for control of storms and floods.

At present, the Ministry of Agricultural and Rural Development is implementing a large project on mangrove restoration for control of natural disasters. This project is part of its 2006 – 2010 research program, prepared in cooperation with some other ministries and branches for submission to the Government for approval in September 2006. The Department of Dyke Protection has included planting of wave-buffering trees in its sea dyke improvement program. The irrigation industry is also planning to plant mangrove stretches along coastal rivers, ponds and lagoons.

The Department of Fishery Economy is making a plan for recovery of shrimp farming areas which are illegal or the contracts of which have expired in order to plant mangroves, with a view to increasing marine resources and protecting fishermen.

In meetings to assess the damage caused by natural disasters in 2005, the authorities in many localities realized their mistakes in relying only on sea dykes without paying attention to mangrove stretches.

In many provinces like Nam Dinh, Thai Binh and Quang Ninh..., directions on strict prohibition of mangrove destruction have been issued.

Quang Ninh Province has employed the Forest Investigation and Planning Institute (FIPI) to make large scale maps of the current use of coastal land based on satellite photographs and site surveys. The province is also preparing a plan for restoration and sustainable protection of mangroves (Department of Agricultural and Rural Development of Quang Ninh Province, 2006).

CONCLUSION

Mangroves and coastal dwellers in Vietnam have for a long time lived in harmony. However, this harmony was severely damaged in the last century due to many reasons, mainly human activities. The herbicides and defoliants spraying by the US Army was the main cause for large-scale destruction of mangroves before 1975. After 1975, population and economic pressures continued to decrease the area of mangrove forests in Vietnam.

There is a Vietnamese saying "If you sow wind, you will reap storms". Many people, especially coastal inhabitants, have suffered from their own actions against the natural environment.

Realising this problem, many scientists and mass organisations in Vietnam, with the funding from the State Budget and especially from NGOs, have been making a lot of efforts in restoring mangroves. Thanks to such efforts, not only the landscape, environment and natural resources have changed for the better, but the living conditions of poor coastal dwellers have also been bettered.

When local people realise a harmonious co-existence with mangrove forests can only improve their life, they will actively protect and develop it and fight against anyone intending to break this valuable relationship.

At present, environmentalists and leaders of coastal communities are facing challenges put forward by both nature and people who only want short term benefits for themselves. We will need more help to deal with these challenges and would welcome the assistance of scientists, individuals and organisations from all over the world.

The achievements in restoring mangroves after the war and protecting replanted forests based on community-involving management in Can Gio, Ho Chi Minh City have served as useful lessons for coastal areas with mangroves in Vietnam as well as in other countries. Scientists, students and people from Japan as well as all other countries are always welcome to visit us.

Finally, please allow me, on this occasion, on behalf of the Vietnamese coastal communities, to express our sincere thanks to the Japanese Government, NGOs and scientists for their kind help along our long and hard journey to regain the Mangrove – People Harmony.

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