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Economic Analysis and Environment Impact Assessment of Water-based Economic Activities in Tam Giang – Cau Hai Lagoon, Thua Thien Hue Province

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Faculty of Economics and Development Studies
Hue College of Economics
100 Phung Hung, Hue

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PROJECT SUMMARY

Implementing Agency	**Faculty of Economics and Development Studies** **Hue College of Economics** Address: 100 Phung Hung, Hue Telephone: 84- 54 538332, Fax: 84-54 8536290
Research Team:	Asso. Prof, Dr. Mai Van Xuan Dr. Bui Dung The Mr. Tran Minh Tri Mr. Nguyen Huu Tuan Mr. Tran Duc Kien
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I. INTRODUCTION

1.1 Background

Tam Giang – Cau Hai (TGCH) lagoon stretches from $16^0$14' to $16^0$42' latitude and upon the longitude of 107^0 East. It lies in the middle of the Northern tropic of cancer where tropical climate of the South and temperate climate of the North met. With the water surface area of 21,600 hectares and the length of 70 kilometers, the TGCH lagoon is known as among the largest lagoon in Southeast Asia. It encompasses the territory of 33 communes and towns belonging to 5 districts of Phong Dien, Quang Dien, Huong Tra, Phu Vang and Phu Loc.

In recent years, under high pressure of economic development, and population growth, Tam Giang – Cau Hai lagoon in particular have been threatened by serious risks from human activities. Rapid expansion of aquaculture, agricultural production, natural catching, and other industries have affected wetland the ecosystems and environment. For instance, a large area of wetland (e.g. lagoon fishing ground, mangroves) was converted into aquaculture, herbicide and pesticide run off from intensive agricultural production. This led to loss of mangrove, loss of aquatic resources and an increase in environmental cost.

Tam Giang - Cau Hai Lagoon is a typical IWRM (Integrated Water Management) and WFE (Water For Ecosystem) issue case, where multiple users and uses of water are competing for limited water resources in both quantity and quality, resulting up till now in an unsustainable water use that is leading to both increased intra- and inter-sectoral water competition. This situation has worsened considerably over the last 15 years due to the unrelenting and unrestricted growth in shrimp cultivation alongside and into Tam Giang – Cau Hai lagoon in response to the growing market demands for cultivated shrimp. Other important water-based activities (most sampan people in the lagoon live on) are catching wild fish and cultivating rice.

To achieve the objectives of sustainability and realize the principles of WFE, the challenge lies now before the Provincial People Committee (PPC) of Thua Thien Hue province and its partners to utilize the increased capacity in water capture, conveyance and control for restoration of the aquatic ecosystem of Tam Giang – Cau Hai lagoon. Another challenge is synergizing the water uses (both in quantity and quality) between aquaculture, irrigated rice and Hue city water supply to the extent that the ecological situation of the lagoon can be stabilized and in some aspects can even be restored to a previous level. Measures to restore the degraded state of the current aquatic ecology of the Tam Giang – Cau Hai lagoon may affect some beneficiaries. Especially in the short-run it may have a negative impact on shrimp farmers as it may require a reduction in the current occupation of the lagoon with fish ponds and “hatching nets”, which may reduce the benefits of aquaculture from the lagoon. In the long-run it may have a positive impact on shrimp farmers as a better water quality in the future will increase the level of shrimp production.

The Provincial People Committee (PPC) of Thua Thien Hue (TTH) Province, its line departments and the Ministries wish to redress the current unsustainable situation in the Huong river system and Tam Giang – Cau Hai lagoon, by adopting an integrated water resources management approach that respects the principles of water for food and ecosystems. In first instance a conventional river management authority approach has been adopted, in which the water resources development investments have been geared towards increasing the water capture, conveyance and control infrastructure:

- Commissioning of three additional dams and reservoirs within Huong river basin to increase the dry season releases in order to restore dry season rice cultivation;
- Building of the salt intrusion barrier in the mouth of the Huong river to protect the domestic water supply to Hue city; and
- Enlargement of the see-outlet of Tam Giang–Cau Hai lagoon to increase the water circulation and refreshment rate of the lagoon as well as to diminish or reverse the hydraulic gradients at its fresh-salt water interface.

Under this new water regime, the districts around the lagoon envision to better meet the water requirements of its two most prominent water use and livelihood sectors: rice production and aquaculture (IUCN draft). Except for these livelihood sectors, the stabilizing of the ecological value of the lagoon is another important point. These different investments have as main target, to (a) restore the dry season rice production to its full potential; (b) enable the district to meet the projected growth in aquaculture; (c) improve the water conveyance and distribution infrastructure and (d) improve the dykes to better protect against saltwater intrusion and flooding.

The increase in dry season rice production will on the other hand avoid salt water intrusion from the lagoon into the agricultural polders. Thus it is clear that various kinds of restoration measures will affect the beneficiaries differently. This means that some sectors will be more affected than others under a particular restoration measure. It is therefore important to undertake an economic analysis and assessment of key water-based economic activities in the lagoon.

This study of economic analysis and environment assessment of three important water-related activities (aquaculture, natural catching and irrigated rice cultivation) aims to support improvements in inter-sector water management to the extent that the ecology of the lagoon can be improved/restored. Insight into the value of water will allow us to weigh the foregone benefits -the so-called opportunity costs. Water valuation is a tool to enhance the ability of decision-makers to evaluate trade-offs between alternative water management regimes and courses of social actions that alter the use of water and the multiple services it provides. Special attention has to be paid to local conditions, as values are highly context-specific. As it is hard to assess the extent to which restoration measures increase the value of ecosystems, this will not be quantified here but described. Foregone benefits or potential additional gains will, however, be quantified.

1.2 Research Objectives

(1) To estimate economic value of three important water-related activities, aquaculture, natural catching and rice farming in and around the lagoon;

(2) To assess environmental impact of these economic activities on the lagoon water environment and biodiversity;

(3) To assess the importance of these activities in the livelihoods of communities living around the lagoon;

(4) To provide recommendations to support the sustainable management of water/fishery resources in the lagoon.

II. RESEARCH METHODS

2.1 Economic analysis

Focus:

In-depth economic valuation of selected water use activities was done at Quang Dien district, Tam Giang – Cau Hai lagoon. The selection of the district was based on several criteria such as the scale and water use conflict, the availability of data and past studies, and the collaboration of local authorities and community. The analysis focused on:

- Aquaculture (differential users and technologies)
- Natural catching (differential users and technologies)
- Rice cultivation (differential users)

Methods:

Valuation of aquaculture cultivation accounted for the following production elements:

- Type of cultivation technique (ponds vs. nets, etc)
- Location within the lagoon and its associated water quality (brackishness, refreshment rate and pollution)
- Level of inputs usage (feed, stock and pharmaceuticals)
- Level of disease
- Type of marketing
- Current yield and economic data to be obtained through surveys
- Characteristics and numbers of households involved in the production
- Size and ownership characteristics of enterprises

Economic analysis of natural catching accounted for the following elements:

- Type of fishmen and type fishing gears
- Overall livelihood patterns of fisherfolk – how important is fishing in their overall livelihoods (including full time and seasonal/part-time fishers)
- Catching season
- Fishing efforts and landings
- Marketing
- Valuation was done for the whole year

Valuation of rice cultivation accounted for the following production elements:

- Type of rice farming (traditional vs. modern, good vs. bad irrigation access etc)

- Location around the lagoon and its associated water quality (brackishness, refreshment rate and pollution)
- Level of inputs usage (nutrients, water, labor)
- Level of production (yield, price and variety)
- Type of marketing
- Current yield and economic data to be obtained through surveys
- Characteristics and numbers of households involved in the production
- Size and ownership characteristics of enterprises

Regression analysis was done to assess factors affecting economic returns of these water-base activities (aquaculture, natural catching and rice cultivation).

Data collection:

Secondary data necessary for the study were collected from different sources, including governmental organizations (Department of Fishery, Department of Environment and Natural resources, Bureau of statistics) and programs and projects in the lagoon (ICZM, IMOLA).

Primary data were collected through household surveys. Sample was drawn using stratification and randomization techniques. The economic valuation was carried out by in-depth surveys and interviews from stratified household samples among the aquacultural cultivation, natural catching community, and rice farming households. Differential classes of economic wealth and/or productivity were applied to the household sample to capture differential water use, productivity and value strategies among water users.

Table 1: Household sample and focus group discussion

	Number of Focus Group Discussion (FGD*)	**Number of households to be surveyed**
1. AQUACULTURE	**9**	**225**
- Intensive	3	75
- Semi-intensive	3	75
- Improved-extensive	3	75
2. NATURAL CATCHING	**6**	**120**
- Fix gears	3	60
- Mobile gears	3	60
3. RICE CULTIVATION	6	150
- Rain-fed/non-IPM	3	75
- Irrigated/IPM	3	75
TOTAL	**15**	**495**

* *Each focus group discussion involved 15 people.*

2.2 Environmental impact assessment

Focus

The assessment focused on the impact of different aquacultural technologies (intensive, semi-intensive and improved-extensive), fishing techniques (fix gears, mobile gears) and the cropping intensity of rice on the water quality and biodiversity of the fishery resources in the lagoon. The inter-sectoral impact between aquaculture, natural catching and irrigated rice cultivation were also assessed. The assessment focused on the present water-using activities and their current value as well as on the possible future transfer of trade between these different activities when the new water infrastructures in the area were constructed.

Methods

Environmental impacts were assessed using participatory approach. A set of PRA tools and techniques were employed. These include household interviews, field observations, focus group discussion, timeline, resource mapping. Spatial and temporal issues were considered.

Delphi methods were also used to assess the impact of aquaculture and natural catching on lagoon water environment. The correlation between water quality and aquaculture scale and natural catching intensity were discussed as well as the correlation between the irrigated rice cultivation and the water demand for aquaculture, since the freshwater demand for irrigation and the resulting drainage water conflicts with the brackish water requirements for shrimp cultivation at the edges of the lagoon

Data

Secondary data on lagoon water environment were collected from Fishery Department, Environmental Institute of Hue University and other sources. Perception of households on the changes in lagoon ecosystem and their causes were explored through a household survey. As mentioned earlier, the Delphi approach and group discussion were employed in this study. Themes for interviews were prepared in advance in the form of semi-structured questionnaires. The face-to-face interviews were carried out with officers and experts in provincial agencies such as Department of Natural Resources and Environment, Department of Fishery, Department of Sciences and Technology, Department of Agriculture and Rural Development, and Center for Fishery Extensions.

Scientists and experts in the field were also interviewed. They include experts in University of Agriculture and Forestry, University of Sciences who have carried out several different studies on the lagoon. Besides, face-to-face interviews with members of Management Board of related projects such as IMOLA, Integrated Coastal Zone Management (ICZM) were also undertaken.

III. OVERVIEW OF TAM GIANG - CAU HAI LAGOON

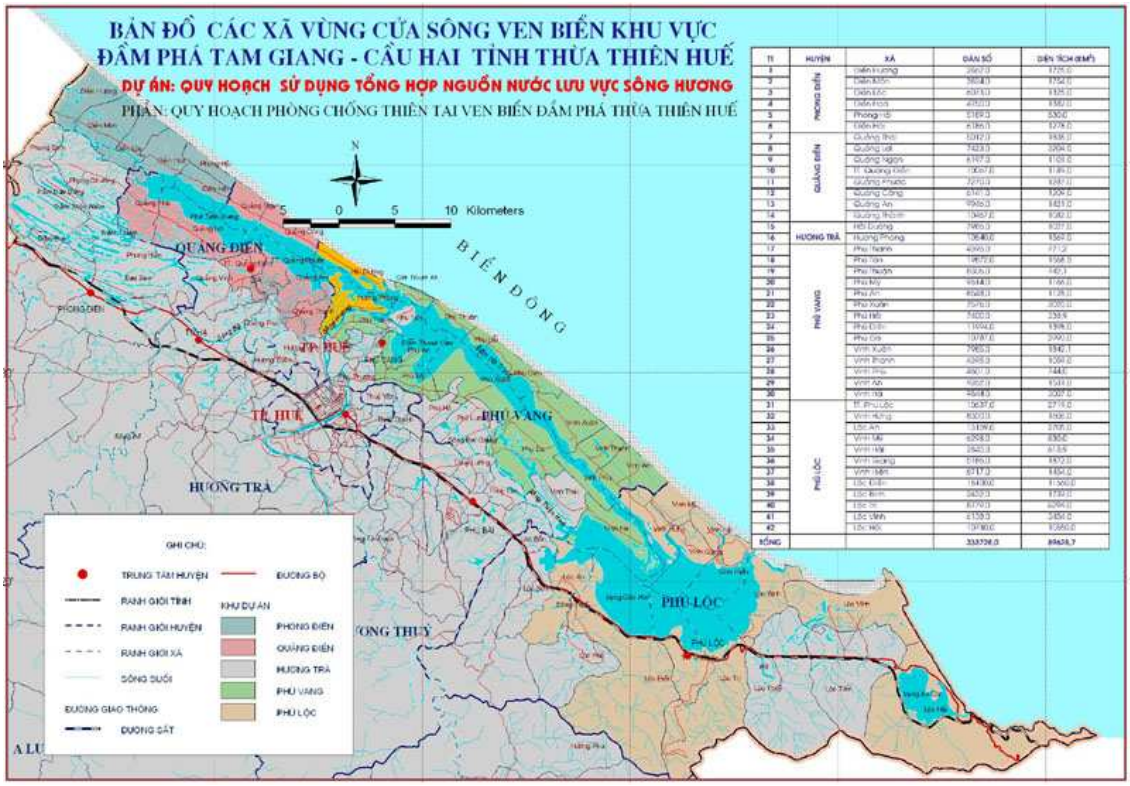
3.1 Background

3.1.1 Location

Tam Giang – Cau Hai (TGCH) lagoon stretches from $16^0$14' to $16^0$42' latitude and upon the longitude of 107^0 East. It lies in the middle of the Northern tropic of cancer where tropical climate of the South and temperate climate of the North met. It encompasses the territory of 33 communes and towns belonging to 5 districts of Phong Dien, Quang Dien, Huong Tra, Phu Vang and Phu Loc in Thua Thien Hue province.

Tam Giang-Cau Hai lagoon is wetland area connected with big rivers and Eastern coast in Thua Thien-Hue province. The lagoon connected with Eastern coast with 2 estuaries; Thuan An in the north and Tu Hien in the south. With total surface area of 21.600 ha Tam Giang-Cau Hai lagoon is the biggest lagoon in Vietnam and considered as one of the biggest lagoon in the world. Its average width is from 0.5 km to 9.0 km and average depth of 1.5m. The lagoon is separated with Eastern coast by dunes; some of them are 4 km in width.

Figure 1: The location of communes in Tam Giang - Cau Hai Lagoon



(Source: Planning for using water from Huong river basin project)

Administratively, Tam Giang-Cau Hai lagoon lies in the area of 33 communes and Thuan An town of 5 districts, including Phong Đien, Quang Đien, Huong Tra, Phu Vang và Phu Loc (See Map 1 and Appendix 1). Specifically, this lagoon system is probably devided into 3 main areas: Tam Giang lagoon in the north; Sam, Chuon, An Truyen, Thuy Tu in the middle; and Cau Hai in the south. Tam Giang lagoon stretches out with 24 km length from O Lau river down to the South (near Huong River) with average width of 2.5km and 1.6m depth on average. Total area of Sam, Chuon, An Truyen and Thuy Tu-Ha Trung is 6,000 ha. This part of TGCH lagoon system lies in along of Huong river to Truoi one (about 33 km length) with average depth of 1.5-2.0 m and about 1.0 km width. Cau Hai is considered as second largest lagoon in this lagoon system with about 10.400 ha. It is shaped as a large semicircle of about 13 km length from Truoi River to Vinh Phong mountain with an average depth of 1.0 – 1.5 m, the deepest area of about 3.0 m in Da Bac[i]. Table 2 presents the total water surface area by district (see Table 2).

Table 2. Water surface of Tam Giang-Cau Hai Lagoon by District

	District	**No. Of commune**	**Total water surface area** (ha)	**Aquacultural area** [1] (ha)
1	Phong Đien	2	639.4	0.0
2	Quang Đien	8	3,618.7	573.3
3	Huong Tra	2	775.4	265.0
4	Phu Vang	13	7,635.2	1,442.0
5	Phu Loc	8	9,239.9	825.5
	Total	**33**	**21,918.5**	**3,105.5**

(Source: Do Nam 2005[ii])

3.1.2 Hydrography and Current in TG-CH lagoon

The hydrography in Tam Giang-Cau Hai lagoon system is largely affected by 4 big rivers, including O Lau, Huong, Dai Giang and Truoi. O Lau river flows down to Tam Giang lagoon from western mountain range of Thua Thien Hue. Huong is the biggest river running from Northwest mountain. Truoi and Dai Giang provide source of fresh water for Cau Hai lagoon. The result of previous studies revealed that the saline level of lagoon surrounding these estuaries is considerable lower in comparison with the rest of lagoon, particular of OLau is 0 ‰[iii]. In dry season (from March to September), the saline level of lagoon is much higher than rainy season (from September to December) due to sea water flowing to lagoon through Thuan An and Tu Hien estuaries (see Appendix 2). Tam Giang-Cau Hai lagoon water is being freshed in rainy season, especially for sub-region near rivers. For instance, the saline level of lagoon surrounding OLau river is much lower and slowly increasing in comparison with other regions in lagoon as it is far from Thuan An estuary. As a result, there is considerable difference in aquacultural calendar between regions. It often delays about 15 days, thus leading to limits in intercropping as well as increasing threat of aquacultural disease. The considerable variation in lagoon salinity also caused affects to aquatic species. For example, fresh water macrophyte and bottom living species such as macrobachium, clams, mussel and goby strongly generate in rainy season while dry season is the growing time for species living in brackish and salt water environment such as Giant seaperch, blue swimming crab. The changes in saline level creates a seasonal diverse ecosystem and contributes to eco-sustainability (Do Nam, 2005).

[1] The figures are calculated only for in-lagoon aquaculture activities (e.g. net-enclosed pond and in-lagoon ponds)

3.1.3 Population and Infrastructure

There is about 350,000 people living around Tam Giang-Cau Hai lagoon, accounting for 31% of Thua Thien Hue total population. The annual growth rate of population is about 1.8%, higher than the whole province average of 1.6%. The population density is relatively high (about 320 person/km^2) while that of the whole province is 211 person/km^2 (Do Nam, 2005). Such high population density and rapid growth rate have put more pressure on exploitation of lagoon resources. It also means the contradictory issue between lagoon resource management and local livelihood security has emerged and challenged local governments.

The weakness in infrastructure is popular issue of communes surrounding TG-CH lagoon. There are still many unconcreted roads or downgraded ones such as provincial road No. 4 and 11 A. The data of Rural Development Project of Quang Dien indicates that about 60% of inter-commune roads and about 14% of inter-hamlet roads were concreted (Do Nam, 2005). It also means that local habitants still deal with transporting difficulties; the problems become more difficult in rainy season that some areas are flooded and isolated from the rest of province.

Fresh water for domestic uses is also a difficult issue for local people who are living in TG-CH lagoon. Communication, health cares and education are also still weak in comparison with other regions in Thua Thien-Hue province thought local government has made great effort to improve in recent years (Thung, et al, 2005)[iv]. Local people find it hard to involve in non-farming activities. There was few non-faming activities in lagoon areas, thus local livelihood depends heavily on lagoon resources.

3.1.4 Biodiversity

TGCH lagoon is rich in biodiversity. It has over 898 aquatic species, including 230 fish species, 73 species of bird, 30 species of crustacean, and other species. Out of 230 fish species there are 100 species are of high economic value (Thung, et al, 2005)[v]. It is stated that fishery resources and plants in the lagoon are very valuable resources for not only natural capture fisheries but also aquaculture development and marketing. The annual catch from the lagoon was about 4000 tons, with many high economic value for export such as snapper, tiger shrimp, and rabbishfish. However, they stated that fish stock and biodiversity in Tam Giang lagoon have declined due to human activities.

3.1.5 Irrigation Construction and Environmental Impacts in TG-CH lagoon

There are a number of dikes constructed to prevent saline intrusion to paddy fields surrounding lagoon, such as Vinh Giang - Vinh Ha, Cua Lac, Dien Hoa, ICO dikes and Dien Hong one. The fact, however, indicates the negative impacts of these dike construction on ecosystem and water environment such as changes in current, and narrowed spawning ground for many species (Ho Phu Ngoc, 2005). According to scientists, the construction of Thao Long dike causes sediment accumulation and break the balance of ecosystem in Thuan An estuary by an increase in sediment from sea, thus leading changes in currents and species migration in this region (Do Nam, 2005). Sediment accumulations might lead to the decline in fish yield in lagoon.

There are also four water reservoirs under construction in upstreams of rivers running into lagoon. The construction of these reservoirs would affect the lagoon‘s environment. For example, the construction of hydroelectric plant in Binh Dien and Huong Dien (Co Bi), Ta

Trach reservoir and Truoi one, have significant contribution to the control of floods and reduction of flash flood. These constructions also reduce direct flows of flood water to lagoon and the instability at the estuaries. However, the length of time of flood at over level 3 would be longer than before. In dry season, these reservoirs also provide a considerable source of fresh water for lagoon, thus leading to changes of saline level, increasing in some areas and decreasing at other areas. The result of previous study also reveals that the construction of these reservoirs will play an important role in reducing the sediment accumulation in lagoon. Without these construction the annual sediment was about 200,000 to 300,000 m^3. The figure would be reduced to 100,000 m^3 (Phu, 2005).

3.2 Water based-economic activities in TG-CH lagoon

The TGCH lagoon with features described above serves as a source of diverse The economic activities for local community. At present, water-based economic activities in the lagoon include agricultural production, wild fishing activities, aquaculture, transportation and mine exploitation, tourism and other activities. They are briefly discussed.

3.2.1 Agricultural production

Although natural catching is a traditional livelihood activity, agricultural production is still the main source of income for most local people. Labour involved in this activity accounted for 55-60% of total rural labor force (Do Nam, 2005) while the proportions of agricultural land of the five lagoon district was only 14.6% of natural area. The figure for the 33 lagoon communes was 19.4%. The statistical data also indicate that paddy area is relatively small accounted for 47% of total agricultural land with annual rice production of 122,000 tons and rice yield of 3-4ton/ha (Thanh, Tien and Cu, undated). Agricultural production uses a lot of water and affects lagoon water environment. The fact has shown that, in recent years, the utilization of chemicals (e.g. fertilizer, pesticide, herbicide) in agricultural production surrounding lagoon caused negative impacts on lagoon environment and aquacultural production. Chemical residues from agricultural production ran into the lagoon. The conflict might occur between agricultural farmers and aquacultural households. Many farmers complain that aquacultural development also causes negative impacts on their paddy fields due to saline intrusion.

Other food crops such as cassava, maize, tobacco, vegetables and short-term industrial trees are also important part of lagoon agricultural production and have a close relationship with lagoon. It is stated that about 150 thousands tons of macrophytes exploited from lagoon are used as feed and green manure.

Local people also engage in animal husbandry such as pig raising, cattle raising, and poultry. Animal husbandry is also important source of households' income. Wetland areas surrounding river estuaries become pastures for grazing local cattle. Local inhabitances also use paddy fields to keep duck and generate extra income. In recent years, especially in 2005 – 2006, number of poultry has dramatically gone down after the bird flu epidemic; from 300.000 heads to 43.270 in 2005).

3.2.2 Aquaculture

Aquaculture production is the most important economic activities in lagoon. It is estimated that aquaculture attracted about 12.8% of total local labour (Chuong, 2006). From 2000 to 2005, there was a rapid increase in aquacultural area with 16% per annum. In 2005, total aquacultural area reached approximately 4.000 ha, two times of that of the year 2000. The rapid development of aquaculture has made important contribution to positive changes in local economy structure; a large number of labour switched to, and large area of agricultural land converted into, aquaculture production. The findings of recent researches indicated that aquaculture made significant contribution to job creation and improvement of local income for about 14,000 households and 21,000 labors (Chuong, 2006). However, the booming of aquaculture in TG-CH lagoon without well-designed plans, thus leads to many issues challenging local governments and households such as environment problems, shrimp disease epidemic and poor harvests (see Appendix 3).

3.2.3 Fishing activities

Wild fishing is traditional activity, exploiting the lagoon's resource directly. It is important source of income for large part of local community, especially for the poor and sampan people (i.e. people who live on boat). The finding of previous study indicated that the highest catch from lagoon reached 4,517 ton in 1973 (Thanh, et al, 1998). Since 1975, statistical data reveals that annual fish catch reached about 2000-3000 tons. There are about 2,500 fishing boats in lagoon (Thanh, et al, 1998 and Binh, 1996).

Fishmen own many fishing gears that are well-adapted improved through long experience and to respond better to changes in lagoon ecosystem. According to the result of IMOLA project, there are about 35 types of fishing gears in the lagoon. They can be classified into two categories: fixed fishing gears (e.g. fishing corral, mullet trap, bottom net) and mobile fishing years (e.g. eel rake, dragnet, pushnet).

During the last two decades, fishery resources have been degraded due to pressure of rapid population growth, difficult living condition and a lack of proper management of lagoon resources. Fishing efforts increased. Local fishmen diversified their fishing gears in order to adapt with the decline in fishery resource. Their fishing gears become more effective and destructive. Local fishers tent to use, for example, dragnet, mororized push-net, electric tapping and recently Chinese fishing pot, which is locally evaluated as most destructive gear in lagoon. The environmental pollution and decline in fishery resources are found as consequences of the use of such fishing gears in the lagoon.

3.2.4 Water-way transportation

Tam Giang-Cau Hai lagoon connects five of eight districts in Thua Thien-Hue province. Thus, water-way transportation in the lagoon plays a very crucial role in movement of not only for the lagoon community but also the whole province. Water-route from North to South of Tam Giang-Cau Hai lagoon is one of two main water-routes of province (TTH People Committee, 2003). There are 18 docks in the lagoon. Every year about 22 thousands people travel via these dock and about 250 tons of goods were transported. The docks of Vinh Tu, Hai Duong, Cu Lai, Vinh Hung, and Vinh Hien were approved to upgrade to be able to accommodate boats with a capacity of up to 15 ton, or 20-30 passengers.

It should be noted that waterway transportation caused adverse impacts on lagoon environment such as water pollution by petrol leaking, making noise, sediment retention and so on. The fact shows that people dropping litters while participating in lagoon transportation. Additionally, constructions surrounding lagoon and dredging passage also lead changes in lagoon's currents. Rapid development of fishing activities and aquaculture have occupied water-routes, thus become an obstacle to water-way transportation in lagoon.

3.2.5 Ecotourism and recreation

Located near Hue, a centre of Vietnam tourism, and Bach Ma National Park, Lang Co beach, TGCH lagoon owns not only biodiversity but also cultural values that are favors for ecotourism development. There are typically traditional festivals such a Fishery Praying Festival, Thu Le Wrestle Festival, Traditional Boat Racing in many lagoon communes. Many traditional historical relics, handicraft villages are characterized as tourism resource attracting visitors to lagoon region. In addition, beauty landscapes are considered to be advantages for tourism and recreation development in lagoon. Some tour operators organized eco-tours such as fishing tours, boating in lagoon, nature exploration combining with traditional festivals around the lagoon. However, the business is operating at a small scale, not well organized.

In order to avoid possible negative impacts of tourism, local government should have proper plan and regulations on environment protection for tourism business. It is better to prevent the problem rather than finding solutions to address the problem.

3.2.6 Sampan people and livelihood

According to Didier (1995) *sampan* people in Huong river and in lagoon originated in historical migration from China. They were fishers along South China Sea and migrated into Vietnam in the 13th century. Other study (Thieu, 2000) states that during the period of feudalism development, due to social stratification, there was a group of people living in villages surrounding the lagoon, who lost their right to land that forced them living on lagoon as present *sampan* people. Having no land for settlement, they had to live on floating boats in lagoon and involved in wild catching. Sampan people live on boat and use lagoon water for daily demands such as washing, cooking and bathing. They are seen as one of the main reasons for over-exploitation of fishery resources in lagoon. Their livelihood has imbedded in lagoon for a long history.

Despite a great effort made by the government to resettle them on land, there have still been 1,800 sampan households living around lagoon and rivers in Thua Thien-Hue. In addition to government effort, some *sampan* people themselves attempt to resettle on land but their livelihood activities are still attached to the lagoon. They claimed that they are very familiar with fishing activities: "*following the fish's tail*". Changes in lagoon environment and fishery resources would lead to changes in livelihood of this group of people. In turn, sampan people exploit fishery resources and create environmental problems in Tam Giang-Cau Hai lagoon. According to provincial plan, about 900 sampan households of 27 communes in Tam Giang-Cau Hai lagoon will be settled on land in the year 2008 and 2009. However, this requires large budget and resources. Lessons learnt from previous resettlement program emphasized the importance of livelihood support to the cusses of a resettlement program.

3.2.7 Other activities

Mining

The result of a geographical survey indicates that Tam Giang-Cau Hai lagoon owns titan-zircon resource in Quang Dien, Phu Vang, Phu Loc, Quang Ngan, Vinh My with average reserve of 210kg/m^3. Exploiting such precious mine is a new economic activity since 1990s. According to the result of survey conducted by Thua Thien-Hue Mining Company, total reserve of titan mine reaches about 5 million tons. Thua Thien-Hue province planned and exploited in an area of 6,182m^2 with an output of 362.5 tons (see Appendix 5).

Despite large profit from Titan mining activity, this mining activity also caused adverse impacts on lagoon environment. Firstly, mining activity has broken vegetation cover in dunes surrounding lagoon. This vegetation cover plays an important role in balancing water sources and preventing erosion. In rainy season, this vegetation cover absorbs water and release slowly into lagoon. Secondly, large volume of waste water form the process of titan sifting discharged into the lagoon. Therefore, this issue need to be well considered in the socio-economic development plan of the region. The problem of benefit conflicts like those experienced by Quang Nam and Binh Dinh should be avoided.

In short, Tam Giang-Cau Hai lagoon system is large wetland of great economic values to the local people and the society. Aquaculture, agricultural production (especially rice cultivation), and wild fishing are main water-based activities in the lagoon area. However, these economic activities have exerted negative impacts, making the lagoon resource degraded. Thus, researches on the sustainable use and management of lagoon resources are really important. It is obvious that if we still keep exploiting and managing the lagoon resource without proper changes in management and utilization, an eco-tragedy is inevitable in near future[vi]. Consequently, many people will be affected.

IV. AQUACULTURE IN TAM GIANG – CAU HAI LAGOON

4.1 Introduction

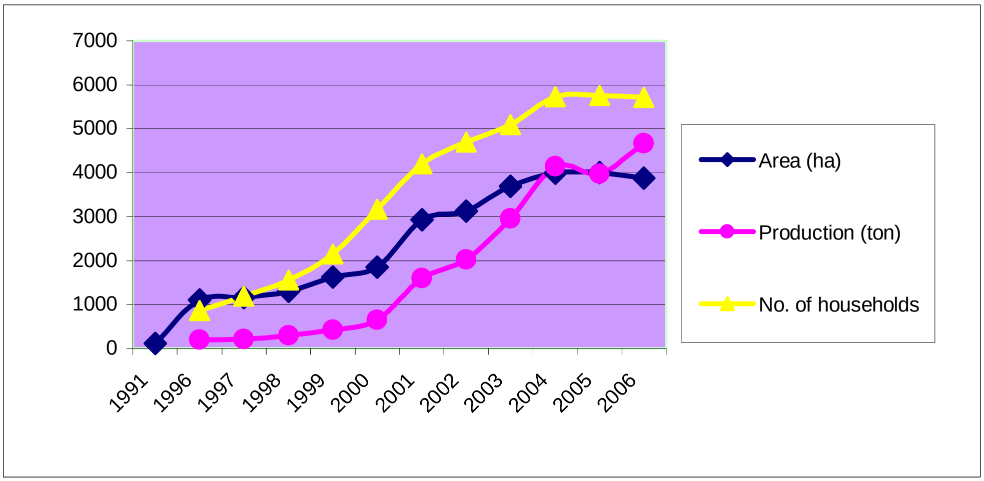
As mentioned above, aquaculture in Tam Giang - Cau Hai lagoon includes fish, crab, mytilus smaragdinus raising, and especially shrimp raising. Lagoon aquaculture started in late 1980s and early 1990s, and it has developed very fast since then. The history of lagoon shrimp culture can be divided into four main phases:

The first phase, which can be called *start-up* phase, started from late 1980s to 1995. It was when people mainly caught and raised natural shrimps or bred artificial shrimps at sparse density, feeding them infrequently with fresh feed only.

The second phase, from 1996 to 1999, can be called *about-to-develop* phase. In this phase, people gradually applied modern aquaculture techniques to increase productivity. The number of people involving in aquaculture also went up.

The third phase, from 2000 to 2005, was a *rapid-expansion* phase. After some greatly successful crops in 2000 and 2001, farmers mobilized all resources to invest in aquaculture production, meanwhile the authorities also created favorable conditions for development of shrimp farming. Therefore, the area of shrimp and the number of shrimp raisers rapidly increased. Specifically, the average growth of aquaculture area in the period of 2000-2005 reached 16% annually. As to 2005, the shrimp area of the whole province was about 4,000 ha, twice as much as that in 2000.

Figure 2: Aquaculture production in TG-CH lagoon



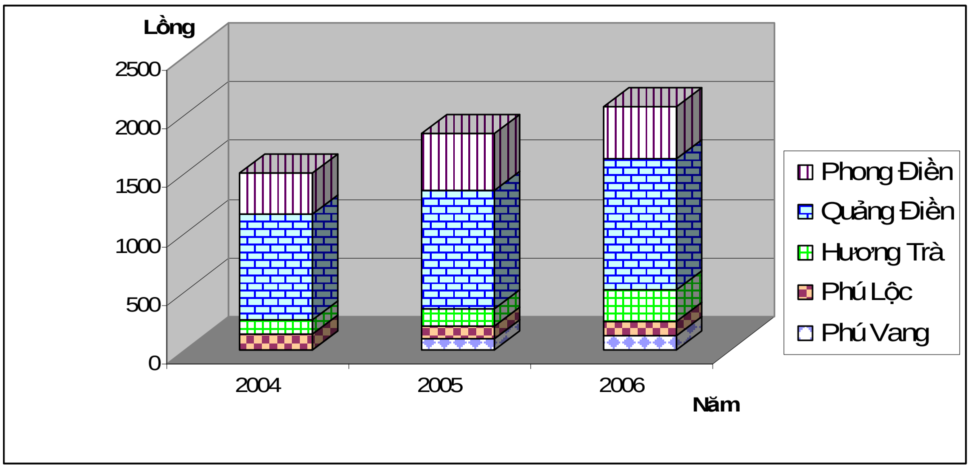
Source: Thua Thien- Hue Fishery Department, 2007.

At present, aquacultural area seemed to have exceeded the carrying capacity of the lagoon. The lagoon got polluted thus resulting in crop failure and loss. The percentage of shrimp households bearing loss was high. For instance, in 2000, only 10% of shrimp raising households in Quang Dien district suffered from loss, but in 2004, this figure was 53% (Quang Dien Department of Agriculture, 2005). This leads to a halt in aquaculture expansion; from 2005 shrimp area did not increased, even slightly decreased. We temporarily called this *stable* phase – the fourth phase. In this phase, shrimp price did not go up but slightly went down while input factors increased.

In order to overcome such disadvantages, people shift from monoculture to polyculture with lower stock density. This transformation is reasonable given the natural conditions of Tam Giang - Cau Hai lagoon. Although this measure can bring about lower yield and turnover in comparison with those of high stock density model, this shift could reduce (Xuan, et al, 2007).

In addition to shrimp raising, different fish species were also raised in earth pond or in cage. The income from fish raising was not high but more stable than shrimp raising, and it required low investment capital and was suitable to the conditions of the households in the lagoon. The number of fish cages is shown in Figure 3.

Figure 3: The number of fish cages in Tam Giang - Cau Hai lagoon



Source: Thua Thien Hue Department of Aquiculture,"Aquaculture Report of Thua Thien Hue province", 2007

4.2 Aquaculture production of surveyed households in Quang Dien district

4.2.1 Aquaculture calendar techniques

Aquaculture calendar/seasons

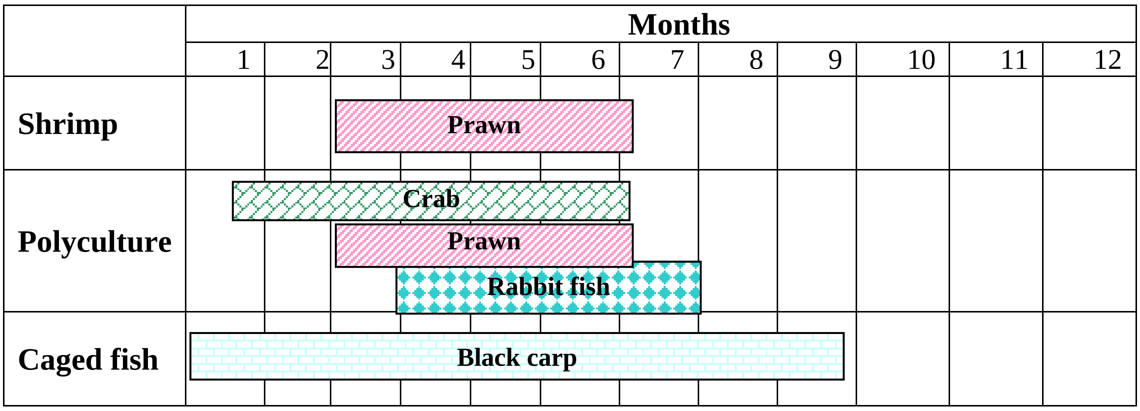
Aquacultural seasons in the coastal lagoon area of Thua Thien Hue depend on climate conditions, saline level, geographical position of aquaculture areas and species. The aquacultural seasons of Tam Giang - Cau Hai lagoon in Quang Dien district are shown in Figure 4.

Sugpo shrimp raising was conducted from March to June every year, when the salinity of lagoon water was at level suitable for raising this species.

There are several polyculture or inter-cropping models, such as shrimp-fish, or shrimp-crab-fish. Small crabs were released into pond from mid of January and then harvested at the same time with shrimps. In the case of shrimp-fish or shrimp-crab-fish intercropping, fish fingerlings were released into pond one month later than shrimps and fish harvest was also one month later than shrimp. The popular fish species raised together with shrimps or crabs was dorabs. Some other species of fish were also reared but with limited quantity.

It should be noted that as for the aquatic species other than shrimps, the raising seasons could be more flexible. However, people usually mange to avoid breeding them in rainy season, when the danger of floods is high, easily to sweep away the fruit of their labour at any time. This seasonality leads to seasonal under-employment in the lagoon areas.

Figure 4: Aquaculture Calendar in Quang Dien (main Crops)



Source: PRA results in Quang An and Quang Phuoc communes, Quang Dien district

In the past, some households made a sub-crop from June to September. To do this it is required to start the first crop (main crop) sooner. This might result in high risks for both crops. The first crop may face the problem of unsuitable salinity, whereas in the second crop, ponds might not be properly treated due to time constraint and flood risk is high. Therefore, currently most households in Quang Dien raise only one crop of shrimps or raise shrimps together with other species so as to prolong raising seasons.

Aquaculture techniques and modes

Aquaculture in Tam Giang-Cau Hai lagoon currently includes various aquatic species. The most popular species is shrimps (tiger shrimp, shrimp with white legs, etc.), accounting for 93.4% of total aquacultural area and 79.6% of total aquacultural production of the whole region (Phuc, 2005). In addition, some other types of aquatic species like crabs, fish (dorab, tilapia, etc), molluses (mytilus smaragdinus, sweet snail) are also cultured.

As discussed above, both monoculture and polyculture models are adopted. Monoculture is to raise only one species in the ponds at a time. This model allows to produce at a large quantity and allow to apply new raising techniques. It requires large initial investment capital. Example of this models include intensive and semi-intensive shrimp farming and caged fish raising. However, monoculture is quite risky, easy to be infected diseases and pond environment is prone to pollution.

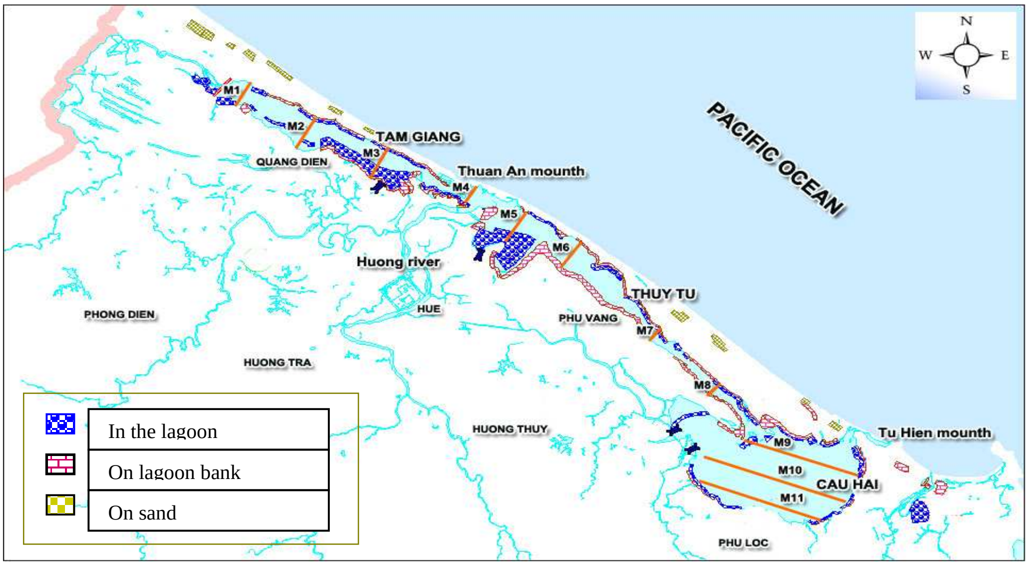
Polyculture is to raise various species in the same pond and at the same time in order to make use of water effectively. This model allows using natural feed source and water volume to gain high yield with low feed cost. It has many advantages but it is required to select suitable combination of species to raise. The species raised in the same pond have to dwell in different water layers, the surface, the mid and the bottom. The species living in the lower layer can use the wastes of those living in the upper layer as feed, for example the model of raising amurs at the upper layer, chubs and tilapias at the mid layer, and black carps at the bottom. At present, popular polyculture models include (1) shrimp – crab; (2) shrimp – fish; (3) shrimp – crab – fish; and crab – fish at some localities.

Based on input use intensity, in the surveyed region there are two popular models, improved-extensive culture and semi-intensive culture. **Improved extensive culture** is the mode basing on extensive models (which mainly rely on natural feed and breed) but it is improved in the sense that additional feed and breed are adopted. In the past this model was applied with raising density of 3-5/m^2, but currently the density is 5-10/m^2 (Tinh, 2003). The advantage of this mode is that it requires low investment and the environmental pressure is low. However, the productivity is not high.

Semi-intensive culture use industrial feed and artificial breed at a higher density 10-20 heads/m^2. It requires good raising techniques such as treating ponds before raising, feeding frequently and periodically. Pond building task has to ensure activeness in moderating and processing water. Besides, **intensive culture** is adopted in some area but with limited scale (17 ha in the whole lagoon).

In Quang Dien, back from 2005, semi-intensive culture was adopted in the majority of aquaculture area. In 2004, there was 580 ha of semi-intensive aquaculture, but this figure decreased to 182 ha in 2006. Conversely, improved-extensive aquaculture area increased rapidly from 71 ha in 2004 to 425 ha in 2006 (Department of Fishery, 2007). This trend is also common in other parts of the lagoon. It is because farmers found that the higher density it was, the higher risk of disease infection is. In addition, investment capital for semi-intensive aquaculture was high. Besides, some households got loss for many years, so the capital to invest in semi-intensive aquaculture was limited. The trend to transform from semi-intensive to improved extensive aquaculture is logical because raising density is likely to have converse impact on income, that is, increasing raising density may lead to decreased income.

Figure 5: Map of Aquaculture area distribution in Tam Giang - Cau Hai lagoon and the slices to take samples for CLN analysis (1998-2004)



Source: Hop, 2005.

Based on type of ponds, it can be divided into two types: earth ponds and cage ponds. Earth ponds include high tide ponds and low tide ponds. The formers are those dug at the earth surface higher than the lagoon surface, easy to drain water and expose pond bottom. This type of ponds is favorable for semi-intensive aquaculture or intensive aquaculture. The later are those banked at the lagoon with water level usually being equal to lagoon water level. It is difficult to apply intensive aquaculture in this type of ponds. At present, most of the ponds in Quang Dien are low tide ponds (97% of total area).

4.2.2 Demographic characteristics of aquacultural households

Based on the distribution of aquacultural households by communes in Quang Dien district, using random sampling techniques sample of 225 households were selected for survey, including 160 households raising shrimp, 44 households adopting shrimp-fish model, and 21 households rearing fish in cage (see Appendix 6).

Survey results show that aquaculture in Tam Giang-Cau Hai lagoon depends on the availability of local resources, such as water surface area, land to build ponds, and family laborers. Other inputs such as feed (grass for fish) and breed are also harvested from the lagoon. Besides, most aquacultural households used to be agricultural households (until now many households still maintain other agricultural production activities such as crop cultivation, pig raising or natural catching in the lagoon).

Table 3: Demographics of aquaculture households

Items	Unit	Shrimp HHs	Polyculture HHs	Caged fish HHs	Average
1. Household size	Person	5.70	5.63	5.66	5.66
Male	Person	2.79	2.89	2.84	2.85
Female	Person	2.91	2.76	2.82	2.81
2. Number of family labors	Labor	2.75	2.51	2.60	2.61
3. Aquaculture laborers	Labor	2.01	2.14	2.33	2.06
Male	Labor	1.11	1.16	1.48	1.15
Female	Labor	0.90	0.98	0.86	0.91
4. Long-term hired laborers	Labor	0.01	0.00	0.00	0.01
5. Years of aquacultural experience of household head	Year	9.57	3.20	9.97	8.17
6. Years of schooling of household head	Year	6.91	4.87	3.95	6.26

Source: Household survey 2008

On average, each household has 5.6 people and 2.6 labors, comparable to the situation on rural areas in central region at present. The average age of the household head taking part in aquaculture was 46 year olds. Their years of experience in aquaculture are rather long, 8 years on average. It means that most of them had attached to aquaculture since the start of aquaculture in the lagoon. This could be seen as one of the advantages of aquacultural households. Noticeably, there were differences in years of experience between different raising modes. Limited experiences in polyculture of survey households proves that this raising mode has just been applied recently. Only a few households did raise shrimps together with crabs before. Inter-culture such as shrimp-fish or shrimp-crab-fish raising has expanded rapidly for the last two years.

In terms of scale and professional features in aquaculture, it can be seen that production still bears self-managing nature with small scale dependent on household resource. Only some households who applied semi-intensive aquaculture hired labor for long term. Most family labors engaged in aquaculture production. Therefore, any changes, for instance production scale and production technology of the sector may have great impact on employment and income of aquacultural households.

4.2.3 Production equipment for aquaculture activity of the surveyed households

The main production equipments for aquaculture production of the households include pumping machines, aeration machines, boats and nets. Most households have boats for transportation on the ponds and exploiting fresh feed (grass and mosses) from the lagoon. However, not many households have expensive tools such as aeration machines and pumping machines. The study found that tools are old and damaged but have yet to be repaired, especially air control machines. At present, the biggest fixed asset of the households is their ponds.

Table 4: Production equipment for aquaculture of the surveyed households
(average of one household)

Norms	**Unit**	**Shrimp households**		**Polyculture households**		**Caged fish households**	
		Qty	Value (1000VND)	Qty	Value (1000VND)	Qty	Value (1000VND)
Pumping machines	Machine	0.7	840	0.7	650	0.0	0
Aeration machines	Machine	0.3	390	0.1	110	0.0	0
Pond	Pond	1.3	28,660	1.2	23,946	0.0	0
Fish cage	Cage	0.0	0	0.0	0	1.9	1,905
Boat	boat	0.8	1,560	0.8	1,190	1.1	1,012
Total		-	31,450	-	25,897	-	2,917

Source: Household survey 2008

Value of the tools that serve production is estimated by deducting depreciation value from initial value (when buying) or through market price (namely remaining value of the tools). When considering by household group, total fixed asset value of shrimp household group was the largest (31.4 million VND/household), whereas that of caged fish household group was only about 3 million VND. Thus, caged fish raising activity may be suitable for poor households as it requires less capital.

4.2.4 Water surface use

Aquaculture in Tam Giang-Cau Hai lagoon in general and in Quang Dien district in particular is mainly of family scale. The water surface area used for aquaculture of each household is small, dependent on the availability of family labor and capital of the households. Each shrimp household owns 0.65 ha of water surface area on average, equal to 1.3 ponds. Most of the ponds have soil edges. As for low tide ponds, the edges are built carefully and costly by driving bamboo stakes deep into the ground of about 4m, and the top of 1.5m, then pouring soil, stones in to form pond edges. The construction of ponds affects water flow of the lagoon and, especially in flood season. The average area of each pond is 0.5 ha. The fish cage is only 25m^2 with a height of 1.5m. On average, each household has two cages. The number of cages of each household depends the availability of family labor. In addition, because the main feed source for fish is water-weed/grass exploited from the lagoon, the number of fish cages has to be in accordance with the feed source.

Table 5: Aquaculture area of surveyed households

	Shrimp farming			**Poly-culture**
	Total	**Semi-intensive**	**Improved extensive**	
Area per household (ha)	0.650	0.311	0.339	0.563
Area per pond (ha)	0.501	0.552	0.461	0.481
No. of ponds per household (pond)	1.298	1.308	1.291	1.170

Source: Household survey 2008

4.2.5 Economics of aquaculture

4.2.5.1 Aquaculture costs

Survey results show that there is a considerable difference in terms of cost and structure of cost items between different aquaculture models (Table 6). Semi-intensive shrimp culture has the biggest cash cost, 59.1 million VND/ha. Whereas improved extensive culture required only VND 36.7 million per ha. The reason for the difference is that improved extensive mode has low stock density and lower feed cost, especially industrial feed (that of improved extensive model is VND 10.6 million, while semi-intensive mode is VND 21.6 million). Similarly, breeder cost of semi-intensive model is 36% higher than that of improved extensive mode.

In terms of cost structure, the more intensive the raising model is, the higher the feed cost share is. While the feed cost in semi-intensive mode accounted for 40%, that of polyculture model is only 28% of the total cost. It may be because raising density in polyculture mode is low, thus the feed required is low accordingly. In polyculture, the sub-species made use of natural feed and feed left-over by shrimps. For example when raising shrimps together with dorabs, shrimps usually eat at night whereas the fish eat in the daytime. If farmers feed shrimp at night, the left-over feed of shrimps will be eaten by fish the next morning. This not only helps save cost but also makes the ponds clean. Shrimp polyculture also bears some other costs such as breeder cost and labor cost.

Unlike shrimp raising which required high cost of feed, raising fish in case required low feed cost. It is because raising caged fish mainly made use of available feed in water and water-weed exploited from the lagoon by households themselves. That is why the opportunity cost of family occupied up to 40% of total cost (Table 6).

In terms of environment, the waste and residuals from the use of chemicals and industrial feed aquaculture might have bad impact on lagoon environment. The processed/industrial feed cost of shrimp raising was much higher than that of fish caging. Semi-intensive mode was the most costly. Conversely, the waste from fish caging activity were mainly water-weed (exploited right in the lagoon), easy to decompose and had little impact on the environment.

Table 6: Aquaculture costs of the surveyed households

Unit: 1000VND

	Items	Shrimp raising (for 1ha)			Polyculture (per 1 ha)	Caged fish (per cage)
		Average	Semi-intensive	Improved-extensive		
	Total Cost	**51,572**	**64,269**	**40,308**	**44,056**	**4,800**
I	Cash cost	47,269	59,111	36,761	39,155	2,879
1	Pond improved cost	5,305	5,785	4,885	4,986	468
2	Cleaning cost	4,088	5,147	3,147	3,391	6
3	Breeder	3,082	3,218	2,966	3,567	1,402
4	Disease preventing cost	3,017	3,959	2,180	1,578	4
5	Feed cost	18,786	25,754	12,586	12,577	449
5.1	Fresh feed cost	2,944	4,109	1,908	2,907	317
5.2	Industrial feed cost	15,842	21,645	10,678	9,670	132
6	Hired labor cost	2,428	2,967	1,950	2,014	0
7	Interest cost	4,316	5,589	3,185	5,251	0
8	Depreciation cost	5,198	5,345	5,078	4,979	550
9	Other	1,049	1,348	784	812	0
II	Family labor cost	4,303	5,158	3,547	4,901	1,920

(Source: Surveyed in 2008)

4.2.5.2 Aquacultural yield

Like previous years, aquaculture in the lagoon in 2007 still suffers from a number of problem. Diseases such as white spot disease in sugpo shrimps, lice in caged amurs still occurred. Therefore, aquacultural productivity and yield were low. Details can be seen in Table 7. The productivity of shrimp monoculture model is 45% higher than that of polyculture. It is because in polyculture model stock density is low and the feed used is little. However, according to PRA results, farmers told that within the same raising time, polyculture model brought about larger quantity of big shrimps. This indicate that polyculture creates favorable conditions for shrimps to grow. This is similar to the results of the household survey. The average selling price per kg of shrimp produced by polyculture techniques was 1500 VND higher than that of monoculture. It proves that polyculture environment creates favorable conditions for growth of shrimps.

Apart from shrimps, polyculture model also produced crabs and fish. Crab productivity is not high (only 33kg/ha). At present, crab variety source in the surveyed region is in difficulty because young crabs exploited from the nature have gradually been exhausted, whereas local artificial varieties have yet to be produced. Some households bought crab breed from Nha Trang but the survival rate is very low, under 50%. Local crab breed exploited from the lagoon has much higher survival rate of 80% (PRA results in Quang Dien). According to an aquacultural officer in IMOLA project working in Quang Phuoc, the reason is due to the differences in environmental conditions. Crabs bought from Nha Trang are raised in much higher salinity than Tam Giang lagoon (in Quang Phuoc). So it was difficult for them to adapt to new environment.

In terms of fish species, farmers prefer dorabs because dorab are available (exploited from the lagoon), at a price cheaper than some other fish species. In addition, feed for dorab are water-weed available in the lagoon. Although until now, no studies have been done to evaluate the ability to clean the pond environment of dorabs. According to assessment of raisers, this type of fish helps make ponds cleaner. Mr Tien, vice head of Agricultural Office of Quang Dien district told that there were some evidences supporting that observation. On dry, sunny and windy days, dirty scums were blown into the corner of the pond and dorabs usually gathered to eat those scums. Besides, mud was observed in fish stomach after being killed in the morning (feeding time of fish). Studies should be done on this problem, not only for dorabs but also other kinds of fish in order to provide useful information for administrators and farmers in selecting suitable species to raise.

Table 7: Aquaculture yield

(Unit: kg)

Item	Shrimp (for 1ha)			Polyculture (per 1ha)	Caged fish (per 1 cage)
	Average	Semi-intensive	Improved extensive		
Shrimp	753	915	610	520	0
Crab	-	-	-	33	0
Fish	-	-	-	157	249

Source: Surveyed in 2008

In terms of caging mode, the main species is local black carps. An advantage of raising this species is that its feed is available in the lagoon, including fugitive vegetation and water-plants. In 2006, local people suffered from a loss due to fish lice outbreak. Therefore, the number of fish cages in the whole district of Quang Dien decreased dramatically from 700 cages to 200 cages. The epidemic occurred again in 2007, affecting negatively on productivity of caged fish. However, it is merely a production risk with low probability. Before 2006, this activity brought rather stable income for farmers. Especially this culture is very suitable for the households those have limited capital but more labours. According to the warnings of the Agricultural Office of Quang Dien district, farmers should pause raising shrimps for some time to clean the environment and raise them again afterwards.

4.2.5.3 Results and economic effects of aquaculture

Although having many experiences in aquaculture and being trained technical knowledge, many households still suffered from a loss due to epidemic. This made gross revenue and mixed income of the surveyed groups decrease, even minus. For instance, gross revenue of semi-intensive models is minus over VND 200,000/ha.

Among shrimp raising models, those that had used high input level (high raising cost) brought about low gross income and mixed income. This judgment seems to be unreasonable, but it is the true. According to PRA results conducted in Quang An, Quang Phuoc, Quang Loi and Quang Cong communes, the higher stock density is, the higher danger of loss it caused. Some main reasons accounting for this included lack of control over shrimp variety quality, polluted ponds due to overuse of feed, especially fresh feed, chemicals used to treat ponds and prevent diseases. This was reconfirmed by recurrent regression analysis results of the surveyed data. Specifically, if other variables are kept at sample means, when the stock density increased by 1%, income from shrimp raising decreased by 1.456% and 0.173% for semi-intensive model and improved extensive mode, respectively (Table 8 and Table 9).

Polyculture model is worth noticing. This culture brought about better results compared to other shrimp raising models. Although mixed income of this model was not high (only 12.2 million/ha), it was 2.1 times higher than that of monoculture. Therefore, the number of households participating in polyculture tends to increase rapidly. In 2008 season, in Quang Dien district, there are 367.4 ha of shrimp – crab – dorab polyculture, 15.5 ha of shrimp – fish culture. The area of polyculture accounts for 69.4% of total aquaculture [ii] area of the district.

Box 1. Successful aquacultural experiences of an excellent farmer

It is the case of Mr Ngon in Quang Loi commune. His family has participated in aquaculture for nearly 10 years without a single year being loss. In order to gain success, he put much consideration in selecting breeders and feeding activity. However, this was not the difference between him and other farmers. The keys were that he had large raising area, logical raising procedures and did not raise prawns with too high density. He used a breeder nursery pond and a raising pond, ensuring that small prawns were taken care of carefully in good environment, so when being moved onto the raising pond they were strong and grew up rapidly without diseases. Besides, his family was lucky enough to have ponds in favorable positions for water drain and supply, and rather separate from the water source of other ponds. In addition to prawns, he also raised crabs and fish, which helped keep the environment clean and increase income without increasing cost much, because they mainly made use of left-over feed of prawns and fugitive vegetation in water. In 2005, while many households got loss, he gained an income from aquaculture of 25 million VND. With the same area, he earned 30 million VND in 2007.

Table 8: Gross margin of aquaculture in lagoon

(Unit: 1000đ)

Item	**Shrimp (per 1ha)**			**Polyculture (per 1ha)**	**Cage fish (per 1 cage)**
	Average	**Semi-intensive**	**Improved extensive**		
Total Cost	51,572	64,269	40,308	44,056	4,800
Cash cost	47,269	59,111	36,761	39,155	2,879
Gross output	52,730	64,050	42,700	51,400	5,120
Mixed income	5,461	4,939	5,939	12,245	2,241
Net-income	1,157	-219	2,392	7,344	320

Source: Surveyed in 2008

In terms of lagoon surface resource use, fish caging brought about higher value per area unit. However, due to limitation in production resources, especially labor force, fish households could maintain a limited scale of 50m^2 of cage per household. Whereas, although shrimp raising has high risk of loss, it can bring a great amount of income in a bumper crop. Therefore, studies on transforming production modes towards diversification of raising modes and raising species need to be conducted. It is necessary to reduce aquaculture area to decrease pressure for lagoon environment. This would consequently reduce risks for raising households.

4.2.6 Modeling influential factors on aquaculture

It is worth to identify factors that may have significant influential on the gross margin of aquaculture, as it is useful information for households in controlling over their crop in order to increase the yield and production efficiency. In order to quantify the impacts of input variables on the income gained from shrimp aquaculture, the Cobb-Douglass production function was estimated for each model of shrimp aquaculture (e.g. improved-extensive and semi-intensive model).

Model is written as follow:

(1) $Y=AX_1^{\alpha 1}X_2^{\alpha 2}X_3^{\alpha 3}X_4^{\alpha 4}X_5^{\alpha 5}X_6^{\alpha 6}X_7^{\alpha 7}X_8^{\alpha 8}X_9^{\alpha 9}e^{\beta 1TH+\beta 2QC+\beta 3QL}$

In logarithmic form:

$LnY = LnA + \alpha_1 LnX_1 + \alpha_2 LnX_2 + \alpha_3 LnX_3 + \alpha_4 LnX_4 + \alpha_5 LnX_5 + \alpha_6 LnX_6 + \alpha_7 LnX_7$
$+\alpha_8 LnX_8 + \alpha_9 LnX_9 + {}^{\beta}{}_1 TH + {}^{\beta}{}_2 QC + {}^{\beta}{}_3 QL$

Y: dependent variable – return from aquaculture (1000đ/ha).

X_i are independent variables, including:

X_1 : Volume of industrial/processed feed (Kg/ha)

X_2 : Volume of fresh feed (Kg/ha)

X_3 : Disease prevention cost (1000đ/ha)

X_4 : Pond preparation cost (1000đ/ha)

X_5 : Stocked density (head/m^2)

X_6 : Age of pond (years)

X_7 : Water (times)

X_8 : Years of experience (years)

Dummy variable:

Training course (TH) : TH = 1: Participated in training courses on aquaculture
TH = 0 : Not yet

Region Variables: QC = 1 Quang Cong commune, QC = 0 Other communes
QL = 1 Quang Loi, QL = 0 Other commune

Semi-intensive shrimp model

The result of production model presented in Table 9, indicates that R^2 = 0,658, which means that there is about 65.8% of total output is explained by selected variables in the model.

The result of model reveals positive relation between the income gained semi-intensive shrimp model and independent variables such as disease prevention cost, pond preparation cost, number of experience years and participation in aquacutural technical training courses. There is a considerable difference in income gained from semi-intensive shrimp model between regions; higher income found from surveyed households in Quang Cong in comparison with of households in Quang Phuoc. The study also found that semi-intensive aquaculture in Quang Phuoc brings more income than that of Quang Loi.

In the condition of all other factors are kept constant at the means of sampled households, if households increase 1% of industrial feed in comparison with mean level that will lead to a decrease of 0.538% of total income from semi-intensive shrimp model. This result is understandable as, in reality, there is an increase in the use of industrial components to feed the semi-intensive shrimp crops while the cost of industrial feed is relatively expensive. It also means that the use of such feed will reduce income and efficiency of semi-intensive shrimp model.

Table 9: Results of Production Function for semi-intensive shrimp model

Variables	Coefficients	Standard error
Intercept (constant)	11.749***	3.688
R	0.811	-
R^2	0.658	-
Valid cases (N)	89	
X_1- Volume of industrial feed used (Kg/ha)	-0.538***	0.195
X_2 – Volume of fresh feed used (Kg/ha)	-0.249***	0.077
X_3 – Disease prevention cost (1000đ/ha)	0.314***	0.145
X_4 - Pond preparation cost (1000đ/ha)	0.665***	0.256
X_5 – Density stocked (head/m^2)	-1.456***	0.481
X_6 - Age of pond (Year)	-0.897***	0.419
X_7 : No. of time renewing water (times)	-0.683***	0.214
X_8 : Years of experience (year)	1.050**	0.517
TH - Dummy variable of training courses	0.883***	0.282
QC - Dummy variable of region	1.008***	0.469
QL - Dummy variable of region	-1.254***	0.467

Note: (***), (**) significant at level of 99% and 95%
(Source: Surveyed in 2008)

The findings also indicate that there is a positive relation between the cost of pond preparation and return of this semi-intensive shrimp model. In the condition of all other factor are kept constant at their mean, if households increase 1% of pond preparation cost that will result in an increase of about 0.665% of total return per ha for households involving this aquacultural model. It is worth of noting that pond preparation that is done at the beginning of crop plays an important role in semi-intensive shrimp crop in Tam Giang-Cau Hai lagoon.

Positive relationships were also found between disease prevention cost, years of experience and income generation of semi-intensive shrimp crop. The result of production model reveals that years of experience of households is important factor that has significant contribution to semi-intensive shrimp crops in lagoon. The fact of aquaculture development shows that in recent years, aquacultural households have to deal with many difficulties such as disease epidemic, pollution and changes in weather. Accordingly, knowledge and experience gained from pats aquacultural development has become important factor in aquacultural development in Tam Giang-Cau Hai lagoon. The similar pattern of relation was also found between the variable of technical training course participation and income generation. In other words, the households those participated in technical training courses are able to make more income from semi-intensive shrimp model than of non-participating households.

There is evidence of negative relationship between independent variables of volume of fresh feed used, stock density, age of pond and times of renewing water and return of semi-intensive shrimp model. The density stocked is relative high while there is a lack of supporting infrastructure and environmental pollution, thus a loss is inevitable. Specifically, if households increased 1% of stocked density, they will have to bear a loss of 1.456% of return.

Improved-extensive shrimp model

As shown in Table 10, there is a statistically significant relations between dependent variable and independent variables. R^2 of 0.639 is significant level of 99%. It also means that up to 63.9% of variation in return is explained by independent variables included in the model.

The result of regression indicates that there are statistically significant relationship between return and quantity of industrial feed used, disease prevention cost, pond preparation cost, years of experience and participation in technical training courses. There is considerable difference in return between regions in Tam Giang-Cau Hai lagoon.

Table 10: The result of regression model for improved-extensive shrimp model

Variables	*Coefficients*	*Standard errors*
Intercept (constant)	2.165***	1.557
R	0.799	
R^2	0.639	
Valid case (N)	119	
X_1- volume of industrial feed used (Kg/ha)	0.447***	0.111
X_2 – Volume of fresh feed used (Kg/ha)	-0.136***	0.053
X_3 – Disease prevention cost (1000đ/ha)	0.268***	0.124
X_4 -Pond preparation cost (1000đ/ha)	0.341***	0.121
X_5 – Stocked density (head/m^2)	-0.173***	0.069
X_6 -Age of pond (years)	-1.180***	0.403
X_7 – Renewing water (times)	-0.556***	0.153
X_8 – Years of experience (years)	1.783***	0.375
TH - Dummy of technical training course participation	1.178***	0.224
QC – Dummy of region	0.748**	0.365
QL - Dummy of region	0.712**	0.344

Note: (***), (**) Statistical significant at level of 99% and 95%
(Source: surveyed in 2008)

The findings point out that if other factors are all kept constant at their means, if households increase industrial feed by 1% in comparison with average level, return from improved-extensive shrimp model in lagoon will increase by 0.447%. This result is opposite with semi-intensive shrimp model. This can be explained that high density stocked in semi-intensive shrimp model that forces households use more industrial feeds, thus might lead to pollution of pond water and an increase in disease risk. Meanwhile, with low density stocked, industry feed is used as supplementary feed for improved-extensive shrimp model that brings more efficiency for households.

Similar pattern of positive relation was also found between return and the cost of pond preparation at the beginning of the crop. As shown in Table 10, if 1% increase in pond preparation cost would result in an increase of 0.665% of return.

As shown in Tables 9 and 10, negative relationship was found between volume of fresh feed used, density stocked, age of pond, times of water renewing and total return for both semi-intensive shrimp aquaculture and improved-extensive model. For example, if households increased 1% of fresh feed total income will decrease by 0.136%. There is a negative correlation between age of pond and income return. Sediment accumulation in the pond increase over time thus affecting the growth of shrimp.

4.2.7 Marketing

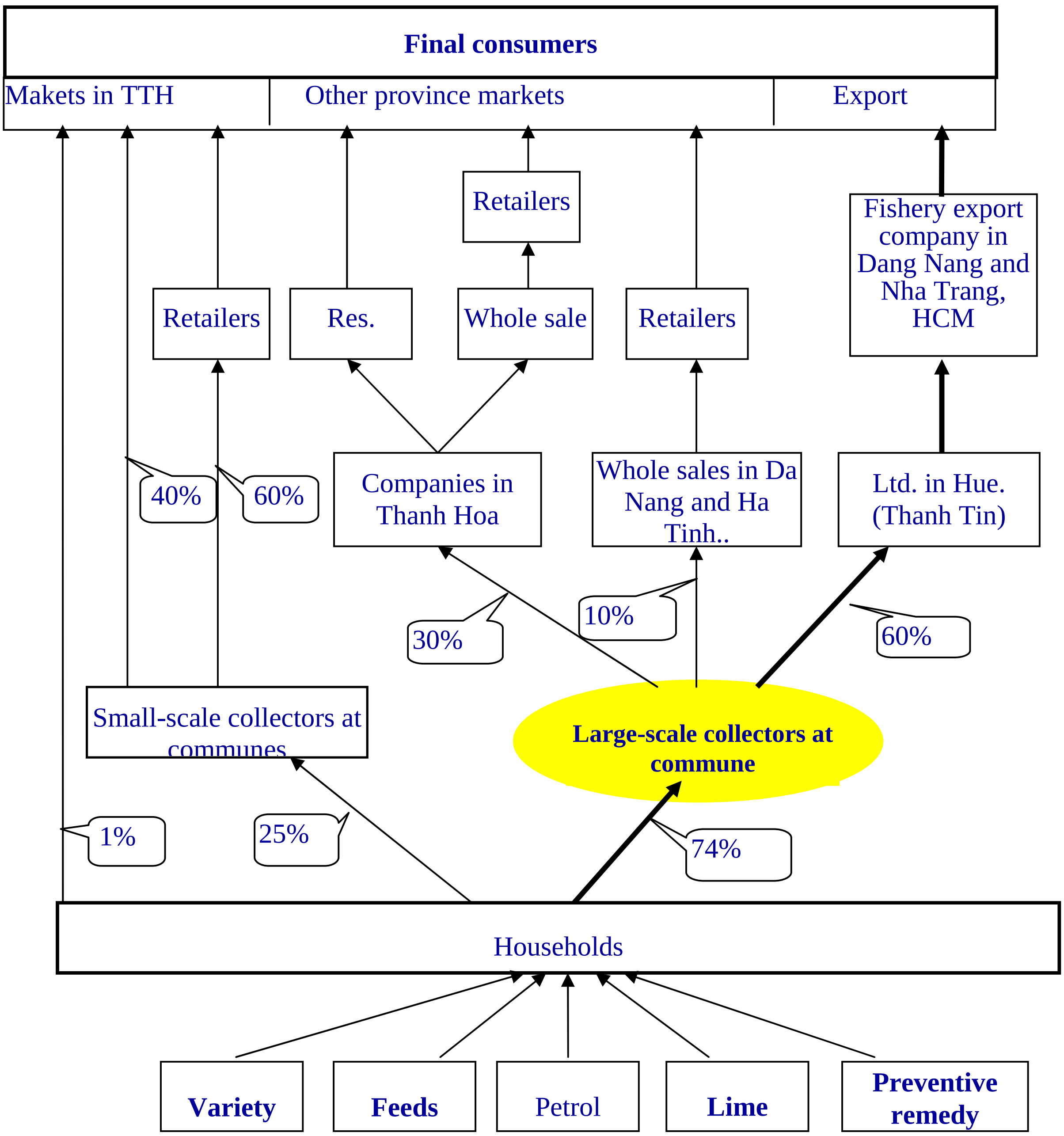
Market plays an important part in socio-economic development. The fact shown that market for aquatic products is characterized according to type of fish products. The scale of market and supply chain are largely dependant on type of fish products. The market for shrimp products is relatively large in scale with many actors involved while fish and crab ones are mainly distributed in domestic markets in Thua Thien-Hue.

Tiger shrimp is mainly consumed in markets outside Thua Thien-Hue province, 44% for export and about of 26% domestically consumed. Ha (2007) stated that 55% of tiger shrimp was export and 20% of yield marketed around local markets in Thua Thien-Hue. Rapid development of tourism industries in the city of Hue as well as development of restaurants and hotels, have resulted in and increase in demand for tiger shrimp products. The supply chain was sketched out in Figure 6.

There are three main channels of distribution of tiger shrimp products in Quang Dien. The first channel: household have direct transaction with final consumers. Only about 1% of total production of tiger shrimp traded via this channel. Second channel: aquacultural households sell the product to small-scale local collectors. Each small-scale collector often buy about 20-40 kg and selling at other local markets such as in An Lo, Dong Ba, An Cuu and Tay Loc. Their customers are both final consumers and retailers. About 25% of total volume of tiger shrimp is distributed to final consumers by this channel. There is no cooperative and supporting relationship between this group of collector and households. This group of collector often collects low quality tiger shrimp (i.e. small size shrimp).

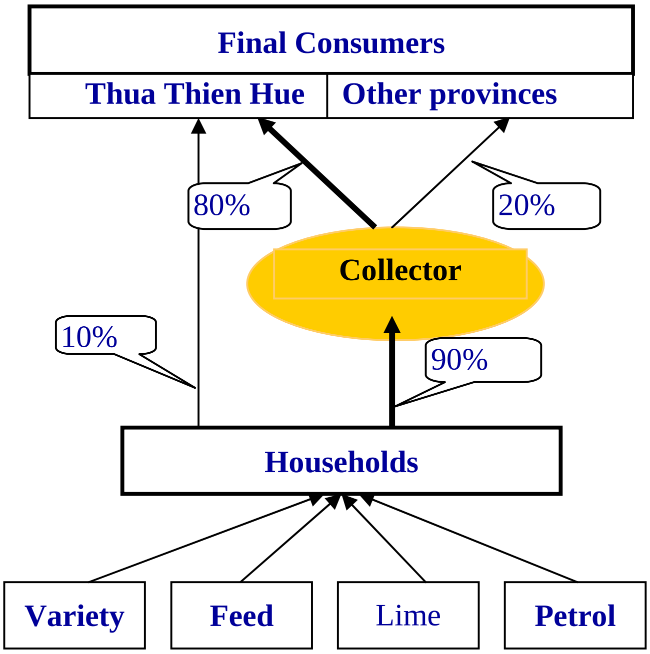
Third channel: households sell their products for large-scale collector at communes. These collectors buy about 74% of total production and transport to large market such as in Hue, Thanh Hoa, Da Nang, Nha Trang, and Ha Tinh. There is also relation between large-scale collectors, private company and processors for export existed in this channel (see Figure 4). Large-scale collectors re-sell right after collection. There are cases the collectors work for commission paid by large companies. It is evidence that there is strong relationship between households and large-scale collectors through credit relation and facility provision for households. The study found that households often sell their products to collector at a price per kg of VND 2000 to 3000 lower than market price, especially in peak season. Some monopoly was observed in aquatic product market in Quang Dien; collectors have hidden agreement to control of aquatic product market. All collectors in certain area work for only one company. Thus, there is control over selling and buying price; households find hard to negotiate the selling price. Additionally, while there is a decline in output price (e.g. shrimp price), the price of inputs such as feed, labor has increased in recent years. This puts shrimp farming at disadvantages, low profitability and higher risk of loss.

Figure 6: Supply Chain of Tiger Shrimp in Quang Dien



Source: Result of PRA in Quang Dien, 2006

Figure 7: Supply chain for caged fish in Quang Dien



Source: Result of PRA in Quang Dien, 2006

Local markets play a crucial role in distribution of crab and fish products. Households often sell their product to small-scale collectors, then these collectors redistribute to local markets or restaurants, hotels. There is stability in price of these products. Price is often decided based on the price in market in the city of Hue. The fact of selling these products, however, shown that a lack of price information is always a difficulty for households in Tam Giang-Cau Hai lagoon. The payment is often made in 2 to 3 days after transaction completed.

Based on the result of interview and PRA conducted in Quang Dien, a supply chain of local carp (caged fish) was sketched out (See Figure 7).The similar supply chains for other aquatic products were also found in Quang Dien. Collectors play an important role in these supply chains, however, multiple options are available for households selling their products. Firstly, households are able to avoid a constraint in selling price as they are actively to decide the time of harvest that normally based on market price. Secondly, there is a high demand for crab products in local market (The price is about VND 110,000 to 120,000 /kg).

4.3 Impacts of Aquaculture on lagoon environment

Environmental impact assessment was done using different methods. Questionnaires were used to understand local people's perception of the impacts of aquaculture development on lagoon environment based on local evaluation (see Table 11). In addition, FGDs on the topics were also held.

As shown in Table 11, there are three main reasons for adverse impacts on lagoon water environment. Majority of respondents (63.2%) reported aquaculture has medium or strong negative impact on water environment in lagoon. About 61.7% of surveyed respondents affirm the impacts of fresh feed used in aquaculture on lagoon environment felt in the same level. A lack of well-designed plan for aquaculture development is also considered as one of main reason for current environment pollution by 61.4% of respondents. Negative relationship between aquaculture development and decline in biodiversity and conflict over access to fishery resources are also mentioned as consequences of rapid aquaculture development.

Table 11: Aquaculture and Impacts on lagoon environment

Unit: % responses

		Not at all	**Little**	**Medium**	**Very**	**Extremly**
1	Using industrial feed and lagoon water pollution	45.3	35.0	10.3	5.1	4.2
2	Using fresh feed and lagoon water pollution	22.0	16.4	9.3	40.7	11.7
3	Waste of aquaculture and environmental issues	17.2	19.5	20.0	28.8	14.4
4	Aquaculture development and decline in biodiversity	29.3	27.0	22.8	14.9	6.0
5	Aquaculture conflicts with fishing activities	33.0	25.1	24.7	14.9	2.3
6	A lack of well-designed plans and environmental issues	17.2	21.4	24.2	34.4	2.8
7	Aquaculture and saline intruded for paddy rice around lagoon	46.5	34.4	15.3	3.7	0.0
8	Aquaculture and prevention of current in lagoon	42.3	29.8	22.3	5.1	0.5
9	Aquaculture and negative impacts on local livelihood	34.9	29.8	22.8	10.2	2.3

(Source: Surveyed in 2008)

The similar results was found by PRAs conducted in 4 communes; nearly 100% of PRA participants assert the negative impacts of aquaculture development on the quality of lagoon water, especially there is about 15% and 30% of participants reported extremely negative environmental impacts and very negative impacts of aquaculture, respectively.

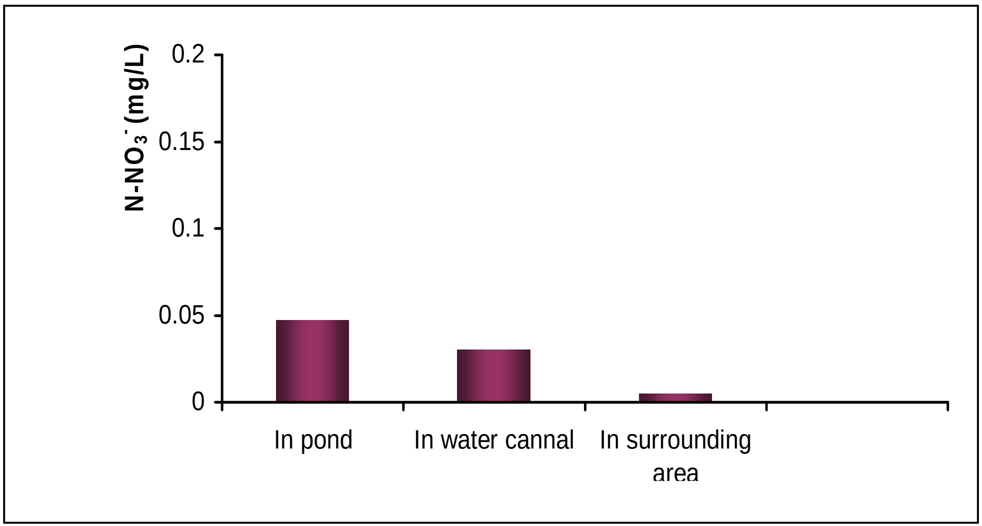
Box 2: "No one dares put their feet down under the water"

Ms. Cuc stated that, in 1995 when I just opened this shop, lagoon water is very clean. At that time, there were many people came and swam in this lagoon, especially on special events such as on 5th May of the Lunar calendar. I provided them with service of life buoy for rent. From 1998, lagoon water has gradually become muddy and then I had to stop life buoy service as there were no more customers. Nowadays, lagoon water is dirty, even "no one dares put their feet down under the water". As you know wastes from aquaculture and from domestic sources around lagoon all run into lagoon. Even in my shop, daily, customers also do the same things for lagoon. I do think that we need dumping ground and regulations on wastes and environment management in the lagoon.

(Ms. Cúc, owner of Minh Cuc shop, located in Con Loc port, Quang Loi commune, interviewed in April 2008).

The findings of ICZM project indicate that shrimp aquaculture eliminated noxious component to lagoon, namely concentration level of $N\text{-}NO_3$ in ponds and intruded into surrounding area (see Figure 8 and 9).

Figure 8: Concentration of $N\text{-}NO_3$ in shrimp ponds, and surrounding areas in Quang An, Quang Dien



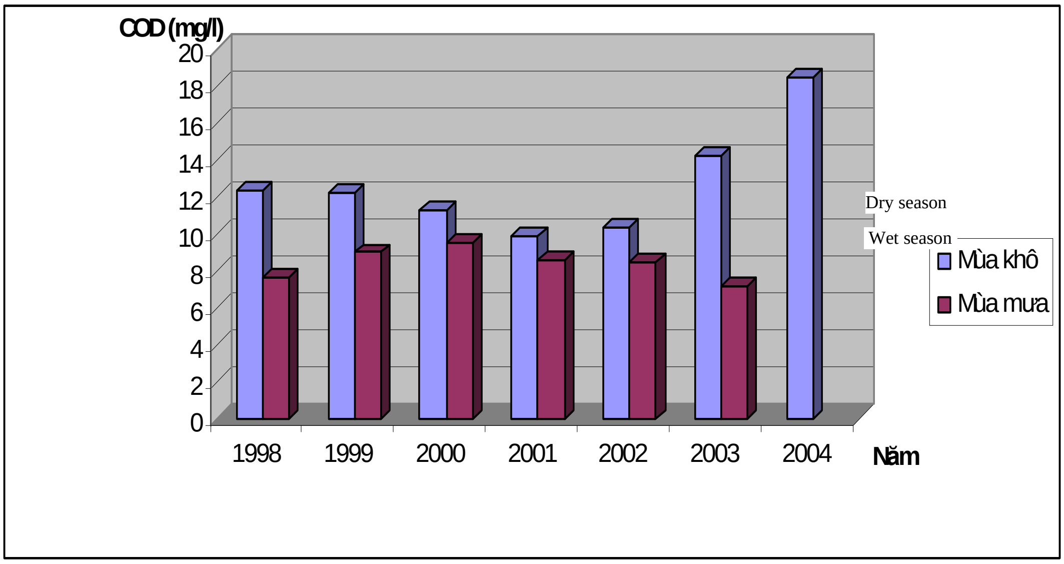
(Source: Hop, N.V., 2005)

Assume that difference in concentration level of $\mathbf{N\text{-}NO_3}$ between ponds and canal is due to shrimp culture. It is estimated that average amount of $\mathbf{N\text{-}NO_3}$ generated per hectare is about 0,21kg/ha. The quantities of $\mathbf{N\text{-}NO_3^-}$ generated annual by shrimp culture in Quang Dien and Tam Giang-Cau Hai lagoon were 127kg and 815kg respectively amount.

The findings of ICZM project also reveals that despite the concentration level of BOD_5 and COD in lagoon water is acceptable for aquaculture (based on TCVN 5943-1995), there is an increase in concentration level from 1998 to 2004. In dry season, concentration level of COD is often higher than the rainy season. Increased in BOD_5 and COD is evidence to affirm that lagoon environment has increasingly been polluted. In other words, organic pollution load is exceeding the assimilative capacity of the lagoon. The concentration level of COD seems to be gone down after the historical flood in 1999, however, rapid development of aquaculture in 2000s, thus leads to a rapid increase in COD concentration level, especially in 2002, in lagoon. This is also the year with extreme drought weather.

The negative correlation between lagoon environment pollution and aquaculture production is found. The result of PRAs conducted in 4 communes in Quang Dien indicates that nearly 90% of PRA participants reported that water pollution is the main reason for the loss of their aquaculture, even many of them (78%) considered it as an extremely negative factor. Hoa (2007) pointed out the significant correlation between level of environmental pollution and probability of bad harvest in Phu Vang and Phu Loc lagoon. In the context of very polluted environment, if level of polluted environment increases 1% that will lead an increase of 0.56% of probability of bad harvest and about 0.24% of probability of bad harvest in the context of polluted environment.

Figure 9: Variation in COD component in Tam Giang Lagoon in dry season and rainy one from 1998 to 2004



Source: Hop, N.V., 200

Box 3: Have to stop finally

In 2000, when prawn culture was a very lucrative activity in lagoon, Ms. Cuc borrowed a loan of VND 60 millions, and withdrew VND 40 million to construct a pond of 0.5 ha. In that year, Ms. Cuc cultured prawn, and gained revenue of about VND 70 millions. This brought her some profit after interest rate payment and depreciation. Unfortunately, Ms. Cuc repeatedly suffered from a loss of prawn culture from the second year. She estimated she lost about VND 10-15 million per year, excluding family labor cost and depreciation cost. Especially in 2003, she lost VND 20 millions. Ms. Cuc has to keep going on with a hope for a good harvest in next crop, so that she could repay loans. Unfortunately, the situation got worse. Finally, she had to stop prawn culture with a loan of VND 100 million.

(Case study: Xuan Tran Thi, Quang An commune, Quang Dien district. Surveyed in 2008)

Aquaculture development has exerted negative impacts on the water quality in Tam Giang-Cau Hai lagoon. This in turn threats and increases risk to the aquaculture sector. Solutions are needed to at the same time restore the environment of the lagoon and to ensure sustainable livelihoods for local people.

4.4 Conclusion and recommendation

4.4.1 Conclusion

Based on results of the analysis above, some conclusions on aquaculture production and its environmental impacts are made as follow:

First, aquaculture area expanded rapidly during the 2000-2004 period and stood steadily at about 4000 ha since 2005. For Quang Dien district, the average area of aquaculture per aquaculture household is about 0.6 ha.

Second, tiger shrimp is main species cultured in lagoon, beside carp, rabbit fish, and crab. Recently, households shifted from mono-shrimp culture to polyculture of shrimp-crab and rabbit fish.

Third, among the culture models, policulture raising shrimp-crab-fish is the most profitable, with an average mixed income of VND 12.2 million per ha. Whereas, that of improved-extensive culture and semi-intensive culture were VND 5.9 million/ha and VND 4.9 million per ha, respectively. The study found that policulture is quite sustainable because low stock density of species, especially of shrimp reduce disease risks. Caged-fish culture seems suitable to the poor in lagoon as it requires less investment capital in comparison with other model. In general, aquaculture currently brings about low return for households because households could not manage disease risks while input prices increase.

Fourth, shrimp products are mainly marketed in other provinces and mainly for export market; the supply chains are long; shrimp farmers lack of bargaining power; and shrimp prices tend to decline. In opposition, crab and fish products are mainly marketed and consumed in Thua Thien-Hue with a stable price.

Fifth, stock density is rather high and overuse of fresh feed creates negative impacts on the lagoon's environment.

Sixth, aquaculture activities caused negative impacts on water environment in the lagoon, conversely the polluted water environment also have adverse impacts on aquaculture.

Seventh, lagoon water get polluted increasingly and there are signs that the scale of aquaculture tends to exceed the carrying capacity of lagoon.

4.4.2 Recommendation and policy implication

(1) Households should diversify cultured species, apply appropriate stock density, and use less fresh feed in order to avoid risks.

(2) It is advisable not to encourage households to further enlarge the area of aquaculture in Tam Giang-Cau Hai lagoon.

(3) Aquacultural households should adopt properly aquacultural techniques and procedure.

(4) It is important to conduct a study on policulture model in order to provide useful information/advice on culture techniques, zoning, economic returns, and marketing options.

(5) It is necessary to re-arrange aquaculture ponds so as that suitable canal systems can be built.

V. FISHING ACTIVITIES

5.1 Overview on fishing activities in Tam Giang-Cau Hai lagoon

5.1.1 Introduction

As presented above, with more than 22 thousand hectares of water surface area, Tam Giang - Cau Hai lagoon is the largest coastal lagoon in South-East Asia. It is endowed with abundant and diversified aquatic resources with many species of high economic value. Livelihoods of over 300,000 inhabitants in 33 communes from 5 districts of Thua Thien Hue province are closely attached to the lagoon.

Being traditional practices, fishing activities are, currently, still the main livelihood of a large number of local inhabitants, especially fishers. Thua Thien Hue statistical data in 2005 indicated that about 4,736 households involving in fishing activities in the whole province. In 2007, the number of households who performed brackish fishing practices in the lagoon was 4,598, accounting for 74% of total households involving in fishery exploitation. There was a decline in the number of households involving in brackish fishing activities in the lagoon as local governments have reinforced management practices on fishing activities, especially rearranging and clearing up fish corrals in some localities.

In the surveyed communes, it was found that natural fishing activities played an important role in daily life of coastal inhabitants. Quang Phuoc commune has 8 villages, in which Phuoc Lap village is conducting natural fishing activities. The total number of households of the commune in 2008 is 150 with 800 mouths, in which 93.33% involve in natural fishing practices, 64% conduct professional fishing practices. Quang Loi commune has 3 villages involving in natural fishing activities and 5 in agricultural production. The total number of households participating in natural fishing practices is 457 (Ha Cong 100, Ngu My Thanh 167, Cu Lac 190), in which 70% of the households live on natural catching by such fishing gears as corrals, nets, nurse-pond, fish traps…

Fishers are classified into two groups: (i) Great enterprise group includes the fishers with regular fixed jobs which require large capital to bid water surface area and buy fishing equipment; (ii) Small enterprise group includes the fishers with minor and flexible jobs, or ‘follow the fish’s tail’ jobs as they are colloquially called, which do not require to bid water surface area... [1]

Historically, lagoon water surface was classified and collected tax according to area and type of fishing gears in the whole lagoon. The villages were allocated the use rights to lagoon resources. Specific regulations on exploitation boundaries were issued and fining measures were made on illegal access to village’s fishing grounds. Such a management mode still proves its effectiveness in lagoon resource management and ensures equality in accessibility to lagoon resource among community members.

Currently, with the settlement policy for fishers, fishers have gradually integrated into the on-land community. However, the majority of fishers still have a strong attachment to fishing activities in the lagoon. Income from fishing activities still plays an important part in the income structure of the fishing households in the lagoon.

At present, fishing activities are involving more and more inhabitants. There has been an increase in number and types of fishing gears. For example, destructive fishing gears tend to be used more widely in the lagoon such as smaller mesh-nets, dragnet, push-net, eel rakes and clam rake. Consequently, the aquatic resource in Tam Giang-Cau Hai lagoon has been declined dramatically.

In response to such situation, the local government has paid much attention to lagoon resource management. Many regulations have been issued such as Decision No. 1577/QĐ-UBND dated on 12/7/1995 on management, protection and development of aquatic resources; Directions No. 36/CT-UBND dated on 04/8/1999 concerning prohibiting destructive fishing gears in lagoon region; General planning on management and exploitation of aquatic resource in Thua Thien-Hue by Department of Fishery; Decision No. 3677/QD-UBND on general planning on management and exploitation of aquatic resource and orientations until 2010. The fact of fishery resource management, however, indicates that there are many challenges facing the management of lagoon resource, especially the difficulties in solving the benefit conflicts between agricultural sector, irrigation, transportation and aquaculture or the internal conflicts of fishery sector.

5.1.2 Fishing gears in the lagoon

Fishing activities have brought the main income source for a large number of coastal inhabitants since many years, especially fishers. Natural fishing activities make use of various types of fishing equipment, including fixed tools and mobile tools. The households can use one or more fishing tools depending on their own conditions and the local natural conditions. According to IMOLA project, there are about 35 types of fishing gears used in lagoon. The results of the PRAs conducted in the surveyed region, however, indicates that about 19 types of fishing gears are still in use. Many other traditional fishing gears are no longer used because of various reasons.

<u>Fixed fishing gears</u>

- Fish corrals

Fish corrals are set up in a fixed fishing ground in the lagoon, which is inherited over generations. In the past, fish corrals were made from natural material such as bamboo and rattan. In the 1990s, local fishers used polyethylene to make fish corrals, marking a new step in increasing the efficiency of households' fishing activities. Nets made of synthetic material quickly replaced traditional ones by local fishers, nets of various mesh sizes were available and construction of motorized boats altered catch sizes of all fisheries. This major event marked the disappearance of bamboo fish corrals in the whole lagoon.

Each fish corral occupies about 2 hectares with around 6 fish traps. There is a considerable difference in the cost spent on fish corral making, depending on water level of where the fish corral was put. It costs about VND 20 million to make a fish corral with 5 fish traps in deep areas of lagoon while the same fish corral costs about VND 12 million in shallow areas. Average annual maintenance cost for a corral is up to 30% of total initial cost, even more in the years with heavy floods and storms.

Fish corral is used to capture aquatic species in all year round. Peak season lasts from March to September (lunar calendar). Each fish corral generates from VND 20,000 to 40,000 per day (about 4.2 to 8.4 million per peak season) dependent on its location. Fish corral is able to capture various species such as shrimp, fish, and crab.

The result of the interviews indicates that fish corral brought the most stable source of income for owners in comparison with other types of fishing gears in the lagoon. However, it is important to rearrange fish corral in order to avoid adverse impacts on the lagoon, as many fish corrals are put in the currents of lagoon, preventing its flows and so on.

Fish aggregating device

According to local fishers, this is a tradition fishing gear in the lagoon. Its number, however, has reduced considerably in recent years. The average size of each set is about 12m x 12m. Branches are dipped in certain area as nursing area for fish to live in. The lagoon areas with 1.5 to 1.7m depth are favorable for this device. Fish aggregating device is made by bamboo, only usable within one year, and costs about VND 2.5 million each.

Households often harvest 2 to 3 times a year with an average cost of VND 500,000 to 700,000 per time, mainly for hiring labor. Turnover gained each time ranges from VND 1 to 2 million. Products harvested mainly are species of high economic value in Tam Giang lagoon like rabbit fish, wrasse, scat, etc.

Lift net

There are two types of *lift net*. This fishing gear is often used to capture big fish (over 0.5 kg). It is still available in the lagoon. The result of PRA indicates that if management practice is properly implemented, this fishing activity will develop strongly and significantly contribute to biodiversity protection of the lagoon.

Bottom net

This is a traditional fishing gear, however only few local people involve in this activity. It is often set up at the bottom of the lagoon to capture aquatic species such as shrimp, fish, crab, in which shrimp is the main species.

<u>Mobile fishing gears</u>

Mobile fishing gears are widely used to exploit aquatic resources in the lagoon. As mentioned previously, there are various types of mobile fishing gears, most of which are traditional ones (e.g. net, long net, hook and line) and new gears (fishing trap, electric tapping, eel rake, clam collection).

Fish nets

Fish nets are traditional fishing gears used to capture fish in the lagoon. Currently, there are about 10% of fishing households using various types of fish nets in the lagoon. Given fast development of aquaculture and that the types of fishing gears are increasing in the lagoon, the number of fish nets used has gone down rapidly.

A long fish-net is about 20m long and 1.5 to 1.7m high. Each fisher owns 10 sets of long fish nets (200m long) with total value of VND 2.5 million.

Gill-net

Gill fish net is a traditional fishing gear that is no longer in use in Tam Giang-Cau Hai lagoon. Each set is about 40m long with mesh dimension of 12-15mm. In peak season, each set is able to capture about 1.5 kg of shrimp and 0.5 kg of other species (about VND 50,000 per day). The result of PRA reveals that there is a dramatic depletion in catching yield. Before 1990s, fishers could capture over 2kg of shrimp and 1kg of big fish/set/night.

Trammel net

This is a three layer-fish net with 12-15mm mesh, often used to capture fish and shrimp. Fishers often use 4 sets with total length of 200 meters. Each set costs about VND 100,000 with usable time of two months. In peak season, each household can earn about VND 60,000 per night and about VND 10,000/night in off-season.

Mullet net

This fishing gear is often used to capture mullets in March and April. Mullet-net is about 200m long, 40cm high with mesh dimension of 7mm. Mullet-net has usable time of 2 years, which is much longer than other types of fish nets. Using mullet-nets, each fisher is able to capture about 3kg of mullets per night (about VND 60,000) in peak season. According to local fishers, this yield is only one half as many as that before 1990, which was 5-6kg of fish/night.

Nurse-pond

Nurse-ponding, which is considered to be environmentally friendly, no longer exists in the lagoon. Development of aquaculture and other fishing gears have narrowed fishing ground for this practice. Involvement in this fishing activity requires more capital and labour than other fishing activities. Each nurse-pond occupies about 10 ha of fishing ground. Fishers often use large mesh-nets to capture big fish in their nurse-ponds.

Fish trap

Fish trap (i.e. Chinese fish trap) is originated from China and has appeared in Thua Thien Hue lagoon since 2006. In 2007, local fishers themselves made fish traps of smaller mesh size (5-6mm). The result of PRA shows that Chinese fish trap is the most destructive fishing gear that is likely to threaten the aquatic resource and biodiversity in the lagoon as it is used widely and able to capture all types of species in Tam Giang-Cau Hai lagoon.

This fish trap may be used for fishing within 11 months. Each household often owns 50 to 60 fish traps, especially some of them have 100 to 150 fish traps. The price of each fish trap is VND 150,000 – 200,000 with usable time of 1 year. According to local fishers, when using fish trap, their fishing activity is more profitable than any other fishing gears.

Clam collection and eel rake

Clam collection and eel rake have recently appeared and are considered as high destructive fishing gears in Thua Thien Hue lagoon. Fishers use motorized boats and metal hooks to rake clam and eel in the areas of over 1.5m depth. This fishing activity captures not only eel, clam but also other aquatic species and disorders the bed of the lagoon.

Flashing

Flashing has recently appeared in the lagoon. Each flashing set, including a boat, batteries and lamp, costs about VND 3000,000. Flashing season operates at night time (about 10 nights per month) from February to September annually. The result of PRAs conducted in Quang Dien indicates that fishers earn about VND 60,000 per night. It is also revealed that income gained from flashing is about 60% lower than that before 1990s.

'Vít báy'

This requires about VND 10,000,000 within usable time of 10 years. Season for this only lasts 2 months per year with average income per day of VND 50,000.

Electric tapping

Using electric tapping to capture fish is the most destructive gear that has been banned in Tam Giang-Cau Hai lagoon. The fact of fishing activities in lagoon, however, shows that there are about 10% of fishing households illegally using this fishing gear. Historically, electric tapping was used to capture fish in paddy field or rivers in 1990s. It was, then, used to capture aquatic species in the lagoon.

Number of fishing gears and captured fish yield in the lagoon

Provincial statistical data since 1975 until now indicates that captured fish yield reaches about 2000-3000 tonnes per year. The data also indicates that the highest yield of captured fish in the lagoon reached 4,517 tonnes in 1973 and 4,042 tonnes in 1966. The variations in fishing gears and captured fish yield are presented in Figure 10. Despite many changes in fishing gears, captured fish yield in the lagoon is quite stable. As shown in Figure 10, there is a rapid increase in the number of fishing gears and households involving in fishing activities in Tam Giang-Cau Hai lagoon, thus leading to a decline in fishing productivity. The year of 1997 could be considered as high time for fishing activities when captured fish yield and fishing gears reached highest figures. From 1997 to 2005, captured fish yield and the number of fishing gears both went down as the result of local government's great effort to manage fishing activities in the lagoon.

Figure 10: General panorama of fishing gears and captured fish yield in the lagoon from 1984 to 2005

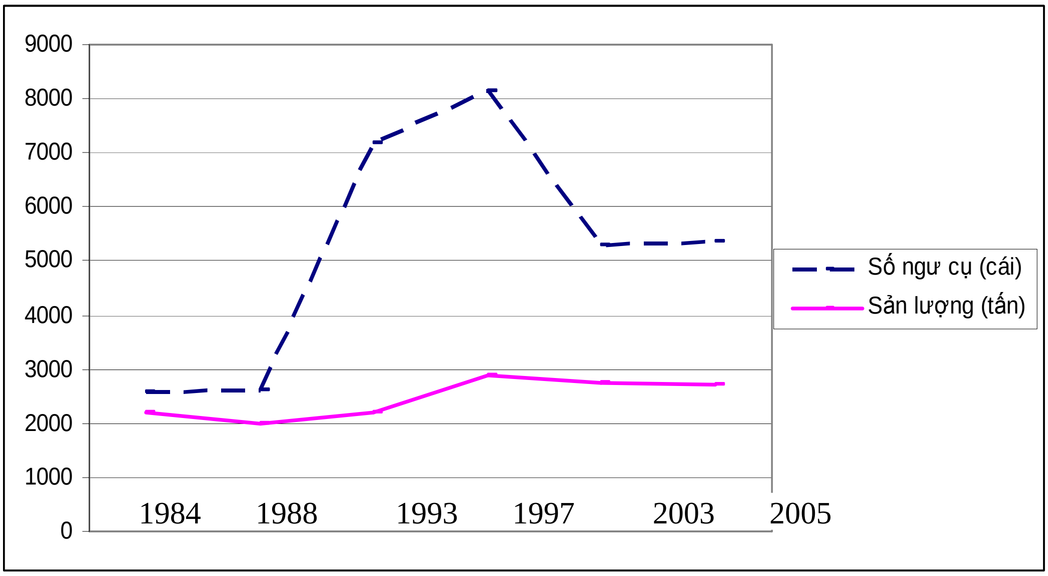


Table 12: Number of fishing gears used in Tam Giang-Cau Hai lagoon

	Fishing gear	Unit	Quantity
Fixed fishing gears	Fish corral	set	1,263
	Bottom net	set	982
	Branches dipped in water	set	17
	Trapping basket	set	24
Mobile fishing gears	Trammel net	set	1,486
	Eel rake	set	8
	Dragnet	set	87
	Pushed net	set	20
	Electric tapping	set	192
	Shrimp gill-net	set	374
	Crab net	set	642

(Source: Department of Fishery, 2005).

It can be stated that the above figures are not the final ones as there are still many fishing gears being used in Tam Giang-Cau Hai lagoon such as clam collection, fish trap, etc., operating mainly in the lagoon area near O Lau estuary to the north of the lagoon.

Fishing gears are available everywhere in Tam Giang – Cau Hai lagoon. However, the density of fishing gears varies in different areas and is so dense in some. Therefore, the natural aquatic resource in the lagoon is decreasing due to overexploitation. The lagoon is facing with severe pressure of over exploitation, even exceeding the reproductive capacity of the lagoon.

Fishing gears in the surveyed communes

The result of PRAs conducted in Quang Cong, Quang Loi, Quang Phuoc and Quang An communes indicates diversity and variations in fishing gears used for fishing activities in the lagoon.

Table 13: Main fishing gears used for fishing activities in surveyed communes

	Fishing gears	Fixed	Mobile	Traditi-onal	New	Year of appearance	Trend and current situation
1	Fishing corral	x		x		Long time ago	Main fishing gears despite a decline in number
2	Nurse-ponding		x	x		Long time ago	No longer in use
3	Fish aggregating device	x		x		Long time ago	Only a few left
4	Dragnet		x	x		Long time ago	No longer in use
5	Gill-Net		x	x		Long time ago	Only a few left

6	Long fish-net		x	x		1980	Only a few left
7	Restrain-net		x	x		Long time ago	Only a few left
8	Lift net	x		x		Long time ago	Only a few left and unstable
9	Electric tapping		x		x	1992	Banned, but some fishers still use it as hidden practices
10	Flashing (lighting to look for fish)		x		x	1997	Still operating in lagoon, however less income earned
11	Clam and eel rake		x		x	1999	Still operating widely in lagoon, considered as the most destructive gears
12	Chinese fish trap		x		x	2006	Recently appeared in 2006, increased in number, considered as one of the most destructive gears
13	Fishing-basket		x	x		Long time ago	Rapid declined in number
14	Fishing trap		x	x		Long time ago	No longer in use
15	‘*Vít báy*’		x	x		Long time ago	Only a few left
16	Line and hook		x	x		Long time ago	Decreased in number
17	Gill-net		x	x		1960	No longer in use
18	Mullet net		x	x		1960	Rapid increased in number with smaller mesh
19	Trammel net		x	x		1990	Rapid increased in number
20	Bottom net	x		x		Long time ago	Fast declined in number, only a few left

(Source: PRA in Quang Dien).

According to PRA participants, the recently appeared fishing gears are more destructive than traditional ones as they are able to capture almost all aquatic species, especially some also cause damages to the bed of the lagoon. Many traditional fishing gears are no longer in use or only a few left in the lagoon such as branch dipped under water, nurse-ponding, dragnet, etc. It is understandable given the context of rapid depletion in fishery resource and aquaculture development. Also, modern fishing gears help fishers catch more fish than traditional ones though they are more environmentally friendly.

Box 4: Fish aggregating device

"Fish aggregating device is an efficient fishing gear, easy to perform and environmentally friendly, however it is difficult to protect, so many households had to abandon it.

Interviewee: Dung Dang Ngoc, Quang Loi commune

5.2 Fishing season and fishing gears of the surveyed households

5.2.1. Fishing season and operation

The study found that there are two fishing seasons in Quang Dien: peak season from March to August and off-season from September to February the next year. However, various types of fishing gears and activities have different fishing seasons. Specific fishing seasons for different fishing gears are presented in Appendix 7.

It is hard to have a clear classification of households into different fishing groups as fishing households often involve in various fishing activities in all year round. However, there is a difference in time and labour spent on fishing activities between peak season and off-season. For instance, the number of person-days/month/household spent in peak season is 74.9 in comparison with 31.8 in off-season. Average person-day spent on fishing activities for the whole year is 640.3.

Table 14: Calendar and fishing time

	Items	Main season (from March to August)	Off-season (from September to February the next year)	Whole year
1	Number of fishing days-fisher/month/household	74.9	31.8	53.4
2	Total fishing days-fisher/household	449.4	190.9	640.3

(Source: Survey in 2008)

The survey result shows that the households make use of various fishing gears, including traditional and new ones in both fixed catching and mobile catching practices.

Among fixed fishing gears, fish corrals are widely used in the lagoon: over 60% of the surveyed households own fish corrals. Fish corrals are able to capture various aquatic species such as tiger shrimp, banana shrimp, sleeper, mullet, etc. As mentioned previously, fish corrals generate a stable source of income in comparison with other fishing activities.

Fish traps are new fishing gears imported from China, which are widely used to capture fish in the lagoon. The survey result indicates that most fishing households use fish traps for fishing activities in the lagoon. As shown in Table 15, each fishing household has an average of 42 fish traps. A rapid increase in the number of fish traps has led to a rapid depletion in, and challenges to management of, fishery resource in the lagoon. PRA participants all claimed that it is necessary to restrict and ban the use of fish traps in near future.

Table 15: Means and fishing gears available in lagoon

(Average of one household)

TT	Items	Unit	%	#	Aquatic species captured
1	Fixed fishing years				
1.1	Fish corral	set	63	0.8	Tiger shrimp, Banana shrimp, mullet, Rock cod, Slender spine, etc…
1.2	Bottom net	set	28	0.6	Banana shrimp, Greasy-back shrimp, mullet, sleeper, crab, etc…
2	Mobile fishing gears				
2.1	Fish-nets	set	91	17.0	Rabbit fish, sleeper, mullet, shrimps, etc…
2.2	Gillnet	set	20	4.1	Shrimp, fish and crab…
2.3	Bamboo boats	boat	42	0.4	
2.4	Motorized boats	Boat	70	0.7	
2.5	Fishing trap	set	100	42.0	Shrimp, fish and crab…

(Source: Surveyed in 2008)

Fish-nets are traditional fishing gears of the households in Quang Dien district in particular and in Tam Giang-Cau Hai lagoon in general. The data in Table 15 shows that the average number of fish-nets of each household is 17 sets, and that of gill-nets is 4.1. Rabbit fish, mullet, sleeper, and shrimp are main captured species of this fishing gear. Fish-nets generate an important source of income for fishing households. It is, however, evident that fishers tend to use smaller mesh fish net for fishing activities in the lagoon, which causes a threat to protection of fishery resource in the lagoon.

Boats (e.g. bamboo boats and motorized boats) are traditional means which play a very important role in fishing activities. The survey result reveals that most respondents own boats, and the majority of them (70%) have motorized boats.

The study also found that some destructive fishing gears (clam and eel rake, dragnet, electric tapping) still appear in Quang Dien lagoon. It is, however, important to keep in mind that most of them are fishers from other districts such as in Dien Hoa, Dien Hai and Hai Duong.

5.2.2 Demographics of the surveyed households

The demography and labour of the surveyed households are presented in Table 16. Among the respondents, the average age is 46.2. The age of those involving in the survey shows slight difference between communes.

Regarding educational level of respondents, it is worth noticing that the number of schooling years is relatively low (about 4.5 years). The reason is that most fishing households used to be sampan people (people living on boats). There is significant difference in educational level between the communes, especially Quang Cong, Quang Loi, and Quang Phuoc. As shown in Table 16, respondents from Quang Cong have better educational level than those from other surveyed communes.

The survey result also indicates that family labour plays an important role in organizing and operating fishing activities. As shown in Table 16, the average number of mouths and laborer in a family is relatively high (about 5.7 persons and 3.1 laborers per household). It is considered as the most important resource for fishing households in the lagoon.

Table 16: Common characteristics of the surveyed fishing households

Items	Unit	Quang Cong	Quang Loi	Quang Phuoc	Average
1. Age of household owners	year	45.1	48.7	44.7	46.2
2. Years of schooling	year	6.2	3.6	3.8	4.5
3. Number of mouths/household	person	5.5	5.2	6.4	5.7
4. Number of laborers/household	laborer	2.6	3.5	3.3	3.1
5. Years of experience	year	26.0	25.9	23.4	25.1

(Source: Surveyed in 2008)

5.3 Economic analysis of fishing activities in the lagoon

5.3.1 Costs of fishing activity

Fishing households have to spend money buying and repairing fishing gears and paying fee, depreciation, loan interests...

Table 17 indicates cost items spent on fishing activities in Tam Giang-Cau Hai lagoon. Generally, one fishing household spent about VND 6.1 million per year, in which over three quarters was spent in main fishing season and a quarter in off-fishing season. There was a difference in fishing cost between communes with Quang Cong having the largest expenditure (VND 7,682 thousand/household/year), next were Quang Loi and Quang Phuoc (see details in Appendix).

It is also revealed that the cost for buying and repairing fishing gears occupied the largest rate (40%), next were depreciation and material costs. Exploitation fee and labor cost occupied low rate in total cost. It is important to keep in mind that the usable time of fishing gears is relatively short and environmentally affected (e.g. fish corral, fish-nets). Thus, the costs for buying, repairing and depreciation of fishing gears are very high.

Table 17: Fishing cost *(average/household)*

(Unit: VND 1000)

	Cost items	Main season	Off-season	Whole year
1	Petrol	1,033	343	1,377
2	Maintenance, repairing and buying fishing gears	1,572	638	2,211
3	Hired labour	158	50	209
4	Fee	5	2	7
5	Loan interest	398	199	597
6	Depreciation	1,340	408	1,748
	Total cost	4,507	1,641	6,148

(Source: Surveyed in 2008)

5.3.2 Captured fish yield and income

Table 18 illustrates the diversity of aquatic species captured by fishing activities in the lagoon, including fish, shrimp, crab, etc., in which shrimp and fish are main products. Generally, peak fishing season brings households three quarters of total family income while the rest is generated from off-fishing season.

Table 18: Yield and value of captured fish in the lagoon *(average/household)*

	Species	Main season		Off-season		Whole year	
		Yield (Kg)	Value (VND 1000)	Yield (Kg)	Value (VND 1000)	Yield (Kg)	Value (VND 1000)
1	Shrimp	343	13,697	114	4,077	457	17,774
2	Big fish	27	976	6	172	34	1,148
3	Small fish	257	4,916	92	2,088	349	7,004
4	Crab	60	1,511	16	460	76	1971
	Total	688	21,100	225	6,796	915	27,896

(Source: Surveyed in 2008)

The survey result also reflects the proportion of income generated according to aquatic species captured, in which over 64% of family income was revenue of shrimp captured. It is understandable as the yield of shrimp captured and its price were much higher than those of fish and crab. The survey reveals that the yield of fish and crab captured was relatively low, especially many species were of low economic value. There was slight difference in the yield of fish captured between communes in Quang Dien, in which fishers from Quang Loi earned the highest income (see Appendix 9).

Further analysis of income of fishing households conducted indicates that the average mixed income reached VND 34,000/person/day. It is worth noticing that there was considerable difference between main fishing season and off-season in terms of mixed income gained. As shown in Table 19, the average mixed income gained from fishing activities of a household per year was about VND 21.7 million, in which VND 16.5 million was from main fishing season. The most successful fishers were those from Quang Loi with up to VND 30.1 million/household/year, whereas the least successful ones were fishers from Quang Phuoc with VND 11.8 million/household/year.

Table 19: Income generated from fishing activities *(average/household)*

(Unit: VND 1000)

	Main fishing season		**Off- fishing season**		**Whole year**	
	Average of person-day	Whole season	Average of person-day	Whole season	Average of person-day	Whole season
Total fishing value	47	21,100	36	6,796	44	27,896
Total cost	10	4,507	9	1,641	10	6,148
Mixed income	37	16,593	27	5,155	34	21,748
Net-income	7	3,112	-3	-573	4	2,539

(Source: Surveyed in 2008)

The average net income (after deducting family labor cost) of a surveyed household was VND 2.529 million, in which net income from main season was VND 3.112 million and that from off-season was minus. It was because the yield gained from off-season was low while the number of person-day participating in exploitation was much lower than main season. Specifically, net income of Quang Loi was highest (VND 6.990 million/household/year), the lowest was of Quang Phuoc (-VND 5,353/household/year).

5.3.3 Modeling influential factors on output of fishing activities

Income from fishing activities of fishing households were affected by various internal attributions and external attributions. The formers included the features of the households, while the latters were the features of external environment like aquatic reserves, climate conditions, and lagoon management policies. Analysis of affective external factors is necessary, but it requires panel dataset. Thus, only analysis of endogenous factors was performed in this study. In doing so, regression model was used to analyze these influential factors.

$$Y = F(X_i)$$

In which:

Y: dependent variable - income generated from fishing activities (VND 1000/household/year).

X_i are independent variable, including:

X_1: Total person-days spent on fish capture (person-day)

X_2: Number of fish corrals (set)

X_3: Number of fish nets (set)

X_4: Number of bottom nets (set)

X_5: Number of fish traps (set)

X_6: Years of experience (year)

Dummy variable by region :

QP (QP =1: Quang Phuoc commune, QP = 0: Other communes)

QL (QL = 1: Quang Loi communes, QL = 0: Other communes)

Correlation regression model is written as:

$$\text{(a)} \quad Y = AX_1^{\alpha 1}X_2^{\alpha 2}X_3^{\alpha 3}X_4^{\alpha 4}X_5^{\alpha 5}\, X_6^{\alpha 6}e^{\beta 1QL+\beta 2QP}$$

(a) is written in logarithmic function as:

$$LnY = LnA + \alpha_1 LnX_1 + \alpha_2 LnX_2 + \alpha_3 LnX_3 + \alpha_4 LnX_4 + \alpha_5 LnX_5 + \alpha_6 LnX_6 + {}^{\beta}{}_1 QL + {}^{\beta}{}_2 QP$$

The result of regression model is presented in Table 20 below.

Table 20: Analysis result of income affective factors from fishing activities

Variable	Coefficient	Standard error
1. Intercept (constant)	6.245***	0.423
2. X_1- Total person-days captured fish of household	0.363***	0.127
3. X_2 – Number of fish corrals	0.267***	0.079
4. X_3 – Number of nets	0.239***	0.043
5. X_4 -Number of bottom nets	0.199***	0.066
6. X_5 – Number of fish traps	0.171***	0.046
7. X_6 -Years of experience in fishing activity	0.178***	0.056
8. QP – Dummy by region	-0.111**	0.055
9. QL – Dummy by region	0.083**	0.054
R^2	0.76	
Valid case	120	

Note (***), (**) have statistical significance at levels of 99% and 95%, respectively
(Source: Surveyed in 2008)

The analysis result of the regression model confirms that 76% of fluctuations in fishing households' income was regulated by independent variables selected in this model ($R^2 = 0.76$).

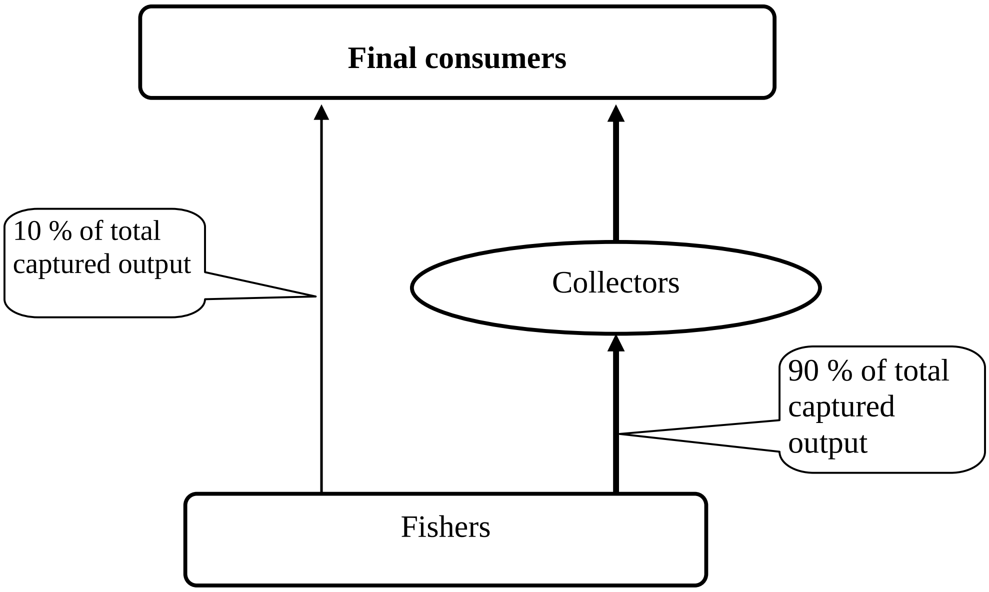
Positive associations were found between income generated from fishing activities and independent variables such as the number of fishing gears, years of experiences, and the number of person-days. In other words, fishing households may gain more income if there is an increase in the number of fishing gears and the number of person-days spent on fishing activities. For instance, in conditions that other factors were all constants, when the number of person-days participating in catching increased by 1%, the income gained increased by 0.363% of their total income. Accordingly, it is important to note that if fishing household aims to increase their income, they should spend more number of person-days rather than increase the number of fishing gears.

As a matter of fact, the number of fishing gears in the lagoon is redundant, thus it is necessary to consider it carefully, otherwise conflicts may occur. In addition, β_i coefficient of Dummy variable: QP had negative value and QL had positive value with statistical significance, which proves that there was a difference in terms of income among Quang Phuoc, Quang Loi and Quang Cong commune.

5.3.4 Distribution of captured fish

Captured aquatic products are distributed to final consumers in simple supply chains. Local markets at communes play a crucial role in consuming captured fish. The survey result indicates that about 10% of total captured volume was used for family demand, the rest (90%) was sold to local and external collectors, who then sold them at the markets in other regions. The selling price was often bargained based on that of the previous day and the yield of fish captured. Due to high demand on natural aquatic products, it was not hard for fishing households to sell their products. It is necessary to note that there is hardly any support or collaboration between fishing households and collectors. The fact, however, shows that variations in price, and low volume of captured fish, are main difficulties for fishing households in selling their products.

Figure 11: Distribution channel of captured fish



5.4 Fishing activities and adverse impacts on lagoon environment

The result of PRAs proves that fishing activities have caused adverse detriments to lagoon environment and resources. For instance, electric tapping and Chinese fish traps have affected negatively on reproductive capacity of the aquatic species in the lagoon. Meanwhile, such gears as dragnet, push-net, eel rake and clam rake have caused damage to the bed of the lagoon. Additionally, a rapid increase in the number of fish corral prevented the flow currents of the lagoon.

Table 21: Fishing activities and impacts on lagoon environment

(Unit: % of total ideas)

Causes	Extreme impact	Medium impact	Little impact
1. Destructive fishing gears (electric tapping...) and new fishing gears (fish trap, small mesh net...) reduce reproductive capacity of aquatic resources	90.7	7.3	2.0
2. Large number of fishing gears, especially fish corrals, constrain lagoon currents and cause water pollution	19.3	75.5	5.2
3. Such gears as dragnet, push net or eel rake disorder the bed of the lagoon	10.5	45.9	43.6
4. Wastes from fishing activities (e.g. petrol) pollute lagoon water	5.2	20.4	74.4
5. Remains of aquatic species due to destructive fishing activities	2.8	21.3	75.9

(Source: PRA conducted in Quang Dien in 2008)

As shown in Table 21, the majority of responses (over 90%) stated that the use of destructive fishing gears caused extremely negative impacts on lagoon environment. Despite great effort made to restrict the use of destructive fishing gears in the lagoon, a part of local fishers still operated them to capture fish. It is evident that the government can achieve strong effectiveness in management of lagoon resources and fishing gears by a combination between government management instruments and measures to involve people in lagoon resource management.

Table 22: Local opinions about variation of fishery resources in the lagoon

(*Unit: %*)

Items	*Reduce*	*Remain constant*	*Increase*
Captured fish yield	86.7	10.8	2.5
Number of species	85.8	14.2	0
Size of fish captured	75.8	24.2	0

(Source: Surveyed in 2008)

Regarding aquatic resources in the lagoon, it was found that there was a dramatic depletion in aquatic reserves, captured fish yield and the size of fish captured, in comparison with 1990. As shown in Table 22, over 86% of respondents affirmed the depletion in captured fish yield. Only 2.5 % of respondents admitted an increase in fish yield captured from the lagoon and about 10% of participants felt in constant level group. About three quarters of respondents evaluated that the size of fish captured from the lagoon was smaller than before.

The study also found that there was strong variations in aquatic species in Tam Giang-Cau Hai lagoon. The result of PRAs are presented in Table 23.

Table 23: Variations in aquatic species in the lagoon

	Aquatic species	*Current situation*	*Before 1990*
Big fish	- Spotted herring	No more	Rather large quantity available
	- Grunt fish	No more	Large quantity available
	- Natal stumpnose	A few available	Very large quantity available (able to catch 3-4 kg/night/household)
	- Rabbit fish	A few available	Large quantity available (able to catch 2-3 kg/night/household)
	- Scat	A few available	Rather large quantity available
Small fish	- Grassfish	Normal	Large quantity available
	- Bartailed flathead	Reduced a little	Rather large quantity available
	- Dusky Sleeper	Reduced about 20%	Very large quantity available
	- Wrasse	No more	Very large quantity available (able to catch 3-4 kg/night/household)
	- Mullet	Reduced about 70%	Very large quantity available (able to catch 5kg/night/household)
Shrimp	- Banana shrimp	No more	Very large quantity available (able to catch 3-5 kg/night/household)
	- Green tiger shrimp	No more	Very large quantity available (able to catch 3-4 kg/night/household)
	-Tiger shrimp	No more	Rather large quantity available
	-Greasyback shrimp	Reduced about 70%	Rather large quantity available (able to catch 3-4 kg/night/household)
Crab	- Mud crab	A few available	Rather large quantity available

(Source: PRAs conducted in Quang Dien, 2008)

As shown in Table 23, the depletion in aquatic reserves has happened since 1990. It was found that some species of high economic value such as grunt fish, wrasse and some special shrimp species have been felt in extinction. The result of PRAs also reveals that environmental pollution, narrow nurse-bed in the lagoon are main reasons for rapid depletion in aquatic reserves. Currently, reproductive capacity of aquatic species is at alert level due to failure in planning nurse-beds and threats from fishing activities and aquaculture development in the lagoon. Although some destructive fishing gears like electric tapping have been banned, some fishers are still using them illegally, thus affecting negatively on bio-ecology of the lagoon. In addition, development of coastal aquaculture has not only narrowed catching water surface area and constrained lagoon flows but also lost breeding area of aquatic species. This is a big issue that should be solved immediately in order to properly plan aquaculture and fishing activities in the lagoon in the time to come.

5.5 Conflicts in management and access to lagoon resources

Conflicts over access to lagoon resources, including internal conflicts within fishing activities and those between different production activities that involve in use of lagoon water source, have emerged. Aquaculture development has narrowed fishing ground of fishers and also caused environmental pollution, thus resulting in adverse detriments to fishing activities and agricultural production surrounding the lagoon. The use of pesticides and fertilizers for agricultural production also caused negative impacts on aquaculture and fishing activities when water in paddy fields with chemical components drained into the lagoon.

Conflicts have also emerged among local fishers. For instance, some fishers used electric tapping gears to capture fish in the fish corrals of other fishers. The conflicts over access to fishing ground among local fishers and fishers from neighbor communities also exist. It is stated that up to 30-40% of aquatic reserves in Quang Dien lagoon has been captured by the fishers from Phu Vang, Phong Dien, Huong Tra, etc. Most of these fishers used destructive fishing gears like dragnet, electric-tapping and eel rake.

Most of PRA participants confirmed a lack of clear definition of fishing ground boundary between communities because local fishers themselves asserted that fishing ground is common property: *private land, common water surface*. Therefore, it is urgent to plan production activities and allocate water surface use right for inhabitants in order to ensure sustainable use of Tam Giang - Cau Hai lagoon.

Managing fishing activities is a pressing need of local government on the way towards sustainable development of Tam Giang-Cau Hai lagoon. Although local government has made much effort, many difficulties are still challenging this practice. One of the most difficult issues is overlapping access to fishing ground among various economic activities such as agricultural production, fishing activities, aquaculture and transportation. In recent years, various solutions have been performed at different levels such as integrated management, co-management and community-based resource management.

Prior to 1975, Tam Giang lagoon was considered, for management purposes, as an asset of the government but was managed by agricultural villages. Those villages then allocated rights over fishery resources by auctions held annually for members of fisherman's association. When fixed fishing gear was developed, individual fishers who won bids had the rights to exploit the area themselves, to hire others to exploit it, or to rent it out for a fee. In doing so, lagoon resource was managed and exploited effectively.

After 1975, management of fishery resources in the lagoon was taken over by the government. According to the Regulations on Protection of Aquatic Resources issued by the Socialist Republic of Vietnam on April 25, 1989, the national government is the highest management body that administers the protection and development of aquatic resources through a system of policies. Thus, fishery resources in Tam Giang lagoon were managed by a system of administrative and functional bodies, with key roles played by Provincial People's Committee, District People's Committees, Commune People's Committee. A closer look at the management of fishery resources lagoon reveals that since 1990, local government has issued permissions for access to certain fishing ground. In other words, most of the fishing areas have been privatized mostly through bidding competition. The common fishery resources, thus, have shrunk down rapidly. This management mode lasted for a couple of years before rapid development of aquaculture, which made it no longer effective.

Fees and taxes were also applied to manage lagoon aquatic resources in some communes in the lagoon. After 1995, this management practice was no longer implemented as most fishing households were poor. Local government collected tax only from fixed fishing households while it was impossible to collect tax from mobile fishing households.

Recently, Thua Thien Hue province has issued many policies on lagoon resource management such as Resolution No. 11 concerning socio-economic development for lagoon and coastal regions; Planning for development of aquaculture in the lagoon until 2010; Planning for management and exploitation of aquatic resources in the lagoon until 2010, etc. Generally, these regulations have had positive impacts on rearrangement and reorganization of aquaculture and exploitation areas in the lagoon. The fact of implementation, however, indicates a lack of proper coordination of these initiatives, resulting in inconsiderable effectiveness in terms of lagoon management.

Toward sustainable management and exploitation of lagoon resources, it is important to enhance the participation of local communities in management practices. Fishing ground allocation and issue of permissions to access fishing ground should be decentralized to communities and fish unions, then communities and unions will allocate permission and fishing ground to the households in communities. Local government at different levels should encourage the establishment of unions in order to create opportunities for the members to involve in lagoon management practices. Working together in unions, the members will be able to find win-win solutions to exploit and manage lagoon resources effectively. Operation of unions should be under the control of local governments and functional departments. Up-to-date, 14 unions of fishers have been established in 14 communes surrounding the lagoon. The first union of fishers is the one established in Quang Thai commune of Quang Dien district with initial 108 members. In terms of management, the unions of fishers manage the lagoon rather effectively, thus this model should be developed in other communes surrounding the lagoon.

In addition, many international organizations have also supported local governments and inhabitants in managing the activities conducted in the lagoon. A number of projects have been implemented in the lagoon such as IMOLA project funded by Italian government, project on integrated management of Huong river basin funded by IUCN, ICZM project funded by SIDA and IDRC, etc., thus making significant contribution to lagoon resource management.

It can be said that lagoon management in general and fishing activities management in particular has been paid much attention to by the government at different levels and inhabitants. In addition, the support of international organizations through various projects has contributed considerably in management of the activities conducted in the lagoon.

5.6 Conclusions and recommendations

5.6.1 Conclusions

Through surveys on fishing activities of fishing households, together with PRAs in the surveyed area and interviews with experts, the following conclusions have been drawn:

- Fishing activities are traditional practices and the main source of income of a large number of households living around the lagoon in Quang Dien. The average mixed income of each household was VND 21.748 million/year. This amount varied between communes.

- Fishing activities mainly make use of family labor. The average number of person-day spent on fishing activities was about 640.3 days-person/household/year. Regression analysis also reveals that the number of day-person participating in fishing activities was the factor having the largest impact on income of fishing households.

- Various types of fishing gears were used to capture aquatic species, which can be classified into two groups: fixed fishing gears and mobile fishing gears. Fishing households tend to use fewer traditional fishing gears, while modern fishing gears were used widely in the lagoon such as fish traps, mullet traps, etc. Some destructive fishing gears such as electric tapping have been banned; however, some fishers still used them to capture fish as hidden practices in the lagoon.

- Captured fish products were mainly distributed in simple supply chains: from fishers to local market, or from fishers to collectors and then to market. Low yield of fish captured, variations in selling price were main difficulties for local fishers in selling their products.

- Lagoon environment has been polluted and aquatic resources have tended to reduce in terms of stock, species and the size of captured species. A lack of proper management as well as clear definition of fishing ground boundary are challenging local government in sustainable management of lagoon resources.

5.6.2 Recommendations

In order to manage and exploit lagoon resources more effectively and sustainably, the follows should be considered:

- Local government should allocate the use right of fishing ground to fishers and fishing communities. Community-based resource management models should be piloted.

- It is necessary to reinforce management of economic activities in the lagoon as well as restrict and ban destructive fishing activities. Additionally, it is important to rearrange the system of nets, especially fish corrals in the lagoon.

- It is important to support local inhabitants to diversify their livelihoods, especially fishing households by involving them in practices with less dependence on lagoon resources.

VI. PADDY PRODUCTION

6.1 Overview of Paddy Production in Lagoon areas

6.1.1 Total Area, Productivity and Yield

With about 14,000 ha of paddy field in which 7500 ha of Spring rice and 6500 ha of Autumn crop, rice production play an important role in local livelihood and economic structure of 33 communes in Tam Giang- Cau Hai lagoon. A lack of irrigation system a large area of paddy fields was used to grow other crops or left unused in autumn crop. Table 23 presents data on area, yield, and productivity of rice production in the lagoon area.

As shown in Table 23, the paddy productivity is relatively low, about 4.35 ton/ha in comparison with average productivity of about 5.03 ton/ha of whole province. Poor and sandy soil is considered as the main reason for low paddy yields in the lagoon area. Additionally, saline-intrusion phenomenon from lagoon and aquaculture ponds also affects paddy productivity in this region. In 2006, total production reached about 67,481 ton, accounted for about 26.71% of total paddy production in Thua Thien-Hue (252,604 ton)[2]. The result of paddy production in lagoon illustrated the important role of agricultural production surrounding lagoon for local livelihood but also significant contribution to food security for the whole province.

Table 23: Area, productivity, and yield of paddy production in TG-CH lagoon in 2006

	Unit	Spring crop	Autumn crop	Whole year
Area	Ha	7,543	6,278	13,821
Productivity	Ton/ha	47.3	34.6	43.5
Yield	Ton	39,708	27,773	67,481

(source: Statistical yearbook of 5 districts belongs to lagoon regions)

6.1.2. Paddy cropping calendar and production techniques

Figure 8 indicates the cropping calendar of paddy production surrounding Tam Giang-Cau Hai lagoon. Spring crop often cultivates in the mid of December and harvest in May of next year. Meanwhile, autumn crop is often prepared after the completion of spring crop. Due to extreme weather condition in Thua Thien-Hue (e.g. storm, flood), farmers often cultivate autumn crop earlier than other regions so that the crop can be harvested before rainy season. The fact of paddy production in lagoon, however, shows that extreme weather condition, specially flood and storm is one of main reason of bad harvest.

Figure 8 also indicates the time of pests appearance in paddy field is normally from stage of panicle initiation, flowering to full maturity (from March to late of April for spring crop and late of July to late of August for autumn crops). In order to avoid negative affect of pests, farmers often spay pesticide in this stage.

[2] Statistical Yearbook of Thua Thien-Hue in 2006

Figure 12: Crop calendar of paddy production in surrounding lagoon

Month	1	2	3	4	5	6	7	8	9	10	11	12
1. Spring crop	→	→	→	→								→
2. Autumn crop					→	→	→	→				
3. Relevant factors												
3.1. Pest appearance			**	***			**	***				*
3.2. Spaying pesticide and herbicides			**	***	*		**	***				
3.3. Drought					……	……	……					
3.4. Floods									…	……	……	

(Source: PRA conducted in 2008

***Note**: *: Medium level; **: High level; ***: Very high level*

Wet-paddy cultivating techniques are relatively traditional and tend to be self-subsistence. As mentioned above, poor soil, saline-intrusion and extreme weather condition, are main causes of low paddy yield though farmers applied intensive cultivating model for paddy production. The study found that local governments have made much effort to encourage farmers to apply advanced techniques in the hope of reducing adverse impacts on lagoon environment such as integrated pest management (IPM), fish-paddy model. The result of PRAs shows that IMP method is applied in more than 35% of total paddy area while the application of fish-paddy model is still very limited. The fact, however, highlights that farmers are cutting down the use of chemicals in paddy production such as pesticide, herbicide, using anti-pest variety, and observation of growing stages of paddy.

The significant difference was found between farmers who applied IPM method in paddy production and farmers those who did not apply. For example, farmers often spay herbicide for paddy field about 3 times/crop (e.g. 1-3 days after sowing; tillering stage and panicle initiation). Conversely, for farmers those who applied IPM method for paddy production, they just sprayed herbicide 1-2 times/crop, mainly in sowing stage. This group of farmers often changes the level of water in their field, pruning off paddy and weeding by manual.

The local knowledge and experiences in paddy production often allows farmers actively control pests, as they know pests' life circle, the time of their appearance in paddy. Thus, farmers often actively apply local knowledge and experience in controlling pests rather using pesticide. This group of farmers only spays pesticide in flowering stage in order to minimize the risk of pests. In this sense, non IMP farmers often abuse pesticide for all stage paddy growth.

Similar findings were also found in the use of fertilizers between farmers who applied IMP method and who did not. The result of study indicates that farmers without involvement in IPM methods often use chemical fertilizers separately based on real observation of paddy growth. For example, farmers often use phosphate and nitrogenous fertilizers in order to increase fertility of cultivated land while potassium fertilizer is supposed to stimulate the resistance and strengths for paddy. This group of farmers often add more fertilizers in the stages of tillering, panicle initiation in order to stimulate the growth of paddy. The result of PRAs shows that farmers who applied IPM method often use NPK fertilizer for their crop. Farmers often cut paddy leaves in order to avoid pestilent related to paddy leaf. There is considerable difference in paddy production of farmers who applied IMP method and farmers did not applied.

6.1.3 Irrigation System

It is obvious that irrigation system is important factor affecting the success of agricultural production in general and paddy production in particular. If paddy field is supported with good irrigation system, it is advantage for farmers to apply advanced techniques for paddy production. The result of PRAs indicates that source of water for paddy fields are largely dependent on its location. The study found that Quang Loi is one of lagoon communes dealing with difficulty in source of water for paddy production. Paddy fields are mainly irrigated by rainwater, reservoirs and underground water from dunes. There are 6 reservoirs in Quang Loi, including:

(1) Dong Giang reservoir: with a distance of 10 meters far from paddy fields with water reserves of 10,000m^3.

(2) Vung Phuong reservoir: with a distance of 50 meters far from paddy fields and water reserves of 500m^3.

(3) Thuy Co reservoir: With distance of only 10 meter far from paddy fields and water reserves of 500m^3.

(4) Mieu Ba reservoir: with distance of 630 meters far from paddy fields, and reserves of 5000m^3.

(5) Tram Nay reservoir: with a distance of 300 meters far from paddy field and reserve of 1000m^3.

(6) Dong Bao reservoir: with distance of 630 meter far from paddy field and reserve of 50.000m^3.

According to participants in PRAs, these reservoirs just supply enough water for spring crop. Quang Loi farmers have to sign contract with water pumping station in Sia town (about 3.5 km far from Quang Loi) in order to supply water for autumn crop. Due to a lack of water, only one third of total paddy area is probably prepared for autumn crop (about 110 ha). A large area of paddy fields was left as fallow and growing other food crops in autumn.

Located near Bo river, farmers in Quang Phuoc and Quang An access easily to water resource for both spring crop and autumn one. Most of canal systems were concreted that created convenience in supply and drain water for paddy fields in these communes.

In sum, irrigation system for paddy production is relatively in good condition. Supplying water for autumn crop is still obvious issue for some communes in Tam Giang-Cau Hai lagoon; paddy production is stilly dependent on rainfall. Thus, it is important to improve of irrigation systems for paddy production in these communes.

6.2 Demograpic characteristics of surveyed households

6.2.1. Manpower of surveyed households

Understanding the characteristics of the respondents is helpful when exploring the association between farmers' responses to paddy production and environmental issues. In this study, the survey of household involved in agricultural activities was conducted in Quang Dien. There were 150 valid responses to the survey. As shown in Table 24, average age of respondents is relatively high (48.1 year olds). It means that respondents are supposed to have good experience in agricultural production and particular of paddy production. The study found that on average each household has about 4 laborer. It is worth noting that 90% of family labours involved in agricultural production. This is important resources for paddy production; however, seasonal unemployment is obvious issue in Quang Dien.

Table 24: Demographic characteristics of surveyed households

	Unit	**#**
1. Total household surveyed	Household	150
2. Age of householder	Year old	48.1
3. Year of school of household head	Year	6.4
4. Number of person per household	Person	5.5
5. Number of laborer per household	Laborer	3.9
6. Number of laborer involved in agriculture/household	Laborer	3.5

(Source: Surveyed in 2008)

As the most common issue, educational qualification of respondents is relatively low; the common qualification is primary school, years of school are 6.4 years. This highlights a challenge to applying advanced technology in paddy production. The fact of paddy production, however, shows that farmers are dependent on their local knowledge, experiences and supporting services of extension staff as well.

62.2 Land used pattern and production means

The result of survey reveals that an area of 4,164 m^2 is average area of household surveyed in Quang Dien in which over 70% of total area is arable area, and the rest are residential land, garden, and fishing ground. There are few of farmers involved in aquaculture. Local governments carried out policy on rearrangement and exchange of paddy fields between farmers, thus each household owns about 2.8 pieces. It is convenient for farmers in application of mechanization and intensive cultivation.

Table 25: Land used pattern of surveyed household (average of household)

	Unit	**Area**
1. Total area	m^2	4164.8
- Arable land	m^2	2947.9
- Others	m^2	1216.9
2. Number of plots	plot	2.8

Source: Surveyed in 2008

The result of study found that farmers own low valuable production means such as hoe, shovel, and rickshaw while some own tractor, harvester and land preparing machine. The result of PRA indicates that local farmers often employ services of land preparation, harvest and transportation.

6.3 Gross margin analysis of paddy production

6.3.1. Cost

The result of survey reveals significant difference in cash costs spent on paddy production between IPM farmers and non-IPM farmers. As shown in Table 26, the cash cost spent on paddy field without IPM is higher than of paddy fields with IPM. For example, farmers sow more variety of 4.1 kg/ha in spring crop without IPM application and 3.5 kg/ha in autumn crop. It is understandable as farmers applied IPM in their paddy field they might avoid a loss of variety because of pests. The result of PRAs also illustrates that some of farmers who did not apply IPM often worry about low rate of sprout of variety, thus they often use more variety than farmers who applied IMP in their paddy field. The significant difference in the use of fertilizers between IPM farmer and non-IPM farmers. As shown in Table 26, farmers often use NPK fertilizers for their paddy field with IMP application. There is also slightly difference in using NPK fertilizer between spring crop (440 kg/ha) and autumn one (480 kg/ha). For paddy fields without IPM application, households often use Potassium, phosphate and nitrogenous fertilizers separately. In spring crop, this group of farmers tend to use less fertilizers (N = 280 kg/ha; P = 170 kg/ha and K=100 kg/ha) than of autumn crop (N=300 kg/ha; P = 180 kg/ha and K = 120 kg/ha). The significant difference in the use of fertilizers between two crops is explained by the decrease in soil fertility after spring crop.

Table 26: Costs of paddy production (average of one hectare)

	Cost items	Unit	Spring crop			Autumn crop		
			IPM (1)	Non-IPM (2)	Difference (1)-(2)	Field with IPM (3)	Field without IPM (4)	Difference (3)-(4)
I	**Variety**							
	- quanity used	Kg	140.1	144.2	-4.1	136.8	140.3	-3.5
	- Cost	VND 1000	700.5	721.0	-20.5	684.0	701.5	-17.5
II	**Fertilizer**							
2.1	**Nitrogenous**							
	- quantity used	Kg	30.0	260	-230.0	40.0	300.0	-260.0
	- Cost	VND 1000	180.0	1560.0	-1380.0	240.0	1800.0	-1560.0
2.2	**Phosphate**							
	- Volume used	Kg	0	170.0	-170.0	0	180.0	-180.0
	- Cost	VND 1000	0	374	-374.0	0	396	-396.0
2.3	**Potassium**							
	- quantity used	Kg	0	100.0	-100.0	20.0	120.0	-100.0

	- Cost	VND 1000	0	500.0	-500.0	100.0	600.0	-500.0
2.4	**NPK fertilizer**							
	- quanity use	Kg	440.0	40.0	400.0	480.0	40.0	440.0
	- Costs	VND 1000	2860.0	260.0	2600.0	3120.0	260.0	2860.0
III								
3.1	**Herbicide**	VND 1000	187.6	220.0	-32.4	190.0	260.0	-70.0
3.2	**Pesticide**	"	300.0	640.0	-340.0	300.0	660.0	-360.0
IV	**Hired labour cost**	"	960	880	80.0	760	720	40.0
V	**Land preparation cost**	"	780	720	60.0	750	720	30.0
VI	**Irrigated cost**	"	480	480	0.0	540	540	0.0
VII	**Others**	"	600	588	12.0	540	534	6.0
	Total	VND 1000	**7048.1**	**6943.0**	**105.1**	**7224.0**	**7191.5**	**32.5**

(source: Surveyed in 2008)

Table 26 presents significant difference in the use of pesticides between paddy field with IPM application and without IPM application. The result demonstrates that applying IPM method in paddy production will help farmer saving the cost. For instance, if farmer applied IPM in paddy field, amount of VND 32,400/ha in spring crop and VND 70,000/ha in autumn crop saved from spending on herbicides. In reality, herbicide is often sprayed in the sowing stage of paddy field with IMP application while in paddy field without IPM application; farmers often spay herbicides according to different stages of paddy growth.

Regarding the use of pesticides, it is worth noting that application of IPM in paddy field made significant contribution in cost saving for farmers. The result of survey reveals that amount pesticide costs saved in spring crop and autumn crop due to IPM application are VND 340,000 and VND 360,000 are respectively. IPM farmers tend to use less pesticide, especially in panicle initiation stage. .

In sum, it is important to conclude that there is difference in cash cost in rice production between IPM and non-IPM. The details of cash costs in paddy production are presented in Table 27.

Table 27 highlights that average cash cost in paddy field with IPM (VND 7136/ha/crop) are slightly higher than that of paddy fields without IPM (VND 7067/ha/crop). Over 41% of total cash cost in IPM paddy production is for NPK fertilizer while a proportion of 23.8% of total cost non-IPM rice production is for nitrogenous fertilizer.

Table 27: Cash costs in cash in paddy production
(average of ha/crop)

	Cost item	Field with IPM application		Field without IPM application	
		(VND 1000)	(%)	(VND 1000)	(%)
1	Variety	692.3	9.7	711.3	10.1
2	Nitrogenous Fertilizer	210	2.9	1,680.0	23.8
3	Phosphate	0	0.0	385.0	5.4
4	Potassium	50.0	0.7	550.0	7.8
5	NPK fertilizer	2,990.0	41.9	260.0	3.7
6	Herbicide	188.8	2.6	240.0	3.4
7	Pesticides	300.0	4.2	650.0	9.2
8	Hired labour	860.0	12.1	800.0	11.3
9	Land preparation cost	765.0	10.7	720.0	10.2
10	Irrigation cost	510.0	7.1	510.0	7.2
11	Other costs	570.0	8.0	561.0	7.9
	Total	**7,136.1**	**100.0**	**7,067.3**	**100.0**

(Source: Surveyed in 2008)

6.3.2 Output and efficiency of paddy production

The findings of this study reveal that output and efficiency of paddy production are largely dependent on cultivating model and costs spent (see Table 28).

Table 28: Efficiency of paddy production (per ha)

	Unit	Spring crop			Autumn crop		
		With IPM (1)	Without IPM (2)	difference (1)-(2)	With IPM (3)	Without IPM (4)	Difference (3)-(4)
Productivity	Ton/ha	5.02	4.74	0.28	4.32	4.07	0.25
Gross Output	VND 1000	13,554	12.798	756.00	11,664	10,987	676.8
Costs in cash	"	7,048.1	6943.0	105.10	7224.0	7191.5	32.5
Family labour	"	5,476	4,960	266.00	4000	3440	560
Mixed income	"	6,505.9	5,855.0	650.90	4440.0	3.795.7	644.3
Net-income	"	1,029.9	895.0	134.90	440.0	355.7	84.3

(Source: surveyed in 2008)

The result of survey illustrates considerable difference in paddy yield between production technologies, IPM and non-IPM. As shown in Table 28, the average productivity of rice production with IPM is higher than that rice with IMP (0.28 ton/ha in spring crop and 0.25 ton/ha in autumn crop). Similar results also found when comparison of mixed income (MI) of paddy fields with IPM application and those without IPM. A close look at paddy production surrounding lagoon shows that spring paddy is the main crop in which farmers probably use high-yielding variety while local varieties are favor in autumn crop.

The result also points to the fact that IPM application often requires more labour as farmers have to spend more time on their field in order to take care of paddy and observe changes during paddy growth stages. The significant difference in labour cost between spring crop and autumn crop is also observed (see Table 28)

It is clear evidence that paddy fields with IPM application generated more net-income (about VND 1.03 million/ha) than that of field without IMP application (about VND 0.895 million/ha) in spring crop. Similar result is also found in autumn crop, however, it is much lower in comparison with spring crop (see Table 28). The result of PRA points to the fact that there are many adverse impacts such as extreme weather, lack of water on paddy production in autumn crop. Unfortunately, paddy production is important for farmers living around lagoon. Viable alternative options (other crops) are constrained by natural condition, and a lack of resources and market opportunity.

Total area of paddy cultivated area of 33 lagoon communes calculated is 13,821 ha (7,543 ha of spring crop and 6,278 ha of autumn crop). The information about percentage of paddy area with IPM application has not fully recorded yet. Accordingly, in order to estimate gross output of paddy production, the assumption is that paddy-cultivated area with IPM application accounts for 50% of total paddy-cultivated area of 33 communes belongs 5 districts in Tam Giang-Cau Hai lagoon.

Table 29: Estimated economic value of paddy production in TG-CH lagoon

Index	**Unit**	**Spring crop**			**Autumn crop**		
		with IPM	Without IPM	Difference	With IPM	Without IPM	Difference
		1	2	(1)-(2)	3	4	(3)-(4)
Yield	Ton	18,933	17,877	1,056	13,560	12,776	785
Gross Output	VND mil	51,119.0	48,267.8	2,851.3	36,613.3	34,494.5	2,118.8
Cash Costs	“	26,582.0	26,185.6	396.4	22,676.1	22,574.1	102.1
Labour cost	“	20,652.8	18,706.7	1,946.1	12,556.0	10,798.2	1,757.8
Mixed income	“	24,537.1	22,082.2	2,454.9	13,937.2	11,920.4	2,016.8
Net-income	“	3,884.3	3,375.5	508.8	1,381.2	1,122.2	258.9

Source: calculated based of statistical yearbook and surveyed in 2008

Case-study: Rice-fish model

Householder: Khai Hoang

Address: Group 2 - Thuy Lap hamlet- Quang Loi commune, Quang Dien.

In spring crop 2007, Mr. Khai used a paddy field of 2,500 m^2 for pilot project of fish-paddy production. In order to carry out this model, he selected a field located near to a irrigation system. He also strengthens the edge of field (carried out after autumn crop harvest). He digs a deeper area of 500 m2 surrounding the field for fish, however fish is also able move around the field if water covered the whole field.

In spring crop, when cultivation completed, he stocks and feeds young fish (late of December). Main species stocked are many African carp, local carp and mud carp.

The result of case study reveals that the costs spending on pesticides and fertilizers in this model are much lower than of paddy monoculture. Mr. Khai put down about 200 kg of N-fertilizer/ha, 120 kg P/ha and 100 kg –K/ha, especially he did not have to spray herbicide. It is understandable as water also covers paddy field, rather than fish will be poison if he spray herbicide. It is worth to note that total cost spending on this fish-paddy model is much lower than of spending in paddy monoculture fields (see Table 26). He saved over 60 kg of N-fertilizer/ha, 50 kg of P-fertilizer/ha and amounts of VND 220,000/ha and VND 180,000/ha saved from herbicide and pesticide respectively.

The study assumes that if there were about 20% of total paddy-cultivated area applied fish-paddy model (about 1,509 ha), total cost savings reached are 90,540 kg of N-fertilizer and 75,450 kg of potassium.

Net-income of fish-paddy model is estimated at VND 1,177,000/ha. It is higher than that of paddy-monoculture crop, even of paddy with IPM application. This model should be developed widely in paddy fields surrounding lagoon as it would make a significant contribution to income improvement and environmental protection by reducing a big volume of pesticides and fertilizers in rice production

Estimated economic value of rice-fish model		
	Index	**Costs (VND ,000)**
1	**Costs in cash**	
1.1	**Cost of fish feeding**	
	- Variety	6,768
	- Feed	2,700
	- Depreciation	420
	- Hired labour	4,400
	- Other costs	3,256
1.2	**Cost of paddy production**	
	- Variety	700
	- Nitrogenous fertilizer	1,040
	- Phosphate	360
	- Potassium	460
	- NPK	0
	- Herbicide	0
	- Pesticide	260
	- Land prepared cost	900
	- Hired labour	450
	- Irrigation cost	300
	- Other costs	489

6.3.3 Modeling influential factors on paddy productivity

Cobb-Douglass production function was used to analyze influential factors on paddy productivity. The model was written as follow:

(a) $Y=AX_1^{\alpha 1}X_2^{\alpha 2}X_3^{\alpha 3}X_4^{\alpha 4}X_5\ X_6^{\alpha 6}X_7^{\alpha 7}X_8^{\alpha 8}e^{\beta 1DQC+\beta 2DQP+\beta 3DIPM+\ \beta 4DTL\ +\ \beta 5DHD}$

(a) can be re-written in logarithmic function as:

$LnY = LnA + \alpha_1 LnX_1 + \alpha_2 LnX_2 + \alpha_3 LnX_3 + \alpha_4 LnX_4 + \alpha_5 LnX_5 + \alpha_6 LnX_6 + \alpha_7 LnX_7 + \alpha_8 LnX_8 + \alpha_9 LnX_9 + {}^{\beta}{}_1 D_{QC} + {}^{\beta}{}_2 D_{QP} + {}^{\beta}{}_3 D_{IPM} + {}^{\beta}{}_4 D_{TL} + {}^{\beta}{}_5 D_{HD}$

In which:

Y: Paddy productivity/ha (quintal/ha)	A: Constant
X_1: variety (kg/ha)	X_5: labour (person-day/ha)
X_2: N-fertilizer (kg/ha)	X_6: Pesticides (VND ,000/ha)
X_3: P-fertilizer (kg/ha)	X_7: Age of householder (year old)
X_4: K-fertilizer (kg/ha)	X_8: Education of householder (schooling years)

Dummy variables:

D_{QC} = 1 Quang Cong; = 0 other communes

D_{QP} = 1 Quang Phuoc; = 0 other communes

D_{IPM}: IPM application: D_{IPM}=1 for IPM field; D_{IPM}=0 non-IPM field

D_{TL}: irrigation: D_{TL}=1 with irrigation; D_{TL}=0 without irrigation

$D_{HD:}$ types of soil: D_{HD}=1 fertile soil ; D_{HD}= 0 poor soil

α_i(i=1-8): coefficients of independent variables

$^{\beta}{}_i$(i=1,5): coefficients of dummy variables

For spring crops

The result of Cobb-Douglass model presented in Table 30, indicates that R^2 = 0.86 at significant level of 99%, which means that about 86% of variation in paddy yield is explained by selected variables in the model. The statistically significant relations were found between independent variables and paddy yield with exception for volume of variety used. As shown in Table 30, there is positive association between paddy production with dummy variables such as IMP application, irrigation and region. In other word, households have good opportunity to gain more income in their paddy field supported with IPM method and irrigation system (see Table 30).

Table 30: Result of Cobb-Douglass production for spring crop

Variables	**Coefficient**	**Standard errors**
1. Intercept (constant)	5.155^{***}	2.143
2. Ln(variety)	0.115^{ns}	0.113
3. Ln(N-fertilizer)	0.133^{***}	0.041
4. Ln(P-fertilizer)	0.092^{***}	0.018
5. Ln(K-fertilizer)	0.143^{***}	0.046
6. Ln(person-day)	0.125^{**}	0.018
7. Ln(pesticides)	0.133^{**}	0.060
8. Ln(year olds)	0.155^{**}	0.054
9. Ln(education)	0.112^{***}	0.034
10. D_{QC}-Quang Cong	0.066^{***}	0.018
11. D_{QP}- Quang Phuoc	0.084^{***}	0.013
12. D_{IPM}-IPM application	0.056^{***}	0.027
13. D_{TL}- Irrigation	0.053^{**}	0.005
14. D_{HD}- types of soil	0.009^{*}	0.003
R^2	**0.86**	
Valid cases	**266**	
F(13,252)	**62.72^{***}**	

Source: Surveyed in 2008

*Note: (***),(**)(*): significant level at 99%, 95% and 90%)*

For autumn crops

The result of Cobb-Douglass reveals that there is significant correlation between input factors and autumn crop productivity cultivated in surrounding lagoon. The result confirms that variation of paddy productivity is mainly affected (80%) by selected factors in model. Similar positive association is also found between all independent variables and rice yield in autumn crop. However, the coefficients are lower than of spring crops. It also means that effects of input factors on paddy yield are lower than that of spring crop. For instance, there is statistical significant association between IPM application and paddy productivity but not as strong as in spring crop (see Table 31).

Table 31: Result of Cobb-Douglass production for autumn crop

Variables	Coefficient	Standard errors
1. Intercept (constant)	4.155^{***}	1.141
2. Ln(variety)	0.118^{ns}	0.114
3. Ln(N-fertilizer)	0.113^{***}	0.041
4. Ln(P-fertilizer)	0.052^{***}	0.018
5. Ln(K-fertilizer)	0.112^{***}	0.046
6. Ln(person-day)	0.095^{***}	0.019
7. Ln(pesticides)	0.103^{**}	0.012
8. Ln(year olds)	0.098^{**}	0.026
9. Ln(education)	0.042^{***}	0.009
10. D_{QC}-Quang Cong	0.057^{***}	0.015
11. D_{QP}- Quang Phuoc	0.073^{***}	0.018
12. D_{IPM}-IPM application	0.051^{***}	0.028
13. D_{TL}- Irrigation	0.047^{***}	0.005
14. D_{HD}- types of soil	0.005^{*}	0.002
R^2	**0,80**	
Valid cases	**219**	
F(13,252)	**89.84^{***}**	

Source: Surveyed in 2008
*Note: (***),(**)(*): significant level at 99%, 95% and 90%)*

6.4 Market

6.4.1. Input market

Input markets play a crucial role in paddy production in Tam Giang-Cau Hai lagoon. The study found that co-operatives are important actor providing farmers with both technical consultancy and inputs for paddy production such as pesticides, variety, land preparation and harvest. As shown in Table 32, over 93% of paddy varieties were provided by local co-operatives. The result of PRA conducted in Quang Dien shows that co-operatives are highly appreciated in the provision of input services. Additionally, low price service, flexible payment are factors attract households. Some individuals also involve in input service provision, however households consider them as secondary option when they could not approach to services of co-operatives.

Table 32: Input market for paddy production

(Unit: %)

	Individual in communes	Individual outside communes	Co-operatives	Others
Pesticides	23.1	8.4	65.9	2.6
Herbicides	24.3	10.2	63.8	1.7
Variety/seed	1.2	2	93.6	3.2
Fertilizers	46.5	2.7	49.7	1.1
Land prepared services	43.2	-	56.8	-
Harvest machine	36.8	10.0	53.2	-
Hired labour	76.8	23.2	-	-

(Source: Surveyed in 2008)

6.4.2 Output market

As shown in Table 33, a large volume of paddy is used for family demands and feed for animal. Only about 12.8% of paddy yield is sold in local markets. It also means that paddy production is still subsistence crop though it is dominant livelihood practice of local community surrounding lagoon.

Table 33: Paddy distribution of surveyed

	%
Feed for animal	20.5
Family	64.6
Selling	12.8
Others	2.1
Total	**100**

(Source: Surveyed in 2008)

Table 34: Sold volume of paddy

	%
At home	88.7
Local market within communes	5.8
Local market outside communes	4.3
Others	1.2
Total	**100**

(Source: Surveyed in 2008)

The result of survey points to fact that nearly 90% of sold volume is sold at home and 10% at local market. However, households often sell paddy at home with lower price in comparison with selling at local market or collectors.

6.5 Paddy production and its impacts on paddy production

6.5.1 Pesticides and Chemical Fertilizers in paddy production

The result of PRA confirms that there has been an increase in pestilent risk for paddy production in lagoon region. This is pressing issue challenging farmers. In order to reduce negative impacts on paddy production, chemicals were increasingly used in paddy fields around lagoon though farmers are aware of health and environmental impact of pesticide use.

Table 35: Opinion on the use of chemicals in paddy production

(unit: %)

	Increase	Decrease	Constant
Pesticides	39.3	18.8	41.9
Fertilizers	38.5	6.8	54.7

(Source: Surveyed in 2008)

As shown in Table 35, nearly 40% of respondents are affirmative of an increase in pesticides use in paddy production. There is about 18.8% of respondent mentioned a decrease in pesticide. These households maybe involve in IPM for pest control in their field.

The use of chemical fertilizers is to increase paddy yield. However, it would affect soil fertility, and consequently leads to unsustainable yield. Nearly 39% of participants confirms the rapid increase in the use of fertilizers in comparison with of 5 years ago. Only 6.8% of respondents said conversely.

It is valid to conclude that there has been an increase in the use of pesticide and fertilizers for paddy production around the lagoon. This is a threat challenging to environment management and sustainable paddy production. It is important to encourage farmers to cut adopt more environmentally friendly technologies for rice production.

6.5.2 Environmental impact assessment of paddy production

As mentioned previously, there is negative relation between paddy production and quality of water in Tam Giang-Cau Hai lagoon. The result of survey reveals that the use of chemical components is the main reason for such impacts. As shown in Table 36, majority of respondents (88.3% of total sample) affirm the adverse impacts of chemicals used in paddy field on the quality of water in lagoon. There is about 19% of respondents said “very negative impacts”. Similar influences of chemical fertilizers on the quality of water in Tam Giang-Cau Hai lagoon was also found from survey participants. About 29% of respondents assessed it at medium influence level and 49% of respondents felt in little level. It is important to keep in mind that for those who considered the use of chemicals caused negative impacts on the water environment are mainly farmers who did not applied IMP in paddy production. In addition, these respondents often own paddy fields located near lagoon.

Table 36: Impacts of chemical components on the quality of water in lagoon

ĐVT: %

	Very	Medium	little	Not at all
Pesticides	18.9	49.2	30.2	1.7
Herbicides	3.8	28.5	48.6	19.1

Source: Surveyed in 2008

6.6 Conclusion and recommendation

6.6.1 Conclusion

Based on result of survey, the study comes to conclusion as follow:

- Paddy production is low net-income activities. However, there is a considerable difference in net-income generation between rice production with and without IPM.
- Farmers should apply IPM to control pest and disease for their field as it will result in higher net-income. It is necessary to note that IPM application often require more labour cost than none-IPM applied fields. On average, adoption of IPM in rice production would result in a reduction in the use of chemical fertilizer of about 200 kg per ha per year.
- IPM application helps farmer to save the cost. Pesticides and herbicides costs saved per ha in spring crop are VND 32,000 and VND 340,000 respectively and about VND 70,000 and VND 360,000 in autumn crop.
- Paddy production is still subsistence activity, which mainly satisfies family demand and feed for animal husbandry. Only about 12% of total production is sold for cash demand.
- IPM method has not been applied widely in paddy fields around lagoon, thus lead to difficulty in controlling pests and the use of pesticides.
- The case study indicates that the rice-fish model bring about higher return as compared to paddy monoculture. It is also considered as environmentally friendly technology for lagoon.

6.6.2. Recommendation

- Local governments should encourage local farmers applying IMP method in paddy production in order to increase both the efficiency and environmental protection.
- Rice-fish model is quite promising. It could at the same time to improve farmer's income and protect the environment. It is necessary to encourage the adoption of this model. However, more pilot trials and researches are needed.

VII. CONCLUSION

This research project undertook economic analysis and environmental impact assessment of three important water-based activities in TGCH lagoon, namely aquaculture production, wild catching, and rice production. Findings and recommendations associated with each activities have been discussed in detail in the respective sections of this report. Here are the important points that need to be emphasized.

- Aquaculture production in the lagoon is transforming to adapt to the degradation of the lagoon water quality and the changes in market. Mono shrimp culture is quite risky due to environmental degradation, increase in input price and decrease in output price. There are promising poly-culture models where different aquatic species are raised together. The government policy should focus, among other things, on the testing and adoption of these polyculture models as they would reduce risk and improve income for farmers and at the same time would protect the lagoon environment.
- Wild catching is still an important livelihood for many poor people in the lagoon areas. Given the degradation of the lagoon fishery resources, local people currently use fishing gears that are more effective and more destructive to environment. This is a very challenging problem. It is therefore necessary carry research and undertake pilot project on community-based resources management model using common-pool resources management approach.
- There are trade-off between short-term and long-term, between different sectors, and between stakeholders. To facilitate policy process it is necessary to develop a simulation model that could predict outcome and welfare effect of different policy scenario. This could help the local governments make choice of policy options soundly and transparently.

APPENDIX

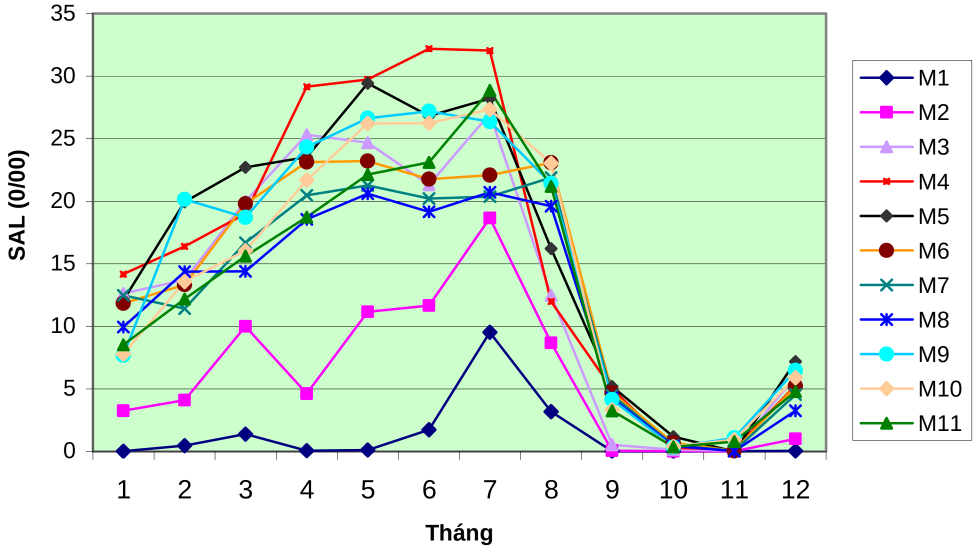
Appendix 1: List of Communes belongs to Tam Giang-Cau Hai lagoon

	Name	Total area (ha)	Lagoon water surface area	Aquaculture area[3]
	Phong Dien		**639.4**	
01	Dien Hoa	1,349,0	89.2	0
02	Dien Hai	1,346,0	560.3	0
	Quang Dien		**3,618.7**	**573.3**
03	Quang Thai	1,841.0	257.2	0
04	Quang Loi	3,328.0	1,107.6	19.0
05	Quang Phuoc	1,226.0	492.5	147.0
06	Quang Ngan	1,099.0	435.3	84.0
07	Quang Cong	1,375.0	646.7	104.0
08	Quang An	1,335.0	400.4	135.0
09	Quang Thanh	1,043.0	104.4	38.3
10	Dia town	1,189.0	174.5	46.0
	Huong Tra		**775.4**	**265.0**
11	Hai Duong	838.2	341.4	55.0
12	Huong Phong	1,574.0	434.0	210.0
	Phu Vang		**7,635.2**	**1,442.0**
13	Thuan An	1,706.0	1,058.6	321.2
14	Phu My	1,150.0	178.1	140.0
15	Phu An	1,119.0	613.6	214.0
16	Phu Xuan	3,017.0	1,256.1	129.0
17	Phu Đa	2,978.0	284.0	36.8
18	Vinh Phu	734.8	244.3	11.5
19	Vinh Ha	3,245.0	2,036.9	271.0
20	Vinh An	1,530.0	123.7	4.0
21	Vinh Thanh	1,066.0	142.9	11.5
22	Vinh Xuan	1,844.0	379.2	57.0
23	Phu Dien	1,382.0	659.9	180.0
24	Phu Thuan	738.1	457.0	57.0
25	Phu Hai	340.0	183.0	9.0
	Phu Loc		**9,239.9**	**825.5**
26	Vinh Hung	1,495.0	427.8	337.0
27	Vinh Giang	1879.0	1,019.4	144.0
28	Vinh Hien	2,280.0	1,634.3	45.0
29	Loc Binh	2,762.0	1,328.8	34.0
30	Loc Tri	6,272.0	1,162.2	30.5
31	Loc Dien	11,380.0	2,308.7	182.0
32	Phu Loc Town	2,743.0	1,245.2	53.0
33	Loc An	2,705.0	113.5	0
	Total	**69,909.1**	**21,918.5**	**3,105.5**

(Source: Do Nam, 2005)

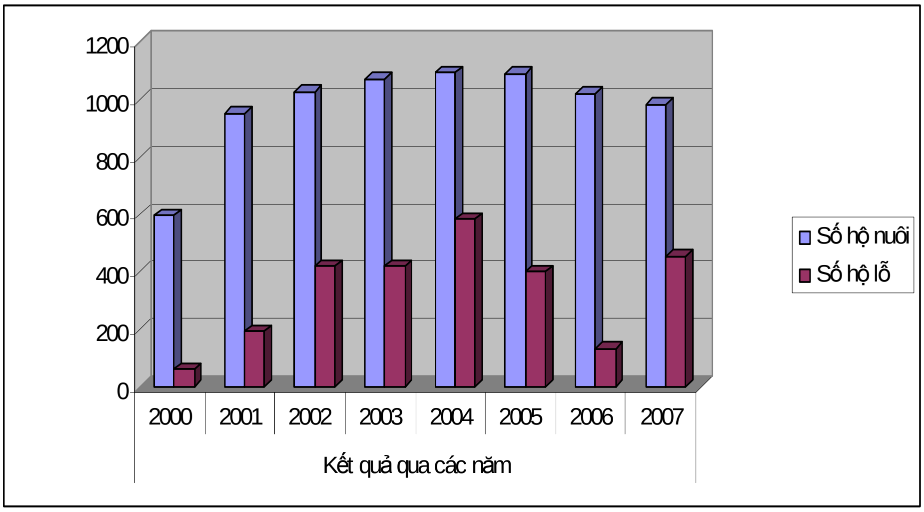
[3] Figures calculted for aquaculture only in-lagoon areas such as pond in lagoon, net-enclosure.

Appendix 2: Variation in Saline Level in Tam Giang-Cau Hai lagoon



(Source : Research on Sustaintable Development in Thua Thien-Hue lagoon in, 2003)

Appendix 3. Number of households with poor harvest in Quang Dien



(Source: Quang Dien People Committee[vii])

Appendix 4. Some photos of lagoon inhabitants

Photo 1 Boats are both sampan dwell and means for their livelihoods

Photo 2: Sampan people

Photo 3. Fishing activities

Appendix 5: Quantity of Titan

General Report on Area and Output of Titan mine enclosed with Thua Thien-Hue People Committee Decree No.*06g /2006/NQ-HĐND dated 28 /07 /2006)*

	Area	Note on map	Area (1000m^2)	Estimated output (1000 ton)	Notes
1	The My A, Dien Hoa commune	KTN1	513.2	32.6	In shrimp ponds and area planned for protective forest. Estimated reserves at C2 level
2	From Hai Nhuan, Phong Hai commune to 11-hamlet, Quang Ngan commune	KTN2	1,602.8	72.8	Area planned for shrimp ponds and protective areas. Estimated reserves at C_2 level
3	Thanh Cong, Quang Cong	KTN3	212.4	13,5	Shrimp pond area. Estimated reserve at C_2 level
4	The My B, Phong Hai commune	KTN4	176.4	11.2	Area planned for protective forest. Estimated reserve at C_2 level
5	Hai Nhuan, Phong Hai commune	KTN5	42.4		
6	Cu Lai, Phu Hai commune	KTN6	226.2	37.1	Area planned for protective forest. Estimated reserve at C_2 level
7	Dien Loc, Phu Dien commune	KTN7	525.0	61.5	Area planned for protective forest. Estimated reserve at C_2 level
8	Thuận An, TT Thuận An	KTN8	290.0	7.0	Tourism resource. Just exploiting in western area, estimated reserves at C_2 level
9	Hamlet No. 6, Vinh Thanh commune	KTN9	150.0	24.5	Resource. Surveyed and estimated reserves at C_2 Level
10	Dong Duong, Vinh Hien commune	KTN10	227.4	22.2	Tourism resort. Surveyed and estimated reserves at P1 level
11	Canh Duong, Loc Vinh commune	KTN11	1,739.9	73.2	Tourism resort. Surveyed and estimated reserves at P level
12	Cu Du, Loc Vinh commune	KTN12	476.7	7.0	Exploiting. Surveyed and estimated reserves at P level
	Total		6.182,4	362.5	

(Note: Exploited Titan calculated by 50 ÷ 70% estimated reserves).

Appendix 6 : Distribution of surveyed sample by commune

	Total	Quang Cong	Quang Loi	Quang Phuoc
Shrimp culture	160	50	20	90
Polyculture	44	15	5	24
Caged fish	21	0	21	0
Total	225	55	46	114

Source: Surveyed sample conducted in 2008

Appendix 7: Peak Season of main fishing activities in lagoon

Month	1	2	3	4	5	6	7	8	9	10	11	12
1.Fishing corral												
2.Fishing pod												
3.Mullet net												
4.Long net												
5. Lighting fishing gears												

Source: Agricultural department of Quang Dien district and reserch team

Appendix 8. Fishing operation cost by communes

(Unit: 1000 VND/household)

Cost item	Quang Cong			Quang Loi			Quang Phuoc		
	Main season	Off-season	Whole year	Main season	Off-season	Whole year	Main season	Off-season	Whole year
Petrol	1781	579	2360	680	186	865	639	265	904
Maintenance and buying new gears	2085	952	3037	1442	481	1923	1190	482	1672
Hired labours	0	0	0	0	0	0	475	151	626
Fees	11	7	18	3	0	3	2	0	2
Interest payment	403	201	604	603	302	905	189	95	284
Depreciation	1275	388	1663	1742	757	2272	1003	436	1308
Total cost	5555	2128	7682	4469	1726	5968	3497	1428	4795

(Source: Survey in 2008)

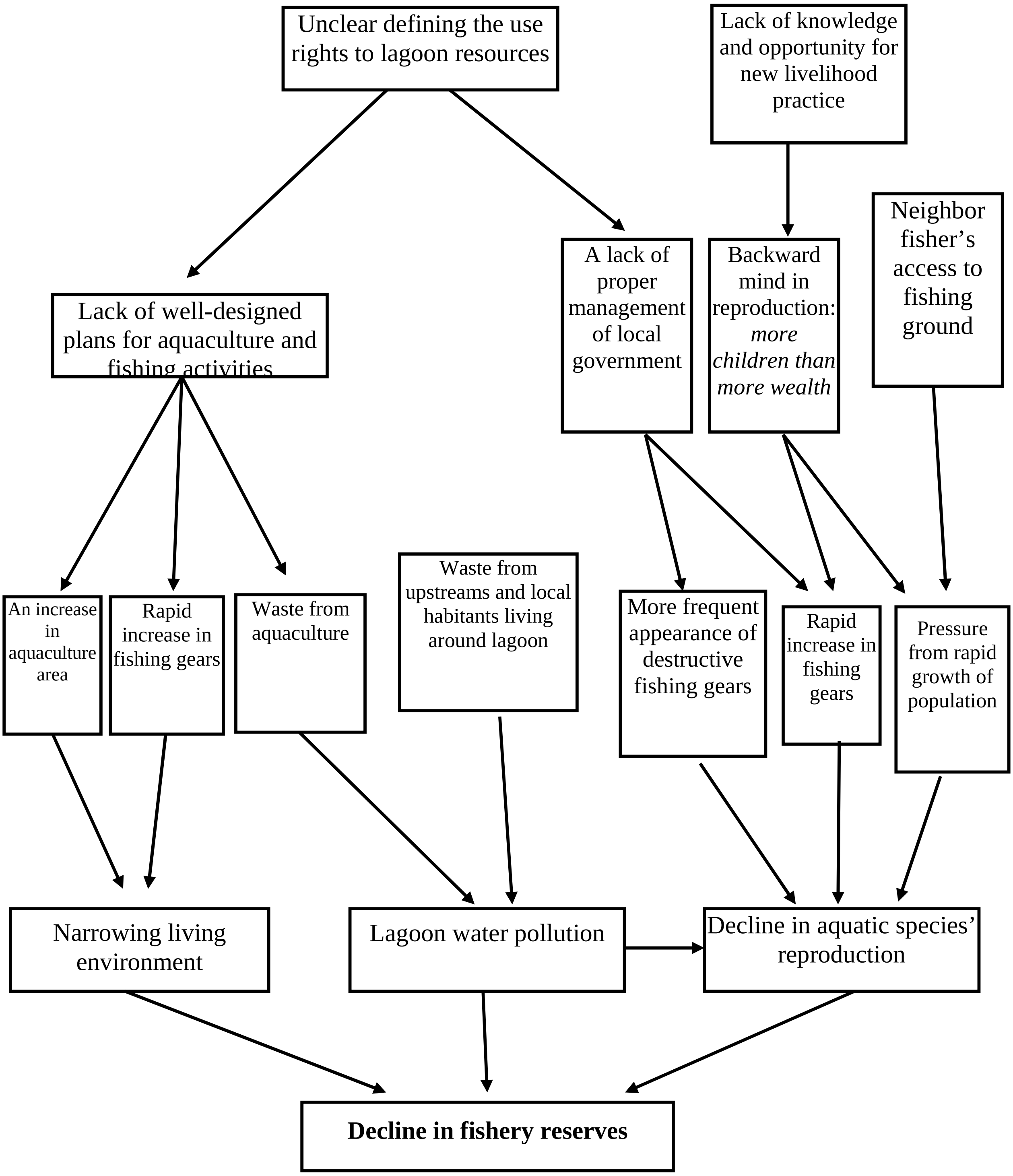
Appendix 9: Captured fish yield by communes in Quang Dien

(Unit: kg/households)

	Quang cong			Quang Loi			Quang Phuoc		
	Main season	Off-season	Whole year	Main season	Off-season	Whole year	Main season	Off-season	Whole year
Shrimp	451	183	634	408	99	507	171	52	223
Big fish	28	10	38	30	4	34	24	10	33
Small fish	176	62	239	366	142	507	230	71	301
Crab	21	5	26	138	35	173	20	8	28
Total	677	260	937	941	280	1221	445	140	585

(Source: Surveyed in 2008)

Appendix 10. Tree of Reasons for Decline in Fishery Resource in lagoon



Source: PRA and Expert interviews (delphi method)in 2008

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