IMPACTS OF THE RESTORATION OF THE MANGROVE FORESTS SPRAYED WITH WARRING HERBICIDES IN CAN GIO DISTRICT, HO CHI MINH CITY

Hong PN[1] and Tuan LD[2]
[1]*Mangrove Ecosystem Research Centre* ;[2]*Can Gio Mangrove Biosphere Reserve Management Board*

INTRODUCTION

Mangrove forests are an ecosystem with very high biological productivity, but also very vulnerable to human impacts. In addition to valuable forest products, they also provide the habitat, breeding and feeding grounds for many maritime creatures. Mangrove forests play important roles in retaining alluvia, preventing erosion, mitigating the energy of storms, waves and high tides, and protecting the life of coastal communities. During the Vietnam war, the Southern mangrove forests served as revolutionary bases for the resistance forces and the reception point of weapons transported from the North. As a result, the American Army used bombs and high-content herbicides to destroy them. Very large areas of mangroves in Can Gio District of Ho Chi Minh City, Ca Mau Province and some other provinces were cleared. After the forests were destroyed, the environment became seriously deteriorated[6]. Many localities in the South replanted mangrove forests soon after the liberation (1975). However, due to economic difficulties, mangrove forests in several localities were then destroyed again for agricultural production, and later, shrimp aquaculture for export[14]. Although mangrove restoration in Ho Chi Minh City started later (in 1978), thanks to the determination and correct direction of the City leaders and the support from local people, the City's mangrove restoration, protection and management have been very effective and attracted much domestic and international acclamation and interests. In January 2000, the International MAB of UNESCO recognized Can Gio Mangrove Biosphere, the first biosphere reserve of Vietnam in the international network[15]. This paper will discuss the impacts of the restored mangroves on the environment, biodiversity and socio-economic development as well as the experience in community-participating mangrove management and protection in Can Gio.

MATERIALS AND RESEARCH METHODOLOGY

The published works of several Vietnamese and foreign authors on the consequences of herbicides used in the Vietnam War on the mangrove environment were consulted. People who directly instructed on and were involved in planting, caring and thinning techniques for the planted mangrove forests were interviewed on their experience. Many field trips in different locations were organized in conjunction with taxonomists. Questionnaires and interviews were used with local people and forestry, fishery and tourism agencies' staff to find out the situation of mangrove forest protection, the living conditions of mangrove protection households, and the revenues from aquatic products and tourism. Statistics methods and the SPSS software were applied to calculate economic efficiency.

RESULTS AND DISCUSSION

Can Gio mangrove forests before, during and after the chemical warfare

Before the American chemical warfare, Can Gio was a mangrove forest containing a diversified flora of 10 mangrove communities[2]. During the Ranch Hand Campaign from 1965 to 1970, the American Army conducted 229 missions, spraying 927,116 gallons of herbicides and defoliants and destroying 35,275.5 ha of mangrove forests in Rung Sat Area (Figure 1)[11, 13].
After the loss of mangrove forests, the soil became dry, chapped,

Figure 1.Base of *Sonneratiaalba* tree destroyed by warring herbicides (photo: Hong PN

sulphate acidic and containing toxics. As a result, the pH became very low[6].

- In order to deal with the food shortage after the war, the City's leaders established a number of agricultural farms to plant various type of crops. However, the huge money and labour invested did not produce any results.
- Under the effect of the semi-diurnal tide flow with high tidal amplitude, the soil along canal and river banks was heavily eroded. In the 1970s, each year Can Gio lost 437 ha of land1. The water surface area kept increasing. In 1958, water surface only accounted for 22.70% of the total area of the district11, but increased to 30.56% in 19781.
- Without vegetative humus as food for aquatic creatures, the fishery productivity after 1975 was very low. We rarely encountered any wildlife during our field trip to prepare for a mangrove restoration project. Locations which were famous for being abundant in animals such as 'Crocodile Canal', 'Howling Dog Canal', 'Boar Canal' now only have such animals in their names.
- The life of the local communities was very harsh due to scant aquatic products and shortage of rice,water, firewood…

Impacts of mangrove forest restoration

The mangrove forest restoration in Can Gio demonstrates the great determination of the City's authorities and local people in the post-war difficult economic conditions with deteriorated soil and no seedlings. In July 1978, Decision165/QD-UB of the City's People's Committee was issued to mobilise the local people and mass organisations in Can Gio as well as the City's scout youths in restoring mangrove forests on the entire area sprayed with warring herbicides under the coordination of forestry agencies. From 1978 to 1999, 21,427 ha of *Rhizophora apiculata* and *Ceriops tagal* were planted, which have developed into mangrove forests[17] and have been well protected.

Environment improvement

After the forests were replanted, the forest vegetation rich in nutrition decomposed by micro-organisms rapidly changed the soil's features.

Only 5-10 years after *Rhizophora apiculata* were planted, many other species of mangroves arrived, creating a diversified vegetation with 15 communities5, 18,. The diversity is higher than that of the mangrove forests before the war (86 species)[7].

The nutritious fallen matters of the mangrove vegetation form a rich food cycle and provide a good habitat for many tidal creatures, attracting terrestrial animals and birds which come for food. As a result, the biodiversity of this ecosystem is very high (table 1).

Table1. Quantity of fauna species in the Can Gio Mangrove Ecosystem[10, 7, 1]

Phylum/Class	No. of species	No. of families	Class	No. of species	No. of families
Invertebrates			*Vertebrates*		
Polychaeta	32	18	Fish	133	40
Crustacea	53	11	Amphibia	9	4
Molusca	32	15	Reptiles	31	15
			Aves	130	41
			Mammal	19	13

Carbon accumulation and contribution to the reduction of glasshouse emission
The research results of Fujimoto *et al.* (2000)5 in Can Gio Forestry Park show that the content of carbon accumulated in the soil at the 0 – 100 cm depth fluctuates from 245.20 to 309.90 ton/ha. According to the calculation of Ho Chi Minh City Scientific and Technical Association (2006) 1,20,000 ha of restored mangrove forests in 25 years absorbed 10,164,440 ton of CO2 emitted from industrial and domestic activities of Ho Chi Minh City and created 6,776,296 ton of oxygen, helping to reduce air pollution.

On the basis of the net photosynthesis productivity of *Rhizophora* forests planted from 1978 to 1996, the amounts of carbon accumulated in planted *Rhizophora* forests (not including natural forests) as of 1999 were calculated to be 465,888 ton/year and in 2005, 497,307 ton/year17. Calculating the cash equivalent value based on the fixed price rate for carbon of the World Bank (US$3 – 5 / ton of C), the minimum C accumulation value in 1999 was US$1,397,664 USD and in 2005, US$1,491,921.

Eco-tourism
After the recognition of Can Gio Mangrove Forests as environment protective forests in 1999, 42,000 tourists have visited the area. Since the recognition of Can Gio as a Biosphere Reserve in January 2000 and the City's investment in its infrastructure, the number of tourists has increased greatly. 185,618 tourists, of whom 3.6% were foreigners visited Can Gio in 2005 alone. The area's attractive features include high biodiversity as well as historical and cultural sites such as its Museum 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 auxiliary 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[16].

Mangrove forest protection
There was once a period (1980-1988) when some replanted Can Gio mangrove forests were cut down for timber by poor, jobless local dwellers. There were too few forestry rangers to patrol the whole area effectively. The City's leaders then issued a policy of allocating the forest protection to poor households in the communes with mangrove forests, including those people who used to cut down mangrove trees. The forest protectors were given training and financial assistance to build their houses in the forests, to buy boats and some basic tools and furniture. The City also procured boats to supply them with fresh water during the dry season. Their children were given scholarship and arranged to go to nearby schools. The forest protection fees have been increased, from the initial 70,000 VND/ha/year to 185,000 VND, then 316,000 VND, and 445,000 VND in 2006. Each household is allocated 80 – 100 ha on average for protection. Many households who used to be very poor and starving have been able to save enough money to dig their own shrimp or crab rearing ponds near the forests (Figure 4), to rear brackish fresh water fish,crab or to raise goats, pigs and chickens. As of 2005, 14,198 ha of planted and natural forests have been allocated to 167 households17. The remaining forests are protected by 24 sub-sections under the Forestry Ranger Bureau. Several excellent forest protectors have been rewarded, with some going on excursions abroad[17].

Improvement of poor people's living standards
Can Gio is an island district with shortage in both fresh water and land for agriculture production, making the life of local people difficult. Since the restoration of the mangrove forests, thanks to the tidal flat expansion resulting in abundant aquatic creatures and the availability of nipa palm leaves as materials for handicrafts the living standards of poor families have been improved. The annual forest planting and rotational thinning of planted forests have created employment for many poor locals, and at the same time, provided firewood and building materials for the communes having the forests. Thinning products alone have been worth 5.2 billion VND[17].

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 together with their postgraduate students. Their researches on the ecology,

soil studies, flows, socio-economic conditions in an area heavily destroyed by warring herbicides have been published on many regional and international journals, making Can Gio well-known to many NGOs and international agencies. Six PhD theses in biology on these forests have been completed. Many localities wishing to restore mangrove forests in coastal areas and foreign scientists as well as forestry officers have visited the biotop and community-participating forest management in Can Gio.

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