



Management of the Integrated Mangrove-Aquaculture Farming Systems in the Mekong Delta of Vietnam

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Management of the Integrated Mangrove-Aquaculture Farming Systems in the Mekong Delta of Vietnam

by

Minh,T.H., A.Yakupitiyage and D.J. Macintosh

The Integrated Tropical Coastal Zone Management at AIT is an area of specialization under the Schools of Environment, Resources and Development and Civil Engineering. This interdisciplinary field aims to develop human resources for coastal zone management in the Asia and the Pacific regions where the coastal areas encompass a diverse array of resources and ecosystems with intense human activities.

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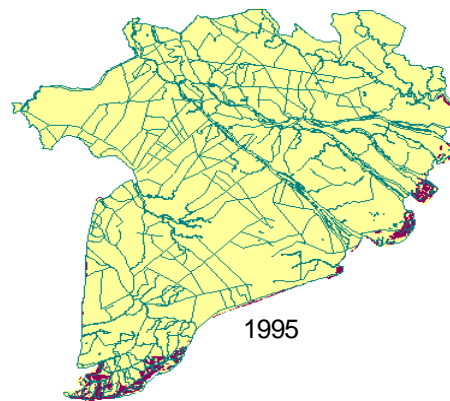
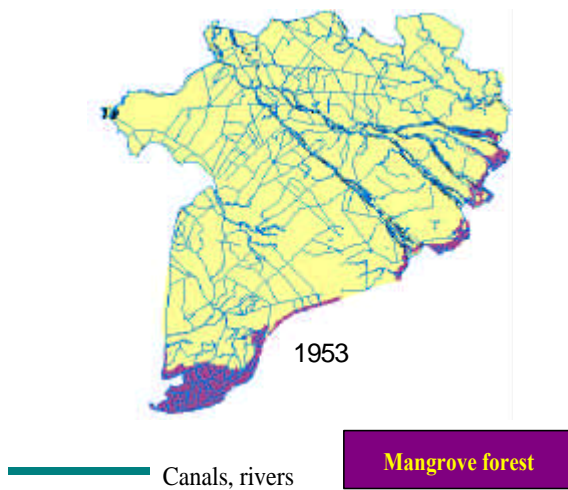
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Introduction

Mangrove clearance for shrimp farms is a major issue in the coastal area of the Mekong delta of Vietnam. In the eastern coastal zone of the Mekong delta, the area of mangrove has been depleted from 190,812 ha in 1953 to 29,534 ha in 1995, which implies that after 42 years, 161,277.5 ha of mangrove forest have been destroyed for shrimp farming and other activities [1].



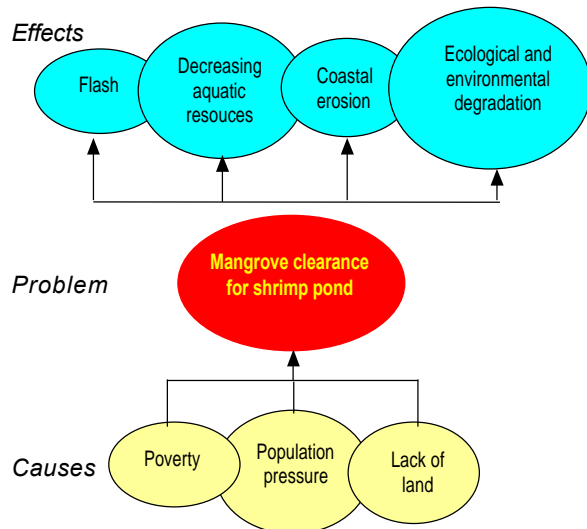
Mangrove clearance for shrimp pond in Ca Mau province



Mangrove clearance for shrimp farming and other activities from 1953 to 1995 in the Mekong delta

Especially, Minh Hai peninsula (Ca Mau and Bac Lieu provinces) host the largest area of mangrove in Vietnam, and also contains a vast area of mangroves destroyed for shrimp farming. Within 8 years (1983-1995), the Minh Hai has lost 66,253 ha of mangrove forest to shrimp ponds [2]. The conversion of mangrove area to shrimp farms increased from 3,000 ha in 1983 to 76,036 ha in 1995 [3]. The increase in shrimp pond area was caused partly by local people, but was mainly by people migrating from other locations [2].

In order to solve the issue of mangrove clearance, local and national management is seen as a key factor.



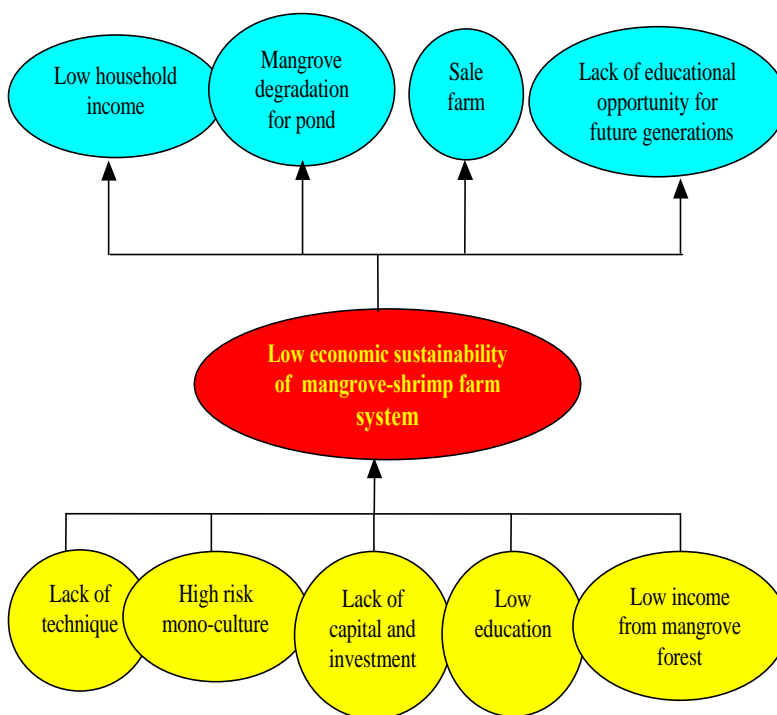
The causes and effects of mangrove clearance for shrimp pond construction in the past

Regarding the overall management of integrated mangrove-aquaculture systems, the Minh Hai provincial authority issued decision No. 64-QD/UB in March 1991 stipulating the policy and measures for local management, protection and utilization of land, forest and water resources including the mangrove ecosystem. The policy, called Forest Land Allocation, has given forest land to farmers with a Green Certificate (Green Book) for lease of 20 years, on the condition that 70% of the area should be replanted with mangrove trees and the rest (30% of total area) be exploited for agriculture, aquaculture, livestock and residential area. As a result, 66,873 ha mangrove area were allocated to 14,251 households in Ca Mau province and this policy has actually led to a reduction in mangrove deforestation in the province.



However, it takes 20 years before wood may be harvested and therefore, this activity may not provide the main income for farmers in the area. This is not interesting for the farmers, since the farmers' attitude to land use is to develop aquaculture to generate income, and farmers increasingly pay attention to the development of mainly shrimp culture. However, the income from the improved-extensive integrated mangrove-shrimp systems is not enough for the basic living expenditures of households [4].

The involvement in shrimp farming includes a high risk for the household economy. The farmer needs support from the bank including loans and extension advice and technical support, besides, help from research institutes



The causes and effects of mangrove clearance for shrimp pond construction at the present time.

and universities. Illiteracy of famers also creates difficulties for future expansion of mangrove-shrimp integrated farming in the Mekong delta [5].

In addition, the migratory policy of the Government for farmers may lead to lack of land for new-comers, which reduce household incomes. As all these factors affect sustainable mangrove-aquaculture integration, an assessment of the management practices for

integrated mangrove-aquaculture farming systems is essential to develop guidelines for the sustainable development of the existing mangrove-aquaculture farming systems in Ca Mau province.

At present, there are two main integrated mangrove-shrimp farming systems in Ca Mau province, namely the separated mangrove-shrimp farm system and mixed mangrove-shrimp farm system [6]. In 1998, 86% of the farms were operating the mixed model in 184 State Forestry and Fisheries Enterprise and 36.4% in Tam Giang III Enterprise. Most mangrove-shrimp farms have relied on extensive shrimp culture, i.e. a culture method based on natural seed and food. However, there is an increasing trend of aquaculture systems intensification in mangrove areas of the Ca Mau in recent years, which involves transport and

purchasing of shrimp postlarvae or juveniles for the farms.

Geographic and climatic conditions

Ca Mau province extends from 8°33'27" to 9°42'20" North latitude and 104°43'10" to 105°26'03" West longitude. The total land area is 5,211 km² (521,100 ha), making up 13.1% of the Mekong delta and 1.6% of the total area of Vietnam in which 154,800 ha (29.7%) is in the coastal area.

Saline and hydro sulfate soil areas make up 28.8% (150,278 ha) and 64.3% (334,925 ha), respectively. In addition, mangrove alluvial potential was evaluated as acid-sulfate soil, soft clay or sulfate generating horizontal layer which is located near the soil surface [7].

There are two tidal regimes in the area: irregular semi-diurnal tides with a tidal amplitude around 3-3.5 m in the East and irregular diurnal tides in the West with a tidal amplitude of about 1.1 - 1.2 m.

There are two climatic seasons, a rainy season (May – November) and a dry season (December – April).

Year	Rainfall (mm)	Sunshine (hrs)	Temperature (T°C)	Mean relative humidity (%)
1997	2,547.9	2,233.3	27.2	83.3
1998	2,595.7	2,232.5	27.9	81.3
1999	3,459.7	1,918.5	27.0	83.6

(Ca Mau Statistical Data, 1999)

Some climatic factors of Ca Mau province

Socio-economic settings

The population is 1,133,747 with a population density of 218/km². Natural population increase and migration from other provinces also increase rapidly. Population structure is young



Mixed mangrove-shrimp farm



Separated mangrove-shrimp farm

(40% are less than 14 years) and 52% are female. Average household size is around 4.7 persons per family and households classified as “poverty” households has declined from 27.9% to 15% in the last four years. Most people (66.7%) have come from other districts and provinces because of lack of land (50%). Only 11.7% of households are local people. In addition, most rented workers had come from other provinces such as Bac Lieu and Soc Trang. Most farmers (83.3%) are first generation settlers who have bought their land from old farmers.

The GDP of the province is gradually increasing, i.e. from 3,487,775 to 4,108,882 million VND in 1997 and 1999, respectively. The main economic sectors are Fisheries, Agriculture and Forestry with 59.7% of the total GDP, of which fisheries represented 1,327,879 million VND in 1999. Per capita GDP was 4,540,000 VND (313 USD) in 1999.

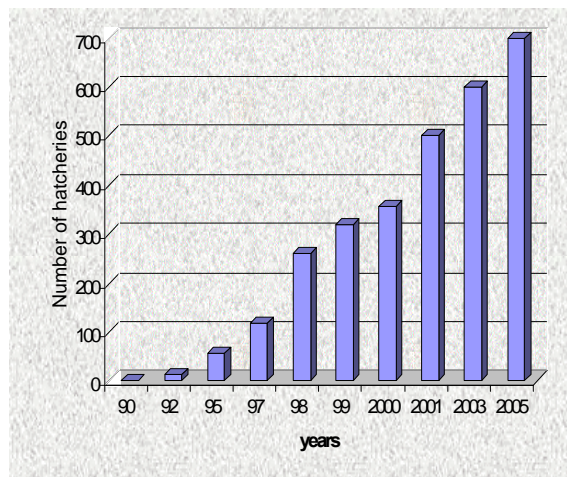
Growth of the shrimp farming sector

Shrimp culture started early in Ca Mau in the 1980s. Initially the farming practice was very simple like fish trapping, in which channels were ditched to form ponds for storage of water and trapping of natural shrimp and fish. These farms had one simple sluice gate that was made from wood with 30 - 40cm widths. And harvesting was done every spring tide period.

By 1990, there were only two shrimp hatcheries located in Nam Can town and reared shrimp was not popular in this period. In 1992, shrimp hatcheries were developed in Nam Can town and elsewhere. Most hatcheries produced *Penaeus merguensis* and *P. indicus*. Few farmers bought shrimp seed and stocked into their farms. Seed size was large (3-4 cm length) at that period. However, hatchery

shrimp culture was not developed in the mangrove area at that time because the natural shrimp source was very rich. In contrast, natural captured mud crab (*Scylla serrata*) seed has been supplied to farms since 1993 but it was not popular.

In 1994-1995, farmers started to transfer reared shrimp seed into their farms. However, they were not successful because there was a big shrimp disease outbreak which destroyed all shrimp farms in Minh Hai (Ca Mau and Bac Lieu provinces). Moreover, this led to a decrease in natural shrimp supply. Thus, some mangrove farmers bought hatchery shrimp seed for stocking into their farm. Hatchery shrimp culture began in the mangrove area by this time. However, the integrated mangrove-shrimp farming and mangrove-shrimp cum crab farming were quite simple, i.e. no liming, fertilizing and feeding. Hatchery shrimp culture developed in the mangrove areas from 1997 and increased quite rapidly in 1999. *P. monodon* seed are now stocked in the farms because hatchery shrimp seed is widely available in Nam Can town.



The time-line of shrimp hatchery development and planning in Ca Mau province

At present, most mangrove-traditional farms are converted into other mangrove-aquaculture such as mangrove-hatchery shrimp farm, mangrove-hatchery shrimp cum crab farm and mangrove-hatchery shrimp cum crab and blood cockle farm by supplementing with hatchery shrimp and natural captured mud crab.

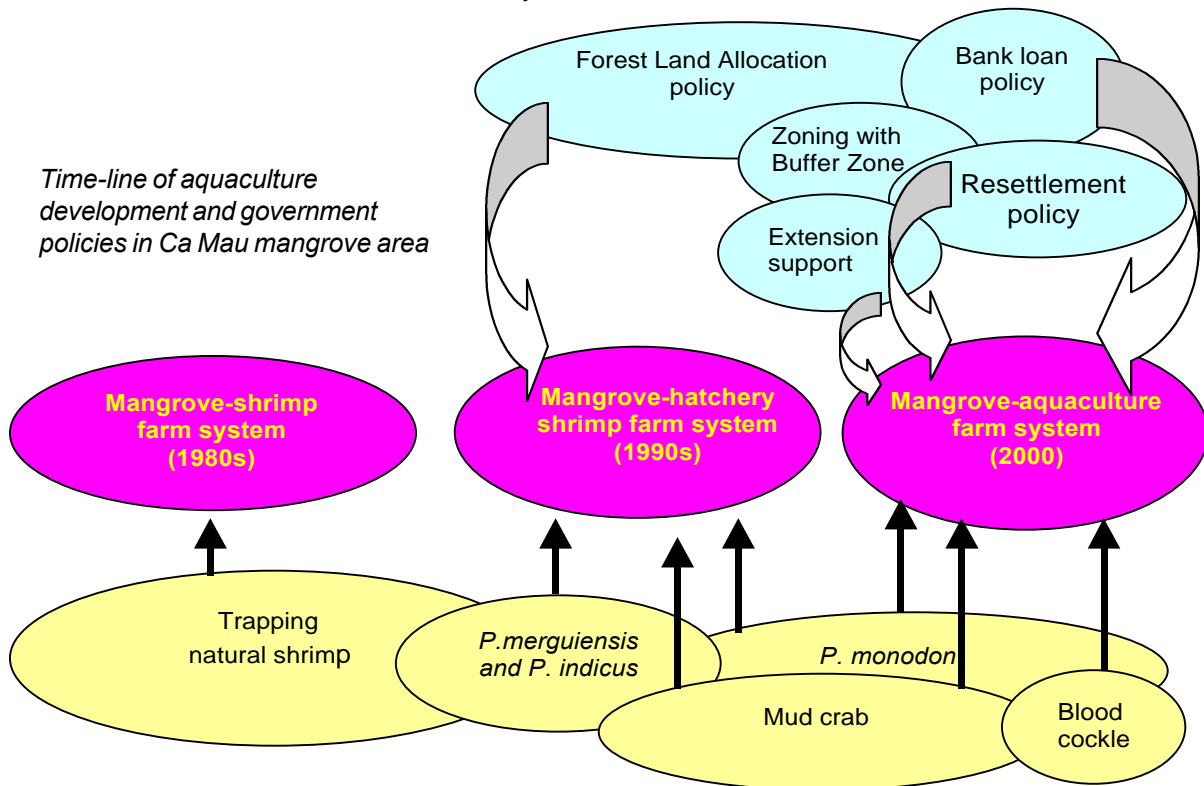
if they do not violate the conditions of the contract. Maximum allocated area is 20 ha for households and 30 to 50 ha for other organizations depending on the approval of the authority. The actual average farm area is 4.7 ha/household.

Households can get benefit from 30% of the area for aquaculture and agriculture development. Besides, farmers can also earn money from wood production although it takes longer (15 - 20 years). However, they have a duty to replant and manage the mangrove trees on their land. They can get benefits from wood harvesting but the rate of sharing depends on capital investment for reforestation, i.e. if the capital for mangrove seedlings is from FFE (Government), farmers get only 30% of net benefit from wood production. In contrast, they can get 70% of net benefit if they provide the trees themselves.

Policies Towards Integrated Mangrove-Aquaculture Farming Systems

Forest Land Allocation Policy

In this policy, allocated objects consist of households, privates and organizations or collectivities. Owners can renew after 20 years



In addition, farmers can get the main benefit from aquaculture in the mangrove area. Land allocation has an important social meaning for homeless and workless people. It has generated employment for around 20,000 households comprising more than 100,000 people (one out of ten of the Ca Mau population) and reduced the constraint of land shortage in Ca Mau province. The implementation of the policy generated positive impacts for the rehabilitation and created 100,000 jobs for the people in the Mekong delta.

In general, the government policy of Land Forest Allocation is suitable for the protection and development of mangrove forest. Land allocation for households to manage a mangrove area is quite interesting for both the government and farmers because the government wishes to manage and protect the mangrove forest while farmers wish to earn money mainly through aquaculture farming. Thus, the integrated mangrove-aquaculture farming systems are considered as a helpful tool to protect and develop mangrove forest. The development of the farming systems has a great potential in the Buffer Zone of Ca Mau province.

Mangrove forest zoning

Recently, a zoning plan for mangrove forest reforestation of Ca Mau, Bac Lieu, Soc Trang and Tra Vinh provinces has been approved by the Prime Minister on May 3, 1999. According to this decision, the mangrove area is zoned into Full Protection Zone (FPZ), Buffer Zone (BZ) and Economic Zone (EZ). 60% of the area is used for mangrove forest development and 40% for aquaculture, agriculture and other utilizations

Resettlement policy

All households living in the FPZ on the eastern side of Ca Mau province will be resettled into



Land zonation of the coastal provinces of the Mekong delta region, covering 173,625 ha with a coastline length of 467 km.

the BZ, except for households living in zoned migration area in river mouths. The number of households who must migrate is 1,175. Most aquaculture households in FPZ will be moved into the BZ, near their present place. Of these 24 are agriculture cultivating households, 21 mangrove forest farming households, 558 mangrove-aquaculture farming households, 79 service households, 26 small-scale fishing, 203 rented workers households and 29 staff households [8]. In general, although the policy to resettle families from the Full Protection Zone to the Buffer Zone is suitable for the protection and development of the mangrove forest, it may create additional population pressure on natural resources utilization in the Buffer Zone.

Aquaculture tax policy

The policy of aquaculture tax has been applied to aquaculture farming systems in mangrove areas since 1999. The tax level is different among farms. It depends on suitable land levels for aquaculture, i.e. high land or low land. In general, average tax is around 265,000 VND/ha/year (18.3 USD).

Bank loan policy

Recently, a new policy for loans has been decided by the Central Government for households and organizations who are engaging in mangrove-aquaculture farm systems if they have the Green Certificate with a loan limit of 10 million VND per household (690 USD). However, only 26.7% of the households have taken loans from RRD Bank and 73.3% of households have not borrowed yet in the first three months of 2001. In general, this is a positive policy that supports the Land Allocation Policy and the development of integrated mangrove-aquaculture farming systems in the Buffer Zone of Ca Mau province.

Needs and roles of stakeholders

Provincial administrators' and local people's roles and needs

Principally, DARD and the Forestry and Fisheries Enterprises (FFE) wish to protect and develop the mangrove forest in Ca Mau province, in which FFEs apply the policies of the Central Government and manage directly the mangrove forest land of the FFEs. Local people wish to gain money mainly through aquaculture activities on their land. This indicates that the integrated mangrove-aquaculture farm systems are a useful tool for the management and development of mangrove forest in Ca Mau province, when applied through local community participatory management.

Line agencies and the local community

The DOF and Extension Center of Ca Mau province have the responsibilities for development of fisheries in the whole province, in which mangrove areas are also one of the potential areas for aquaculture development.



Ngoc Hien Forestry and Fishery Enterprise

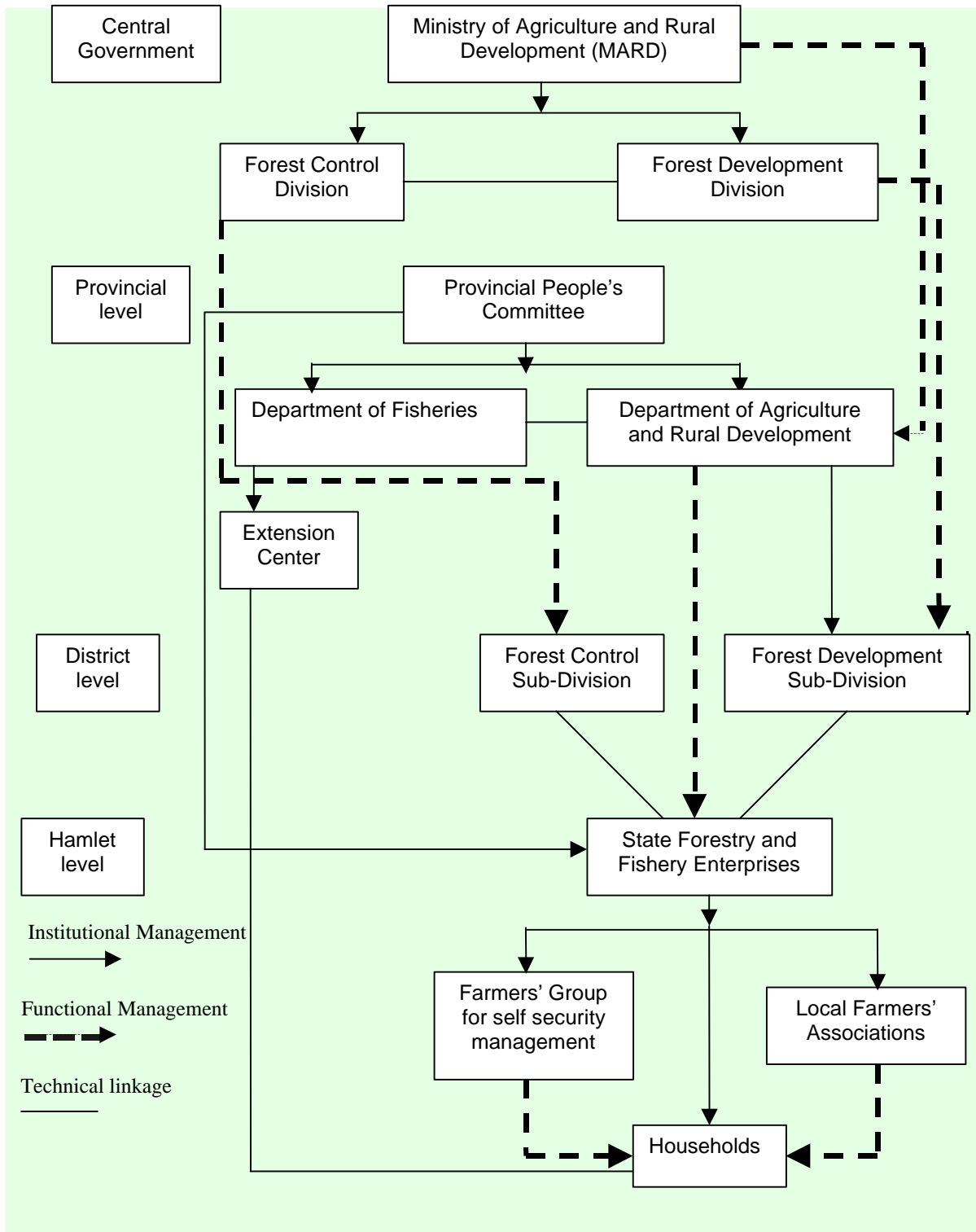


184 Forestry and Fishery Enterprise

However, the technical support for shrimp culture is still very limited in the mangrove area. Although provincial aquaculture staff has been trying to keep up with the trends in aquaculture development in the province, they have failed due to lack of staff. Training courses on the integrated mangrove-aquaculture farming systems have been limited so far, and this may affect the development of aquaculture systems in the future.

There is a new opportunity for the development of extension work in the province, where successful farmers in the mangrove area who have the "best management practice" may be selected as local extension staff. They should be trained in aquaculture and environmental protection. Besides, the Loan Banks of the province and districts have implemented their duty to supply the capital for the development

Existing Institutional structure for mangrove area management in Ca Mau province



of mangrove-aquaculture farming systems. In general, to develop the mangrove-aquaculture farming system sustainably, technical support, extension activities and loans are helpful for the local people and essential for promoting the sustainable development of mangrove forests and aquaculture.

In order to promote sustainable development of mangrove-aquaculture farming systems, a good linkage among different sectors, especially DARD and DOF is very necessary. Besides, administrators should develop strategic plans that are appropriate for the trend in development of aquaculture farming systems in mangrove areas.

Farmer organization

Farmers' Associations have only recently been established (1999) in FFEs, typically with 25-50 farmers per group. The objectives of this establishment are to implement government policies and aspirations; and to help in the development of mangrove-aquaculture farming. The establishment of Farmers' Associations in mangrove area would seem to be suitable for the development of aquaculture and mangrove forest. The FFEs can organize aquaculture training courses using the Association's fund and help the poor by supplying credit for aquaculture development. Farmers' organizational changes are necessary for the aquaculture development in mangrove area of Ca Mau province.

Farm management

There is a trend towards diversifying the number of species used for aquaculture in Ca Mau province. The mangrove-hatchery shrimp cum crab farming system is the most popular farming system for the management and

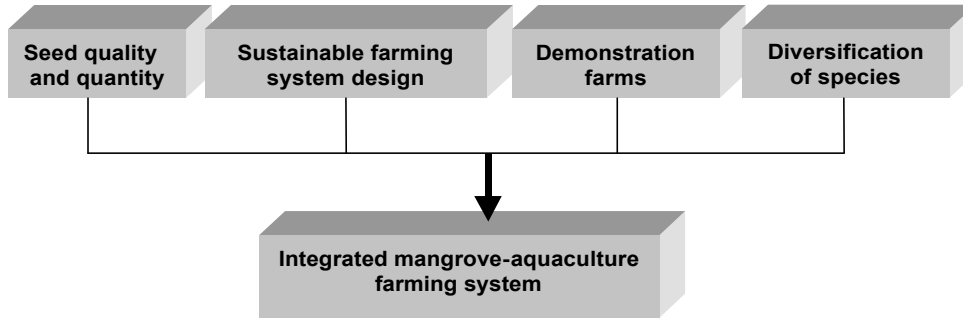


A Farmers' Association in 184 Forestry and Fishery Enterprise

development of both mangrove forest and aquaculture. Besides, it is the economically most efficient system that can be applied to develop households' economy in mangrove areas of the Mekong delta, in which mud crab is a good potential alternative income species that can be stocked with shrimp in mangrove areas to increase households' income. In addition, blood cockle is a new species introduced in the mangrove-aquaculture farming system, which is also a good alternative income species for households in mangrove area.

In addition, aquaculture technique (especially shrimp culture) with integrated culture should be researched to improve farm yields. However, multiple stocking of shrimp seed in the same crop, stocking of shrimp postlarvae mixed with mud crab and high stocking density are not recommended due to high risk of diseases. In contrast, experiments on semi-intensive shrimp culture should be conducted to improve shrimp yield of small ponds.

In addition, in order to optimize the use of dikes, research on planting of some valuable varieties on the farm dikes and the effect of high land platforms on mangrove trees is required.



Technological requirements for managements of mangrove-aquaculture farming

Integrated Mangrove-Aquaculture Farming Systems

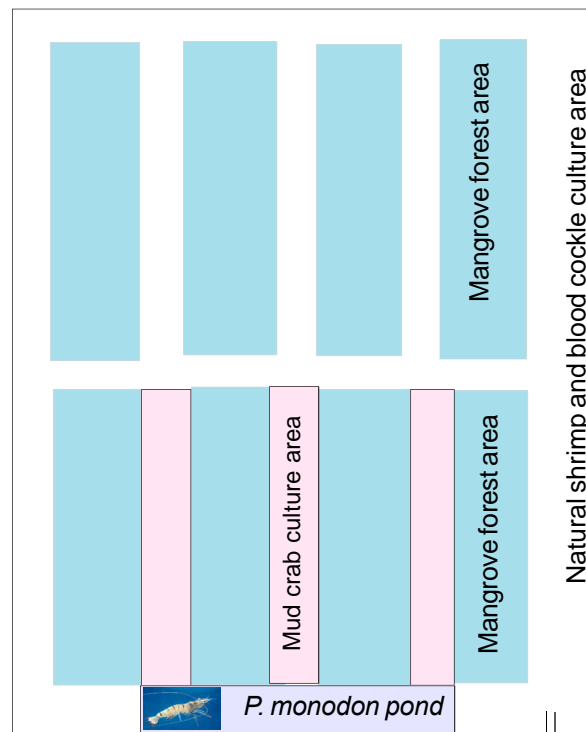
Typical physical condition of the farm

Mangrove area

Generally, the mangrove area of farms is 54.6% ($\pm 16\%$) of the total farm land area which is 15% lower than the government policy (70% for mangrove area in old guidelines and 60% in the new guidelines of the Government). This indicates that either the policy has been issued after farmers' unplanned development in the mangrove area, or farmers are not following the government policy.

Mangrove topography

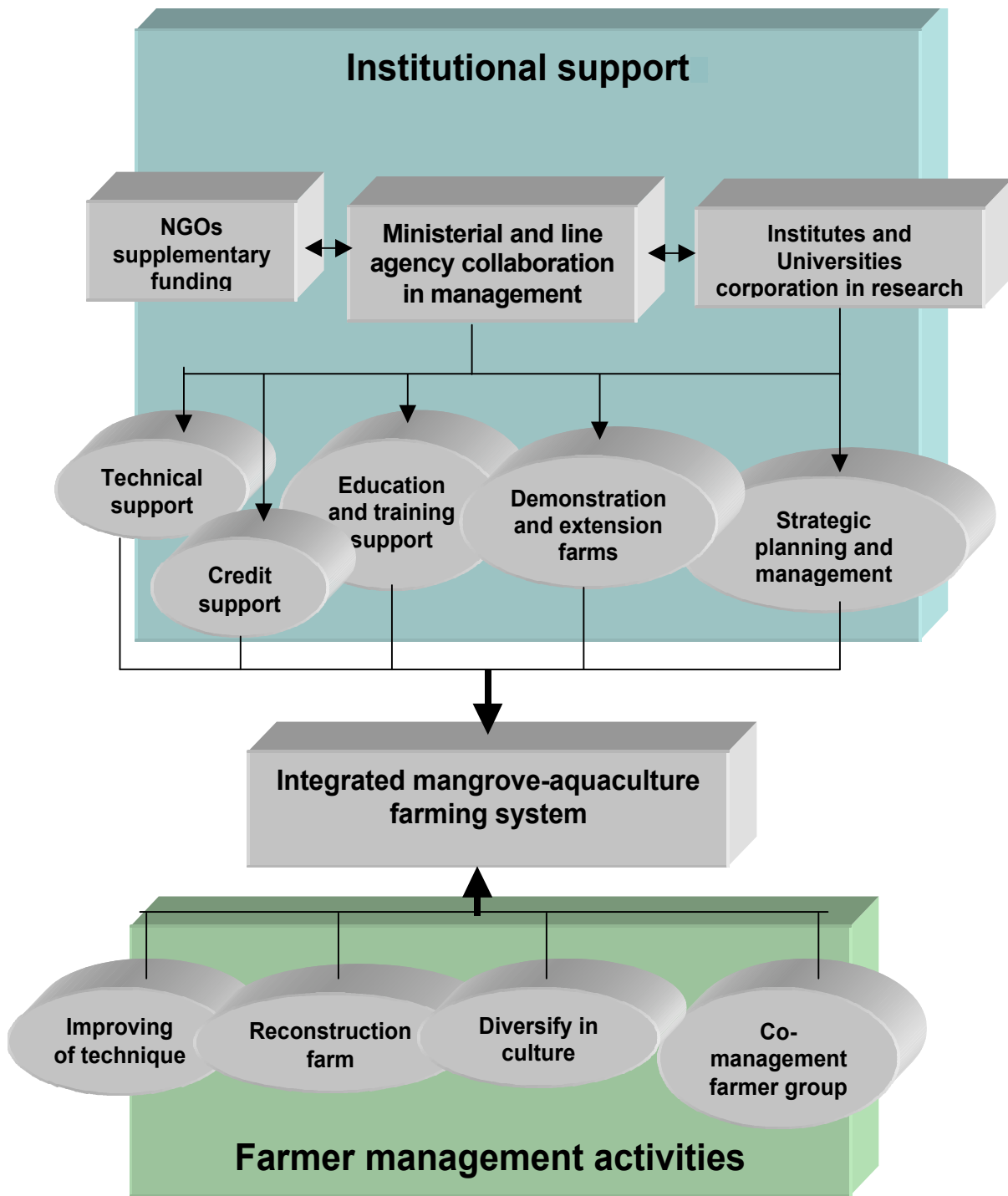
Up to 79% of the farms have a high topographic height due to sediment deposition from pond year by year. So, water cannot flood mangrove beds even during spring tide. Mangrove soil exposed under sunlight without flooding in long periods will lose nutrients, and this soil condition may affect the growth of mangrove trees. Both mangrove tree productivity and soil phosphate levels correlate with topographic height of mangrove beds, *i.e.* the higher the topographic level the lower the



Legend

- Natural shrimp and blood cockle culture area
- Mangrove forest area
- P. monodon* pond
- Mud crab culture area
- House area
- Sluice gate

Proposed design for mangrove-aquaculture farming system



Proposed management framework for mangrove-aquaculture farming system in Ca Mau

primary production of mangrove trees and soil phosphate. This is also a concern for mangrove replanting after total harvesting during a 20 years cycle. In addition, the creation of high dikes on the platform, which should have been a good feeding habitat for shrimp, may lead to loss of integration between the mangrove and shrimp pond, and also natural aquatic animals in the mangrove area and even estuary and coastal area. The flooding level of mangrove beds in the dry and rainy seasons has a positive correlation with shrimp production on the coasts of the Mekong delta of Vietnam [5]. Thus, the physical conditions of mangrove-shrimp farms may not be optimal for both mangrove and shrimp culture in the integrated mangrove-aquaculture farming system in the study area.

The integrated mangrove aquaculture farming systems

There are four existing integrated mangrove-aquaculture farming systems in the Buffer Zone of Ca Mau’s mangrove area. These systems consist of mangrove-traditional farming system, mangrove-hatchery shrimp (*P. monodon*) farming system, mangrove-hatchery shrimp cum mud crab farming system and mangrove-hatchery shrimp cum crab and blood cockle (*Anadara granosa*) farming system. There are two main farming systems dominating in the area: (1) integrated mangrove-hatchery shrimp cum mud crab (58.3%) and (2) mangrove-hatchery shrimp (*P. monodon*) farming systems (38.3%).

The Mangrove-traditional farming system:

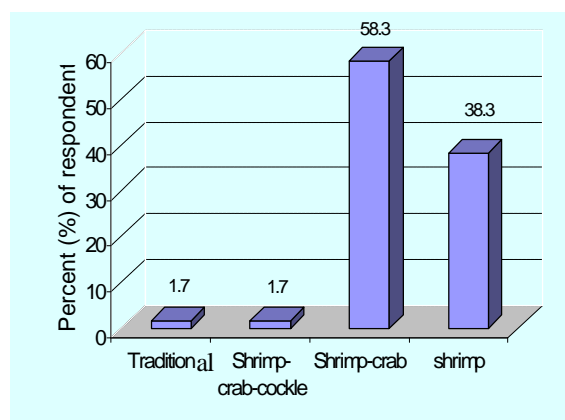
Seed comes mainly from the wild. Feed, fertilizer and lime are not used. Water exchange is based on tidal fluctuation. Harvesting is by tidal water exchange during the spring tide. Natural shrimp production was 290 kg/ha/yr.



Sediment removal in mangrove-aquaculture farm system



High topography of platform



The percentage of respondents practicing the integrated mangrove-aquaculture farming systems in the Buffer Zone of Ca Mau’s mangrove area, 2001.

The Mangrove-hatchery reared *P. monodon* farming system: hatchery-reared *P. monodon* seed is stocked with naturally collected seed. Most farmers do not supply food, fertilizers and lime in their farm during growing out period. Average production is around 72 ± 85.5 kg/ha/yr (0 - 360 kg/ha/year). Besides *P. monodon* production, farmers still harvest natural shrimp, fish and crab, of which fish is used for family food (not for selling) because fish production is just enough for family food. In contrast, natural shrimp production was 333 ± 111.4 kg/ha/year and natural crab production is considered as alternative income for households. Average crab production is around 23.9 ± 13.3 kg/ha/yr.



Water current harvest technique in mangrove-traditional shrimp farm system



Mangrove-hatchery shrimp farming system in Ca Mau province



Crab seed

Marketable sized crab

The Mangrove-hatchery reared *P. monodon* cum crab (*Scylla* species) farming system: *P. monodon* and naturally collected crab seed are stocked with natural shrimp. However, no feeding, fertilizers and liming are supplied in most farms. Natural shrimp and *P. monodon* productions were 425 ± 102 and 107 ± 98.8 kg/ha/year, respectively. Besides, crab is harvested every spring tide period by fishing (hooks). However, only marketable size crabs are harvested in this period. Small ones are restocked in the farm for continued growing. They are considered as alternative species and income for most households. Crab production is around 65.2 ± 49.6 kg/ha/yr.



Mud crab is stocked with shrimp in mangrove areas in Ca Mau province

The Mangrove-hatchery reared *P. monodon* cum crab and blood cockle farming system:

Blood cockle seed is stocked in polyculture with *P. monodon* and natural shrimp and crab in the same farm. The stocking size and density of blood cockle are around 6g/ind and 0.09 ind/m², respectively. Growing out period was 5 months and harvest size was around 25 g/ind. Harvesting is normally by hand with a production of 1,323 kg/ha/year. This is also one of the potential alternative species for integrated mangrove-aquaculture farming systems in Ca Mau province.



Mangrove-hatchery shrimp cum crab and blood cockle farm system

Social aspects of the two main aquaculture farming systems

The household size is approximately 3 - 4 people per household in both types of system. Most of them (69.6%) came from other districts and provinces for the mangrove-hatchery shrimp farm system and 65.7% in the mangrove-hatchery shrimp cum crab farm system. The majority of farmers migrated to mangrove Buffer Zone due to lack of land in their home district and province (52.2% of total households in the mangrove-hatchery shrimp farm system and 48.6% in the mangrove-hatchery shrimp cum crab farm system). 82.6% of the farms were bought from the former owner (for the mangrove-hatchery shrimp cum crab farm system) and 85.7% in the mangrove-hatchery shrimp farm system. Only 8.7% and 11.4% of the farms were inherited from their parents (occupied land) in the mangrove-hatchery shrimp farm and mangrove-hatchery shrimp cum crab farm systems, respectively.

Most of the farmers are laborers and have low education, with little or no training in shrimp culture. Most farmers have capital constraints for farming investment and have not borrowed money from the Agriculture Rural Development Bank.



Marketable size of blood cockle

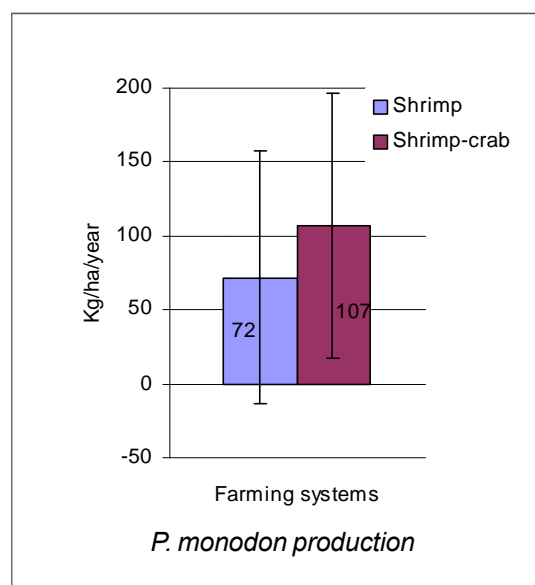
Population changes

The data on migration from FPZ to BZ shows that the total number of households which are required to migrate is 1,175 of which 558 households are farming on mangrove-aquaculture systems. This is a further concern for the sustainable development of aquaculture farming in the mangrove area in the BZ of Ca Mau province. The amount of land is limited (773 ha belong to FFEs). This land will be allocated to migrating people, but it may not be sufficiently large for farming, because the average area per household will be only 1.4 ha. Thus, in order to develop the integrated-aquaculture farming systems sustainable, migration should be considered carefully.

In general, the integrated farming of mangrove-aquaculture systems contributes significantly to mangrove forest protection and management through local community participation. Besides, the integrated mangrove-aquaculture farming systems have given working opportunities for the poor through sediment removal works. This indicates that the mangrove-aquaculture farming systems have offered and contributed to reducing poverty.

Technical aspects of the main aquaculture farming systems

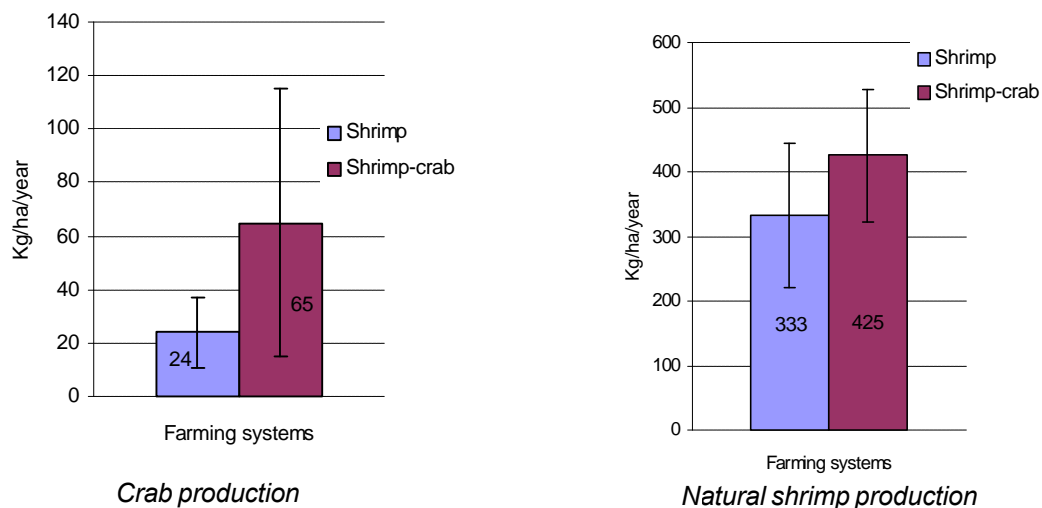
In terms of the main technical aspects, differences between the two main aquaculture systems are summarized below:



Characteristics	Hatchery shrimp model		Hatchery shrimp cum crab model	
Water area	1 ± 0.4	ha	1.1 ± 0.7	ha
Channel width	2.93 ± 0.9	m	2.87 ± 0.9	m
Channel depth	0.66 ± 0.1	m	0.75 ± 0.1	m
Gate width rate	0.9 ± 0.3	m/ha	0.95 ± 0.4	m/ha
Sediment removal	2 times/year		2-3 times/year	
Killing predator	Yes		Yes	
Liming	No		No	
Fertilizer	No		No	
<i>P. monodon</i> seed size	PL ₁₂₋₁₅ (hatcheries)		PL ₁₂₋₁₅ (hatcheries)	
Nursing at farm	7-30 days		7-30 days	
Seed stocking	multi-stocking		multi-stocking	
Stocking density	6.41 ± 4.91	inds/m ²	6.6 ± 4	inds/m ²
Feeding	No		No	
Water exchange	Tidal (34.1 ± 8 cm/time)		Tidal (34.7 ± 10 cm/time)	
Natural shrimp yield	333 ± 111 kg/ha/year		425 ± 102 kg/ha/year	
<i>P. monodon</i> yield	72 ± 86 kg/ha/year		107 ± 99 kg/ha/year	
Natural crab yield	24 ± 13 kg/ha/year			
Crab seed size			0.5 - 80	g/ind
Crab stocking density			0.09 ± 0.1	ind/m ²
Crab marketable size			> 100	g/ind
Crab yield			65 ± 50	kg/ha/year

The technical features of the two main mangrove-aquaculture farming systems in Ca Mau province.

There are significant differences in natural shrimp and crab production of the two farming systems but not for *P. monodon* production ($P < 0.05$).



Production of mangrove-shrimp and mangrove-shrimp cum crab farming systems in Ca Mau province, 2000

Some parameters correlated with natural shrimp production in the mangrove-aquaculture farming systems of Ca Mau province.

1. The general integrated mangrove-aquaculture farm system ($n = 60$)

In general, natural shrimp production depends on several factors such as environment, technique and pond management. However, some factors correlate with natural production such as water area, water depth and harvesting technique ($r = 0.79$). These parameters contribute 61.7% of the natural shrimp production in mangrove areas. The regression is as follows:

$$\text{Production} = 22.7 - 1.21 \text{ water area} + 486 \text{ water depth} + 107 \text{ harvesting techniques}$$

$(R^2 = 61.7\% \text{ and } r = 0.79)$

2. The integrated mangrove-hatchery shrimp farm system ($n = 23$)

Some factors correlate with natural shrimp production such as location of farm, water area, sediment depth, harvest technique and exchanged water level ($r = 0.78$). These factors contribute 59.9% of the natural shrimp production in this farming system with significance at level $P < 0.01$. The regression is as follows:

$$\text{Production} = 426 + 31.7 \text{ coded location} - 1.94 \text{ water area} - 2.42 \text{ sediment depth} + 142 \text{ harvesting techniques} - 2.46 \text{ exchanged water level}$$

$(R^2 = 59.9\% \text{ and } r = 0.78)$

3. The integrated mangrove-hatchery shrimp cum crab farm system (n = 35)

Some factors correlate with natural shrimp production such as water area, water depth, harvest technique and exchanged water level. These factors contribute 58.6% of the natural shrimp production of this farming system with significance at level $P < 0.01$. The regression is as

$$\text{Production} = -122 - 1.25 \text{ water area} + 595 \text{ water depth} + 90.1 \text{ harvesting technique} + 2.66 \text{ exchanged water level} \quad (R^2 = 58.6\% \text{ and } r = 0.77)$$

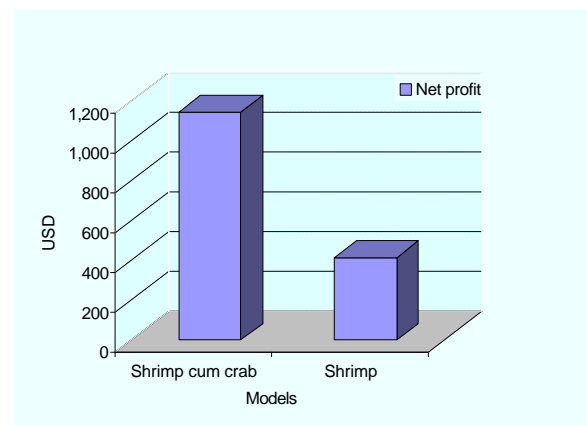
Shrimp culture technique is also one of the important factors that affects successes or failure. The proportion of trained farmers was quite low in both farming systems and farmers managed their farms based on own experiences. This is a significant constraint for the development of mangrove-shrimp farming systems. Moreover, because of farmers' attitude is to wait and see if a farming system is successful, and then believe. In fact, there has not been any demonstrated technical model on mangrove-aquaculture or mangrove-shrimp culture so far. Therefore, these things are constraints for aquaculture development in mangrove area.

Economic aspects of the mangrove-hatchery shrimp farm and mangrove-hatchery shrimp cum crab farm systems

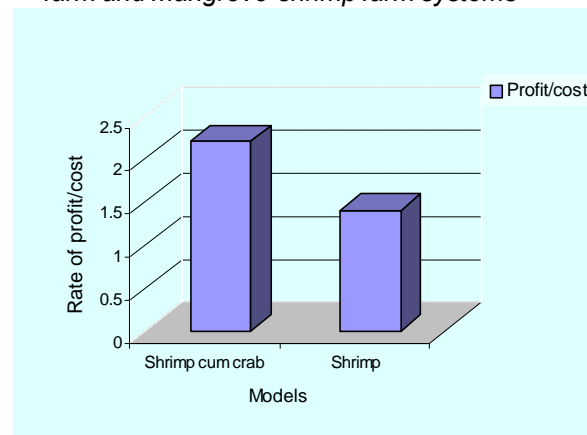
Proportion of costs

The proportion of costs are not significantly different between mangrove-shrimp and mangrove-shrimp cum crab farming systems. The main cost proportion for production is shrimp seed (24.3% and 21.2% of total cost, respectively). In addition, cost of sediment removal is significant in both farming systems (15%). Other costs such as education cost for their children take about 8% and 10% of total costs in mangrove-shrimp and mangrove-shrimp cum crab farming systems, respectively.

In terms of financial analysis, the net profit and ratio of profit/cost of mangrove-shrimp cum crab farm is better than that of the mangrove-shrimp farming.



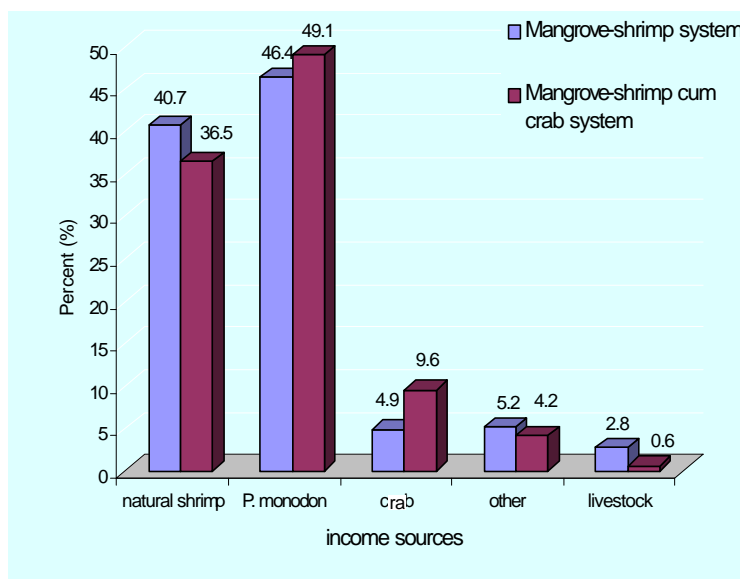
The net profit of mangrove-shrimp cum crab farm and mangrove-shrimp farm systems



Ratio of profit per cost of the aquaculture-shrimp cum crab and mangroveshrimp farming systems in the mangrove area of Ca Mau province, 2000

Aquaculture gross income

The main incomes of mangrove-shrimp farm and mangrove-shrimp *cum* crab farm are from *P. monodon*, 46% and 49%; and natural shrimp production, 41% and 37% of gross income, respectively. There is significant difference between the gross income from natural shrimp of the two farming systems ($P < 0.05$). Besides, mud crab is also a good alternative income of mangrove-shrimp and mangrove-shrimp *cum* crab farming systems. It accounts for 5% and 10% of the gross income, respectively.



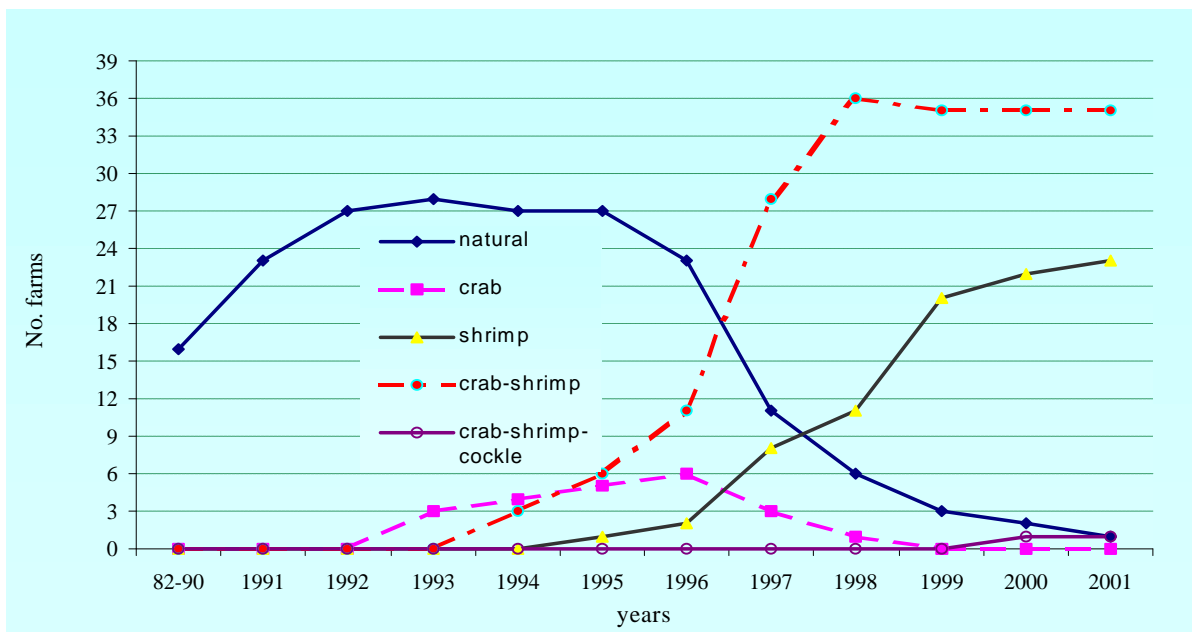
The proportion of income components of mangrove-shrimp and mangrove-shrimp *cum* crab farming systems in Ca Mau province, 2000

Income from mangrove forest

Rhizophora apiculata is the main species dominating in Ca Mau's mangrove area. It has an economic value ranging from 300,000 to 350,000 VND/m³ (20 USD/m³) and average income from wood production is around 500,000 VND/ha/household/year (34.5 USD) (Liem *pers. comm*, 2001). Mangrove collection/selling wood products contributed 1.1% of household income. The income from selling of thinning was reported by farmers as \$ 238 - 253/ha. However, this took place at a first thinning when the trees are around 5 years old. Farmers have to follow the thinning schedule of mangrove trees at 8, 12 and 15 year and then all trees will be harvested 20 to 25 years old. As the cycle for wood production takes long term but income from wood production is not high, farmers are not interested in wood production. However, farmers have to accept and follow the regulation and policy of the mangrove forest protection and development of the Government.

The Dynamics of the Development of Mangrove-Aquaculture Farming Systems

The dynamics of aquaculture in mangrove areas developed from a traditional farming system to hatchery shrimp and/or captured mud crab farming systems. Recently, blood cockle has also been stocked to increase farm production. Most farmers wish to reduce the high risk of shrimp monoculture by increasing the alternative income from other species. The trends in aquaculture development in mangrove areas is illustrated in the following diagram.



The dynamics of aquaculture development in mangrove area of Ca Mau province

Mangrove-hatchery shrimp farming system

This farming system is one of the two most popular farming systems in Ca Mau mangrove area. 52.2% of the farms are converted from the traditional system and the remaining 47.8% from hatchery shrimp *cum* crab farming system. The development of the farming system was started in 1996-1997 and increased rapidly from 8.7% to 69.5% of total farms in 1996 and 1999, respectively. The reasons are low income from traditional farming systems, the high value of *P. monodon* and crab poaching.

Mangrove-hatchery shrimp cum mud crab farming system

The farming system is the second most popular in the mangrove area of Ca Mau province. This farm system has been developed from other farm systems, 25.7%

from mangrove-improved crab farm, 22.9% from mangrove-traditional farm, 17.1% from mangrove-hatchery shrimp farm systems and the remaining 34.3% of the farms are new comers. The development of the farm system was rapid and highest in 1998. The reasons are low income from mangrove-traditional farm, not enough income from mangrove-crab monoculture farm, high risk from mangrove-shrimp monoculture, and especially from new comers who came and bought from failed old farmers in 1997.

Mangrove-traditional farming system

This farming system was formed earlier than other aquaculture farming systems in mangrove areas of Ca Mau province. This farming system was the most popular in 1992 and 1993 after the policy of Forest Land Allocation was established in 1991. However, this farming system has decreased rapidly



Traditional shrimp farm system

since 1996 due to converting into other farming systems such as mangrove-hatchery shrimp farm (52.2%) and mangrove-hatchery shrimp *cum* crab farming system (22.9%). The reasons were low income from this farming system, available hatchery shrimp seed, high price of *P. monodon* and monthly alternative income from crab. Therefore, the number of traditional farming households was reduced rapidly during 1998 and 1999.

Mangrove-hatchery shrimp cum mud crab and blood cockle farming system

Recently, aquaculture farm systems in mangrove area have been developed more abundantly. That means, new species (blood cockle) has been introduced into mangrove-aquaculture farming systems. This is a new aquaculture farming system in the mangrove area of Ca Mau province. The farming system has been developed from the mangrove-hatchery shrimp *cum* crab farming system since 2000 because the cockle and mud crab can provide an alternative income for the household.

The Development of Integrated Mangrove-Aquaculture Farming Systems

The expected development for shrimp culture is that 78.3% of mangrove-hatchery shrimp *cum* crab farms and 77.1% of mangrove-hatchery shrimp farms will increase shrimp density without feeding because they think the more they increase shrimp density, the more they increase shrimp production. Only 2.9% of mangrove-hatchery shrimp *cum* crab farms will reduce shrimp density because shrimp culture has been more risky than crab culture. Besides, semi-intensive shrimp farming will not be adopted due to the poor physical condition of farms, and lack of technique and capital for investment. In addition, blood cockle will not be supplied in their farms due to the lack of seed, technique and experience.

Mangrove-hatchery shrimp cum crab farming system: 31.4% of these farms will increase crab density without feeding. However, 20% of the farms will reduce crab density and another 20% of the farms will stop stocking crab because of the constraint of stolen crabs.

Mangrove-hatchery shrimp cum crab and blood cockle farming system: shrimp and blood cockle densities will be increased in the farm because blood cockle culture seems to be simple and is a good alternative production.

Mangrove-traditional farming system: the farmer will stop farming with this system and supply *P. monodon* in the farm because income from traditional shrimp systems is not enough for the family.

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Further reading

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