Ecological Rehabilitation and Restoration of Mangrove Forests and Coastal Swamp Ecosystems in Vietnam

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Abstract
Swamp ecosystems including mangrove forests and *Melaleuca* forests play an important role in conserving tropical coastal zones. In the Can Gio district in Vietnam, 40,000 ha of mangrove forests was completely destroyed by warfare, but now more than 50 % of the area has been recovered by rehabilitation and restoration efforts. Therefore the district provides a case study of past and future changes of environment and socio-ecosystems caused by rehabilitation and restoration of coastal swamp ecosystems.

Keywords: ecosystems, mangroves, restoration, swamps, tropical coastal zones, Vietnam

Introduction

To solve issues such as shortages of food and energy and damage to the global environment, plants play an important role by providing materials for food, energy sources and environmental conservation. Tropical coastal zones have recently been damaged by the pressures of increasing population, food production and industrial and urban development in many parts of the world. Especially in mangrove swamps, excess cutting of plants for fuel and construction materials and conversion of the forests to agricultural land and aquaculture ponds for commercial production have caused environmental problems. Re-afforestation of mangroves and restoration of coastal zones, therefore, has recently become an urgent issue.

In the paper, we emphasize the importance of swamp ecosystems including mangrove forests and *Melaleuca* forests. We propose that the Can Gio district is a suitable site to investigate past and future changes of environment and socio-ecosystems caused by rehabilitation and restoration of mangroves and coastal swamp ecosystems.

Role of Swamp Ecosystems

There are vast areas of lands used as paddy fields on earth, and most of them had their origin in natural swamps. Considering only areas not influenced by seawater, it is estimated that there are over 5-9 hundred million ha of swamplands globally. The role of swamps is important because they do not only control environmental systems in the basins, but also provide for coastline preservation, microclimate control, water purification, soil formation, wild biological habitat, and human use.

Large tracts of swamps and wetlands can be found in the tropical zone. Particularly in Southeast Asia, where weather conditions are humid, there can be found vast swamp areas, including mangroves. Historically, most of these swamps were not exploited before the 1970s' increase in land development. There are some areas where agricultural development had first taken place some decades ago, but most of them were abandoned. Now they have become tropical savannas that do not support plant cultivation, and thus present a significant social problem in countries such as Vietnam.

Geo-ecological and environmental characteristics of mangrove ecosystems

With recent advances in research, and also increased interest in environmental problems globally, it has begun to be recognized that the mangroves and their associated ecosystems are important components not only of tropical coasts but also the global environment. The values of mangrove ecosystem are not only in terms of goods, such as timber and charcoal derived directly from the mangroves themselves, and fish, shrimp and other aquatic resources indirectly supported by inputs from the mangroves, but also from a series of less tangible services which mangroves provide, such as shoreline protection and sediment and nutrient trapping (Hutchings & Saenger, 1987). Recently, the function of below ground carbon sequestration by mangrove peat accumulation has also been identified (Fujimoto et al, 1999; Miyagi, 2000) which emphasized the role in mitigation of atmospheric carbon dioxide accumulation. In spite of their importance, mangrove forests and ecosystems in Southeastern Asia have been disturbed and destroyed by urbanization, timber cutting, shrimp farming and war pressure etc. In addition, the mangrove ecosystem faces serious threats from global environmental change especially rapid sea-level rise (Miyagi, 1998). On the other hand the conservation of mangrove environments and restoration forestry have become popular in many countries recently. The development of comprehensive awareness of the ecosystem functions and improvement in skills of ecosystem restoration are not only useful for local people but also offer a solution to some global environmental problems.

The importance of mangroves in the Can Gio District

Before the 19th century the Vietnam coast was widely covered by natural mangrove forests. The area was quickly reduced following growth in other land uses such as agricultural development, shrimp farming, charcoal production and destruction following several wars. The Can Gio District is located in 20 km southeast of Ho Chi Minh City. During the two Indochina wars, the mangroves in Can Gio were destroyed. An area covered with about 40,000 ha of natural or semi-natural mangrove forest before the war was completely destroyed by herbicide spray by 1971 as shown in Fig. 1 (Hong, 1996). After many years of herbicide spraying, the degraded land still remains degraded and bushy or bare. After the end of the war, great efforts have been made towards the rehabilitation of mangroves. An extensive plantation project was started in 1986 by local government and 54 % of the area was recovered by 1998 (Fig. 2).

The mangroves in Can Gio are amongst the richest in the world, with more than 72 species of mangrove flora (Nam & My, 1992; Hong & San, 1993) and 440 species of fauna (Mien et al., 1992; Hong et al., 1996), constituting an environment of high biodiversity. Common mangrove species found in Can Gio are *Avicenia alba, A. officinalis, Bruguiera cylindrical, B. parviflora, B. gymnarrhiza, Ceriops tagal, C. decandra, Kandelia candel, Rhizophora apiculata, R. mucronata, Sonneratia alba, S. caseolaris, Xylocarpus granatum, X. moluccansis, Phenix paludosa, Lumnitzera racemosa, Excoecaria agallocha, Acrosticum aureum, Acanthus ilicifolius*, etc. The area was appointed as a mangrove nature reserve by UNSCO/MAB in 2000 and named "Can Gio Mangrove Biosphere Reserve, Ho Chi Minh City" (Tri et al., 2000, Fig. 3).

Reforestation of mangroves

Since 1968, mangrove reforestation has been undertaken at a small scale by local people. Since 1978, a much larger mangrove reforestation programme has been undertaken by Ho Chi Minh City Forestry Service, NGO groups and local people (Fig. 4). During the process many remarkable environmental changes have become apparent. Fig. 5 shows the changes of land cover in a part of Can Gio district. The natural vegetation in 1958 showed clear zonation in similar to the typical mangrove forest in other areas (Mochida et al. 1999). These zones were classified into *Sonneratia alba- Avicennia alba* forest, *Rhizophola apiculata* habitat, *Ceriops - Avicennia - Rhizophola* forest, *Avicennia - Ceriops - Phoenix* forest from the mean water marginal side to the highest inland side respectively. The middle map shows the traces of the defoliation operation during the war. The right hand map shows that the replaced vegetation in the same area. The spatial arrangement and zonation of forest groups and species components had changed dynamically.

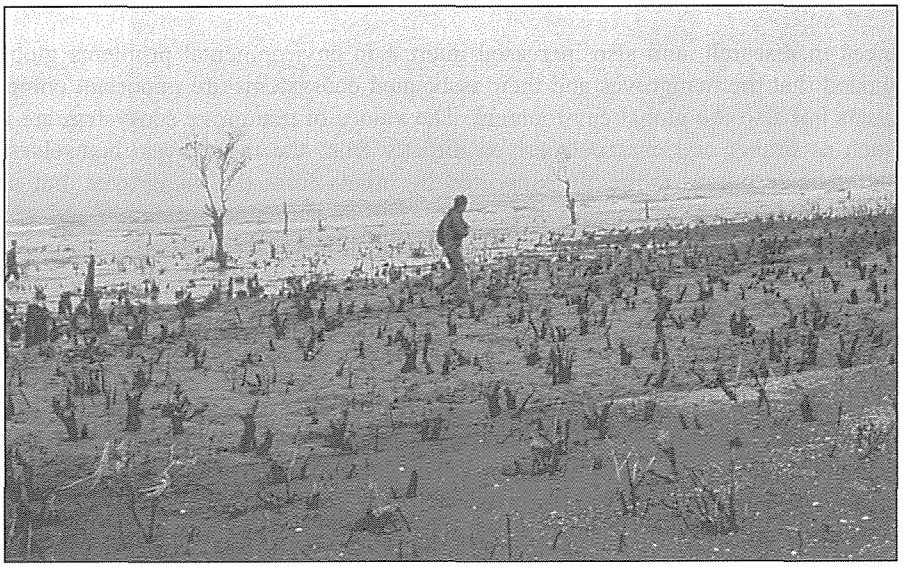


Fig. 1. In southern Vietnam, most of the mangroves were victims of herbicides during warfare (Hong, 1996).

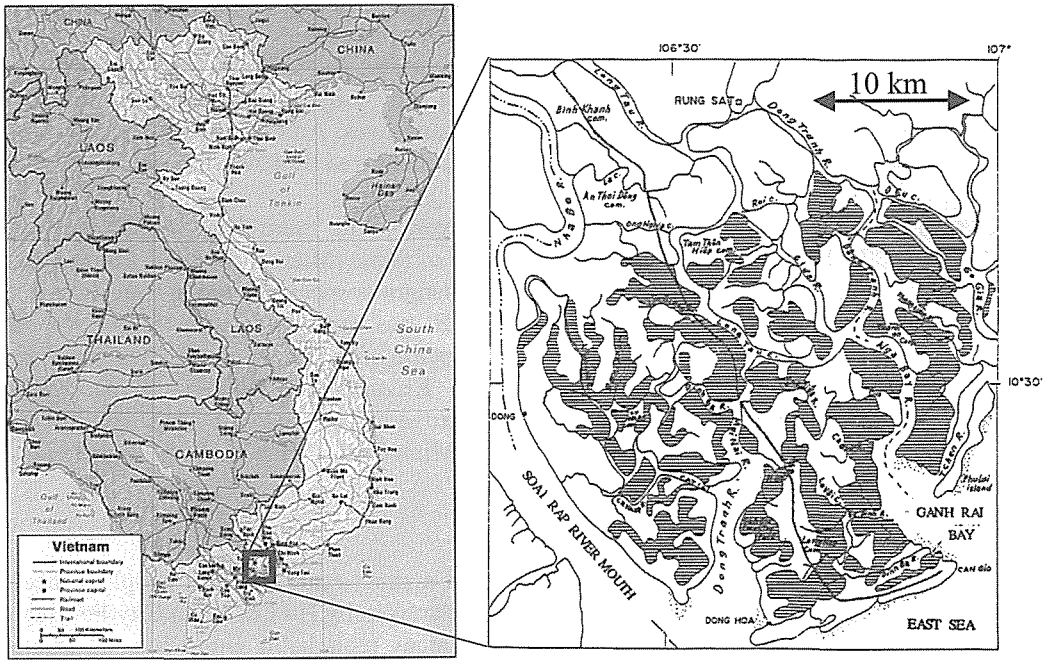


Fig. 2. Distribution of replanted forests of *Rhizophora apiculata* (shading areas) in the Can Gio District (from Hong, 1996).

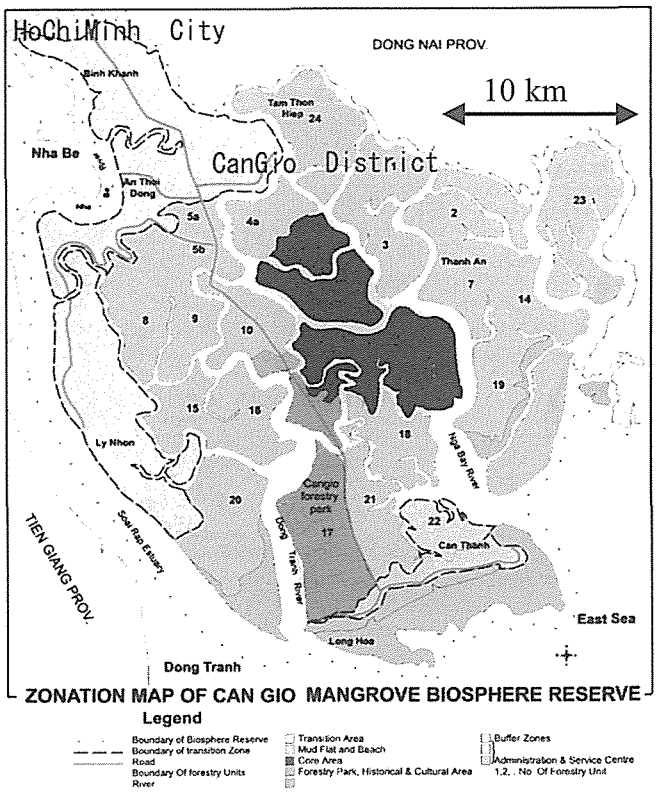


Fig. 3. Zonation map of Can Gio Mangrove Biosphere Reserve, Ho Chi Minh City, Vietnam (Tri et al., 2000).

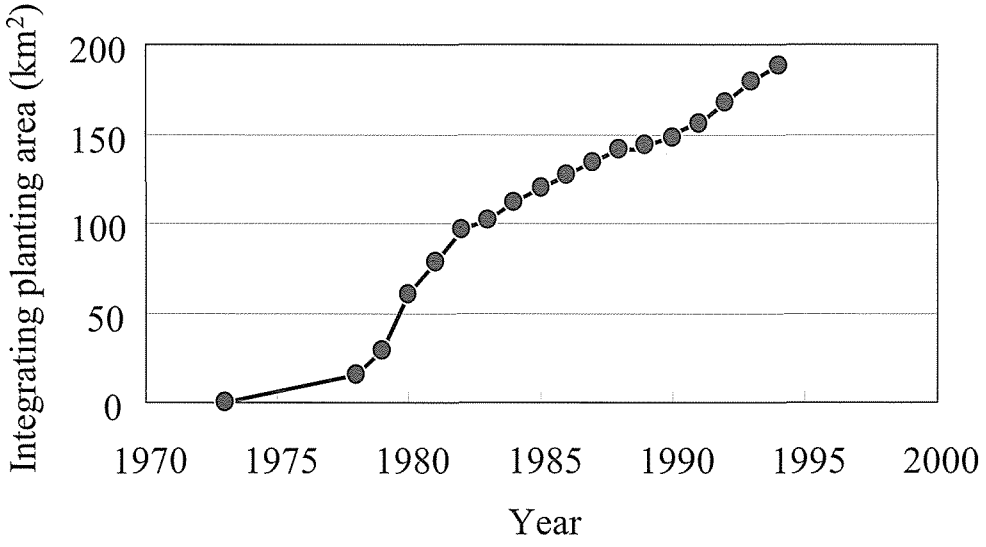


Fig. 4. Area of replanted forests of *Rhizophora apiculata* in Can Gio District (from Hong, 1996).

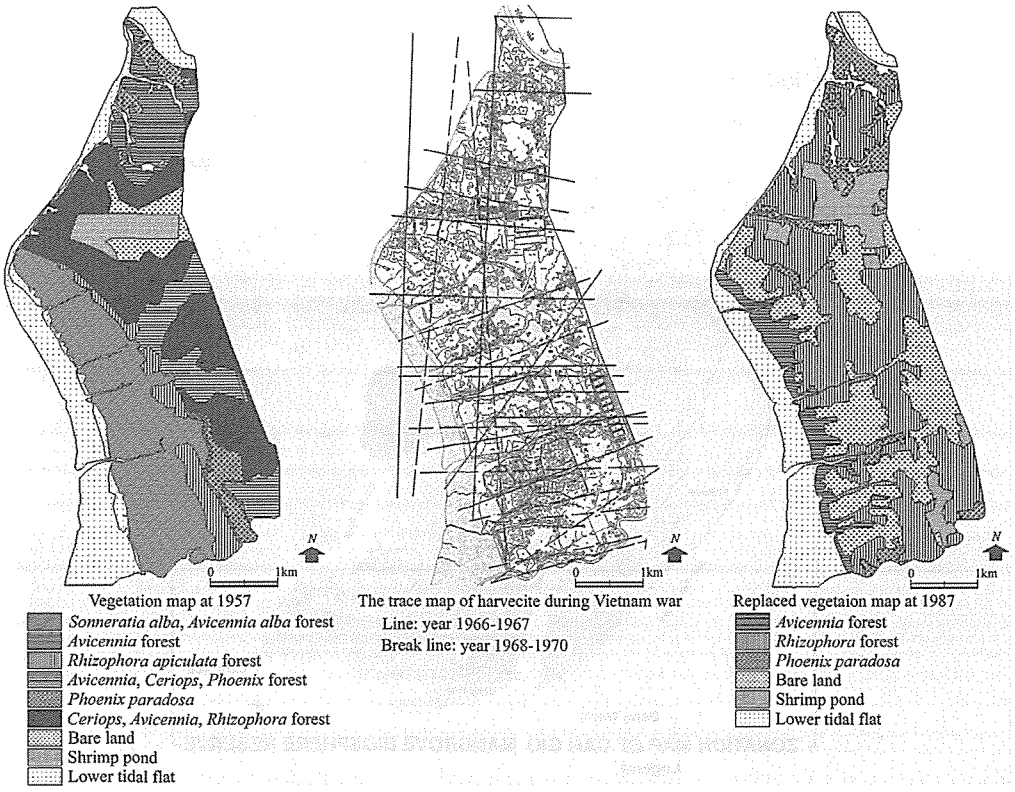
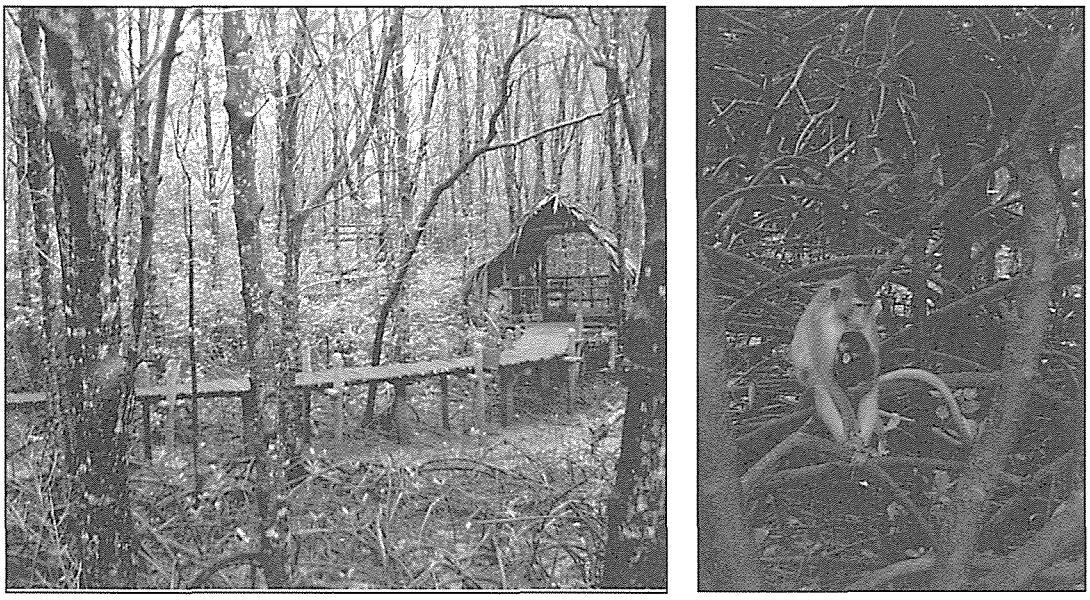


Fig. 5. Change in the mangrove forest in the mangrove park area Can Gio Biosphere Reserve, Ho Chi Minh City, Vietnam.

As a result of the reforestation, there are again large areas covered by mangrove forests and ecosystems (Figs. 6 and 7). The main species of planted mangroves are *Rhizophora apiculata*, *Avicennia* spp. and *Sonneratia* spp., which are 10-20 meters high. Statistics from the Fishery Sector (Fig. 8) show a significant effect of mangrove plantation on fishery production as a socio-economic impact of mangrove restoration (Hong, 1996). However, some parts of the reforested mangrove forests have been destroyed again by new economic factors such as shrimp farm development (Fig. 9).

Fig. 6. Mangroves recovery 30 years after destruction (Photograph of June, 2001).



(a) (b)

Fig. 7. Inside view of the mangrove forest twenty years after starting the reforestation (Photograph of June, 2001). The shelter hut is a reconstructed Vietnamese base for tourism (**a**). Monkeys (*Macaca fascicularis*) live in a replanted mangrove forest (**b**).

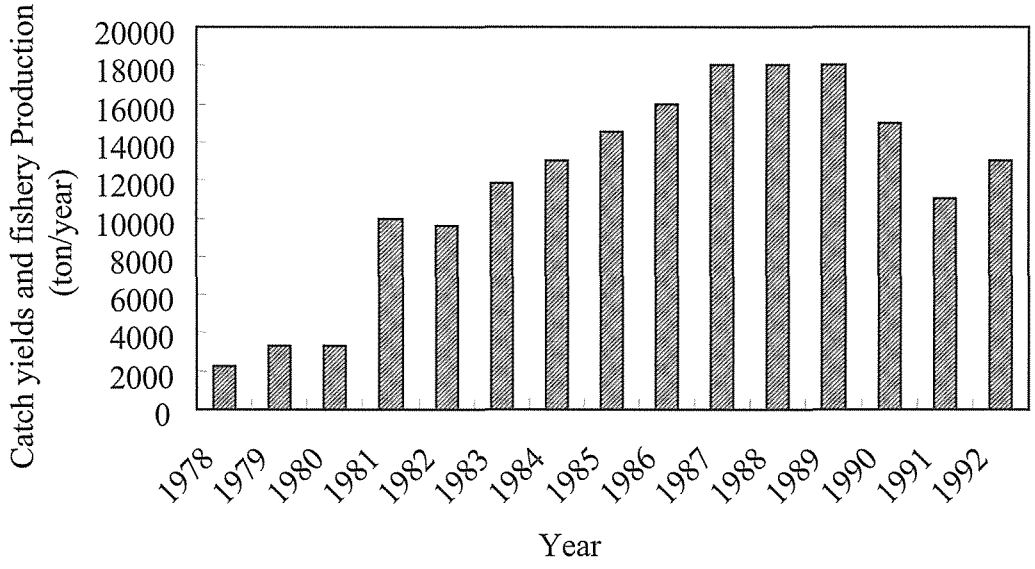


Fig. 8. Annual variation of catch yields and fishery products at Can Gio (from Hong, 1996). In recent years, the catch yields have decreased because the use of unsustainable methods such as mines has been prohibited by the government (Hong, 1996).

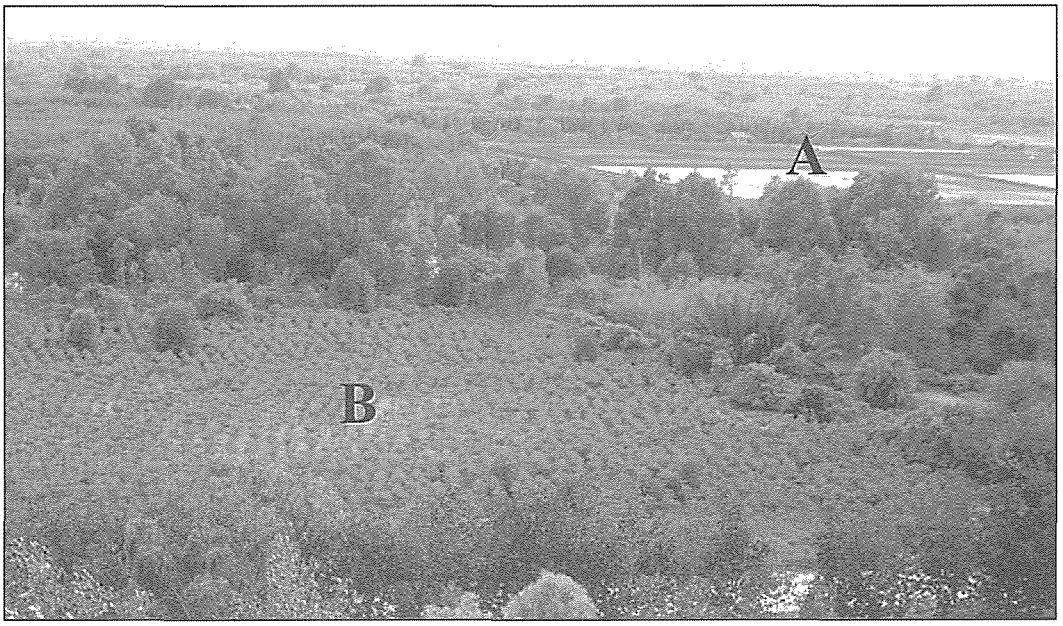
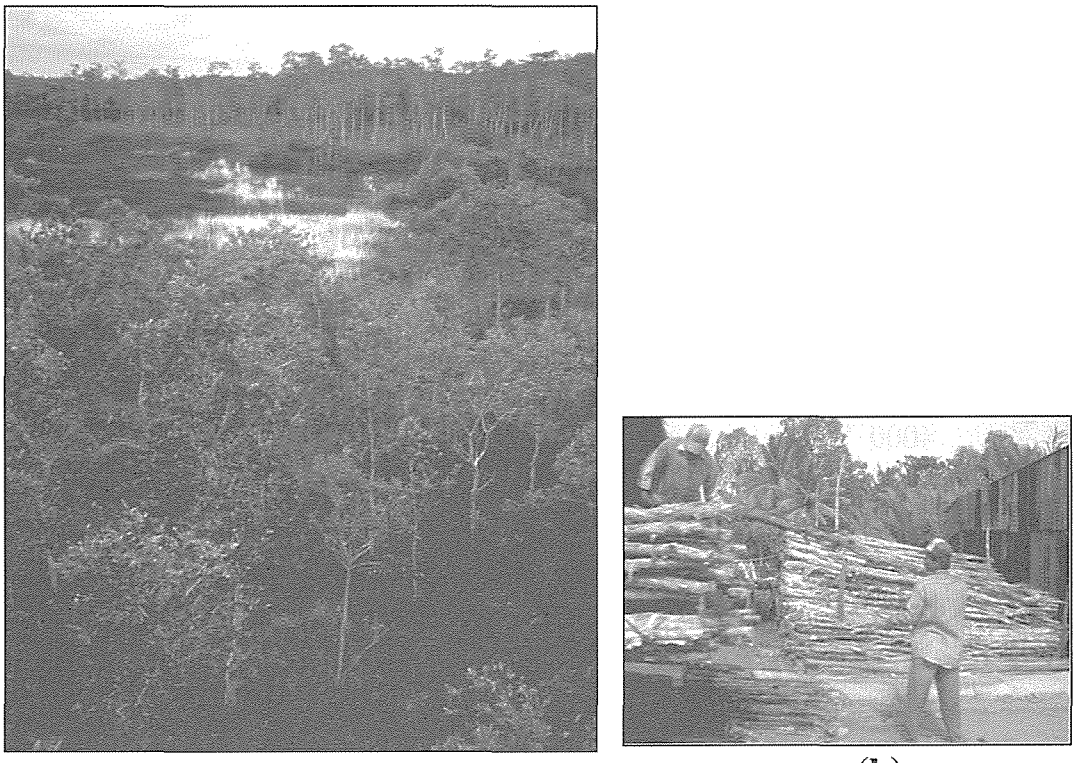


Fig. 9. Today the major agent leading to the destruction of the mangroves is shrimp cultivation (**A**). The cultivation site, constituted of ponds, can be used only for ten years. Some of the afforestation has taken place in abandoned shrimp cultivation sites (**B**).



(a) (b)

Fig. 10. *Melaleuca* forests in a seasonally waterlogged site in the coastal areas of Southeast Asia (**a**) and utilization of *Melaleuca* timbers in Vietnam (**b**).

Melaleuca forests in coastal swamps

The genus *Melaleuca*, of the family Myrtaceae, has approximately 150 to 250 *Melaleuca* species in the world. Most are native to Australia and occur in diverse plant communities. Species of *Melaleuca* are common and representative in swamps and seasonally waterlogged sites in the coastal areas of Southeast Asia and Australia (Fig. 10). Vietnam is the northern (or northeasten) end of Asian forests of the *Melaleuca* species. *Melaleuca cajuputi* is the only dominant tree species in the developed coastal wetlands in tropical Asia (including Vietnam), although the natural distribution is difficult to assess since it has been widely cultivated for oil over many centuries.

Melaleuca may play an important component in wider reforestation. There is not much scientific information about *Melaleuca* in Southeast Asia and Vietnam but local people have been using it in many living appliances and are aware of the many values of this species.

From the phytosociological viewpoint, forests and woodlands dominated by *Melaleuca* species have common characteristics: the tree layer forms pure stands of *Melaleuca*, the shrub layer is usually absent or with few species, and herbaceous layer is sometimes absent after extended water logging. Many reports on *Melaleuca* in Australia and Southeast Asia (not including Vietnam) are already available and can provide important information for study of tropical swamp vegetation.

Discussion and Conclusion

The restored mangrove forest is not a complete recreation of the natural forest. *Rhizophola apiculata* has been planted widely because of the high demands for commercial use and some of the habitat areas used were not so suitable for this species. *Sonneratia alba* has been almost completely lost but the reason is still unsolved. On the other hand *Avicennia alba* has extended naturally within the mean tide zone. Natural and artificial factors have lead to a great deal of environmental change in the area. These changes have also affected the life of local people and the Ho Chi Minh City government. A significant part of the area is now strongly influenced by urbanization and redevelopment of shrimp ponds for intensive use.

The Can Gio district is like a natural laboratory to investigate past environmental changes and estimate future environmental changes. We have to understand what kinds of change occur at there and the differences between the natural mangrove forest and the reforested one. How, where and what rates of sedimentation and erosion occur in the area? How much carbon accumulates naturally and following plantation both above and below ground? If we are able to identify the differences we will be able to identify the real value of mangrove reforestation.

Mangroves are not only forests but also ecosystems that include human activity. Reforestation of mangroves should be evaluated from both the ecological and economical point of view. When we wish to conserve and reproduce the mangrove forest, we always keep the mangrove ecosystem in our minds (Baba, 1999). To maximize the value of the reforestation *Melaleuca* forests must also be included as an important subject of investigation for tropical coastal zone ecosystems.

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