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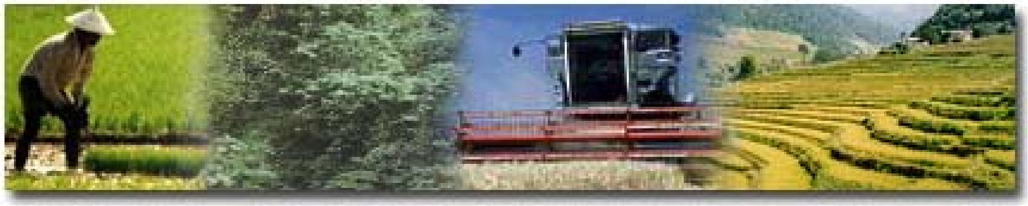

Technical Note

Guidelines for Environmental Management of Aquaculture Investments in Vietnam

Institute of Fisheries Management
Research Institute for Aquaculture Number 1
Network of Aquaculture Centres in Asia-Pacific
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This Technical Note was prepared for the Viet Nam Ministry of Fisheries and the World Bank. Technical notes are prepared as part of World Bank work. The contents do not necessarily represent the official Bank view, nor have been formally reviewed with Government.

FOREWORD

The Ministry of Fisheries (MOFI) of Vietnam and the World Bank are pleased to provide this important guideline document on environmental management of the aquaculture sector in Vietnam. The sector is one of the most valuable to the Vietnamese economy, with a proven record in poverty reduction, an important foreign exchange provider and a sector with substantial potential for further growth. With substantial comparative advantages, and an increasingly dynamic business sector, the aquaculture sector is poised for future growth. The Ministry of Fisheries predicts up to USD4 billion worth of exports of fisheries products by 2010, up from USD2.6 billion in 2005, with aquaculture as the major contributor to this growth. While the sector has significant potential, it now also faces major environmental challenges, related to increasing competition for the land and water resources upon which aquaculture relies and the need for improved environmental management to reduce environmental impacts of the sector on the countries natural resource base.

This study report, prepared by a group of Vietnamese specialists, supported by an international and regional team, in consultation with farmers, farmer organization, government institutions, NGO's and specialists throughout Vietnam, identifies the key challenges faced by the sector, and provides a set of development and management guidelines for prior and future investments in aquaculture. The report also provides important recommendations for implementation of these guidelines, which can facilate their wide use in the sector.

MOFI and the World Bank wish to thank the Danish government for providing support to the study, and the team comprised of specialists from Research Institute for Aquaculture Number 1,2 and 3, the University of Can Tho, Institute for Fisheries Management (Denmark), Network of Aquaculture Centres in Asia-Pacific (NACA), World Wide Fund for Nature (WWF) and the Food and Agriculture Organization of the United Nations for their support and cooperation in the study implementation and preparation of this report.

Ministry of Fisheries, Viet Nam   The World Bank

ABBREVIATIONS

BSP	Bank for Social Policy
BMP	Better management practices (for aquaculture management)
CIB	Commercial & Industrial Bank
Danida	Danish International Development Assistance
DARD	Provincial Department of Agriculture and Rural Development
DPF	Department of Planning and Finance
DoA	Department of Aquaculture
DOFI	Provincial Department of Fisheries
DONRE	Provincial Department of Natural Resources & Environment
DoST	Department of Science and Technology
DPC	District Peoples Committee
EC	Environmental Capacity
ECC	Environmental Carrying Capacity
FAO	Food & Agriculture Organization
GAP	Good aquaculture practices
GoV	Government of Viet Nam – usually refers to GoV institutions
MARD	Ministry of Agriculture & Rural Development
MOF	Ministry of Finance
MOFI	Ministry of Fisheries
MOLISA	Ministry of Labor, Invalids & Social Affairs
MONRE	Ministry of Natural Resources and Environment
MOST	Ministry of Science and Technology
MOSTE	Ministry of Science, Technology and Environment
MPA	Marine Protected Area
MPI	Ministry of Planning and Investment
NACA	Network of Aquaculture Centres in Asia-Pacific
NAFEC	National Fisheries Extension Centre
NAFIQAVED	National Fisheries Quality Assurance and Veterinary Directorate
PPC	Provincial Peoples Committee
RIA	Research Institute for Aquaculture
VAC	Integrated pig, garden, pond farming system
VASEP	Vietnamese Association of Seafood Exporters & Producers
VBARD	Vietnamese Bank for Agriculture & Rural Development
VIFEP	Vietnamese Institute for Fisheries Economics & Planning
VIFINET	Viet Nam Fishery and Aquaculture Institution Network
VINAFIS	Vietnamese Fisheries Association
WTO	World Trade Organization

EXECUTIVE SUMMARY

The 2004 Viet Nam fisheries and aquaculture sector study, conducted by the Ministry of Fisheries (MOFI) of the Government of Viet Nam (GOV) and the World Bank, concluded that the sector shows considerable potential to contribute to economic growth and poverty reduction in Viet Nam. The study also noted that aquaculture development had, particularly in coastal areas, contributed to environmental problems, such as deterioration of coastal habitats and other environmental impacts. With ambitious government plans for further expansion of the aquaculture sector, including aquaculture export targets of US$2.5 billion by 2010, improved environmental management of the sector will be essential for its sustainable growth.

This document provides an analysis of the environmental impacts and risks associated with aquaculture development in Viet Nam and guidance on better environmental management and monitoring for its future development. Part 1 provides a summary of the main findings, and guidelines for future development of the aquaculture sector. Part 2 provides the detailed case study findings.

The guidelines presented in Part 1 are based on cases studies of all major aquaculture commodities in Viet Nam, but gives special attention to aquaculture systems appropriate for poor coastal and inland provinces in northern, central and southern areas of Viet Nam.

The document provides individual chapters covering each of the following major farming system/commodities:

- Coastal shrimp aquaculture
- Marine cage farming of grouper/cobia
- Marine cage farming of lobsters
- Freshwater cage and pond culture of *Pangasius* catfish
- Freshwater cage culture of carps, emphasizing grass carp
- Freshwater pond culture of carps/tilapia and integrated fish farming (VAC)
- Coastal mollusk farming (clams)
- Coastal seaweed farming

Based on the findings from the case studies, the document assesses the environmental issues and identifies recommended better management practices. The purpose is to provide a concise set of guidelines to assist in future development of the sector.

The final part of the document provides key recommendations for implementation of the environmental guidelines; it emphasizes that public and private investment in environmental management and monitoring capacity will be critical to sustaining Vietnamese aquaculture and its importance for Viet Nam's economy.

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1.1. Introduction

1.1.1Background

The 2004 Viet Nam fisheries and aquaculture sector study, conducted by the Ministry of Fisheries (MOFI) of the Government of Viet Nam (GOV) and the World Bank, concluded that the sector shows considerable potential to contribute to economic growth and poverty reduction in Viet Nam. Aquaculture in particular is necessary to meet the growing shortfall in demand and supply of aquatic products caused by stagnating capture fisheries, and is being prioritized by government for future development. In the northern coastal provinces and northern mountains aquaculture has been identified by government and prioritized because of its particular role for poverty reduction in these poor and isolated areas.

Aquaculture development in Viet Nam, and especially in coastal areas, whilst having contributed to economic growth and poverty reduction, has also contributed to environmental problems, including deterioration of coastal habitats and other environmental impacts. The Vietnamese government 2010 export target for aquaculture products is 2.5 billion USD/year; a further increase in production risks higher environmental impacts, unless avoided through better planning and management of the sector. As identified in the MOFI/World Bank review, there is clearly an urgent need for improved environmental management of aquaculture to sustain the future development of the sector.

This document is intended to provide guidance to MOFI and the World Bank on better environmental management of the sector. It is based on a detailed study of the environmental impacts and management of aquaculture in Viet Nam, involving case studies of selected aquaculture commodities and systems and review of existing experiences, intended to provide preliminary guidance on environmentally sound investments in the sector. Classical environmental issues facing aquaculture in other countries are described and put into a Vietnamese context. The study also explores the opportunities and constraints for adopting international principles for better management of aquaculture, developed through the World Bank/NACA/WWF/FAO Consortium Program on Shrimp Farming and the Environment, to the Vietnamese situation.

1.1.2 Objectives and methods

The main objective of the study was to prepare guidance for mitigating environmental impacts in planning and operational management of aquaculture investments in Viet Nam, thus helping to maximize the potential contributions of aquaculture to poverty reduction with adequate environmental safeguards.

The study covered all major aquaculture commodities in Viet Nam, but gave special attention to aquaculture systems appropriate for poor coastal and inland provinces in northern, central and southern areas of Viet Nam.

In order to ensure an optimal use and relevance for the guidelines, existing and potential mechanisms for implementation and enforcement of the recommendations given in the guidelines were investigated. Responsibilities for institutions and other stakeholders involved in environmental impact assessments were analysed and recommendations given on how to make the guidelines work best within these institutional settings.

In addition to a review of the sector, eight commodity case studies were initiated (Table 1). Several study teams from various national institutions and organizations were assigned to execute the case studies with support from an international team. Each team carried out the following activities during the case studies:

- Secondary data collection (preparation of review of relevant environmental references/information concerning aquaculture in Viet Nam, general and by each commodity/farming system);
- Site selection for field case studies of selected farming systems/commodities;
- Case studies of selected farming systems/commodities;
- Institutional analysis of environmental management systems for aquaculture, and related natural resource management, in Viet Nam;
- Analysis of data collected and report writing;
- Workshop to review and build consensus around findings and recommendations; and
- Finalization of report for submission to MOFI/the World Bank.

Site selection was conducted in consultation with MOFI and among the study teams during the inception phase of the project (February 2006). The species selected comprised those prioritized by MOFI but seaweed was also included due to it ability to uptake nutrients and low input and skill requirements, making it especially suitable commodity for poorer communities to execute (Table 1).

Table 1 Overview of selected commodities for in-depth case studies including geographic area for conducting the studies

Farming system/commodity	Case study province
Coastal shrimp aquaculture	Quang Ninh and Nghe An
	Ca Mau/Mekong delta
Marine fish cage farming (grouper/cobia)	Ha Long and Hai Phong
Marine lobster cage farming	Khanh Hoa/Phu Yen
Freshwater cage and pond culture of *Pangasius*	An Giang/Mekong delta
Freshwater cage culture of carps/grass carp	Tuyen Quang
Freshwater pond culture of carps/tilapia/VAC/Rice paddy	Nghe An (with secondary review of all mountain provinces)
	Mekong delta
Coastal mollusk farming	Nam Dinh
	Ben Tre
Coastal seaweed farming (*Gracilaria* and *Kapaphycus*)	Hai Phong Ninh Thuan

The studies were carried out from April to June 2006 and concluded with a workshop hosted by MOFI at RIA-1 on the 23rd June 2006. The workshop participants reviewed the key findings of the study, the draft guidelines and made recommendations for follow up actions. The members of the study team and the workshop participants are provided as Annex 1.

1.1.3 Organization of document

This document is divided into three main parts namely:

Part 1: Sectoral guidelines

This part of the document provides a synthesis of study findings, including a background section on Vietnamese aquaculture, an assessment of environmental issues, recommended management practices and implementation recommendations. The purpose is to provide a concise set of guidelines to assist in future development of the sector.

Part 2: Commodity reports

This part of the document provides individual chapters covering each of the following major farming system/commodities:

Coastal shrimp aquaculture
Marine cage farming of grouper/cobia.
Marine cage farming of lobsters.
Freshwater cage and pond culture of *Pangasius* catfish
Freshwater cage culture of carps/grass carp.
Freshwater pond culture of carps/tilapia and integrated fish farming (VAC).
Coastal mollusk farming (clams)
Coastal seaweed farming (*Gracilaria* & *Kapaphycus*)

Annexes:

Annexes provide further background information on the study, including key people involved, reference list of key documents, and a synthesis tables describing the environmental management recommendations for each key commodity.

1.2 Aquaculture in Viet Nam

1.2.1 Background

Aquaculture has grown rapidly in Viet Nam in the past two decades and today the country is among the world's top 10 seafood exporters, with products from aquaculture accounting for more than 40% in volume of seafood produced. In 2005, aquaculture produced over 1 million tonnes of aquatic products divided evenly between freshwater and brackish/marine aquaculture (Table 2). The aquaculture sector created employment for more than 2 million people while reaching an export value of US$ 2.65 billion for the whole fisheries sector and above US$1.6 billion for aquaculture alone (MOFI 2006a). The land based aquaculture production area accounts for almost 1 million hectares and in addition there is a large area (or volume) of marine and freshwater surface utilized for farming of fish and lobsters in water-based cages.

Having exceeded the targets for production and value set by the GoV in the 1999-2010 Master Plan for aquaculture development (GoV, 1999), the GoV and MOFI expect further significant growth of the sector from 2006- 2010. In January 2006, MOFI conducted a review of its 2001-2010 Master Plan and made further projections for aquaculture for the period from 2006 to 2010, which were approved by GoV. In March 2006, MOFI also published a more detailed plan for development to 2010 clearly showing ambitious goals for development of the sector. Production tonnage is expected to increase more than 25% with increased employment and production area. Increases in foreign earnings from the sector are expected to be a major driver in defining the development strategy as well as ensuring that the sector contributes to poverty alleviation by creating additional jobs and securing existing ones. The aquaculture development targets for 2010 are provided in Table 2.

Table 2 Aquaculture production in 2005 and development targets for 2010 according to GoV and MOFI estimates

	Observed in 2005	**Estimated for 2010**		
	(MOFI, 2006b)	(GoV, 1999)	(GoV, 2006)	(MOFI, 2006b)
Production (tonnes)	1,437,350	2,000,000	2,000,000	2,100,000
Fresh water	958,870	938,000	980,000	998,000
Shrimp	324,680	360,000	-	400,000
Marine fish farming	3,510	200,000	200,000	200,000
Mollusk	114,570	380,000	-	380,000
Seaweed	20,260	50,000	-	50,000
Others	85,270	-	-	72,000
Export Value (mill.USD)	1,627	2,500	-	2,500
Labor (person)	2,550,000	2,000,000	-	2,800,000
Areas (ha)	959,945	992,000	1,1-1,400,000	1,100,000
Fresh water	318,900	652,000	500-600,000	-
Marine and brackish	641,045	340,000	600-800,000	-

Associated with its fast development, aquaculture in Viet Nam has already encountered significant challenges in recent years, including disease outbreaks, food safety issues with products for export and local consumption, negative environmental impacts on habitats and poor water quality and, in some areas, social conflicts (MOFI, 2005a). The problems typically arise from the cumulative effects of rapid development of many small-scale aquaculture farms on barren land or conversion of ineffective rice fields or mangrove forest into aquaculture. While the development of scattered extensive aquaculture will result in fewer environmental or social impacts, it is evident that the cumulative impacts of many small-scale developments do create adverse environmental and social impacts (MOFI, 2005b). Environmental problems are particularly serious within semi-closed lagoons, estuarine, and mangrove ecosystems with sensitive habitats and limited water exchange. However, even outside these areas, uncontrolled development has lead to self-pollution of aquaculture farms resulting in continued disease outbreaks and severe economic losses for farmers. Introductions and movements of aquatic animals have also contributed to the problems, increasing risks of introduction of new pathogens, and impacts on native biodiversity, which is already under severe stress.

Due to the predicted future expansion of aquaculture it is important that practical strategies are developed and investments made to ensure sustainable development and that aquaculture development goals are achieved without major negative impacts. It is unlikely that aquaculture can develop at the same pace without substantial improvements in management of the sector. The study and these guidelines provide the basis for identifying the critical issues and investments needed.

1.2.2 Government policies

Government policies in Viet Nam have been and continue to be highly supportive of aquaculture development. This strong government support, combined with the dynamism of Viet Nam's farming community, is a principal reason why the sector has seen substantial growth. Government policies for aquaculture development are defined in laws and a considerable number of decrees, ordinances, decisions, circulars and regulations[1] (Annex 2).

A new Fisheries Law was approved by the National Assembly in 2004. The law does not specify the regulatory settings for conducting aquaculture production but rather refers to the Ministry of Fisheries (MOFI) as having the responsibility[2] of implementing guidelines, regulations and standards for sustainable production.

The Fisheries Law empowers managers, particularly at provincial level, to manage the resources through formulation and implementation of provincial regulations and plans. The Law refers closely to the National Programme for Aquaculture Development – Master Plan 1999-2010, which sets the objectives for the sector's development. The progress in implementation of this Master Plan has recently been reviewed, and as noted above new targets established for 2010, and in some cases 2020.

Several initiatives to promote sustainable development within the aquaculture sector are currently being executed by the Ministry of Fisheries and other stakeholders within Viet Nam in accordance with the new Fisheries Law and Government policy. These range from capacity building programs to introducing new technology. Programmes and projects consist of an array of national supported initiatives to co-funded donor and private investments from Vietnamese and foreign investors. The main Government master plans and programs guiding MOFI's aquaculture programs are:

- National program on aquaculture development (Decision No 224/1999/QĐ-BTC) by Department of Aquaculture/MOFI from 1999-2010.

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[1]Examples of relevant legislation include: Decision no 6 of 2006 on the issuance of the regulations on safe shrimp culturing area and facility management. Directive No. 32 of 1998 on overall planning for socio-economic development. Decision by the Minister of Fisheries to issue the regulation on the functions, responsibilities, authority and organizational structure within MOFI. Sector standard 28 of 2004 on shrimp cultivation areas and conditions for ensuring food sanitation and safety. Decision no 6 of 2006 on the issuance of the regulations on safe shrimp culturing area and facility management.

[2] The decree 43 of 2003 specifies the overall responsibilities of MOFI as the key institution in aquaculture management.

- Master Plan for Fisheries Development to 2010 and orientations towards 2020 (Decision No 10/2006/QD-TTg) approved by the Prime Minister
- National program on extension promotion (seed, black tiger shrimp, offshore fisheries, freshwater aquaculture, marine, brackish water aquaculture, post harvest and processing) by NAFEC/MOFI from 1999-2010.
- National program on seed production supplying for fisheries sector (Decision 112/2004/QĐ-TTg) done by Department of Aquaculture/MOFI from 1999-2010.
- National program on strengthening industrialization and modernization in the fisheries sector (decision 21/2004/QĐ-BTS) by MOFI from 2001 – 2010
- Assessment and strengthening institutional capacity for management of coastal areas, and improving living conditions in Central Viet Nam done by MOFI from 2006 – 2010.
- National program on promotion of communication & education of law within the fisheries sector (Decision No 11 /2004/QĐ-BTS) by MOFI.
- National program on development of mechanization in fisheries sector toward 2020 (33/2005/QĐ-BTS) by MOFI from 2006 – 2010

The Ministry of Fisheries has also identified certain key activities to support the new aquaculture targets as provided in Table 2, some of which include recognizing the need for interventions to improve environmental management. Concerned activities planned for implementation "to improve technology" from 2006-2010 include:

- Speeding up sustainable aquaculture planning
- Developing ecological maps using GIS techniques to define optimal culture zones for specific species
- Extending GAP/BMP models to all the shrimp farming areas and gradually extend models also to other commodities such as e.g. basa/tra, tilapia, *Macrobrachium* and marine fishes
- Focus on making "concentrated" zones for hatcheries, shrimp farming and marine finfish farming
- Importing technology and conducting research and development of technology for hatcheries, feed production and marine farming focusing on high value species e.g. lobster, as well as mollusk and seaweed
- Developing large concentrated hatchery centers capable of managing the quality of seed as well as reduce the costs of production and prevent environmental pollution

A number of institutional issues and activities are also defined by MOFI through the review Master Plan for 2006-2010:

- Ensuring that sustainable aquaculture planning principles are institutionalized with clearly defined responsibilities including planning and management capacity building of government offices
- Defining the standards, limits, administrative procedures as well as functions and responsibilities of communities in relation to natural resource management.
- Setting up monitoring and evaluation systems
- Investigate, plan and establish ecosystem protection zones serving as nursing for juveniles and stock conservation grounds for aquatic species, such zones also includes coral reef protection.

Whilst promising, the detailed implementation strategies have not yet been formulated, and it is yet unclear how these will be effectively implemented. In addition, as it will be seen, the recommendations do not cover all the key issues.

The year after the approval of the Aquaculture Master Plan for 1999-2010, the Government hosted an international workshop which produced a strategy for "Sustainable Aquaculture for

Poverty Alleviation" – the SAPA strategy. SAPA complies with the Master Plan 1999-2010 but is strategically focused on poverty through improved institutional capacity and better understanding of local complexities.

A step forward towards the implementation of the proposed targets for environmental and socio-economic sustainability is represented by the development of cross-sectoral Environmental Impact Assessment Guidelines and a set of Sustainable Coastal Aquaculture Planning Guidelines. The EIA Guidelines were prepared by MOFI with support of Danida, and are in the final approval stage. The guidelines are to be applied prior to approving aquaculture development projects and are a joint MOFI/MONRE initiative. Coastal Aquaculture Planning Guidelines, also prepared with support from Danida, are also pending approval. Although important, the approval of these documents will not compensate for the lack of detailed environmental management strategies for key commodities and geographical areas. It is envisioned that the next few years will require substantial investments in environmental management if Viet Nam is to sustain its aquaculture growth.

Although many of the environmental problems facing the aquaculture sector derive from other sectors which conduct environmentally damaging activities, few environmental management initiatives in the aquaculture sector can be termed 'multi-sectoral'. This is indeed a major weakness for the sustainable development of the sector.

1.2.3 Institutions and stakeholders

The public administration in Viet Nam has undergone major changes since the 1986 adoption of the Doi Moi policy, which was designed to prepare the country for its transition from a centrally planned economy to a socialist-oriented market economy. The Government's approval of the Public Administration Reform (PAR) Master Programme in September 2001 is a continuation of this policy.

The changes in the spending in public administration through the 1990's indicate the delegation of responsibilities from central to local level. From 1997 to 2002 the spending conducted at the central level fell from 41% to 22%, while local levels grew from 59% to 78% (MOFI and World Bank, 2005).

Restructuring of public management is a long term process which includes strategies to promote civil servants' awareness and participation within the administrative system and involves the public at large in the change process. The rapidity with which this will happen will differ between administrative units. Despite the good intentions and the thorough knowledge about the benefits of decentralisation and shared decision making, these initiatives are still new in Viet Nam and still a challenging experience for officials and the people involved, including those engaged in the aquaculture sector.

The following descriptions summarize the responsibilities and capacities of key institutional stakeholders in managing aquaculture development.

Ministry of Fisheries (MOFI)

The Ministry of Fisheries (MOFI) is the Public Administrator at national level regarding the aquaculture sector in Viet Nam. The responsibilities include resource management, scientific research, aquaculture sector development and formulation and implementation of regulations according to plans and directives from the Government. The Ministry is responsible for organizing and guiding extension work; providing technical support, disseminating information and transferring technologies in aquaculture. Furthermore MOFI also conducts market research and various market development activities.

The Ministry cooperates with other ministries upon request of higher authorities with the Government. To assist MOFI work there are 11 administrative units (e.g. Department of Aquaculture, Department of Planning and Finance, Department of Science and Technology) and 9 service units (including three Research Centres for Aquaculture, RIA's 1-3). The total staffing of MOFI is now 222 (excluding drivers and watchmen, and its affiliated institutes) with a current annual operating budget of almost 9 billion VND (MOFI and World Bank, 2005).

MOFI is also the lead agency for Marine Protected Areas (MPA) development at national planning level.

Although the responsibilities of all the MOFI units have some bearing on the management of environmental issues within the fisheries sector, the following departments play a particularly important role in management of aquaculture.

Department of Science and Technology (DoST) assists the Minister in the management of activities related to science, technology and environment. The Department has the responsibility to develop regulatory documents on science, technology and environment in the fisheries sector. All sector standards related to the fisheries sector are produced by the DoST sometimes in collaboration with other MOFI units (e.g. NAFIQAVED).

National Fisheries Quality Assurance and Veterinary Directorate (NAFIQAVED) is the national authority for fisheries food safety assurance and quality control. The Directorate has a head office in MOFI and six branches located in key fisheries areas. Since August 2003, the responsibilities of NAFIQAVED have been expanded to include aquatic animal disease control and has been conducting activities on the implementation of GAP which target better quality production through environmental protection.

Department of Aquaculture (DoA) is responsible for the development of strategies, masterplans, long-term and annual plans, programs, projects in aquaculture. DoA is also responsible for the development of regulatory documents related to aquaculture and issued by MOFI, such as the recently issued "Regulations on safe shrimp culturing area and facility management" (April 2006).

Provincial and District administration. At provincial and district levels, MOFI operates through the Provincial Department of Fisheries (DOFI) - in 28 coastal provinces and via fishery sections in some districts. The District level is the lowest administrative level where there are some professional staff with responsibilities for aquaculture. At the commune level there is no formal representation of MOFI, however policies are being implemented at this level through village extension agents. In inland provinces, aquaculture extension activities are conducted through fisheries units established in the Provincial Department of Rural Development (DARD).

Ministry of Natural Resources and Environment (MONRE)

The Ministry of Natural Resources and Environment (MONRE), which together with the Ministry of Science and Technology (MOST) originated from the division of the Ministry of Science, Technology and Environment (MOSTE) in 2002, manages the state function in the areas of land use, water resources, minerals, environment, meteorology and hydro-geography. The key responsibility of MONRE is to submit proposals for legislation, development strategies and annual plans regarding utilization of natural resources. The Ministry organizes and directs the implementation of approved legislation, plans and strategies and manages[3] the allocation, lease and restoration of land as well as the transfer of land-use rights.

In aquaculture development the Ministry's responsibility is to regulate and direct the implementation of measures to protect water resources, under the responsibility of the Department of Water Resources Management of MONRE.

A number of other departments and bureaus with MONRE support implementation of environmental protection measures that relate to aquaculture, including the Department of Environment, Viet Nam Environmental Protection Agency and Department of Science and Technology.

At Provincial and District levels, MONRE is represented by Provincial Departments of Natural Resources and Environment (DONRE).

MONRE and DONREs have recently been assigned the task to review the land use in every province. Although this review will include the use of land for agriculture, including aquaculture, it is reported that this activity has been conducted with limited MOFI and DOFI consultation.

Other key ministries

The public planning of aquaculture involves several other ministries and directorates. The Ministry of Agricultural and Rural Development (MARD) play a key role through management of irrigation infrastructures and policies for land use and land allocation in relation to changes in land use. The Ministry of Planning and Investment (MPI) and the Ministry of Finance (MOF) are involved through review, approval and provision of budgets for plans and strategies for aquaculture management at central and through equivalent provincial departments at provincial level.

People committees

People's Committee's (PC's) at provincial or lower administrative levels have the authority and the obligation to issue management plans on aquaculture sites under its jurisdiction on the basis of approved development plans from higher administrative levels. The PC's must approve public budgets and local plans for resource utilization and ensure implementation of socio economic policies. The PC's are playing varying roles depending on the political regions. In some areas the PC's are progressive facilitators of reforms while in other areas the PC's are conservative or leave the initiative to other institutions (e.g. DOFI).

Research organizations, hatcheries and extension services

The Research Institutes for Aquaculture (RIAs) includes three institutes (RIA 1, 2 and 3) with several affiliated experimental stations located throughout the country. The research is divided in five major areas: fish genetics, freshwater aquaculture systems, coastal aquaculture, aquaculture environment and socioeconomic studies. The RIA 1 is the largest research institute involved with aquaculture, with over 250 staff with various experience and expertise.

Researchers traditionally give advice to decision makers and provide scientific input to formulation of government legislation and development plans and strategies and to the capacity building of extension services at province and district level. The three RIAs have also been

[3] This includes inspecting the provincial, centrally-governed city people's committees in determining land price according to the land price frame and principles and approaches regulated by the Government in determining prices of different types of land (No. 91/2002/ND-CP).

instructed by MOFi to develop and operate an environmental and disease early warning system for aquaculture, which was recently started.

Universities also play a major role in conducting research and supporting decision making. Among others, the University of Fisheries (Nha Trang), Can Tho University and Nong Long University (also known as University of Agriculture and Forestry, Ho Chi Minh City) have been key to capacity building and generating knowledge for the development of the aquaculture sector.

The recently established Viet Nam Fishery and Aquaculture Institution Network (VIFINET) is a network of institution aimed at promoting effective collaboration among education and research institutions for the sustainable development of fisheries and aquaculture in Viet Nam. VIFINET's Steering committee includes most of the important research institutions including the 3 RIAs and the 3 Universities mentioned above.

Department of Fisheries (DOFI) operate extension centres in coastal provinces, whereas aquaculture extension activities in inland provinces are carried out or coordinated by the provincial DARD Extension Centre. Despite considerable investment from the government and donors (e.g. Danida) extension services remains inadequate. Lack of human and technical capacities at different levels to service a rapidly growing numbers of fish farmers and environmental problems is a major constraint.

Extension service workers play a key role by being the immediate connection between central/provincial administration and the farmers. Due to weak organisation of farmers throughout the country the extension workers must often relate and communicate to smaller groups or individuals. This is time consuming but does create inter-personal relationship with farmers. The farmers' respect for the extension workers is a key capacity for facilitating changes in farmers' behaviour and for motivating groups to organize.

Farmers' access to seed and high quality seed is essential for establishing productive and environmentally sound aquaculture systems free from diseases and costly production losses. The 3 RIAs control 3 National Broodstock Centres and 14 hatchery centres across the country. Despite increasing production of high quality seed, the production cannot meet the rising demand and private hatcheries have therefore been developing rapidly in particularly the Central and Southern provinces, dwarfing the production of government hatcheries.

Shortage of fish seed in the remote and more poorly developed aquaculture regions of Viet Nam, particularly the Northern and mountainous areas, is still a significant problem.

Aquaculture farmers

The Vietnamese aquaculture industry is characterized by huge numbers of farmers, which number in the order of hundreds of thousands. The group of aquaculture farmers is heterogeneous, consisting of small and medium scale households producing for subsistence or local markets, and highly commercialized farms. This mixed group of producers means there is a variety of preferences which must be balanced when planning the sectors development.

Generally Vietnamese farmers are poorly organized into operational groups and associations, which impedes participation in decision making with government (co-management), sharing of knowledge, adaptation to changing opportunities and others. Implementing environmental management often require that farmers change practices and comply with new regulations. It is essential for the success of any environmental management programme that decision makers can communicate and negotiate with all stakeholders, including the farmers.

Sector organisations and farmer groups do exist across the country. Mass organizations are an official and integral part of the Viet Nam government system, forming a separate branch to the central ministry/provincial department structure. They are members of the Fatherland Front and are strongly represented in the National Assembly. They have their own budgets, staff and programs.

VINAFIS is a governmental initiated mass association operating in aquaculture, capture fisheries, fish processing and fisheries logistic services. VINAFIS has established branches in 13 provinces. The Association has a rather fragile organizational structure and it cannot be concluded it is organizing the grass-root level. On the contrary, powerful organisations seem to be coming more from farmers getting together on their own in smaller groups and clubs. Initiatives to support the establishment of producers' organizations are also being incited by exporters and their organisation (VASEP) whose members need to communicate effectively and simultaneously with large groups of farmers to address modern food safety requirements of exported fish and shrimp.

The Farmers' Union (10 million members) is another important organization representing mainly agriculture farmers.

Norms and legitimacy

The practices of farmers are to a large extent driven by norms, traditions and the legitimacy of aquaculture management and based on market demand. If management decisions are not well incorporated with these informal institutions it is unlikely that regulations and development plans will be fully accepted and followed by resource users. Through participatory planning, decision makers gain access to understanding the prevailing norms among farmers and implementation of management measures will be more effective.

Fish buyers and fish processors

The Viet Nam Association of Seafood Exporters and Producers (VASEP) was established in 1998. Its 185 members mainly comprise the larger seafood processors and account for about 90% of the total value of the Vietnamese seafood exports. The Association has played an important role in providing advice to MOFI on trade policies, including notable US antidumping cases, and is a key stakeholder in adjusting the primary sector to export market demands (MOFI and World Bank, 2005). To facilitate the organisation of fish processors and thereby empower small scale processors, it has been suggested to further differentiate VASEP membership fees by maintaining the present levels for export companies and introducing a lower fee for very small companies producing for the domestic market. In reality, the participation of smaller processors, and small-scale farmers is presently limited.

VASEP is also an important institution for market-sided "ecolabelling" strategies, such as MSC for wild fisheries products, and the various eco-labelling schemes developing for aquaculture products. As Viet Nam more embraces the open market, environmental certification, based on user demands in Europe and the North America, is likely to become more significant. VASEP, as the main representative of fisheries processors, will probably play an important role.

Credit institutions and middlemen

A constraint to poor people's involvement in aquaculture is the lack of savings and access to credit and so credit institutions play a key role in facilitating the sector's development in this area. Poorer farmers face particular problems associated with access to collateral for loans.

Various institutions provide credit to the aquaculture (and fishing) sector in Viet Nam. Among them, the state owned banks such as the Viet Nam Bank for Agriculture and Rural Development (VBARD), Commercial and Industrial Bank (CIB), and the Bank for Social Policy (BSP) and the Bank for Investment and Development. Viet Nam Women's Union, the Farmers Union and the

Youth Union are providing credit at the local level primarily from national development programs and including some foreign donor support.

In aquaculture, traders and input suppliers (eg feed companies) are also an important source of credit for aquaculture farmers and their households at the local level. Viet Nam has an elaborated system of traders providing credit for investments in inputs such as feed and seed.

Mass organisations and civil society

The Women's Union, a national union in Viet Nam is active in promoting women in aquaculture, and micro credits for aquaculture given through the Women's Union have proved effective. The Youth Union is also an important mass organisation which plays an important role in providing information and micro-credit access to farmers. The Youth Union has also sometimes been involved in large investments (in the range of several billions of VND) for the development of aquaculture.

There are also international NGOs' operating in Viet Nam, with interests in aquaculture. With the aim of promoting sustainable shrimp farming, in 1999 WWF partnered with the World Bank, the FAO, and the Network of Aquaculture Centres in Asia-Pacific (NACA) to form the Shrimp Farming and the Environment Consortium which has been working with projects in Viet Nam and other countries. CARE is another NGO which is collaborating with the Vietnamese Government in natural resource management projects focusing on poor communities and aquaculture.

IUCN (The Worlds Conservation Union) is also conducting activities related to the aquaculture sector in Viet Nam. Analyses on shrimp farming in sandy soil areas and the use of aquaculture as an alternative income for people living in or around MPAs are two examples.

International stakeholders

As a member of FAO, Viet Nam was one of the member governments that adopted the FAO (1995) Code of Conduct for Responsible Fisheries which includes environmental and management concerns for aquaculture. Viet Nam is also a member of a number of regional bodies involved with aquaculture management issues, including ASEAN, SEAFDEC, NACA, APEC and APFIC. ASEAN is seeking to harmonise standards for intra-regional trade under the ASEAN Free Trade Agreement which has implications for aquaculture management.

Of particular importance is Viet Nam's imminent membership of the World Trade Organisation (WTO) which implies agreements on sanitary and phytosanitary measures, technical barriers to trade, harmonization of standards and equivalency in food control systems and the use of scientifically-based standards. By adopting WTO standards, aquaculture producers will be subject to higher quality standards, which will also influence the costs and practices of aquaculture. The large number of small-scale producers in Viet Nam could be at a particular disadvantage, and special measures will probably be necessary to ensure their continued participation in the increasingly stringent international trading environment for aquatic products.

There are a growing number of certification schemes and labels – aimed mainly at ensuring market access for aquaculture products to some markets - being introduced in Viet Nam by a range of private organizations. Among the larger schemes include Naturland (Organic shrimp), ACC (Aquaculture Certification Council) and Eurepgap. However, the progress in the practical implementation of these schemes has been so far very limited.

Donors have contributed substantially to the development of the sector. The major foreign donors within the fisheries sector are Danida and Norad, as well as a number of international organizations including. UNDP, FAO, NACA and NGO's including IUCN and WWF.

The Vietnamese aquaculture industry is also attracting increasing foreign private investment, particularly in servicing, fish and shrimp feed production and aquaculture of high value species, such as shrimp and marine fish.

1.2.3 Aquaculture systems and production

Vietnamese aquaculture is a very diverse sector including several species cultured in freshwater and coastal environments.

Freshwater aquaculture

Freshwater aquaculture has a long history in Viet Nam. It developed from catching wild fish and gradually moved to extensive and intensified aquaculture. The main native species cultured are common carp and catfish and introduced exotic species such as tilapia, Indian and Chinese carps. New exotic species such as rainbow trout, sturgeon, and mandarin fish are being introduced in an attempt to diversify freshwater production and increase value.

In 2004 the total freshwater aquaculture area in Viet Nam was around 335,760 ha, which is a 2.7% increase from 2003 (MOFI 2005cc). The total freshwater culture production is approximately 639,700 tonnes/year of which 300,000 tonnes are *Pangasius* catfish and 20,000 tonnes tilapia. The national production of freshwater fish culture is present in Table 3 below.

Expectation for further expansion of the sector is huge and by 2010 it is expected that the existing annual production will be increased to 900,000 - 1,150,000 tonnes. While the carps are a low value species and mainly for domestic consumption they are a popular fish with consumers, and provide an important protein source for the communities as well as creating employment from producers and other stakeholders along the market chain. Often carp are farmed in small scale VAC systems recycling organic fertilize from the agricultural activities the farmer might have. The Vietnamese government has identified carps and tilapia as suitable for development of aquaculture in mountainous and remote areas, and there are some good successes which deserve further replication with promotion of these freshwater species in such areas.

Pangasius (basa and tra) culture is the powerhouse in the freshwater aquaculture sector and large quantities are produced and exported. The Mekong river delta is the main culture area with a culture area that is 37% of national freshwater fish area, and with a high proportion of national freshwater fish production. The highest fish production is from An Giang province with a production of 151,391 tonnes in 2004. Can Tho and Dong Thap were ranked second and third with production of 80,000 tonnes and 72,500 tonnes respectively. Besides the Mekong river delta, the Red river delta also has a considerable freshwater production with total fish production of 141,076 tonnes.

Table 3 Fish production by regions in 2004 including tonnage increase compared to 2003 (MOFI 2005c)

Region/Province	Units	2004	Increase since 2003
North (highland)	tonnes	37,557	18.1
Red river delta	tonnes	141,076	13.5
North central	tonnes	34.634	26.6
South central	tonnes	9,500	28.5
Tay Nguyen	tonnes	8,991	32.2
South East	tonnes	41,789	17.2
Mekong Delta	tonnes	464,148	-

Fresh water aquaculture is both practiced in ponds and cages, but small-scale ponds produce the majority of production, in systems of great diversity.

Coastal aquaculture

Shrimp farming

The black tiger shrimp industry in Viet Nam started in the 1980's when it was an undeveloped and low technology industry depending on wild shrimp seed for stocking and occasionally use of home made feed for feeding.

This is not the case in Vietnamese shrimp aquaculture today. The increase in culture area and the intensified production have lead to a strong demand for seed and the hatchery sector emerged creating a stable supply of seed. Also the development of industrial feed (based on mainly fish meal), improved management practices and new farming technologies have made the industry the most important export commodity in Vietnamese fisheries. However, despite this development the main production still comes from small-scale farms with improved extensive and semi-intensive production systems. These systems still account for 60% of the production (in volume), and the expansion of production has come largely from expansion of shrimp farming area, with limited improvements in technology for many farmers. The productivity of improved extensive, semi-intensive and intensive shrimp farming are around 0.25-0.30 tonnes/ha/crop, 2.5-3 tonnes/ha/crop and 5-7 tonnes/ha/crop, respectively (MOFI, 2005c).

Tiger shrimp is by far the most important coastal aquaculture commodity in terms of tonnage, area and economic value. It has been the driving sector for the past two decades and it still receives high growth expectations. In 2005, about 600,000 ha were used for shrimp farming that produced about 325,000 tonnes of shrimp.

The Mekong river delta is considered as the most important region for development of aquaculture in Viet Nam, in term of both available areas that suitable for aquaculture farming and for production. This is especially the case with shrimp farming. This is due to favorable conditions such as the tropical climate, ecological conditions and a large potential area with suitable brackish water and soil conditions (Nien 2004).

While being a very important commodity there are several short-comings regarding low production risks and environmental impacts. Disease is endemic in some areas due to poor seed quality as well as self-pollution. Little attention and investment has been given to develop infrastructure to supply water and discharge effluents, an environmental protection. Other limitations are on man power, skilled staff and workers, short-comings in the administrative capacity to sustainably develop the sector, and the low educational level of aquaculture farmers.

In addition, growth for the sector to date has focused on reaching production targets rather than production efficiency targets. Production efficiency is essential if the industry is to achieve a competitive edge on the international markets and environmental investments will be one intervention to assist in reducing production risks and the image of the commodity.

Marine fish farming

In the past decade, farming of marine fish, mainly in cages located in sheltered coastal waters developed by small scale enterprises, has started to grow significantly. The businesses are typically single household investments, with households having from 5 to 50 cages depending on wealth and credit worthiness. Recently, some larger businesses have developed with foreign investment, but small-scale farmers still dominate this sector. The main marine fish species cultured are cobia, grouper, sea bass and red drum, the latter an exotic species from the United States.

MOFI has very high growth expectation for marine fish cage farming, due to the high prices received for the products produced. In 2001, the annual production was estimated to around 5,000 tonnes and expectations for 2010 are between 200,000 to 300,000 tonnes. This will require considerable investments in hatcheries and grow-out facilities and will undoubtedly have a significant environmental impact unless improved environmental management practices are adopted. Due to the environmental "open-access" culture conditions with this type of farming it is essential that careful site selection is made and improved management are adopted in order to minimize wastes. The main locations for culture are in the Northern and Central regions (Table 4)

Table 4 Production figures from most important marine fish farming provinces

Provinces	**Production (tonnes)**	**Number of Cages**
Total national production	3 510	16 319
Quang Ninh	1 300	5 700
Hai Phong	1 200	6 000

Mollusk farming

Several species of mollusk are cultured in Viet Nam and development of the community receives high development priority within the fisheries sector. In 2005, the total production of was reported to be 185,000 tonnes and 2010 annual production targets are in the range 380,000 - 500,000 tonnes.

From an environmental point of view there is great scope for developing mollusk culture in nutrient rich areas, especially where nutrient loads originates from intensive aquaculture. Mollusk farms can act as nutrient extractors reducing the environmental impact of high polluting activities. This could be a good example of a positive environmental impact from aquaculture.

One of the main species cultured are hard clams of which there are three native species cultured in Viet Nam (Table 5). The species receives a good farm-gate-value and there is a high local demand for the product as well as a good international market for the species. Production is associated with very high productivities, typically between 10-40 tonnes/ha/yr. Culture is mainly conducted on sand/mud flats near the coast but can also be done in ponds, depending on the bottom substrate.

Table 5 Clam species and major culture provinces

Vietnamese name	**English name**	**Scientific name**	**Main culture areas (province)**
Ngheu Ben Tre	Hard Clam	*Meretrix lyrata*	Ben Tre, Tra Vinh, Tien Giang, , Soc Trang
Ngao dầu or ngao vạng	Asiatic Hard Clam	*Meretrix meretrix*	Nghe An, Thanh Hoa, Thai Binh, Nam Dịnh, Ben Tre, Tien Giang.
Ngao Vân	Poker Chip Venus	*Meretrix lusoria*	Nghe An

In the North a shift from the local Asiatic Hard Clam to the Hard Clam (native to Southern Viet Nam) was made in 1998 and the species currently represents around 90% of total clam production in one of the major Northern clam producing province Nam Dinh.

Lobster farming

Lobsters are a native species of Viet Nam and farming began in 1988-1990 when fishermen caught small lobster juveniles in central Viet Nam. Since 1992, lobster farming has grown rapidly; for

example in 1992 there were a few cages in Song Cau district, Phu Yen province but by 2000 the number of cages reached 7,500. The main culture region is in Central Viet Nam which accounts for more than 99% of the production. The production figures in the main provinces are given below in

Table 6.

Table 6 Lobster production (tonnes) in Viet Nam during 2005 and planned 2010 production

Region/Province	**2005**	**Planned**	**Total cages**
North (Total)	0.3		
Quang Ninh	0.3		30
Central (Total)	1,795		
Khanh Hoa	1,000		15,000
Phu Yen	750		15,000
Ninh Thuan	45		450
Binh Dinh	0		
Quang Ngai	0		
National (Total)	1,795.3	2,000.0	43,516

Note: Binh Dinh and Quang Ngai are nursing juveniles, so do not contribute to production volume.

Lobsters are high valued species and generally regarded as less disease prone than tiger shrimp. However, as farming has expanded so have the disease problems and in recent years lobster mortalities have been recorded in Nha Trang Bay and Phu Yen provinces, with unknown causative agents. Due to the high feed inputs and low feed utilization lobster farming has experienced conflict with the tourist sector in Nha Trang Bay where farmers were forced to move in order to avoid further environmental degradation.

Binh Dinh province supplies the majority of wild lobster juveniles with an annual production of 600,000-800,000 seeds per year for on-growing. The dependency on wild seed is considered a major constraint to further development of the commodity.

There are no specific production zones defined in the Master Plan 2005-2010 but the Central region is considered to provide the best ecological conditions and thus expansion would be expected in this region.

Seaweed farming

Seaweed has been cultured in Viet Nam since the early 1990's mainly in the Northern provinces Hai Phong and Thai Binh, and in the Central provinces Ninh Thuan, Phu Yen and Khanh Hoa. The two dominant species cultured are *Gracilaria* in the northern region and *Kapaphycus alvarezii* in the central region. *Kapaphycus* is an exotic species which was introduced into Viet Nam in 1993. The production figures for 2005 can be found in Table 7.

Despite rapid development of seaweed culture in the central provinces and high productivity in Northern provinces, further development of seaweed culture isn't included in the Master Plan 2006-2010. This may be because of it relative low farm-gate-value and export value. However, seaweed is considered a highly suitable business venture for poorer communities, due to its low investment cost and low risk, and thus could be promoted in line with the SAPA strategy. Also the culture of seaweed is a net remover of nutrients and could therefore contribute a positive environmental impact.

Table 7 Seaweed production in Viet Nam 2005

Province	**2005 production (tonnes of dry product)**	**Main water areas used for seaweed farming**

Hai Phong	12,700	Brackish water in estuaries
Ninh Thuan	1,285	Lagoon, and open sea
Khanh Hoa	1,310	Open sea

1.2.4 Summary

The aquaculture sector in Viet Nam is expanding, but is at a cross-road where it will have to strengthen environmental management if production targets are to be achieved. In terms of existing areas where pollution has caused environmental degradation and self-pollution there is a need to invest in cleaner technology, infrastructure, ecosystem restoration and utilize production inputs more efficiently. In the few remaining "virgin" culture areas it is essential that environmentally sound planning is made prior to development of the sector.

Aquaculture has a great potential to be developed further and for improving the livelihoods of inland and coastal communities by increasing household incomes and creating job opportunities. Furthermore, there is still great potential for further expansion of coastal aquaculture in the country, and the government is giving high priority to the future development of marine fish farming. Freshwater aquaculture has excellent potential as an alternative source of income and nutrition in remote mountainous areas.

The next sections of this guideline provide a more detailed picture of the diversity of aquaculture systems in Viet Nam, an assessment of their present and potential impacts on the environment and better management practices to support future development.

1.3 Environmental assessment of aquaculture

The information generated through the commodity case studies, and various consultations provide an assessment of the key environmental issues that have to be addressed, and challenges facing Viet Nam's aquaculture industry. The key issues emerging from the commodity cases are summarized below, with reference to individual commodity case studies with examples where appropriate.

1.3.1 Overview

Environmental issues in aquaculture arise because aquaculture relies heavily on environmental "goods" (e.g. water, feed ingredients, seed *etc*) and "services" (e.g. coastal ecosystems for pond water discharge). Interactions between aquaculture and the environment are affected by various interrelated factors including availability, amount and quality of resources utilized, type of species cultured, size of farm, farming systems design and management, and environmental characteristics at the location of the farm. Major issues are:

- Aquaculture in general is highly sensitive to adverse environmental changes (*e.g.*, water quality, seed and feed quality), and can be seriously affected by aquatic pollution
- Aquaculture inevitably interacts with stakeholders not directly involved in aquaculture that rely on similar "common" resources such as water and public land and conflicts may arise where formal and informal institutional/legal/social structures are inadequate for conflict resolution and allocation of resources among competing groups.
- It is in the long-term interests of farmers working with aquaculture to work towards protection and enhancement of environmental quality. This issue raises interesting possibilities for aquaculture farmers to work in partnership with communities and other

groups with a mutual interest in protection of aquatic environments using community-based or co-management arrangements.

The main environmental interactions of aquaculture globally are now well known, due to impacts of environmental change ***on*** aquaculture; ***of*** aquaculture on the environment; and impacts ***of*** aquaculture ***on*** aquaculture. Major environmental issues include:

- Impacts of environmental change on aquaculture operations
- Ecological consequences of conversion and changes in natural habitats, such as mangroves, associated with construction of aquaculture farms and associated infrastructure
- Biodiversity issues primarily arising from collection of broodstock and wild seed, and escape of farmed animals
- Over-harvesting of wild fish for farm feed, and related net loss of overall fish protein (biomass) at national, regional and international scales
- Trans-boundary movements concerning spread of genetic materials, exotic species and disease causing pathogens
- Discharge of aquaculture farm effluent leading to water pollution in farming and coastal areas
- Seepage and discharge of saline pond water that may cause salinity changes in of groundwater and surrounding agricultural land
- Use of trashfish or fish meal and fish oil in aquaculture diets
- Improper use of chemicals and drugs raising health and environmental concerns
- Spread of aquatic animal diseases
- Human health and food safety issues

An important issue also relates to the *efficiency* of use of resources in aquaculture, compared to other alternate or competing resource users.

As shown in the commodity case studies, and summarised below, the extent and significance of environmental interactions is highly variable, depending on farming system, location, economic and social factors and other incentives and disincentives. Although this makes it difficult to generalize, the commodity cases do provide examples of better management and farming systems that have reduced environmental impact and better efficiency. One of the features of the diverse aquaculture sector is that there is opportunity to considerably improve farming practice to address environmental impacts, in ways that are profitable. The following summarizes the major issues.

1.3.2 Impacts of environmental change on aquaculture

The Vietnamese economy has been developing rapidly in recent years. In line with this development, environmental issues have emerged and environmental awareness has increased. Whilst the vulnerability of aquaculture varies considerably from place to place, and farming systems, the case studies highlight several major threats for the sustainable development of the Vietnamese aquaculture sector caused by environmental change. Recent assessments of land-based pollution in Viet Nam (MONRE, 2005a) identify a number of pollution source and hot-spots as well as sensitive and high risk areas that are significant for Vietnamese aquaculture.

Population and urbanization

Coastal provinces of Viet Nam comprise 41.30% of total land areas and contain 51.70% of the total population; the latter is considered as a major pollution source, especially impacting coastal water quality. The largest coastal cities are: Ha Long, Hai Phong, Da Nang, Nha Trang, Qui Nhon, and Vung Tau. These cities include aquaculture in their development plans, even though the urban pressure for land is high. Effluent discharge from large cities already has a major adverse affect on Vietnamese aquaculture, both in terms of effluent discharge and land use conflicts such as urban expansion and encroachment of land based activities into the sea. In Hai Phong, for example, it seems unlikely that the seaweed farming can sustain in future. Although peri-urban aquaculture, such as in the district of Tranh Tri around Hanoi, has contributed to providing sources of protein and vegetables to cities, these systems may gradually disappear in view of the increasing food safety concerns. From present trends, it seems unlikely that aquaculture can sustain further in these areas due to economic pressures for land use, and poor water quality.

Industrial development in coastal areas

Coastal areas are also major targets by Government for development of industry. Industrial parks and processing zones have been increasingly developed in coastal areas from Ha Long to Ho Chi Minh City. These zones benefit from proximity to estuaries and rivers. These locations however inevitably lead also to significant pollutant entering rivers and flowing into the sea. The commodity case studies identified several cases of water pollution, from industrial and urban waste, affecting aquaculture. Contamination of water resources is associated with a range of industrial sectors such as ship building, food processing, mining, production of chemical and fertilizer, steel making, oil refining, and others. Pollution is made worse due to discharge of industrial and urban effluents directly into canals and rivers without treatment, causing surface water pollution as well as downstream pollution of coastal water bodies (MONRE, 2005a). As a great deal of aquaculture production in Viet Nam is conducted in coastal areas, particularly near the industrial and urban centres in the Red river in the north and Mekong river in the South, it appears obvious that industrialization poses a major risk to the sustainable development of aquaculture, unless environmental laws for industry and urban effluents are strictly applied.

Oil spills and maritime transport

The number of recorded oil spills has been rising over the years due to the increase in maritime transport (MONRE, 2005a). Oil pollution arises from navigation activities and port operation, vessel refitting and other activities related to use the oil and chemicals. Land based sources provide the largest amount of oil polluting marine and coastal water bodies. The estimation of oil and oil products entering Viet Nam marine water was 17,650 tonnes per year in 1995, and is expected to have increased significantly since then (MONRE, 2005a). Oil spills are considered as the biggest threat to the aquatic ecosystem and the aquaculture sector in nearby areas.

Pollution hot-spots

The Country Report on Land-based pollution in Viet Nam identified also water pollution “hot-spots”. These are places in which the above activities exert a particularly strong pressure on the environment. Interestingly, these are also major aquaculture production areas and this overlapping between industrial and aquaculture areas is likely to increase if the plans for industrial sector development are implemented (MONRE, 2005a).

Ha Long bay and Hai Phong

Coal mining in Ha Long Bay is responsible for several environmental issues impacting on the aquaculture sector. These include: loss of shoreline habitat, nearshore and offshore declines in water quality due to surface water contamination, contamination of bottom sediment, damage to important biological resources such as coral reefs, sea grass beds, spawning ground for fish and other aquatic species. The industrial sector of Ha Long is also responsible for environmental degradation. Industries discharge 22,000,000 m^3 of waste water per year with large impacts on water quality in terms of BOD, COD, TSS, T-N, T-P, heavy metal, pesticides, chemical and fertilizers, oil and grease (MONRE, 2005b).

Hai Phong faces similar problems. It is the third biggest city of Viet Nam and a place where the combined effect of several types of industries and high population is responsible for an estimated waste water discharge of 19 million m^3 per year.

Ha Long bay and Hai Phong represent the biggest production of aquaculture in the northern provinces for finfish marine cage, shrimp farming and seaweed culture. The fact that this area is considered a hot-spot for environmental pollution indeed raises several concerns.

Da Nang – Dung Quat areas

Da Nang is the fourth biggest city of Viet Nam and Dung Quat is planned to be developed as an industrial park which will include also an oil refinery. Da Nang Bay currently receives an estimated 117.5 million m^3 of waste water a year and is estimated to receive 144 million m^3 waste water a year by 2010. Such levels of pollution clearly pose significant threats to local as well as neighboring coastal water bodies.

Vung Tau City and Ganh Rai estuary

These areas have also been categorized as a hot spot of pollution. This is due mainly to the increased oil exploitation and tourist development as well as the fact that this area is a primary recipient for the Sai Gon and Dong Nai river flows, which are both heavily contaminated by the industrial sector and urban development.

Other sensitive and high risk areas

In addition to the above areas, the Red river delta and Mekong river Delta and also categorized as sensitive and high risk areas.

The Red river delta stretches from Hai Phong to Ninh Binh with two river systems: Thai Binh and Bach Dang. These systems are a vehicle for contaminants to coastal zones and cause significant threats to the aquaculture sector in the Northern provinces. Heavy metals such as copper and zinc are above allowable limits in the Red river mouth (MOSTE, 1995). The Red river delta, especially Nam Dinh province, is also a key area for clam culture and the threat for contamination of these bivalve organisms and the resulting human health threat would seem to be significant. Increased monitoring of these areas is needed to ensure product quality.

The Mekong river stretches over a large area along the coastline from Ca Mau Cape to Ho Chi Minh City. This area contains coastal mangrove forests which are considered ecologically sensitive with a biodiversity that has sustained for centuries native shrimp species and a high quatic productivity in the delta. Among other sources of pollution, the industrial park of Gases – Power Generator – Fertilizer which is currently under construction in Ca Mau will represent a significant threat to aquaculture in the delta, which is responsible for most of the shrimp production and value in the whole country. In fact, this kind of enterprise is considered as high risk for environmental impact because of the chances of pollution associated with the operation of the pipeline system which will be used to transfer gases from offshore crude oil exploitation located in the South China Sea.

Resource limitations

Beside these environmental threats, increasing limitations on natural resources have also been shown in the commodity case studies to be impacting the aquaculture sector. One of the major concerns emerging from the freshwater studies, and some coastal pond farms, is freshwater shortage, which has been used for salinity control in shrimp ponds in the provinces of central Viet Nam.

The implications of these environmental impacts, especially because highly polluted areas are often also major aquaculture producing zones, are considerable. The increasing trend of environmental contamination and simultaneously increasing targets for aquaculture production in affected areas are bound to exacerbate the negative impacts on aquaculture. This situation poses management challenges at all levels, from farm to central Government, and involvement of a wide range of stakeholders from both the public (fisheries and environmental institutions alike) and private sector.

1.3.3 Environmental impacts of aquaculture

In addition to the implications being posed by environmental change on aquaculture, the commodity case studies show significant environmental implications caused by aquaculture itself. The commodity case studies have highlighted a number of major environmental issues which are assessed below.

Farm location in relation to habitats and other resource users

The sites selected for aquaculture and the habitat at the farm location play one of the most important roles in the environmental and social interactions of aquaculture. Although this is most commonly a problem in coastal aquaculture, this is a common issue across the aquaculture sector.

There are numerous examples of farms located in suitable areas, which cause few or no environmental problems. Conversely, there are many examples across all aquaculture commodities of poorly sited farms, for example shrimp farms located in mangrove areas or sandy areas that have clearly damaged mangrove, mud flats, salt marshes, freshwater supplies and natural resources.

Shrimp farming clearly exemplifies the environmental impact of poor siting. The impact of siting shrimp farms in mangrove areas has been widely recognized and, in Viet Nam, it affected wide areas from Quang Ninh and Hai Phong to Khanh Hoa and in the Mekong delta in Soc Trang, Bac Lieu and Ca Mau provinces. Destruction of mangrove areas and other environmental impacts associated with siting of shrimp ponds are primarily due to poor planning of the sector's development. In central provinces such as Ninh Thuan and Binh Thuan, the siting of shrimp ponds in sandy soil areas also led to several adverse effects such as groundwater shortage, salinity intrusion, water pollution and, in turn, self-pollution resulting in disease outbreaks and economic losses. This year, news coverage within Viet Nam highlighted how siting of farms in sandy soil shifted from being a success story for poverty alleviation in earlier years to being responsible for crop failures, abandonment of farms and heavy farmers debt. Sandy-soil shrimp farming in other provinces such as Quang Binh, Nghe An and Ha Tinh was also developed without careful consideration of the carrying capacity of fresh water resources. Lesson learnt form Ninh Thuan should be disseminated to other shrimp farming provinces to avoid similar negative impact and encourage the development of careful aquaculture plans or the introduction of corrective measures in a timely manner.

Poor planning and consequently, siting of aquaculture farms is increasingly affecting the production of other aquaculture commodities. Marine finfish cage farming in Cat Ba – Hai Phong has been causing deterioration of water quality also offsite. According to the marine fish study, in Benbeo gulf (where Catba Island is located) and Vungoan Gulf (containing Halong bay) the contamination by organic and inorganic wastes from cage farming is increasing significantly because of the increasing number of cages. Phytoplankton blooms in Vungoan Gulf, including 28 kinds of toxic algae, and nutrients such as NO^{2-}, NO^{3-} and PO_4^{3-} in water or sediment reach high amounts around marine fish cages. This often leads to disease outbreaks within the cages with obvious economic losses. Poor siting of marine cages has not only effected on water quality but also led to conflicts with other sectors such as tourism (Ha Long Bay is a UNESCO World Heritage site), navigation and fishing.

Inland aquaculture is not immune from the negative impacts of poor planning and siting of farms. The large production of catfish in ponds has yet to be regulated by aquaculture plans, resulting in farms being sometimes located in proximity of markets and land based pollution sources. Although zoning regulations had been issued for cage catfish culture, poor implementation of those plans by farmers led to high density of cages in some areas and consequently to high levels of water pollution and obstruction to navigation and fishing.

Fish and shrimp seed

The need for seed and broodstock to support the rapid growth of the Vietnamese aquaculture sector raises several concerns.

The high pressure for *P.monodon* broodstock led prices to climb to levels of several hundred dollars per shrimp female. As a consequence, hatcheries often conduct multiple spawning and multiple mating, leading to poor quality of the seed produced and affecting seed performance in farms. The trend towards overexploitation of tiger shrimp broodstock resembles the one of lobster seed harvests. Also in this case, poor availability led prices to climb. These increases in price often lead also to increased fishing pressure because of the potentially high revenues, further depleting natural resources.

Although it is difficult to assess with a reasonable degree of accuracy the size of wild broodstock reserves, circumstantial evidence indicates that the increased fishing pressure to satisfy the demand from the aquaculture sector is leading to a decline in the numbers of wild seed of shrimp.

This chain of increased fishing pressure, increased prices, overexploitation of broodstock in hatcheries and poor performance in farms represents a vicious cycle which threatens the sustainability of the whole shrimp farming sector, unless the industry can move to domesticated (farmed) sources of broodstock.

The common practice of harvesting wild seed to sustain marine aquaculture also appears to be poorly sustainable from an environmental point of view. The wild seed stocks have been depleted in recent year, with daily harvests by fishermen decreasing from 100 to 10-20 fingerlings/day in Cat Ba and Ha Long marine areas. At present, hatchery production for marine fish seed is still low, while grouper and cobia seed does not meet demand, not only increasing pressure on natural resources, but also inducing farmers to import seed from China, with consequences associated with the risk of pathogen introductions.

Clam farming, which by and large exerts a positive effect on the environment, is also exerting a negative impact on the environment when the use of wild seed is considered. In fact, use of wild clam seed is likely to be of increasing concern unless hatchery production of clam seed is not developed further. This would be highly unfortunate since mollusk culture has huge potential for alleviating poverty among coastal communities in a generally environmentally-friendly manner and the technology for clam seed hatchery production is available.

Water resource use and quality

Most Vietnamese aquaculture systems are still heavily reliant on large amounts of water. For example, closed shrimp farming systems are not yet as widespread as in other countries (e.g. Thailand) and water is still exchanged in abundance. Heavy water exchange allows the adoption of feeding practices which generate large amounts of wastes, self pollution and health problems, ultimately causing financial losses to farmers.

Eutrophication of water resources is not only a problem of coastal and marine aquaculture. Heavily fed catfish ponds in areas with high farm density can lead to high amount of nutrients being discharged in the environment.

Eutrophication of surrounding marine ecosystems due to excess feeds may lead to algal blooms due to excessive nitrogen and phosphorus present, sediment enrichment and anoxia below and in the vicinity of cages and poor water quality due to waste build up. The blooming of phytoplankton can lead to the proliferation of toxic algae (as in the case of marine fish culture in Vungoan Gulf) which may develop into red tides, which, as in the case of Cat Ba island, with a boomerang effect negatively affect cage farming (Nguyen et al, 2004). Organic matter and N and P nutrients are known to accumulate in sediments around cages. Following several years of activity it appears as if marine cage farming has increased the amount of waste sediment of about 3 - 5 cm, negatively affecting the marine environment in those areas (Long, 2006). The deterioration of the water quality caused by lobster farming has led to higher levels of NH_3 and H_2S in the lower layer of the water column and in the benthos and this is considered as the major causative agent for the increased mortality observed in recent years (i.e. since 2001).

Water pollution leads also increased conflicts between resource users, even within the aquaculture sector itself. In fact, lobster farmers in Khanh Hoa perceive that the effluent of shrimp farms is also responsible for the degradation of the environment and for lobster mortality.

In addition to water pollution, the unsustainable exploitation of water resource has also negative impacts on the environment and other resource users. The exploitation of groundwater in the central provinces for salinity control in sandy soil shrimp farming had a serious adverse impact on other sectors (e.g. tourism) and is threatening the livelihood of communities residing along the coastline by limiting freshwater availability for household consumption and agriculture. In fact, groundwater bodies are extremely fragile and highly prone to seawater contamination. Salinity intrusion is an irreversible consequence of poor groundwater management and has undoubtedly serious social impacts.

Feeds and feed management

Although extensive farming of commodities such as mollusks and seaweed has a positive environmental impact associated with their feeding, feeding of some aquaculture species is still a major concern for sustainability of the sector.

In spite of feed being the most expensive input of most aquaculture systems, over-feeding is still a common practice in many Vietnamese farming systems and is often responsible for the deterioration of the environment surrounding farms, health problems and financial losses. Overfeeding is often due to the poor technical knowledge of farmers, especially in small scale enterprises, which are also the more important from a poverty alleviation perspective.

The use of trashfish is also a major concern from the environmental point of view. The low cost of this kind of feed makes it very popular for marine fish farming and often induces farmers to overfeed their crops, consequently generating high levels of water pollution. In addition, trashfish is made of a combination of species of different age classes, including early development stages of several aquatic organisms. The use of trashfish is therefore bound to be associated with depletion of natural resources. This situation is clearly not sustainable and finding replacements for trashfish is a priority for the sustainability of the mariculture sector.

It is well-documented that antimicrobials used as feed additives will pose a pressure for development of resistance among natural occurring microorganisms when excessive feed and/or fish faeces containing antimicrobials are released and accumulated in the environment. Any such resistance development represents a potential risk to food safety and for the development of resistant pathogens.

Resource use efficiency

In a context in which the aquaculture sector will continue to expand very rapidly while many of the resources used are limited, the efficient use of those resources is of paramount importance. In general most aquaculture systems seem to operate below optimal efficiency, mainly owing to poor management practices.

For example, it appears clear that the expansion of land is largely responsible for the rapid growth in shrimp production observed in recent years, while increase in efficiency of land use played only a minor role. High amounts of often poor quality seed are used, making survival and performance poor therefore pressing towards higher demand of seed. Because of limited assessment of the amounts of uneaten feed and the possibility to improve water quality through water exchange, farmers often prefer overfeeding.

The commodity studies highlighted also that some farming systems are more efficient than others. Because of the relatively limited inputs, freshwater pond systems are generally operated in a rather efficient manner. Polyculture and integrated systems confirmed their potential for effective use of resource and removal of water nutrient to reduce environmental treatment.

Seaweed farming and integrated mariculture also appeared to present a great potential for efficient use of resources. *Kapaphycus* culture integrated with lobster farming in Khanh Hoa province and Dam Nai lagoon where effluent from shrimp pond are received appeared to be successful. Culturing *Glacilaria* in rotation to shrimp in Hai Phong also appeared to be successful. Polyculture of brackishwater systems with sea bass, tilapia and seaweed is also becoming increasingly popular in Hai Phong and offer a great potential for poverty alleviation, provided marketing issues are carefully considered.

Aquatic animal health and genetic pollution

Aquatic animal health problems appeared to be one of the most direct and damaging consequences from environmental deteriorations. Health problems associated with a negative effect on the environment can be generated through a range of mechanisms.

Water pollution and degradation of water quality is a significant source of problems. Experience from the production of several commodities (e.g. shrimp, catfish, marine fish, lobsters) show that excessive amounts of NH^3 and high levels of organic matter lead to the occurrence of diseases caused by opportunistic bacteria (e.g. *Vibrio* sp., *Aeromonas* sp., etc). In addition, poor water quality has sometimes been linked also to viral diseases such as white spot disease of shrimp.

Excessive water use and lack of recirculation exposes the farming system to the introduction of pathogens present in the water or within carriers. This is particularly of concern in areas with a high density of farms, where the transmission of infectious diseases between farms and the consequent propagation of epidemics has been observed on several occasions.

Use of wild seed and broodstock can also lead to the introduction in the farming system of several pathogens. Although testing of the fished stocks could be performed, use of domesticate animals (when available) is by far preferable. Through a similar mechanism, the use of unprocessed trashfish may open the gate to the introduction of a wide range of pathogens into the farming systems.

Aquatic anima health problems cause enormous losses to Vietnamese farmers and have led to the development of so-called “Better management practices” or “Good aquaculture practices” (BMP/GAP) approaches by both the public and private sectors alike.

The irresponsible transboudary movement of aquatic animals for aquaculture is a further issue, including both the introduction of exotic species and the movement of already existing species across boundaries that has led to the occurrence of disease outbreaks such as Taura Syndrome in shrimp and VNN in marine fish.

Similar considerations also apply to the contamination of genetic pools. In Viet Nam, the effect of escapees on wild stocks has yet to be properly assessed. However, because of the many uncontrolled transboundary movements and the frequent occurrence of escapees because of poor farming practices or in response to disease outbreaks in early stages of production, the impact on the endemic genetic pool is likely to be significant.

Food safety and chemicals

There are two food safety issues to be dealt with at the pre-harvest level; namely chemical and biological. The chemical risk is associated with chemicals applied to the aquaculture production and the biological is associated with bacteria and parasites that can be transferred to humans from the seafood products.

Interviewing local authorities and farmers leads to the conclusion that high amounts of chemical and drugs have been used especially in shrimp and catfish farming. Occasionally, banned chemicals and drugs such as chloramphenicol, nitrofurans and malachite green have been used, with huge repercussions from a marketing point of view. Although data from the first months of 2006 would seem to indicate a downward trend, data from 2003 to 2005 on exports to several countries show an increase in the number of batches rejected because of banned chemicals (see Table 8). A similar picture can be observed when looking at microbiological contamination.

Table 8 Number of rejected batches of fisheries products by key importing countries

Country(ies) rejecting	Category of contamination	2002	2003	2004	2005
EU	Chemical	49	10	24	46
	Microbiological	10	9	15	39
USA	Chemical	1	0	6	17
	Microbiological	18	41	25	29
Canada	Chemical	7	1	15	54
	Microbiological	23	16	17	12
Korea	Chemical	0	0	6	7
	Microbiological	3	3	1	11
TOTAL		**111**	**80**	**109**	**215**

In addition to food safety risks associated with consumption of products containing antimicrobial residues, it is likely that importing countries in the near future will begin screening imported foods for presence and levels of resistant bactera (total bacteria and specific pathogens). Importing authorities and countries will also argue that such measures and subsequent rejections are taken to protect the health of their consumers.

Increasing research-based evidence in Viet Nam show that different types of zoonotic trematode parasites occur widespread in mainly freshwater fish species, but to some (magnitude still unknown) extent also in brackish water species. This group of parasites is of particular importance to the health of south-east Asian peoples as they are associated with different types of liver cancer. Humans are infected when consuming raw or otherwise inadequately prepare dishes. Currently, parasitological examination of organisms produced in aquaculture are mainly done by visual inspection, e.g. of fillets. However, with an anticipated increase in the export of fresh and live aquatic organisms, it is likely that importing authorities will begin testing imported foods for presence of this group of parasites.

This general upward trend in chemical residue findings and microbiological-associated safety issues can be due to several reasons, such as increased amount exported or more stringent import requirements. However, it also indicates that these issues have indeed to be seriously addressed and there are strong signals from MOFI/NAFIQAVED that action has been taken in this regard.

Food safety issues rise also from the contamination of filter-feeders mollusks which filter large volumes of water daily to obtain food. Any pathogen present in such water will be accumulated in the mollusks. Food safety concerns are particular high for mollusks consumed raw or inadequately heat treated. Mollusk culture is often located in areas (e.g. coastal) of high feacal and chemical pollution mainly through discharge of wastewater from urban and industrial areas. Although it is true that Viet Nam can export mollusks to the EU, food safety concerns are yet preventing the EU to allow the importation of live bivalve mollusks from Viet Nam, while similar permits have already been granted to other countries such as Thailand, Malaysia and Indonesia (Deboyser, 2006), depriving Viet Nam from huge market opportunities.

Social benefits and poverty alleviation

In spite of the several environmental concerns highlighted, this study confirms the huge potential for poverty alleviation of the aquaculture sector.

Poverty alleviation can be achieved through 3 main mechanisms:
- providing revenues to aquaculture farmers, especially when crops target the export market
- generating affordable sources of protein for consumption within and outside the farming household
- generating labor opportunities for extremely poor households

In 2005, export revenues from the fisheries sector reached US$ 2.65 billion. Of these, US$ 1.3 billion were generated by the shrimp sector in which small scale producers play a very important role making up to about ¾ of the total shrimp aquaculture production. Catfish farming also contributed significantly to export revenues, with a total of US$ 320 million being generated in 2005 (MOFI 2005c). Because of the importance of the aquaculture sector to generate revenues, at present primarily through export but increasingly also from domestic consumers, it is of paramount importance that the farm abandonment observed in some cases because of poor siting and management are avoided in the future. In addition, credit schemes should be made available to small scale producers to allow proper investment and avoiding of marketing problems such as off-flavor of catfish associated with improper feeding practices.

Although the capability of the shrimp and catfish farming sectors to earn foreign currency are largely exploited, the export of mollusks and seaweed has still a huge potential for further development provided that the necessary seed inputs are sustainably generated and food safety and marketing issues are carefully taken into account, so that the problems associated with low farm-gate prices faced by seaweed farmers in Hai Phong can be prevented.

The production of freshwater fish for domestic consumption contributed significantly to providing affordable sources of protein to rural communities. So far, food safety seems mainly to have been an issue of concern in relation to exported products and less a concern in relation to production and consumption nationally. In general, but also because of the steady increase in national consumption of aquaculture products, food safety of products consumed nationally should receive more attention.

The aquaculture sector has also not only been a major provider of labour, giving employment to over 2 million people (MOFI 2006b), but it is also suitable for providing alternative income generation for communities affected by the establishment of Marine Protected Areas.

Although aquaculture has been proven to be capable of providing social benefits and poverty alleviation, the sector has still addressed the social conflicts with other resource users and between farmers of different commodities. Salination of groundwater and freshwater resources has led to severe impacts on agricultural farmers and on rural communities in general. Poor location of cages created conflicts the tourism, navigation and fishing sectors. Within the aquaculture sector, lobster farmers hold shrimp farmer responsible for the increasingly frequent outbreaks of lobster mortality. All the above concerns should be addressed through the development of comprehensive plans and adopting a combination of community-based and co-management approaches to resource use.

1.3.4 Costs of environmental problems

The costs associated with negative impact on aquaculture productions associated with the poor aquatic environments but also negative impact of the aquaculture on such environments appears highly significant, providing significant economic incentives for change.

On average about 25-30% of shrimp farmers of Viet Nam experience crop failures every year (Sinh, 2004). Pollution of water resources by shrimp farms resulted in self-pollution of farms and disease outbreaks which in provinces like Khanh Hoa led to the abandonment of 70-80% of ponds in 2006, an increase of 50% compared to 2005. In the Mekong delta more than 60% of shrimp farming households was indebted from loan, with an average debt of more than 20 VND millions per household (Sinh, 2005). The cost of chemicals, including antimicrobials, to prevent and treat shrimp diseases average 14-15% of total production costs in semi-intensive and intensive shrimp farms in the Mekong delta.

Although catfish farming has been affected by marketing issues, environmental impacts such as water pollution also hinder the sector. In 2006, 1200 cages were abandoned in An Giang according to an announcement from the An Giang People’s Committees.

Marine fish farming has yet to experience similar dramatic scenarios, although the first signs of the negative environmental impact are starting to show, with more than a third of the farmers being interviewed encountering economic losses. In addition, looking at the targets set for the exploitation of this sector, having reached only less than 2% of the production expected in 2010, it would appear that marine fish will be the next on this line of environmental and socio economical impacts.

1.3.5 Outlook to 2010

In view of the above impacts and costs, it is important that environmental issues are properly addressed if the ambitious targets set by VietNam are to be reached in a sustainable manner.

Table 9 below reports some of the inputs and environmental costs that will be experienced to comply with the MOFI “conservative” targets for 2010.

Table 9 Expected inputs required and wastes produced by main aquaculture commodities in 2010

Indicators	**Unit**	**Shrimp**	**Marine fish**	**Mollusk**
Expected production	tonnes	400,000	200,000	380,000
Seed requirement	Mill. seed/year	62,265	400	11,000
FCR		1.5	13.6	
Feed (trash fish for marine fish)	tonnes/year	600,000	2,720,000	
Waste				
Aquatic pollution				
Nitrogen	tonnes/year	15,960		
Phosphorus	tonnes/year	1,120		
Solid waste				
Nitrogen	tonnes/year	14,160		
Phosphorus	tonnes/year	9,100		
Organic mater	tonnes/year	491.52		
Waste water discharge	$1000m^3$/ year	2,601,021		

Shrimp

According to the Master Plan, in 2010 the shrimp sector will require 35,000 million post-larvae. However, intensive shrimp farming has been stocking up to 60 PL/m^2 in some locations. By performing the calculation using stocking densities derived from farmers interviews, i.e. 40 PL/m^2, 20 PL/m^2 and 10 PL/m^2 for intensive, semi-intensive and extensive respectively resulted in a total demand for 62,265 million seed. This figure is nearly double of the one reported in the Master Plan and gives an insight in the amount of broodstock that might be needed to sustain this growth.

The total amount of nutrients discharged in 2010 is estimated as 15,960 tonnes/year of nitrogen, 1,120 tonnes/year of phosphorus and 2,601 million m^3 of waste water. In addition, more than 23,000 tonnes/year of nitrogen and phosphorus contained in solid wastes would also be released to the environment unless proper sludge treatment is conducted.

Marine cage

Looking at the present situation, the target set for marine fish production in 2010 appears to be rather unrealistic, unless action to respond sustainably to the needs of the sector is taken immediately. In fact, to comply with the expected production of 200,000 tonnes/year of marine fish, approximately 400 million seed would be required. This figure appears to be highly unrealistic in the present situation, since most of the seed at present comes from the wild and large scale hatchery marine fish seed production has yet to take off in Viet Nam.

The high need for trash fish to sustain marine fish production is another big environmental concern. If existing practices are not modified, figures generated through farmers interviews indicate that the total quantity of trash fish required to sustain the sector will be 2.7 million tons!

This is extremely unrealistic since the total fish production of Viet Nam is just above 1,5 million tons and it is expected to reach only 2 million tons in 2010[4].

Mollusk commodities

The major constraint in reaching the expected target for mollusk production is seed. It is expected that 11,000 million seed will be required in 2010, a value which, although little information is available on wild mollusk seed resources, would appear to be reachable only through the establishment of hatcheries in key locations. Environmental monitoring programs needs to be established ensuring that mollusks are only produced in areas with acceptable levels of chemical and faecal pollution.

[4] Report on Viet Nam Aquaculture Program, period 200-2005 years.

1.4 Better management of aquaculture

1.4.1 Introduction

Future growth of aquaculture in Viet Nam faces increasing environmental constraints, and requires vastly improved management. Whilst there are some differences between commodities and farming systems, the studies show the following key areas for better management of the sector:

- ***Farm siting and spatial planning***. Improving the siting and spatial planning for aquaculture in coastal areas. Locating farms in areas that make efficient use of land and water suitable for aquaculture production and conserves ecologically sensitive habitats and ecosystem functions. Integration of aquaculture into coastal management plans. However, there are few successes in spatial planning. Furthermore, most planning initiatives still follow the more centralized planning processes, and focus only on land allocation. The institutional aspects are usually ignored. In coastal areas, zones should be identified with infrastructure to support aquaculture on land and in the sea.

- ***Farm designs and construction practices*** that reduce or limit off-site ecological damage.

- ***Water management practices*** that make efficient use of water and minimize impacts on water resources.

- ***Seed supplies.*** Improving the quality and sustainability of seed supplies and reduced demand on wild stocks.

- ***Feeds and feeding.*** Feed types and feed management practices that make efficient use of feed resources, and ideally do not contribute to net loss of aquatic animal products.

- ***Aquatic animal disease control.*** Minimizing risks of disease affecting farmed and wild stocks.

- ***Food safety and quality*** Improving the quality and safety of aquaculture products and reduce risks to ecosystems and human health through prudent use of chemicals, including antimicrobials, and prevention and control of occurrence and transmission of pathogens (bacterial, viral and parasite). The quality and safety of foods will become increasingly important to remain competitive on domestic and international markets.

- ***Social benefits and employment.*** Developing and operating farms in a socially responsible and way that benefits local communities and the country. Contributing effectively to rural development, and particularly poverty alleviation.

The following sections identify the key management actions, together with institutional and legal requirements and adjustments required to support implementation of better management. The major issue of investing in institutional strengthening for environmental management of aquaculture in Viet Nam is addressed in more detail in the subsequent section. The present section also attempts to analyse the key sectoral management responses with reference to the following questions:

- What are the key better management approaches required?
- What are the system/commodity/geographical area specific differences?
- What are the impacts, benefits and costs of implementation?
- What are the key constraints to implementation and how can these be overcome?
- What should the state sector being doing to support implementation of better practice.

- What should the business sector being doing to support implementation of better practice.
- Special considerations for the small-scale farmer.

1.4.2 Farm location and spatial planning

Commodity reports show clearly that Viet Nam's aquaculture sector continuous to develop largely in the absence of harmonized and environment-sound spatial plans. There are increasing conflicts in use of resources, particularly in coastal areas. The needs for better management are most significant in coastal areas where following activities should be conducted to ensure the sustainability of the sector.

Most aquaculture plans are centrally driven, often focusing on spatial planning, or production targets. Substantial improvements are needed in preparing and regularly update national development strategies and plans for aquaculture, as the basis for promoting responsible management practices, equitable sharing of benefits and balanced use of natural resources in harmony with other coastal and inland activities. A participatory approach involving public and private sectors, and local communities, should be used to ensure the intended provisions are understood and to facilitate adoption by ensuring stakeholders have a role and responsibility in implementation.

Better management practices for coastal aquaculture emerging from the commodity studies include:

- Siting new aquaculture farms away from sensitive coastal habitats
- Ensuring access of other coastal resources is not restricted by farm development (eg fishers and others needing to access sea for boats and fishing)
- Ensuring no net loss of mangroves or other sensitive wetland habitats
- Ban on further development of farms on sandy soils or other areas where seepage or discharge of salt water may affect agricultural land or freshwater supplies
- Not locating new farms in areas that have already reached the carrying capacity
- Retaining buffer zones and habitat corridors between farms and other users and habitats
- Improving existing farms in inter-tidal and mangrove areas through mangrove restoration, retiring unproductive ponds and intensifying remaining farm areas above the inter-tidal zone.
- Initiating ecosystem restoration programs

In inland aquaculture, similar management practices should be employed to ensure that inland ponds and cages do not impact on freshwater wetlands.

Sectoral management

State sectoral management is important in supporting aquaculture farmers to culture products in suitable locations through more effective spatial planning, location of farms away from critical habitats and also areas not affected by other industry or urban development. Key supportive actions by the State include:

- Strengthening coastal planning and integration of aquaculture into coastal water and land use planning
- Establishing land use and other planning laws and coastal management plans in aquaculture farm siting
- Investing in restoring abandoned sandy soil aquaculture areas, and developing the area to other uses, including aquaculture, and potential tourism developments.
- In existing sandy soil aquaculture areas investigating the economic feasibility of developing infrastructure to supply fresh surface-water through irrigation.

- Encouraging the development of “aquaculture parks” with integration of different species to balance positive and negative environmental impacts
- Using the Fisheries Legislation as the basis, develop regulations to support better spatial planning and sectoral level
- Registration documents to be provide to all aquaculture farms in legal locations
- Awareness campaigns to ensure community awareness of links between pollution and natural resource
- Supporting Provincial level capacity building for coastal planning and enforcement to ensure sustainable development plans are designed and implemented at provincial and district level
- Facilitating the establishment of marine protected areas as in the Master Plan of MOFI
- Improving the cross-sectoral coordination in planning process
- Investment in infrastructure and institutions to support farming in suitable locations

1.4.3 Farming systems, design and construction

The commodity studies shows that considerable improvements in farming system design and construction of aquaculture farms can be made to minimize environmental impacts. With the increasing intensity and expansion of aquaculture operations evident in recent years, suitable design and construction techniques should be used when establishing new farms. Advantage should be taken of improved techniques for designing and constructing farms that take into account not only the requirements of the cultured animals and plants and the management of the farm, but also integrate the farm into the local environment whilst causing the minimum possible disturbance to the surrounding ecosystems.

Better management practices for coastal aquaculture emerging from the commodity studies include:

- Incorporating buffer areas and techniques and engineering practices that minimize erosion and salinisation during construction and operation
- Minimizing disturbance of acid-sulfate soils during construction and operation
- Conserving biodiversity and encouraging re-establishment of natural habitats in farm design
- Minimizing creation of degraded areas such as unused soil piles and borrow pits
- Designing dykes, canals and infrastructure in ways that do not adversely affect hydrology
- Separating effluent discharge points from inlet canal to reduce self pollution and maintain biosecurity
- Improving all round the efficiency of use of natural resources, such as feed, seed, water, energy, and reducing waste (including garbage) from aquaculture farms

Better management practices for inland aquaculture emerging from the commodity studies include:

- Encouraging integrated farming systems but with focus on food safety issues related to using organic fertilizer.
- Discouraging or banning use of “night soil” or identify sustainable ways of treatment to obtain safe waste products before use.
- Using traditional knowledge (VAC systems) together with better management practices to ensure high production and high quality
- Encouraging use of local species if possible
- Developing and focusing on species suitable to be produced in remote mountainous areas

Sectoral management

The State sector has an important role in supporting research and extension of information to the farming sector on farming system development, design and construction through communication and standard setting. Standard setting should not be too prescriptive, but farmers should be allowed to develop and design their farming systems according to local conditions.

Traditional farming systems such as the VAC system are highly efficient in recycling and efficient use of nutrients and organic matter. Incentives should be explored (eg organic products, “credits” for not polluting?) for promoting and encouraging such efficient systems.

In inland mountainous areas, investment in developing suitable farming systems and species for use in mountainous areas would help development in these areas.

1.4.4 Water resources and management

The commodity studies show that water quality is a major and common concern across the sector. Minimizing the use of new water is an essential part of modern, environmentally responsible aquaculture farming. Reducing water exchange benefits the farmer by lowering pumping costs and reducing the chance of introducing toxic compounds, pathogens, disease vectors or competitors into the farm. It also benefits the environment by reducing the discharge of nutrients and organic matter from the farms and by reducing the utilization of precious freshwater resources.

Recent innovations have shown that proper management protocols can reduce water use, even in highly intensive systems, with no loss in performance. This has benefits for all parties and should be encouraged at all levels.

Better management practices for use of water in aquaculture emerging from the commodity studies include:

- Not using fresh groundwater for salinity control in coastal aquaculture
- Using water efficiently through minimizing water abstraction
- Minimizing discharge of farm effluents and sediment to the environment
- Aiming to return water with lower concentrations of nutrients, organic matter and solids to the ecosystem than that taken out
- Incorporating settlement and sedimentation ponds into the water inlet and outlet designs
- Managing water quality to maintain suitable water quality conditions in the aquaculture ponds
- Balancing development of high polluting systems with pollution removing systems i.e. integrated systems, either with the farm, or local area, such as shrimp-balanced with mollusc and seaweed.

State sectoral management

State sectoral management has an important role in ensuring efficient use of water in aquaculture systems, as well as protecting aquaculture water resources from degradation caused by other sectors. These management actions include:

- Setting of regulations and standards on water use and effluent discharge for aquaculture
- Supporting aquaculture development planning and implementation within environmental capacity
- Ensure that environmental capacity and carrying capacity assessments are conducted prior to development of high polluting aquaculture

- Ensuring coordinated use of fresh surface water with other sectors
- Setting and enforcement of water quality standards for aquaculture areas
- Where the environmental carrying capacity has been exceed with intensive aquaculture, plan for developing mollusc, seaweed or other appropriate nutrient-uptake commodities
- Coordinate use of fresh surface water with other sectors
- Engage with other sectors and MONRE for reducing impacts of other sectors on environmental quality in aquaculture areas.

1.4.5 Seed supplies including introduction of exotic species

The commodity studies and projections show a significant need for improving the quality and sustainability of seed supplies and reducing demand on wild stocks throughout the sector. Where possible, domesticated selected stocks of disease free and/or resistant broodstock and post-larvae should be used to enhance biosecurity, reduce disease incidence and increase production, whilst reducing the demand for wild stocks.

Recent trends in aquaculture have seen a change towards the use of domesticated stocks of animals, following the current agricultural paradigm. Elimination of the need to source broodstock and/or post-larvae from the wild has allowed the industry to develop successful programmes for the enhancement of their aquaculture stocks, in terms of both their reproductive and production characteristics. It has also led to the development of some disease free and/or disease resistant stocks. Concomitantly, these developments have lead to reduced demands for wild stocks and hence reductions in unwanted by-catch and habitat losses involved with their collection. However, further work is required to achieve these advances for all currently cultured species in Viet Nam. The problems with transboundary movements of non-indigenous species which brought new threats of disease transmission and reduced biodiversity must be addressed.

Better management practices for aquaculture emerging from the commodity studies include:
- Avoiding collection of wild stocks to negative impacts on local biodiversity
- Avoiding use of wild caught post-larvae and fish fry
- Giving preference to local and indigenous species
- Adopting on-farm quarantine and biosecurity measures to reduce risks of disease introductions
- Using domesticated stocks wherever possible
- Stocking good quality post-larvae and fish fry to improve chances of successful harvest
- Complying with national, regional and international criteria controlling the movement and quarantine of animals
- Developing programs for release of hatchery reared stocks to conserve wild stocks.
- Implementing risk assessment, biosecurity protocols and include quarantine for introductions of new species and strains

State sectoral management

State sectoral management has an important role in supporting the supply of quality seed for aquaculture. The management options include:

- Continuing to invest in genetic programs for maintenance of genetic materials for freshwater aquaculture.
- Investing in hatchery production of molluscs and marine fish.
- Providing incentives and mechanisms for private sector investment in hatcheries for bivalve seed, grouper and cobia seed, and SPF *P.monodon* post-larvae
- Set and enforce standards for high quality seed production.

- Preparing and enforcing national regulations that comply with regional and international criteria for the movement and quarantine of aquatic animals and plants

1.4.6 Feeds and feed management

The commodity studies and projections show a significant need for addressing feed issues, and considerable efforts are needed to utilize feeds and feed management practices that make efficient use of available feed resources, promote efficient shrimp growth, minimize production and discharge of waste nutrients and organic materials.

Control and rationalization of feeds and feeding in modern aquaculture is of critical importance in maintaining a cost-effective and environmentally sound industry. This is due to many factors including: feeds and feeding account for 50-60% of the operational costs of semi- and intensive farming; and wasted (uneaten and unmetabolized) feed in addition to affecting pond water quality and predisposing animals to disease is also a major contributor to the discharge of nutrients and organic matter from intensive farms leading to eutrophication of the environment and introduction of chemical residues and resistant genes. Increasing concern is also being expressed regarding the wasteful use of increasingly scarce resources of fishmeal going into aquaculture diets for a net loss of protein resources and allied losses due to by-catch from the fishmeal industry. Formulation of cost-efficient and high quality, low polluting diets, and proper management of the feeding regime are thus crucial in attempting to optimize the efficient use of feeds in aquaculture farming.

Better management practices for aquaculture emerging from the commodity studies include:

- Use of good quality formulated feeds
- Make efficient use of feed resources
- Minimizing feed wastage in farm operations
- Investigating potential of protein sources other than fishmeal (e.g. soybean).
- Giving preference to expansion of non-carnivorous farmed species

Sectoral management

State and other stakeholders have an important role in improving feed management through communications and extension activities and encouraging private sector investment in processing plants to increase the value of trash fish to encourage consumption of trash fish rather than its use for aquaculture. Specific management options include:

- Support research for the development of artificial feeds to be used as alternatives to trashfish
- Develop and disseminate extension material on responsible feeding practices
- Encourage the development of small-scale pilot processing plants by the private sector. These should comply as much as possible with HACCP methodologies, even if products are to be consumed locally.

The sectors management also needs to address food web issues and “farming up” the food chain as well as impacts on national, regional and global fisheries. The impacts on ecosystems of harvesting fishmeal, most of which are unknown levels of harvest in the trashfish category and of importance to marine tropho-dynamics (i.e. food webs), are clear and will only exacerbate current pressures of over-fishing. However what is also clear is the growing trend of “farming up” food web, in which more and more carnivorous fish are being farmed. While this is largely a phenomenon outside Asia, even in Viet Nam where traditionally vegetarian fish like carp and tilapia were so dominant, now there is increased use of fish fat and protein in these operations. While detailed recommendations in better management cannot be prepared at the moment, this issue deserves more attention for future management of the sector.

1.4.7 Aquatic animal health management and disease control

The commodity studies and projections show a significant need for addressing aquatic animal disease issues. Health management plans should be strengthened that aim to reduce stress, minimize the risks of disease affecting both the cultured and wild stocks, and increase food safety.

Maintenance of the health of aquatic animal stocks in farming situations should focus on maintenance of a healthy environment in the ponds at all phases of the culture cycle in order to prevent problems in the ponds before they occur and reduce the likelihood of disease transmission outside the farms. Attempting to limit the introduction of diseases through use of disease free stocks, thorough preparation of the ponds before stocking, maintenance of optimal environmental conditions through management of stocking densities, aeration, feeding, water exchange and phytoplankton bloom control etc., routine monitoring and recording of aquatic animal health to detect any developing problems, and maintenance of biosecurity in quarantining and treating any diseased ponds are all critical elements in any health management plan.

Better management practices for aquaculture emerging from the commodity studies include:

- Implementing health management practices that reduce aquatic animal stress and focus on disease prevention rather than treatment
- Maintaining biosecurity and minimize disease transmission between broodstock, hatchery and growout systems
- Implementing management strategies that avoid spreading aquatic animal diseases within and between farms
- Ensure rational and responsible use of veterinary drugs and minimizing the use of antibiotics

Sectoral management

State and other stakeholders have an important role in improving aquatic animal health management and disease control. Aquatic animal health management should be conducted in harmonization with regional and international efforts. Some management options include:

- Develop a harmonized aquatic animal health strategy in which the role of different institutions is clearly specified and agreed upon
- Revise on a regular basis regulations on the transboundary movement of fisheries products and on aquatic animal health management, including protocols for effective quarantine.
- Build capacity on Import Risk Analysis among key MOFI personnel
- Investment in quarantine facilities at key points of entry of fisheries commodities.
- Development and implemention of a disease surveillance and early warning system which allows the collection of data from the farming system in an accurate and timely manner. This system should be harmonized within MOFI and with efforts conducted by stakeholders outside MOFI (e.g. MONRE/DONRE) to monitor environmental and health variables
- Using surveillance data to develop zones in relation to the aquatic animal disease status of different areas. Regulations to ensure that zones are effectively managed to contain the impact of diseases should also be developed and implemented
- Development and implementation of contingency plans for disease emergencies. These should focus on key commodities/systems but should also attempt to accommodate for emergencies occurring in other commodities/systems

- Establishment of level II and III[5] laboratories and the necessary capacity within NAFIQAVED branches and, where necessary for DOFI Aquatic Resource Protection laboratories
- Establishment of level II diagnostic laboratories and the necessary capacity in key farming areas.
- Through training of trainers' activities, build capacity on level I (naked-eye) diagnostic systems among field officers and key farmers (i.e. voluntary extension workers)

1.4.8 Food safety and aquatic product quality

Improving the quality and safety of aquaculture products and reducing risks to ecosystems and human health from chemical use and microbiological contaminations will be essential to remain competitive on domestic and international markets. Normally seafood is considered as healthy food but there are some risks associated with it as well that should be minimized.

There are two food safety issues to be dealt with at the pre harvest level namely a chemical and a biological. The chemical risk is associated with chemicals applied to the aquaculture production and the biological is associated with bacteria and parasites that can be transferred to humans from the seafood products.

Increasing focus is being placed on the safety of foods being consumed in the worlds' markets. These concerns include not only ensuring that foods for human consumption are free from excesses of harmful or undesirable chemicals, harmful pathogens and resistant microorganisms bacteria and parasites, but also the workers producing and processing these foods can be a source of contamination. It is also important that the environment from which the production facility draws its water and other resources have been protected from negative effects of contaminants. Increasing calls for total traceability of food products are also affecting the food production industry such that consumers can be assured that the product has been produced without the use of transgenic technologies, without addition of undesirable or harmful chemicals or additives, and that all of the environments and ecosystems affected by the production facilities has not been compromised in any way.

Better management practices for management of food safety in aquaculture production systems emerging from the commodity studies include:

- No use of banned veterinary drugs and chemicals
- Applying quality control systems to produce safe and quality products
- Implementing sanitary harvest, handling and transport of aquaculture products
- Discouraging or banning the use of "night soil" in aquaculture
- Implementing better management practices e.g. HACCP-based, that will ensure chemical and microbiological safe products, e.g. prevention and control of residues, resistance development, occurrence and transmission/contamination of pathogens.

Sectoral management

State and other stakeholders have an important role in improving food safety and quality control including

[5] According to the FAO/NACA Asia Diagnostic Guide to Aquatic Animal Diseases (Bondad-Reantaso *et al.*, 2001) level I diagnostics is based on gross observation of the animals, farming system and the use of pond-level diagnostic kits; level II include parasitology, histopathology, bacteriology and mycology; level III consists of more advanced methods such as biomolecular and immunology techniques

- Strenthening the capacity at national and local level to prevent and control the use of chemicals, including antimicrobials, and in general to ensure chemical and micrbiological safe products.
- Establishment of prudent use guidelines and practices of using permitted veterinary drugs and chemicals
- Investment in centres in compliance with international standards for shellfish depuration

1.4.9 Social benefits, poverty reduction and employment

The employment generated by Viet Nam's aquaculture sector during its recent growth has been highly impressive. The future development and operation of farms will need to be done in a socially responsible manner that benefits the farm, the local communities and the country, and that contributes effectively to rural development, and particularly poverty alleviation, without compromising the environment.

There are increasing demands for products which are not only environmentally friendly (that have been produced through the adoption of environmentally sustainable practices), but that have been produced by employees who were treated fairly, and that the enterprise that produced the product is a respected and active component of the society. It should be the responsibility of a civilized society that the benefits derived from aquaculture farming are shared equitably.

Better management practices for aquaculture emerging from the commodity studies include:

- Minimizing conflicts with local communities that may result from aquaculture farm development and operation and ensure that the project is mutually beneficial
- Taking measures to ensure aquaculture farming benefits the communities in farming areas
- Ensuring aquaculture farm worker welfare
- Minimizing risks to smallholders engaged in aquaculture farming
- Providing training to farmers and workers in responsible aquaculture farming practices.

Sectoral management

State and other stakeholders have an important role in improving the social benefits from aquaculture, and assisting in minimising any potential negative social impacts from aquaculture. The management actions include:

- Implementation of pro-poor policies for extension and technical and investment support from government for aquaculture
- Encouraging participation of poor groups in planning and implementation of aquaculture planning and projects.

1.4.10 Cross-cutting sectoral management issues

Whilst there are sectoral management improvements related to key management practices, there are also some related cross-cutting sectoral management issues where substantial improvements can be made.

Legislation and regulations

The better management identified above can be used as a framework or "check list" of key issues to review and develop regulations for aquaculture farming. Better management of each of the environmental issues requires supporting regulations and standards. The Fisheries Law is now in place, a substantial achievement, but detailed regulations and standards are now required to support implementation of better management across the aquaculture sector.

Environmental impact assessment (EIA)

There is a need to should establish effective environmental impact assessment (EIA) procedures at appropriate levels for aquaculture farms, and other coastal developments. The management practices highlighted above provide a “check list” that can be used for environmental assessment of aquaculture, to ensure all relevant points for responsible aquaculture farming are considered. Strategic and project level environmental impact assessments enable the integration of environmental, social, technical and economic considerations during the planning and decision making processes for allocation of land, water and other natural resources during aquaculture farm planning and operations. Project level EIA procedures require early discussions among the project proponents, the regulatory agencies and the stakeholders, and should allow the evaluation of alternative sites, designs and management measures before investment is committed.

Strategic or sector level environmental assessment is recommended for management of the cumulative impacts of large numbers of small-scale aquaculture farms.

Registration of aquaculture farms

Aquaculture farms in legal locations should be registered to encourage the use of better management practices, ensure traceability and assist in maintaining quality controls over production.

Integrated coastal area management

Integrated coastal area management (ICAM) plans should be prepared including aquaculture and other coastal activities, to ensure that aquaculture sites and activities are within carrying capacity and that conflicts with other key coastal sectors (e.g. tourism, fisheries, housing, industry, agriculture) are minimized. Integrated coastal area management plans should be prepared through participatory planning and suitable areas for coastal aquaculture designated. Responsibilities for integrated coastal area management planning and aquaculture should be devolved to the lowest administrative level and capacity building provided to local institutions to support this approach. Land use rights should be clearly defined in the coastal area management plans to encourage long-term investment and responsible design and construction of aquaculture farms.

Land and water use zoning

There is a need to identify and designate suitable locations for aquaculture farms, particularly in coastal areas, providing an effective mechanism to minimise physical alteration and degradation of coastal habitats as well as socio-economic conflicts that arise from poorly sited aquaculture farms. Siting of aquaculture farms should take into account the sustainability of ecological functions, carrying capacity, as well as technical, social and economic considerations.

Land and water use zoning effectively directed towards maintenance of the primary functions of the local environment can allow multiple uses of areas and to accommodate competing demands and activities and limit cumulative impacts.

Areas suitable for longer term investment in aquaculture should be identified. These are likely away from major industrial or tourist development.

Monitoring of aquaculture

There is as yet no systematic framework for environment monitoring and early warning of aquaculture operating in Viet Nam. Some regional monitoring system exists, but methodologies are still to be developed and there is insufficient capacity for effective implementation.

There is therefore a need to strengthen monitoring to assess and improve environmental performance of aquaculture farming. The monitoring should include the health and disease status of the stock (and complying with international regulations for aquatic animal disease control as specified by OIE where applicable), water quality within farms and receiving waters, any chemical, antibiotic or pathogen residuals in harvested animals and plants to ensure international seafood standards are met, and other inputs to the farm to ensure use of permitted and suitable ingredients and supplies. Involvement of all stakeholders in monitoring programs will encourage and ensure shared responsibility for meeting the objectives of monitoring.

The states should develop water quality standards for local waters and a strategy to maintain these standards within the context of integrated coastal area management.

The means of financing environment monitoring also needs to be further explored, and the role of the public and private sector carefully defined. There are also lessons to be learned from other countries in the region, including China and Thailand, which might be applied in Viet Nam. The domestic and export value of aquaculture products, the latter expected to reach US$ 4 billion by 2010, provides a strong economic justification for substantial investment in environmental monitoring and management of the sector to secure its future development. The role of public and private sector in monitoring also needs to be further evaluated. As in Thailand and India, for example, private laboratories and environmental monitoring services, could play an increasing role, with oversight by the State.

1.5 Strengthening institutions for aquaculture management

1.5.1 Introduction

Implementation of better sectoral management of aquaculture should be supported through strengthening of institutions for extension, monitoring, planning and implementation of legislation. Investment should be made in educational and training to improve the capacity of public and private institutions for management of aquaculture. Mechanisms for sharing of experiences and information on policies, legislation and better management practices should be further developed, making optimal use of financial, human and information resources.

The requirement for an institutional analysis of the aquaculture commodities comes from the need to implement environmental and poverty oriented policies in a rapidly developing, but minimally controlled, sector that is heavily influenced by the development of other sectors. Planning of aquaculture production in Viet Nam is conducted in a heterogeneous sector and in provinces with varying human and financial capacities to implement planning. Furthermore, the institutional setup is different between commodities and so for example economically important export commodities like coastal shrimp are often receiving more public investment in terms of extension services, monitoring and administration and infrastructure etc.

Institutions (legislation, offices, organisations and norms) in Viet Nam may facilitate sustainable development and reduce the risks of unpredicted environmental or economic problems by:

- Decentralized, robust, transparent, and resilient management system working with applicable legislation and plans which are supported and understood by the affected stakeholders.

- Giving decision makers access to continuous updated and reliable data on production, natural resources, market and socio economic issues.
- Adjusting production and the development plans towards sustainability targets through incentive based measures and cross-sector planning.
- Considering the limited financial and human capacities in public administration and promoting a simplification of data collection on the sector and conduct participatory decision making.
- Ensuring that the implementation of legislations and development plans are adjustable to different administrative, socio economic and political contexts and that they are enforceable.

Finding solutions for environmental problems involves a palette of institutions

Environmental problems are rooted in a complex of natural and societal conditions and so the solutions must often be found using an interdisciplinary approach that involves a multiple set of stakeholders, procedures, legislation, enforcement, learning processes and communication between persons. It is difficult to prescribe exactly how each environmental problem should be solved as the institutional conditions may change considerably, depending on the management approach and the stakeholders being involved. However, there are some immediate institutional activities which are recommended for bringing the planning process forward as note in

Table 10 below,

Different problems and different capacities (commodities and planning areas)

Environmental problems and the institutional setup vary between commodities and administrative areas and so public management institutions must adapt to local differences in human capacities and natural conditions. Allocation of institutional resources must be prioritized to environmental "hot spots" and experiences of successful planning (best case studies) must be shared between planning areas (districts and provinces) through workshops, field visits and other awareness raising activities.

1.5.2 Public institutions capacity building

Substantial investment in public institutions is required to build capacity for effective environmental management and monitoring of the aquaculture sector, including extension centres, research institutions, MOFI and provincial administrations.

Capacity building for public sector

Capacity building needs for public sector should be paid attention as this sector is still not sufficiency to implement their own function of state management.

Table 10 Some suggested institutional activities and responsibilities to address environmental constraints in Vietnamese aquaculture

Activities	Stakeholders and responsibilities
Publishing and promulgating guidance and manuals and disseminate to farmers	MOFI, DOFI, Farmer, NGO, program
Strengthening environment and disease management system under MOFI	MOFI, RIAs, NGO, program
Human capacity building for system in both quality and quantity improvement through workshops and training courses	MOFI, RIAs, NGO, program

Establishing better mechanisms of sharing information among MOFI institutes, sharing to MONRE and other stakeholders	MOFI, MONRE, PPCs, DOFIs/DARDs, DONREs
Promoting economic incentives for implementation of better management practices though market tools as well as taxes imposed on environment pollution.	MOFI, RIAs, NGO, program
Capacity building for DOFIs and DONREs in environmental management of aquaculture at provincial levels	MOFI, MONRE, PPCs, DONREs, DOFIs

1.5.3 Mass organizations and NGOs

Implementation of all better management practices and regulations requires as a basis that there is a good understanding and involvement of mass organizations and NGOs. These organizations can identify farming communities with limited access to extension services or to other information sources, such as the "One-stop Aquaculture shops" showing promise with support of MOFI and the Danida program.

Mechanisms for transfer of information to and from the farming communities, and particularly to assist small-farmer groups require more investment. The National Fisheries Extension Centre of MOFI (NAFEC) has a particularly important role to play here, with other stakeholders in a substantially enhanced communication initiative focused on better management.

1.5.4 Private sector capacity building

Weak organisation of farmers is a key barrier to sustainable development

Involvement of farmers is a prerequisite for sustainable management of the sector. Decisions must be coordinated with farmers preferences and be fully understood by the people affected by management decisions. However, the ambition to involve farmers in Viet Nam does not always correspond with the farmer's aspiration and experiences to participate in aquaculture planning. In order to be heard in competition with other stakeholders (business and sector organisations), and for farmers to speak with a unified voice it is crucial that they are better organised and that local leaders are appointed. Public management and non-governmental agents (aquaculture business enterprises or NGO's) simply do not have the capacity to approach millions of farmers on an individual basis. However there are increasingly good examples of farmers being organized. The An Giang Farmers Association (AFA) is a strong stakeholder in the *Pangasius* industry in An Giang province. The shrimp farmers groups in Nghe An and Ha Tinh provinces are another example. Through the establishment of farmer groups and the implementation of better management practices, farmers significantly reduced their risk of experiencing shrimp mortalities and improved yields (Corsin et al. 2005).

Capacity building of private sector

Most of the capacity building has been implemented for public sectors while private sectors play an important role as they are entities in charge directly of implementation of aquaculture development in Viet Nam. Possible private sector initiatives to build the capacity of farmers to implement better management are highlighted in Table 11.

Table 11 Suggested activities for private sector capacity building

Activities	Stakeholders and responsibilities
Dissemination of well developed better management	RIAs, NAFEC, NGOs, program

practice (BMP) information to farmers	
Implementation of BMPs in pilots for all commodities from hatching production to farming	Farmer, MOFI, NGOs, business sector
Promoting establishment of aquaculture associations and/or cooperative	Farmer, MOFI, NGOs, business sector
Certification scheme to support BMP implementation	Farmer, MOFI, VASEP, NGOs, business sector
Strengthening the extension network in both quantity and quality for aquaculture	MOFI, NAFEC, DOFI, farmer associations, NGOs, business sector
Assisting setting up the linkage between farmers to middle men and to market	MOFI, VASEP, DOFI, farmer associations, NGOs, business sector
Assisting in supporting poor aquaculture farmers in market access for some commodities	MOFI, VASEP, DOFI, farmer associations, NGOs, business sector

In general, the role and responsibilities of farmers and the business sector in better management, and investment in better environmental management should be enhanced.

1.5.5 Build capacity of local institutions to coordinate efforts and implement legislation and strategies

The decentralization policy and allocation of public budgets to provincial and district units is contributing to a more adaptable planning system. However, DOFI, DONRE and PC's often lack capacity (experienced staff, reliable data and finances) to meet aquaculture development objectives, to conduct participatory planning and to collect and synthesize relevant data and coordinate planning efforts with other authorities. In nearshore capture fisheries management, third parties such mass organisations and NGO's are often involved in official environmental planning. This approach should be reviewed, as the experiences may be adapted in aquaculture management.

Coordinating and bringing the existing knowledge into management

In the Vietnamese public administration much effort is put into collection, analysis and reporting of provincial and districts statistics on aquaculture (among other sectors). Several sets of aquaculture production statistics are produced by different agencies each year and the offices collecting data do not always have the capacity to compile and compare these data. These uncoordinated parallel data collection exercises occasionally lead to mismatch between figures produced by different offices which to an outsider (e.g. farmers) creates mistrust and disturbance with the management decisions. The attempts to unify and simplify data compilation should be promoted along with an introduction of alternative data collections.

In recent years, considerable capacity has been built through research and application of environmental assessment guidelines for aquaculture. Such guidelines have either not been officially approved or the staff which were involved in the research are now displaced to other positions and so there is a loss of valuable (scientifically based) capacity. Such guidelines and practical experiences should be collected and be effectively implemented and passed on to other institutions to encourage further learning.

1.5.6 Cross-sectoral coordination

Finally, the aquatic resources of Viet Nam are used and managed by many people, and institutions, at all levels. There if therefore a strong need for cross sectoral coordination, at ministerial levels, and also at provincial and district levels. Such high level coordination in Viet

Nam requires higher level instructions; given the importance of the sector to the country and its future development such an approach should be strong justified.

1.6 Implementation and Follow Up Action

The analysis of commodity case studies and assessments has provided an initial set of recommendations for better management of the aquaculture sector in Viet Nam. The challenge now is implementation. Implementation involves consideration of various factors, including overcoming the constraints identified during the study, investment, capacity building and other actions. The following recommendations, discussed and agreed by a stakeholder consultation that was hosted by MOFI on 23 June 2006, provide key actions to be taken to support implementation.

Action point 1: Mobilize financial and technical resources

The implementation of better management will require investment by farmers, and by government. It will be necessary to mobilize resources and investment to support implementation.

- Government aquaculture investment projects should be based on the better management guidelines
- MOFI investment in institutional capacity building should be oriented to supporting BMP development and adoption.
- Government and private sector investment is required in coastal zone planning, and aquaculture zones/parks with proper infrastructure
- BMPs should be built into MOFI and Provincial government investment
- Funding sources should be identified to assist small-scale farmers to adopt the guidelines and make the transition to better management practices

Technical resources for BMPs should also be identified and mobilized, possibly through working groups on key commodities.

The adaptation to local levels also needs to be based on careful consideration of the local circumstances and fully involve local stakeholders. In practice, considerable local differences in implementation may occur. Farmers should be supported and given flexibility to adopt and adapt better management practices following general principles but suited according to local conditions.

Responsibilities – MOFI, MPI, DOFI, private investors.

Action point 2: Communication and dissemination

The communication of better management guidelines should be through wide dissemination of the study findings in Vietnamese and English.

- Develop and disseminate extension material containing environmental management messages, with prior field testing to ensure their relevance and effective communication.
- Ensure messages contain clear information on links between profitable farming and better environmental management
- Utilize Training of Trainers and Aquaculture Farmer Field School methodologies to maximize dissemination
- Assist the Viet Nam Fisheries Association to develop and implement a BMP extension program
- Encourage the establishment of voluntary extension worker systems for effective farmer extension.
- Encourage the establishment of One-Stop Aquaculture Shop Information Systems (OASIS) to assist the effective delivery of BMP messages to farming communities

- Conduct seminars/workshops with Provincial DOFI/DONRE in key provinces to raise awareness of issues and management solutions identified in the guidelines.
- Conduct stakeholder consultations to improve the BMP messages and satisfy especially the needs of small scale producers
- Disseminate widely environmental management messages through the MOFI website and NGO email listservers

The need for continued dialogue and consensus building on the major issues identified through the case studies and the development of effective measures to support BMP implementation is also emphasized.

Responsibilities – MOFI (particularly NAFEC and NAFIQAVED), RIAs, Universities, in cooperation with study partners (WB, IFM, NACA, FAO, WWF, Others).

Action point 3: Develop commodity specific standards

Better management practices identified through the commodity studies should be refined, disseminated and their implementation must be encouraged. A balanced stakeholder group should be brought together for final agreement on the drafts prepared through this study and development of standards to provide further guidance and support monitoring of better practices.

- Develop refined sets of BMP for all stages in the production chain for all major commodities
- Support the creation of commodity groups through which stakeholders involved with different stages in the production chain collaborate to increase sustainability of the sector
- Develop standards that can provide a basic direction for improvement of management, and a means of monitoring progress.
- Conduct a review of MOFI standards and update the relevant standards to incorporate the BMPs

To assist new standard development, a further follow up activity should be to review the BMPs identified in these guidelines and prioritize the work on new standards. Each management recommendation should also be scored against potential impacts - environmental, economic and social – to strengthen the arguments for investment in better management and standard development in the priority areas.

Furthermore, the development of production targets for some commodities (e.g. marine fish) should also be reviewed regularly, and development plans revised with the objective of minimizing aquaculture's impacts on the environment. MOFI is therefore recommended to include environmental assessment in the next review/revisions of aquaculture development targets (normally conducted on an annual basis).

These tasks (ranking, revising plans, etc.) should be conducted by MOFI in consultation with a wide range of stakeholders (public, private, national, regional, international, etc.) as a further step towards supporting improved environmental sustainability of the sector.

Responsibilities – MOFI as lead institution (especially Department of Aquaculture, Department of Science and Technology, NAFIQAVED and Legal Department), RIAs, farmers and business sector, mass organizations/NGOs and community representatives.

Action point 4: Implement incentives for better management

Because of the difficulties of enforcing regulations on such a large number of producers, an incentive system should be developed that will support farmers to voluntary adopt better management practices.

- Explore market incentives to promote cooperation among local farmers and processors to promote marketing of BMP aquaculture products
- Engage with importers, retailers and consumer organizations to encourage sourcing from BMP farms
- Explore potential for development of certification to support farmers to implement BMPs.
- Build capacity and awareness of certification issues among government staff.
- Local DOFI to explore ways of linking compliance with better management to provision of services
- Registration of aquaculture farmers adopting better management, and favorable market access and services support for those farms.
- Promote the development of farmer groups to support effective communication of BMPs
- Explore opportunities for preferential access to finance and/or insurance for farmers adopting BMPs
- Develop pilots for application of aquaculture BMP as part of community development
- Develop pilots for Alternative Income Generation strategies at proposed marine protected areas.

Incentives for new developments that should be required to follow the new guidelines versus old development should be investigated. For example, the costs for new developments, or replanning/improvement of existing systems will be different and may require different approaches in legislation and even modification of the tax incentives.

It is important to recognize that reducing the environmental impact from aquaculture can come from better technologies and management practices on existing and new farms that can significantly reduce the impact. Also better planning and integration of complementary farming systems will minimize the impact. If the production is measured in value, then an emphasis on high quality products and value added products will be a way of increasing the value of output for the same environmental impact. A major initiative for better management of the sector is recommended as a more productive and acceptable way to go towards reducing impacts. Regular review of progress in implementing better practice, as well as a more regular assessment of environmental impacts against progress in achieving MOFI's targets would also help.

Responsibilities – MOFI as lead institution, RIAs, private sector, mass organizations/NGOs and community representatives.

Action point 5: Building farmer-oriented service institutions for extension

The extension system to the farmer level needs considerable improvement. Effective servicing systems should be developed for more effective extension to disseminate information and share experiences on BMPs and their implementation.

- Support establishment of local servicing structures, operated by farmers and farmer groups, with support and cooperation from local government (eg co-management type arrangement).
- Develop material concerning polyculture and integrated systems in coastal areas. Focus on degraded areas in central Viet Nam.

- Explore and develop effective mechanisms for communication of findings to industry and government.
- Prepare technical guidelines that support implementation of better practices, and particularly their implementation at local and national levels.
- Develop manuals, which could be developed through consultation, at national, or regional level, and in local languages, to support implementation of better management practices.

Responsibilities – MOFI as lead institution, DOFIs, business sector.

Action point 6: Environmental monitoring

Create a more effective environmental monitoring and evaluation system.

- Develop more specific guidelines on environmental monitoring
- Develop system that make effective use of the data collected by different stakeholders
- Identify gaps in the present monitoring systems and develop strategies for their overcoming
- Invest in the implementation of the system
- Develop more specific standards for BMPs to assist in monitoring implementation
- Test monitoring system in pilot sites, as demonstration systems for wider dissemination.
- Ensure the monitoring systems cover all levels from "grass roots" to central level.
- Encourage the participation of farmers and farmer organizations in environmental monitoring and management

Responsibilities – MOFI as lead institution, DOFIs and local authorities, private sector.

Action point 7: Capacity building

There is the need for significant capacity building efforts, such as through in-country training/workshops, consultation with farmer groups and participatory meetings on implementation of BMPs and their adaptation to local levels.

- Hold training courses and workshops for national and local authorities, extension workers and private sector
- Organize study tours for national and local authorities to learn from regional experiences on environmental management
- Ensure wide capacity building within stakeholder groups by creating and strengthening peer to peer (e.g. farmer to farmer) capacity building mechanisms

Responsibilities – MOFI as lead institution, DOFIs, private sector

Action point 8: Provincial pilots

Invest in pilots and demonstrations on key commodities in selected provinces to show practical benefits of implementing BMPs (assessment, management, monitoring) to generate accurate data on cost-effectiveness of individual BMP and to rank BMP based on their ability of generating profits while minimizing environmental impacts and maximizing social benefits.

Priority should be given to marine culture, which is least developed but a high priority of MOFI for development – the stakeholder consultation group recommended molluscs and marine fish.

The pilots should assist to put in a complete system of management and monitoring systems for wider demonstration and to inform policy and wider development for investment by government and private sector.

Responsibilities – MOFI, DOFIs, business sector

Action point 9: Harmonization of efforts

Harmonize efforts conducted within MOFI and by other institutions such as MONRE, MARD, MPI etc. towards better management of resources, developing legal and policy framework, developing capacity and environmental monitoring and management

- Establish structured mechanisms (e.g. working group) for more effective exchange of information
- Conduct regular stakeholder consultations to avoid overlapping and increase synergy

Responsibilities – MOFI, MONRE, MOSTE, MARD, MPI, other Ministries as relevant, provincial authorities, private sector

Action point 10: Facilitating the next steps

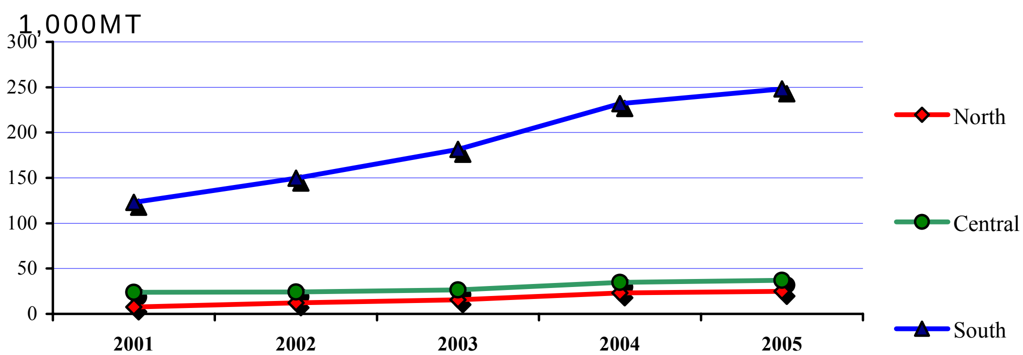
The case studies have created a framework for review and evaluating successes and failures in aquaculture, which can now be used to inform policy debate and movement towards implementation of better management practices for aquaculture. The findings have come from a consultative process that has involved cooperation and inputs from different groups, including government, non-government, research institutions and industry inputs. The work has started to identify future development activities and assistance required for the implementation of better management strategies that would support moves toward a more sustainable aquaculture industry. The stakeholder consultation agrees that the cooperative approach provides an important platform for gaining understanding and sharing experiences on aquaculture management and should be continued.

Part 2: Commodity Reports

2.1. Coastal shrimp aquaculture

The development of coastal shrimp aquaculture in Viet Nam has been impressive during the past 10 years. Shrimp takes the largest proportion of seafood commodities exported from Viet Nam and is of great importance to the Viet Namese economy. The development of the shrimp production (2001 – 2005) is showed in Figure 1. Significant production is from the south of Viet Nam but there is also a considerable production from central and north Viet Nam.

Figure 1 Shrimp Production of Viet Nam (VASEP 2006)



The shrimp industry in Viet Nam started with shrimp seed from the wild in 1980s. An increase in production area and level of intensification has led to a high demand for seed (post larvae). Many shrimp hatcheries have also been developed and most of them are located in the central provinces (e.g. Khanh Hoa province). According to Sinh (2004), the central region produces around 70% of the total shrimp seed used in the Vietnamese shrimp production. Other 20-25% is located and produced in the Mekong River Delta and a limited seed production is taking place in the Northern provinces.

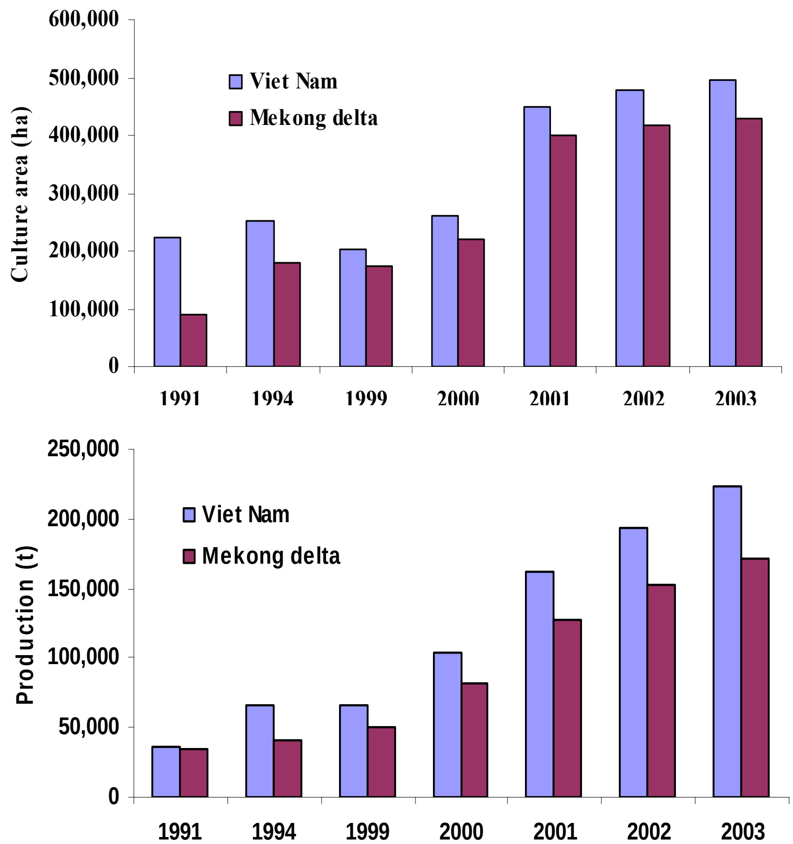
2.1.1 Commodity Status and System Description

There are many different shrimp aquaculture practices in Viet Nam differing in terms of species cultured, production intensity and climatic conditions. Therefore the environmental impacts are also quite diverse.

The most popular cultured shrimp species in Viet Nam is *P. monodon* (Black tiger shrimp). In 2004, *P. monodon* made up 80% of the farmed shrimp production, while the newly introduced species *P. vanamei* (White shrimp) approximately 20%. In the south however there is only production of *P. monodon.* The white shrimp is currently permitted to be cultured experimentally in the North and the Central, from Quang Ninh province to Binh Thuan province and only under control of the Viet Namese government.

P. monodon is the most important and dominant species cultured along the coast of Viet Nam. The main production area is the Mekong Delta covering about 80-85% of the total cultured area with 70-75% of the total national production (
Figure 2). In 2003, about 460,000 ha were used for shrimp farming that brought about 223,000 MT in 2003. The yield is still improved due to a higher level of intensification and development of skills of farmers and extension workers (MOFI, 2004a).

Figure 2 Shrimp culture area (ha) and production (tonnes) of Viet Nam compared to the Mekong Delta (Phuong et al. 2004)



The development of shrimp aquaculture in Viet Nam has been transforming from extensive towards more intensified farms. According to MOFI (2004a), shrimp farming systems in Viet Nam in 2003 comprised of 3% semi-intensive and intensive, 22% improved extensive and 75% extensive culture. Of the total production (MT) the intensive culture produced around 10% and extensive culture produce 60% of total shrimp production. The productivity of improved extensive, semi-intensive and intensive shrimp farming were 0.25-0.30 MT/ha/crop, 2.5-3 MT/ha/crop and 5-7 MT/ha/crop, respectively (MOFI, 2005c).

The intensification of the coastal shrimp farming has led to a number of concerns for farmers, government, authorities and scientists. These issues are:

- Local environmental impacts and regulations for environmental protection
- Disease outbreaks
- Increased demand for more and better quality seed
- Decrease in high quality wild brood stock
- Increasing demand for certified safe food especially for the export markets,
- Unplanned development of shrimp culture resulting in severe adverse social, economic and environmental impacts,
- Infrastructure and canal system is not geared for the heavy expansion of shrimp aquaculture. Lack of investments to upgrade the infrastructure
- Need for technical capacity building (skilled farm workers and technicians)
- More sufficient administrative capacities for the sector
- Promoted export and deeper integration into main international markets.

In order to obtain a sustainable development of shrimp aquaculture in Viet Nam, there is an increasing need for studies and investments that help finding solutions for the above issues and other potential future threats to the sustainable development of the sector.

Brief overview

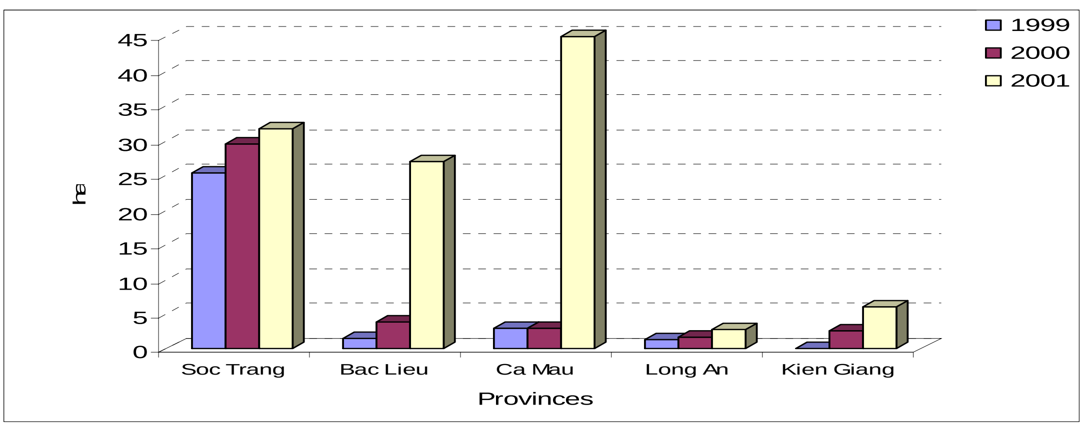
Coastal shrimp farming in south provinces

Coastal shrimp aquaculture in Viet Nam started in the 1980s with extensive systems, collecting wild seed through tidal regime (Nhuong and Ha 2005). The wild living shrimp seed were collected and kept in ponds in the coastal tidal zone with densities as low as 1-3 shrimp/m^2.

Extensive shrimp farming took place broadly in the Southern part of Viet Nam at the beginning of the 1990s, and artificial shrimp seed from shrimp hatcheries were used since the mid 1990s. Since 2000, more advanced technologies allowing higher stocking densities and a higher level of investment in construction and input supply have contributed to the rapid development of shrimp farming in the Mekong Delta, yielding production outputs up to 10 MT/ha/crop in some intensive farms.

The Mekong Delta is now the biggest shrimp aquaculture region in Viet Nam and the area used for shrimp farming makes up around 80-85% of the total productive area in Viet Nam and 70-75% of the total national production (Figure 3). The production has increased continuously up to 2005 (MOFI 2006b). Due to the fall in rice prices and the high prices of seafood products, the Viet Namese government supported an expansion of shrimp aquaculture. With Decision No 09 NQ/CP in 2000 the government allowed the conversion of inefficient rice farms to shrimp ponds which lead to a fast increase in especially rotation rice-shrimp farming in the Mekong delta and in Ca Mau province.

Figure 3 Rotation rice-shrimp farming area development in the Mekong Delta (Phuong et al. 2004)



In 1994-1995, a disease outbreak in the southern province affected 85,000 ha of shrimp, equivalent to 294 billion VND (MOFI, 1996). In addition, a number of hectares of mangrove forests have been destroyed because of development of brackish water shrimp aquaculture (MOFI, 2001). This is not only a loss of habitat for a species-rich ecosystem, but also compromises coastal defense against erosion as well as filtering silt-bearing rivers.

Coastal shrimp farming in north provinces

Also in the North and Central Viet Nam there has been an expansion of shrimp production both in terms of increase in production area and intensification level. Shrimp is cultured in one or sometimes two crops a year. The production has quickly changed from 0.15 – 0.30 MT/ha/crop up to currently about from 1.5 – 2.5 MT/ha/crop in some central provinces. The productivity of several intensive shrimp farms in Nghe An province reached 8-11 MT/hectare/crop. In the northern parts of Viet Nam, both areas and production of shrimp culture are lower than in the Centre and the South.

The production of brackish shrimp culture of coastal provinces of Red River delta in 2005 was 15,750 MT which was an increase of 5.3 times compared to 1999. The total area of shrimp aquaculture in 2005 was 27,320 ha, of which 85.9% was improved extensive farming. The average production was only 850 kg/ha.

Beside tiger shrimp, white shrimp was also cultured in the north. In 2005, an area of 1,100 ha was used for white shrimp culture in Quang Ninh province and produced 3,000 MT with an average production of 2.7 MT/ha, however some farms had productivity of 12-15 MT/ha and there was especially one outstanding farm which produced 18 MT/ha.

Shrimp aquaculture in the north also faces environmental problems including water pollution, sedimentation, toxic chemicals used in agriculture and disease.

Development plans

Coastal shrimp farming in south provinces

The recommendations from MOFI are that planning/zoning of new shrimp aquaculture areas is needed as well as investments for upgrading infrastructure in already established areas.

The planning should follow systems as BMP, GAP and CoC. Additionally, it needs to encourage culture systems based on community management; develop organic shrimp culture in combining with tourist services (MOFI 2006b).

In order to control the use of chemical/drugs and banned antibiotics in shrimp product processing activities, seed quality, feeding and chemical control and water environment will be also checked and managed strictly in next coming years.

Brackish shrimp, especially tiger shrimp, are the main commodity cultured in all coastal provinces and some inland provinces which has brackish water sources such as Dong Nai and Long An. Beside tide areas, brackish shrimp were also cultured in conversion areas from sedge-field, salt-field, unused land, sand-field and low yield rice-field.

Location of production & development plan

Coastal shrimp farming in south provinces

The Mekong Delta is considered as the most important region to the development of aquaculture in Viet Nam, in term of both available area that is suitable for aquaculture farming and aquaculture production, especially shrimp culture. Shrimp cultured area of Mekong River Delta region were 535,145 ha, occupying 88.5% of total shrimp production area of the whole country, of which, Ca Mau province has the largest shrimp cultured area (236,255 ha in 2005). The brackish water areas of South Central region decreased from 15,558 ha in 2004 to 14,391 ha in 2005 due to disease break out and natural disasters.

Depending on natural ecological and socio-economic conditions of each province, different shrimp farming systems have developed by province. In general, three popular shrimp farming systems have been developed in the coastal area of the Mekong Delta such as improved extensive shrimp farming, semi-intensive, and intensive farming systems.

- *Improved extensive systems* consist of:
  - Integrated mangrove-shrimp farming: exists in each coastal province, but is more popular in Ca Mau, Ben Tre and Kien Giang provinces.
  - Rotation rice-shrimp farming, this type is common in Ben Tre, Soc Trang, Bac Lieu, Ca Mau, Tra Vinh and Kien Giang, especially from 2000; and
  - Improved extensive farming of shimp only can be observed in every coastal provinces of the Mekong Delta.
- *Semi-intensive system* exists in Bac Lieu, Soc Trang, Tra Vinh and Ben Tre provinces and to some extent, in coastal area of Long An and Tien Giang provinces.
- *Intensive system* has been strongly developed in Bac Lieu, Soc Trang, Tra Vinh, and Ben Tre provinces.

It can be seen from Table 12 that the total brackish water shrimp aquaculture area in 2005 was higher than the targets set in plan (604,479 ha compared to 562,650 ha). Northern Coastal and Mekong River Delta are examples of two regions where current culture areas are larger than the target for 2010. This is due to the economic attractiveness of shrimp aquaculture. The two regions have a high potential for shrimp aquaculture while the centre coastal region have less favorable conditions. One of the reason for this is the poor economic situation that leads to the difficulty for shrimp aquaculture development.

Table 12 Brackish shrimp areas in 2005 and planned target

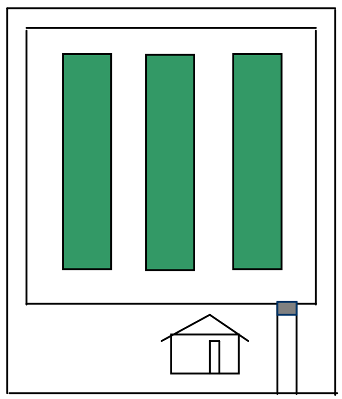
Region/province	**Unit**	**2005**	**Planned target (2010)**
Whole country	**Ha**	**604,479**	**562,650**
Improved extensive	Ha	-	399,250
Semi-intensive		-	86,400
Intensive		-	77,000
North Coastal Provinces	**Ha**	**37,321**	**32,917**
Improved extensive	Ha	-	16,250
Semi-intensive	Ha	-	10,667
Intensive	Ha	-	6,000
North Centre Coastal provinces	**Ha**	**17,622**	**18,083**
Improved extensive	Ha	-	3,750
Semi-intensive	Ha	-	5,333
Intensive	Ha	-	9,000
South Centre coastal provinces	**Ha**	**14,391**	**19,583**
Improved extensive	Ha	-	4250
Semi-intensive	Ha	-	5,333
Intensive	Ha	-	10,000
South provinces	**Ha**	**535,145**	**492,067**
Improved extensive	Ha	-	375,000
Semi-intensive	Ha	-	65,067
Intensive	Ha	-	52,00

Farming system design and production performance

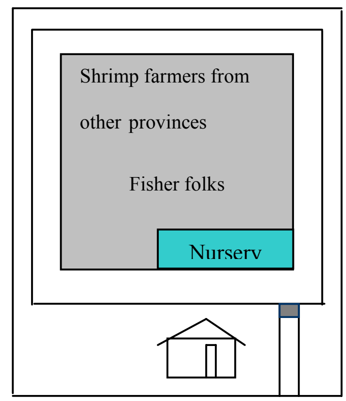
Coastal shrimp farming in south provinces

In the Mekong Delta, there are two major shrimp farming systems designed with specific characteristics as following figures:

(i) Integrated mangrove and rotation rice-shrimp farming systems

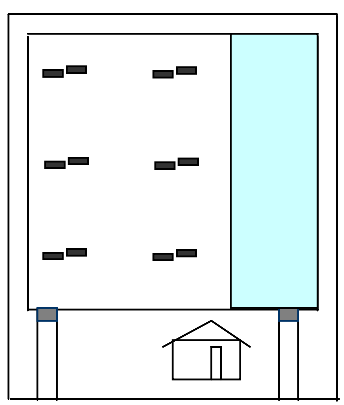


Integrated mangrove-shrimp farm



Rotation rice-shrimp farm

(ii) Semi-intensive and intensive shrimp culture system



Semi intensive/intensive shrimp culture pond

Farming systems vary in culture techniques (input) and yields. Major characteristics of each culture system are as follows:

(1) *Improved extensive systems* exist broadly in the Mekong Delta in a range of forms. This system accounted for 75% of the total shrimp culture area and 66% of aquaculture production in the Mekong Delta (Phuong et al., (2004). The system is without stocking or low stocking density of artificial shrimp post larvae (less than 5/m^2). Natural food or/and supplemented feeds are often added into the farms. Average shrimp yield per crop per ha varies from 0.3 to 0.87 MT (Sinh, 2004).

(2) *Semi-intensive system* has been applied since the beginning of the 1990s in the Mekong Delta. This farming system has higher post-larvae stocking densities (5-15 PL/m^2); commercial pellets are added; water exchange is controlled, mostly by pump; aeration is used occasionally. Average shrimp yield per crop per ha varies from 1.2-2.65 MT (Sinh, 2004).

(3) *Intensive system* has been developed recently in the Mekong Delta. Shrimp PL_{15} are stocked in high density (20-40 PL/m^2); good control of the water environment including water exchange and treatment, feed supply and aeration are used. Average shrimp yield per crop per ha varies from 2.5 - 5.0 MT and some farms reach up to 7-10 MT (Sinh, 2004).

The above shrimp farming systems, improved extensive culture system is considered as having less negative environmental impacts. In contrary, semi-intensive and intensive systems have been concerned about negative impacts on water environment.

According to culture systems, land use levels are different (Table 13):

Table 13 Typical design of shrimp farming in south provinces

Land use per hectare	Intensive	Semi-intensive	Improved extensive
Total farm area (ha)	1-2	2-4	2-6
Production area (%)	70-75	80-85	90
Inlet water treatment pond (%)	20-25	10-15	0
Outlet water treatment pond (%)	0	0	0
Sludge deposit area (%)	0	0	0

Total production cost for semi-intensive and intensive shrimp culture system is estimated at about 50 – 70 mils. VND and 90-110 mils. VND per crop per ha, respectively. Production cost is much lower than that of intensive culture system i.e. 10 – 30 mil. VND per crop per ha (Sinh et al., 2006).

The following are cost estimations for some major inputs for semi-intensive and intensive shrimp culture in Soc Trang and Bac Lieu provinces 2005 (Viet, 2006 & Dung 2006) (Table 14).

Table 14 Major inputs for shrimp farming in the south province

	Inputs per ha	Semi-intensive	Intensive
Soc Trang	Post larvae(VND millions /ha/crop)	4.8	11.9
	Feed (VND millions/ha/crop)	18.7	61
	Fuel/oil (VND millions/ha/crop)	2.5	4.8
	Chemical (VND millions/ha/crop)	6.3	20.3
	Maintenance (VND million/ha/crop)	4.0	5.3
	Labor (VND millions/ha/crop)	2.0	4.2
Bac Lieu	Post larvae (VND millions ha/crop)	4	9.8
	Feed (VND ha/crop)	9.6	104
	Fuel/oil (VND ha /crop)	2.5	3.3
	Chemical (VND millions ha / crop)		12.3

	Maintenance		
	Labor (VND million /ha/crop)		5.9

Shrimp yields and typical size of harvested shrimp are different in each farming system (Table 15):

Table 15 Outputs of shrimp farming in south provinces

Outputs per ha	Units	Intensive	Semi-intensive	Improved extensive
Shrimp yield	Tons/ha/crop	2.5 – 5	1.2 – 2.5	0.3 – 0.7
Typical harvest size	Individuals/kg	40	40	20-30
Farm gate price	*000 VND/kg	80	80	110

Management performance and risks are also summarized in the following table:

Table 16 Main production performance parameters for intensive and semi-intensive shrimp culture in Soc Trang based on 2005 data (Viet, 2006)

PRODUCTION	Units	Intensive	Semi-Intensive
Tiger shrimp aquaculture			
Crops per year	***no/year***	2.0	2.0
No of stockings per year	***no/year***	2.0	2.0
Seed size	***PL size***	15	15
Total stocked seed per year	***seed/year/ha***	800,000	400,000
Stocking density per year	***PL/m2/year***	114	50
Yield per year	***kg/year***	6,000	3,800
Average size at harvest	***no/kg***	40	40
Survival rate	***%***	30.0	38.0

Coastal shrimp farming in Northern provinces

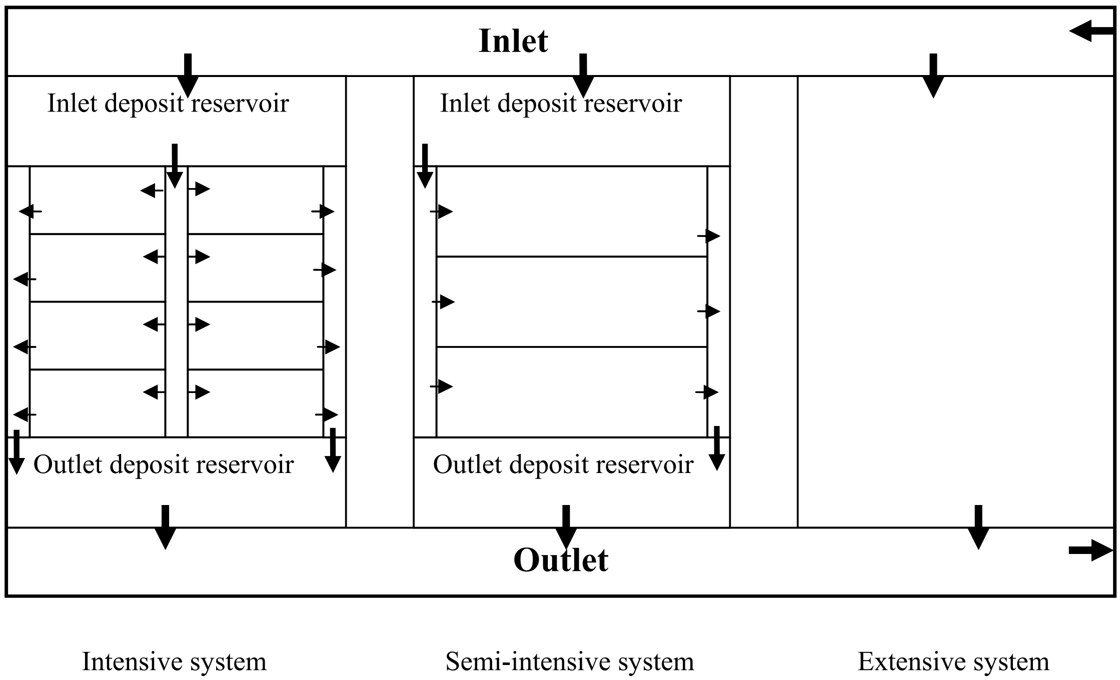
Normally, intensive and semi-intensive systems in well-developed areas have sludge deposit and inlet water treatment reservoirs operating for a group of farms. About 30 percent of total area is used for sludge deposit and water treatment in intensive and semi-intensive systems. Extensive farms have no area for deposit and treatment water pond, water is supplied directly from the sea by tide and discharged water also direct to the sea.

Table 17 Typical design of shrimp farming in north provinces

Land use per ha	Intensive	Semi-intensive	Extensive
Total farm area	100 %	100 %	100%
Production area	60%	60 %	85 %
Inlet water treatment pond	15 %	15 %	0 %
Outlet water treatment pond	15 %	15 %	0 %

Sludge deposit area and edge	10 %	10 %	15 %

Figure 4 Illustration of typical design of intensive, semi-intensive and extensive shrimp production systems in North Viet Nam



Major input-water use

Coastal shrimp farming in southern provinces

Shrimp culture systems often use brackish surface water from the coastal water of the Mekong Delta. Improved extensive shrimp farming system use directly brackish water from the rivers or canal around farms. Water exchange is carried out after stocking 1.5 month (first period of the crop). Then, water in farms is exchanged 2 times per month in spring tide period of month. In this farming system, supply and drainage canals are often a combined single canal. Particularly for semi-intensive and intensive shrimp culture systems, brackish water is often pumped directly from rivers or canals into sedimentation/treatment pond before being used for shrimp culture. Water from sedimentation/treatment pond is used for exchange water in the shrimp pond during the crop. However, effluent from shrimp pond is often discharged directly into rivers or canals without treatment. This point is one of issue that should be of concern in terms of environmental pollution. Another point that should also be considered is that supply and drainage canals are not standardized or upgraded for semi-intensive and intensive culture systems, while the tidal regime is semi-irregular tide, i.e. twice high tides per day. This makes water effluent from shrimp farm area not reach the coastal water body for diluting. Especially in the case shrimp disease outbreak, transmission of disease is an issue in the shrimp culture area.

Major input- seed supply

Coastal shrimp farming in south provinces

The increase in cultured areas and intensification level has led to a strong dependence of the industry on the supply of artificial seed from the hatcheries. Most shrimp hatcheries are located in the central provinces from Danang to Ba Ria-Vung Tau. This region covers about 70% of the total shrimp hatcheries and shrimp seed production for shrimp farming in Viet Nam. Another 20-25% is located and produced in the Mekong River Delta and the remaining is in the North. Since about 70% of the total cultured shrimp areas are in the Mekong Delta, inter-province exports of shrimp post-larvae exceeded 15 billion PL_{15} per year in 2000. A major risk in this trade is the transfer and introduction of pathogens between provinces. At present, about 65-75% of total post larvae used in the Mekong Delta are imported from the central provinces (Sinh et al., 2006). Coastal provinces in Mekong Delta produce about 7 billions post larvae yearly of which, the approximate 900 shrimp hatcheries of Ca Mau province provide about 4.1 billions post larvae per year (Phuong et al, 2006). Although the increase in number of shrimp hatcheries of Viet Nam and the Mekong Delta has been significant in recent years, the current seed production does not meet the demand in terms of quantity and quality for the shrimp industry.

Figure 5 Shrimp hatchery development in Viet Nam and the Mekong Delta, 2004 (Phuong et al. 2004)

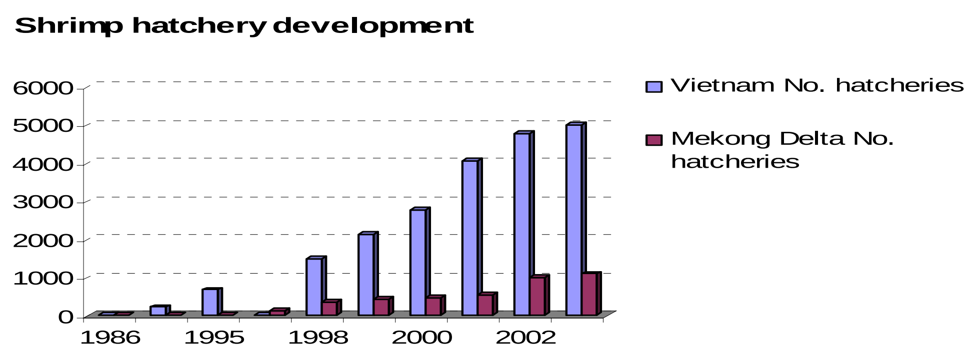
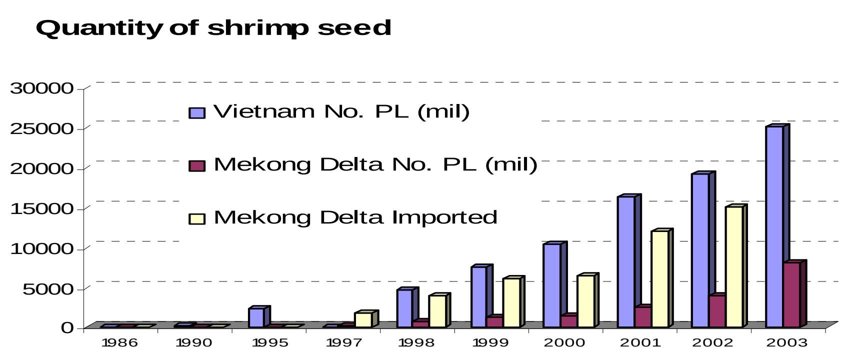


Figure 6 Quantity of shrimp seed in Viet Nam and the Mekong Delta, 2004 (Phuong et al. 2004)



According to National Extension Center for Aquaculture (2003-2004), the program of seed production for aquaculture to 2010 was submitted in July 2004. It targeted to supply 35 billion shrimp post larvae per year. With the premeditated increase in demand for shrimp seed, the availability of brood stock has been an issue for development of hatcheries. At present, all of the hatcheries in Viet Nam still entirely rely on wild brood stock. The central part of Viet Nam is well known as a source of *P. monodon* spawners which are usually collected by the fishermen upon request from the hatcheries. The increasing demand for wild gravid females is placing a lot of pressure on the natural stocks of brood stock. According to Phuong et al. (2006), brood stock were almost caught from offshore by trawl net, however, it became scarcely in recent years, about 11% of total hatcheries in Ca Mau province has used brood stock source from shrimp ponds. Brood stock demand has increased yearly, this leads to increase in price of brood stock in the Mekong Delta. According to Sinh (2004), the average price of gravid females have already increased significantly from around VND 100,000 per gravid female in the late 1980s to 2-3 million VND in the later 1990s, and recently up to 5-6 million VND per gravid female. While a brood stock can be used for breeding from 2-6 times, then rejected (Sinh, 2002). Low quality of shrimp seed and high seasonal demand are the most important problems now to the shrimp farmers.

Coastal shrimp farming in north provinces

Stocking densities are different between systems. Intensive systems have a stocking density ranging between 15 and 25 shrimp/m^2, stocking density of semi-intensive is from 10-15 shrimp/m^2 and stocking density of improved extensive system is much lower which from 4 to 7 shrimp per m^2.

The amount of feed supply for shrimp culture of intensive is 5,5 MT per ha per year on average. Semi-intensive and extensive systems invest 3,5 and 0.6 MT per ha per year. Money value of fuel of intensive system is noticeably higher than that of semi-intensive and extensive system. In intensive system power is used not only for lighting and pumping but also for aeration. Semi-intensive and extensive system power or petroleum is used for lighting and pumping only. The value of fuel of intensive, semi-intensive and extensive systems were 6, 2 and 1.5 million VND per ha on average, respectively.

Major input- feeds and feed management

Coastal shrimp farming in south provinces

Recent surveys show that there were 30 feed producers cooperating between Viet Nam and foreign companies that provided about 500,000 MT of feed for aquaculture in 2000. In 2001, these number were 40 feed producers and 85,000 MT, covered 55% of the total feed demand for aquaculture. To meet the demand of aquaculture feed, about 40,000 MT of feed were also imported from Thailand, Hong Kong and Taiwan. The remaining was by unidentified or unregistered suppliers (Sinh, 2004). Informal data show that there were about 120 types of feed traded in the market in 2003, but only about 70 types have been tested, registered and allowed to be traded (MoFI, 2003). To the end of 2003, there were 15 big companies and 20-30 small and medium ones participating in production and trading of feed for aquaculture in Viet Nam with the total capacity of 250,000 MT of feed for shrimp and 100,000 MT for fish per year. The demand for feed is predicted to be 300,000 in 2004. In order to obtain the national objectives on protein for the population to 2010, about 0.5-1 million MT of feed for aquaculture are needed per year.

Feed costs to produce shrimp in Viet Nam continue to be higher than that of Thailand (USD 0.9/kg compared with USD 0.75/kg). Total feed used for shrimp in Viet Nam was estimated about 13,000 MT in 2002 and production of trash fish used for aquaculture was about 5,000 MT per year.

In the Mekong Delta, shrimp farmers have used commercial feeds (pellet) from joint-venture companies with Viet Nam. The quality of shrimp feeds depend on producers. In general, feed content consists of 35-40% protein, 5-7% fatty acid, 9-11% moisture and vitamins and minerals. The price of feed varies from 16,000 to 19,000 VND per kg, depends on quality of feeds.

In order to manage shrimp farming well, in terms of environmental management and reduce production cost, feed management for shrimp culture is considered most important technique for effective shrimp production in the Mekong Delta, because feed cost took about 60% of total shrimp production cost. It is indicated by FCR (Feed Conversion Ratio) in shrimp farming systems. For semi-intensive and intensive shrimp culture systems, average FCR of shrimp farms varies from 1.7 to 2 (informal interviews).

Coastal shrimp farming in north provinces

Following table illustrated the major inputs for shrimp farming in the north, consists of seed, feed, chemical uses and labor.

Table 18 Major inputs for shrimp culture

Input per ha	Unit	Intensive	Semi-intensive	Extensive
Tiger shrimp seed	PL15/ha/yr (,000.)	150-250	100-150	40-70
Feed	Kg/ha/yr	5,500	3,500	600
Fuel	Mil VND/ha/yr	6	2	1.5
Chemical	Mil VND/ha/yr	6-8	5-6	3-4
Maintenance	Mil VND/ha/yr	5-7	4-5	2-3
Labor	Man-day/ha/yr	450-500	250-300	150-200
Labor cost (for rent labor only)	Mil VND/ha/yr	5	2.5	0.5

Other inputs/ resource use

Coastal shrimp farming in south provinces

Regarding to chemicals/drugs used for aquaculture, according to NAFIQAVED (2003), there were 1,361 registrations for production and 199 for import of chemicals/drugs for aquaculture. Among these, 340 products with antibiotics (304 produced in Viet Nam and 34 imported). Imported chemicals/drugs increased very fast from 146 MT and 3,500 litters in 2001 to 123,000 MT and 200,000 liters in 2003. Despite of Decree 18/202/QD-BTS dated 3/6/2003 by MoFI (2003) on the procedure for testing and checking the seed, feed and chemicals/drugs used for aquaculture, only 53 products were reported up to the end of 2003.

In shrimp farming, chemical/drugs used for shrimp culture has been concerned for environmental issues and safety and clean of shrimp product. Especially for semi-intensive and intensive systems in the Mekong Delta, chemical/drug cost accounted about 14-15% of total shrimp production cost. Studies conducted by Trinh (2004), Nga (2004) and Tuan (2004) show an increasing level in the use of chemicals/drugs for aquaculture, especially for intensive shrimp farming along the coast of the Mekong Delta.

Organic shrimp culture may be a good alternative that help to solve marketing issues related to consumer preferences and reduce the risks caused by the use of chemicals/drugs.

Other inputs for shrimp culture are involved in shrimp culture systems in the Mekong Delta such as cost of oil for paddle wheel operating, equipments (paddle wheel), labors and interest from banks, all of these take a costs about 10% of total cost in shrimp production cost.

Coastal shrimp farming in north provinces

Chemical and maintenance costs occupy a not much percentage of total cost of shrimp aquaculture farms. The value of chemical used of intensive, semi-intensive and extensive were 6-8, 5-6 and 3-4 million VND per ha per year. Maintenance cost value range between 2 and 7 million VND per ha.

Labor for intensive system was about 450 to 500 man-day per ha including on-farm and rent labor. Intensive farm paid around 5 million VND per ha for rent labors. The number of man-day per ha of semi-intensive system was from 250 to 300 and cost for rent labors was 2.5 million VND. Extensive farm used 150 to 200 man-day per ha for shrimp culture with mainly on-farm labors and paid only 0.5 million for rent labors.

Risk

Coastal shrimp farming in south provinces

Shrimp disease has been the biggest problem in the Mekong Delta, and 61.5% of shrimp farmers was lost in 2005 (Sinh et al, 2006). Recently, shrimp farming has become the most important aquaculture commodity, especially in the coastal provinces; however, this is also the practice which has the highest level of risks.

Statistical data and information show that an average of 36% in 2001 and 56.2% in 2002 of the total shrimp cultured areas of Viet Nam was reported to be infected by different diseases. In 2003 about 36% (156,841 ha) of the total shrimp farming area in the Mekong Delta suffered negative profits. On average, about 25-30% of the total shrimp farmers of Viet Nam have an annual net loss (Sinh, 2004). The Rice-Shrimp system is considered as a suitable system for several main shrimp provinces in the Mekong Delta, however, also this system seems to be facing occasional losses.

Unsuccessful farmers of this system in Soc Trang province in 2002 increased up to 58% when a lot of these farmers stopped planting rice in the field. In 2003 this number was 28.1%, with some improvement in the rotation of rice-shrimp and the water management. According to Soc Trang DOFI (2004), the ratio of shrimp households that failed was 48 % and 47% in My Xuyen and Vinh Chau districts in 2003, respectively (DOFI Soc Trang, 2005a). White spot has been the most serious issue in shrimp culture with 60-70% of infected shrimp ponds. It was approximately 21,322 ha (43.6% of total area of shrimp culture area) that was failed in 2004 (DoFI Soc Trang, 2005b). In Bac Lieu province, shrimp farmers faced also to shrimp disease problem. In 2005, disease symptoms of yellow head were 5.2% of shrimp households and 68.7% of white spot disease (Dung, 2006).

Table 19 Sensitivity analysis of Intensive shrimp in Soc Trang 2006 subjected to various externality scenarios. The first part of the table illustrates single an externality's impact upon Annual Net Profit i.e. drop in farm-gate value, increase in feed and fuel costs. The second part of the table illustrates three multi-externality scenarios

Single Externality Scenarios					
Farm gate value	**Baseline 2006**	**20% reduction**	**30% reduction**	**40% reduction**	**Unit**
Annual Net Profit (ANP)	236,940	140,940	92,940	44,940	**'000 vnd/ha/year*
Percentage impact ANP		-41%	-61%	-81%	
Feed price	**Baseline 2006**	**20% increase**	**40% increase**	**60% increase**	**Unit**
Annual Net Profit (ANP)	236,940	212,540	188,140	163,740	**'000 vnd/ha/year*
Percentage impact ANP		-10%	-21%	-31%	
Fuel price	**Baseline 2006**	**20% increase**	**50% increase**	**100% increase**	**Unit**
Annual Net Profit (ANP)	236,940	235,020	232,140	227,340	*'000 vnd/ha/year
Percentage impact ANP		-1%	-2%	-4%	

Multi Externality Scenarios		**FGV -20% Fuel +50%**	**FGV -30% Fuel +50%**	**FGV -40% Fuel +50%**	
	Baseline 2006	**Feed price +20%**	**Feed price +40%**	**Feed price +60%**	**Unit**
Annual Net Profit (ANP)	236,940	111,740	39,340	-33,060	****'000 vnd/ha/year***
Percentage impact ANP		-53%	-83%	-114%	

Table 20 Sensitivity analysis of Semi-Intensive shrimp in Soc Trang 2006 subjected to various externality scenarios. The first part of the table illustrates single an externality's impact upon Annual Net Profit i.e. drop in farm-gate value, increase in feed and fuel costs. The second part of the table illustrates three multi-externality scenarios

Single Externality Scenarios					
Farm gate value	**Baseline 2006**	**20% reduction**	**30% reduction**	**40% reduction**	**Unit**
Annual Net Profit (ANP)	209,340	148,540	118,140	87,740	**'000 vnd/ha/year*
Percentage impact ANP		-29%	-44%	-58%	
Feed price	**Baseline 2006**	**20% increase**	**40% increase**	**60% increase**	**Unit**
Annual Net Profit (ANP)	209,340	201,860	194,380	186,900	**'000 vnd/ha/year*
Percentage impact ANP		-4%	-7%	-11%	
Fuel price	**Baseline 2006**	**20% increase**	**50% increase**	**100% increase**	**Unit**
Annual Net Profit (ANP)	209,340	208,340	206,840	204,340	*'000 vnd/ha/year
Percentage impact ANP		0%	-1%	-2%	

Multi Externality Scenarios		**FGV -20% Fuel +50%**	**FGV -30% Fuel +50%**	**FGV -40% Fuel +50%**	
	Baseline 2006	**Feed price +20%**	**Feed price +40%**	**Feed price +60%**	**Unit**
Annual Net Profit (ANP)	209,340	141,060	103,180	65,300	****'000 vnd/ha/year***
Percentage impact ANP		-33%	-51%	-69%	

Creating scenarios in which FGV was reduced whilst the cost of feed and fuel increased clearly revealed that the semi-intensive operation was much more resilient than the intensive (see

Table 20). In the worst-case scenario the intensive system was not economically viable opposed to the semi-intensive system which could still generate an ANP of 65 mil. vnd/ha/yr.

It is to be expected that FGV will continue to drop in the coming years and thus it is essential that more efficient input utilization is achieved if the production systems are to continue being economically viable.

Trash fish still constitutes a major part of the protein in the formulated feed and given the high global demand for raw fish protein product and the high pressures on the natural stocks prices are expected to rise. This will result in higher feed costs unless substitutes to the fishmeal based protein can be found. This is clearly an area which research must concentrate on in the coming years.

Whilst the data above indicates that both intensive and semi-intensive shrimp farming are very profitable business venture it must be stated that 50% of all farms in Soc Trang province (where the data originates from) were making a loss in 2005. The main causal reason for this was related to disease outbreaks. The message to get through here is that both business venture are highly risky and should not be conducted by capital-poor individuals. It must be noted that the semi-intensive system will still make an ANP if every second crop fail opposed to the intensive system.

It can be concluded that shrimp farming in the south conducted without following better management practices or similar scheme have a considerable risk in failing to generate income.

Coastal shrimp farming in north provinces

Shrimp farming in the Northern provinces easily get disease outbreaks since the source of seed supply is not monitored and it is difficult to control imported seed from other provinces and China without inspection of disease pathogen.

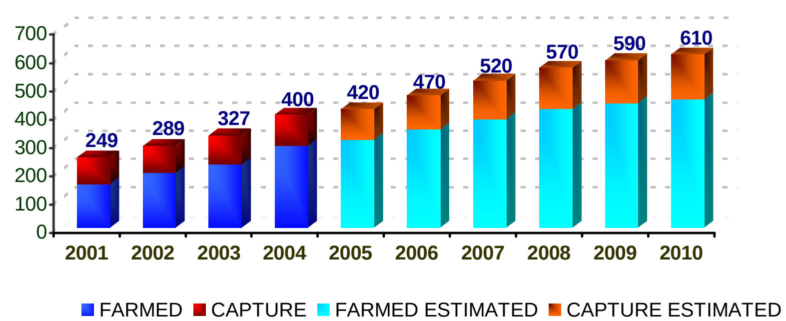
There are also climatic conditions that make the northern provinces more risky than the south. Natural risks such as typhoons can cause big damages to coastal areas and shrimp ponds in Northern provinces, e.g. the typhoon No 2 and No 7 (Damrey) in the 2005 which destroyed nearly all shrimp ponds in Nam Dinh, Hai Phong, Thai Binh and Ninh Binh provinces. Due to the characters of climate condition (temperature and rain), shrimp farming in Northern provinces last from April – August/September and this coincide with the typhoon season.

Therefore, shrimp farming in the Northern provinces experience higher risks of crop failure compared to shrimp farming in the southern provinces. The risk can be minimized if only one crop is cultured per year. There is a good potential to rotate the shrimp crop with other commodities under these conditions. Good planning is also essential to avoid damage from typhoons.

Market and market chain

It is estimated that in the coming years, shrimp will still be the leading commodity in fisheries sector. The capture production will increase slightly but the increase in total sector production is mainly related to the continued quick growth of aquaculture production (See Figure 7).

Figure 7 Shrimp production Outlook

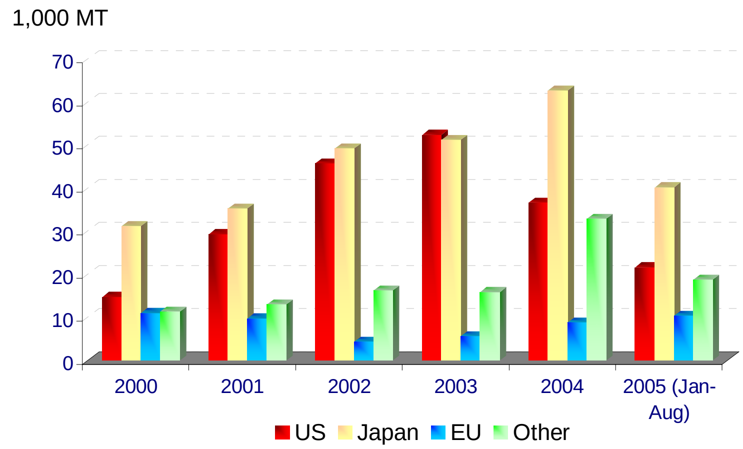


Source: VASEP

The shrimp sector makes the biggest contribution to the export value of Viet Nam. In 2005, the total foreign currency gained by shrimp export was US$ 1.3 billion. The shrimp production consists of 24.86% in quantity and 50 % in value of fisheries export. Viet Namese shrimp are present in more than 24 countries around the world.

The biggest importer of Viet Namese shrimp is Japan with 41.17% in quantity (equal to 39.55% in value) out of the total export. The second is the US (with the quantity and value of 26% and 32.33% respectively).

Figure 8 **Viet Namese shrimp by main markets (Quantity)**



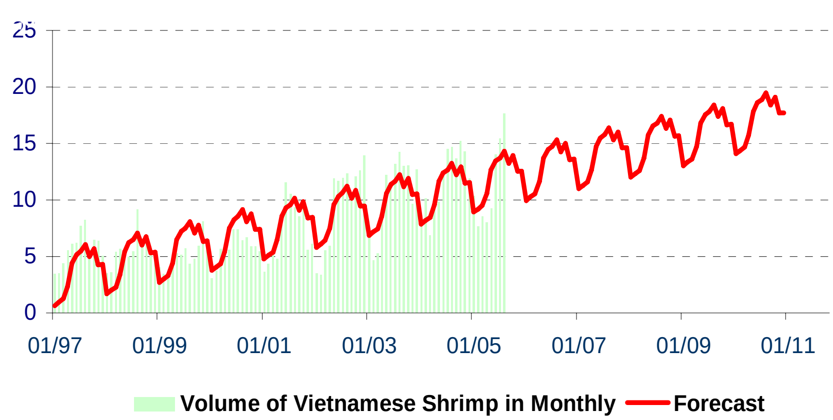
Source: VASEP

Despite of the obstacles for Viet Namese shrimp export like the anti-dumping tariffs by the US, the constantly increasing demands for higher food safety requirements by the largest importers like Japan and the EU, the shrimp export volume from Viet Nam have experienced a stable growth throughout recent years and is expected to maintain this growth speed in the coming years by exploring and benefiting from new markets as well as widening the existing potential markets.

Understanding the importance of raising awareness for customers of Viet Namese seafood, the Viet Namese government has approved a national strategy on trade promotion of seafood 2006 – 2010, especially three key export commodities namely tuna, shrimp and *Pangasius*.

A project on developing a brand for Viet Namese shrimp has been implemented and will run until November 2007 when product brands for the shrimp products will be developed. This is expected to maintain a stable market growth and ease the process of marketing Viet Namese shrimp products.

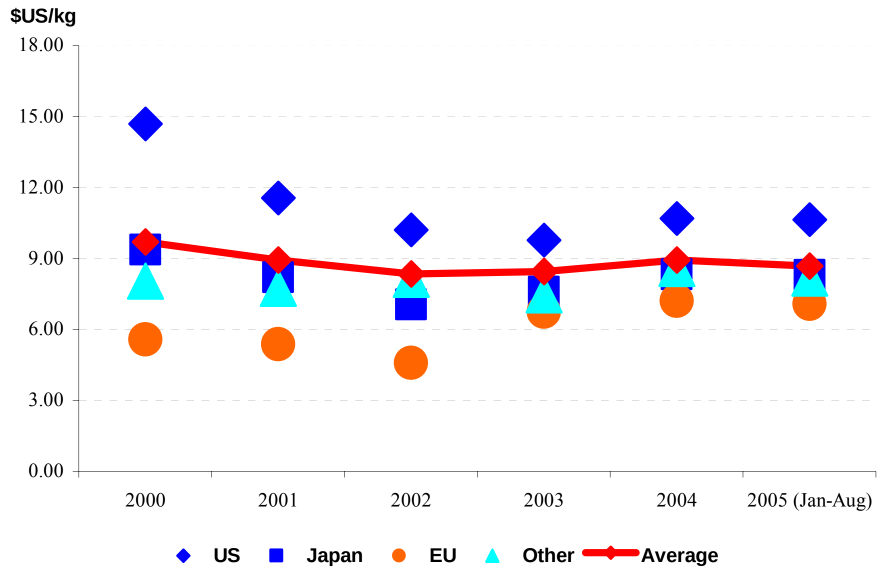
Figure 9 Volume of monthly Viet Namese export shrimp and forecast



Source: VASEP

The export of shrimp maintain a stable export volume and is at the same time experiencing a rather stable, even a slightly increasing market prices though the trend of shrimp price in the global market has declined in recent years. Besides, the farmers have tried to reduce the production cost by improving shrimp culture technique, well managing of feeding and reducing other costs. Processing companies have applied advanced technological process, diversified shrimp products, improved shrimp quality for export market, and expanded international export and domestic markets.

Figure 10 Export prices of Viet Namese shrimp



Source: VASEP

Shrimp has the most complicated market chain of all the commodities (See Figure 12 & Figure 13). This chain is characterized by the appearance of middlemen in most of the chains. Nearly 80% of farmed shrimp is produced by small-scale shrimp farmers. These farmers can sell their product directly to a near processor or through middlemen (wholesaler). The number of processing mills is, however, limited and, in many cases, inaccessible for many farming areas. Even in the area where there is a processing mill nearby, for economic reason, the processors can directly collect shrimp only in the peak harvesting time when a lot of shrimp farmers in an area sell their output at the same time. However, the harvest day can vary from one farmer to another. Therefore, in case of small amounts harvested, farmers also have to sell raw materials to middlemen. This also explains the fact that nearly 70% of raw materials sold to processors are of wholesalers.

Figure 11 Market chain to and from shrimp wholesalers (FAO, DANIDA and Ministry of Fisheries, 2003)

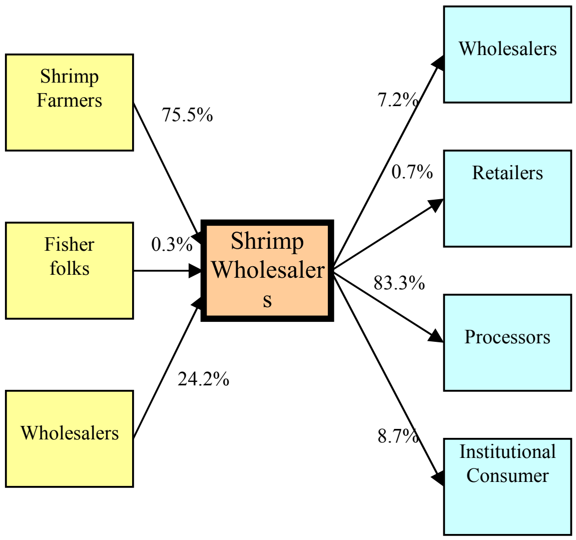


Figure 12 Market chain to and from shrimp processors (FAO, DANIDA and Ministry of Fisheries, 2003)

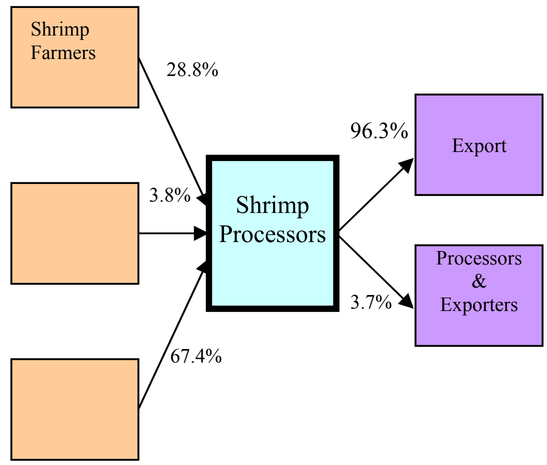
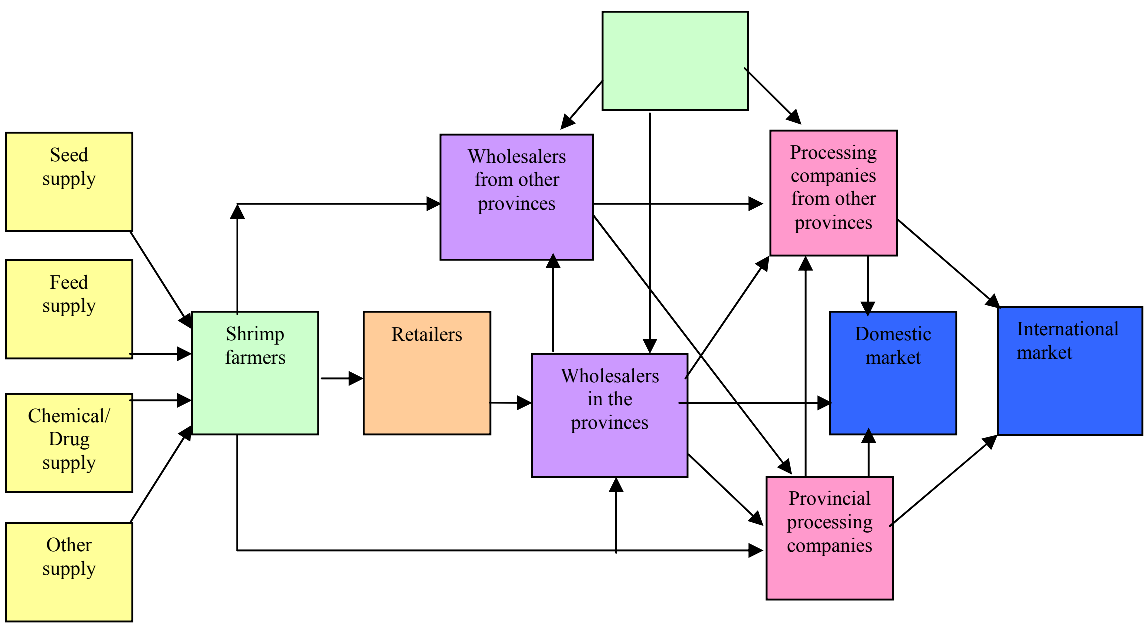
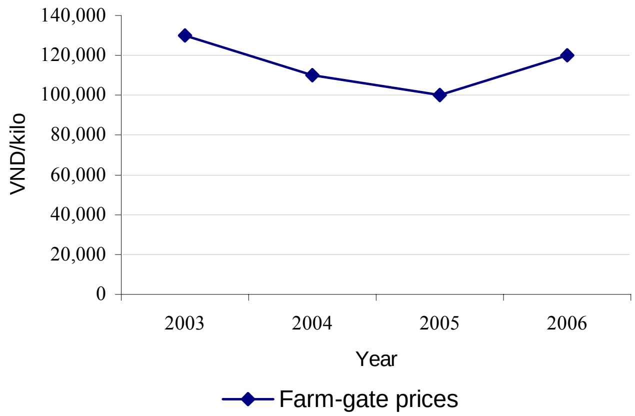


Figure 13 The market chain of tiger shrimp in the scoped provinces



With the market size of tiger shrimp of around 30-40 shrimp per kg, the farm-gate prices went down in the period 2003-2005 but were still at a reasonable high level. The price difference between sizes is about VND 10,000-5,000. Average farm gate price with popular size of tiger shrimp from 2003 to 2006 is shown below Figure 14.

Figure 14 Farm-gate price (Can Tho University 2006)



Compared with export prices, the farm-gate prices are affected by many more factors. As most of the farmers are small-scale, they don't have cold storage. Their products must be sold within few days of harvest. If there are too many farmers selling at the same time, the prices may be downed by middlemen. Therefore, normally, the average difference of price from farm-gate to middlemen is VND 2,700/kilo, from middlemen to wholesalers/processor is VND 2,000/kilo and from farm gate to processor is VND 5,900/kilo but in some cases, the differences can be larger. There are also difference in prices between the beginning time and the ending time of a crop. The difference is about VND10,000-15,000 depending on sizes.

Economic and social issues

Development of coastal shrimp culture is mainly steered by MOFI, however other ministries do also play important roles (See chapter on institutional issues). Production of shrimp contributes significantly to economic development in coastal rural regions (MOFI, 2004a).

In the Mekong Delta, 63.5% of households earned a higher income from shrimp cuture compared with five years ago. The other side of the story is that 22.5% of households involved in shrimp farming were worse-off (Sinh et al, 2006). 61.6% of shrimp households were indebted from loans, averaging 22.6 VND millions (US$ 1,413) per household, 51.6% of indebted households went bankrupt in 2004; it caused high risk for bank activities (Sinh et al, 2005).

Recent studies show that 100% of intensive and semi-intensive shrimp farmer's livelihood is based on shrimp culture, and shrimp play an important role in the coastal communities of the Mekong delta. According to Newspaper of Viet Nam Education (2006), 15% of children in Vinh Chau district Soc Trang province dropped out of school because of failures in shrimp culture. They have to work for shrimp farming activities of their household or other farmers. The poor were often lost in shrimp culture due to low investment; they could not adapt technical requests. Many shrimp farmers were indebted by unsuccessful shrimp farming. They had not an opportunity to loan from banks for shrimp production (Sinh et al, 2006). The "Interaction between Trade Liberalization, Rural Poverty and the Environment
Case Study on Shrimp Aquaculture in Ca Mau" (in press, WWF), showed that large borrowing in shrimp production has lead to increased financial risk to farmers, with many having problems paying back loans. Correspondingly, there has also been a significant school drop-out rate for children whose parenets are involved in shrimp aquaculture, associated with farm failures.

Table 21 Labour indicators for intensive and semi-intensive shrimp production in Soc Trang province assuming 2 crops per year

Labour Indicators	Intensive	Semi-Intensive	Units
Job Indicators			
Labour fixed	1.00	0.67	man-months/ha/yr
Labour seasonal	1.40	0.67	man-months/ha/yr
Total labour	2.40	1.33	man-months/ha/yr
Investment per job*	47,916.7	80,250.0	*'000 vnd/man year

* Capital costs are used as the sole basis for comparing investments

The intensive system requires only 60% of the investment per job when compared to the semi-intensive system mainly due to the lower labour requirement of the semi-intensive systems. The intensive systems requires a higher amount of seasonal labour which is often recruited amongst the poorest in the community as little skill is require for this type of work i.e. harvest and other types of manual labour.

Table 22 Economic performance indicators for intensive and semi-intensive shrimp production in Soc Trang province assuming 2 crops per year. TVC= Total variable costs; TFC=Total fixed costs; NR=Net Profit; TOC=Total operating costs; CC=Capital Costs

Economic Indicators	Intensive	Semi-Intensive	Units
Net profit/ha/yr	236,940	209,340.0	*'000 vnd/ha/year
Total farm gross revenue (Farm Gate Value)	480,000	304,000.0	*'000 vnd/ha/year
Total operating costs (TVC+TFC)	243,060	94,660.0	*'000 vnd/ha/year
Value added (Net profit+labour costs)	262,140	221,40.0	*'000 vnd/ha/year
Benefit/cost (NR/TOC)	0.97	2.1	
Minimum start-up costs (TOC+CC)	358,060	201,660.0	*'000 vnd/ha/year

Surprisingly the net profit does not differ substantially between the two systems. The main reason for this is the very high total operating costs (TOC) for the intensive system which are around 150% higher compared to the semi-intensive systems.

The benefit-cost ratio clearly indicates that the semi-intensive system is a superior production system in relation to economic returns with a net profit around twice of the TOC. This high B/C ration for the semi-intensive system also indicates that this system will have a higher degree of economic resilience compared to the intensive system.

Finally the minimum start-up costs of semi-intensive system amounts to 55% compared to the intensive system. However, start-up costs for both systems are high and it is not realistic for poor households gather sufficient funds to invest in either of the two systems.

2.1.2 Environmental assessment

The development of shrimp farming has faced environmental and disease related problems. The area of shrimp culture in 2005 was 604,497 ha which exceeded the 2010 planned target of 562,650 ha while the total production was 330,220 tons in 2005 and compared to the 2010 targeted number of 400,000 tons (alternative 1) and/or 420,000 tons (alternative 2) as specified in the Fisheries Sector Master Plan. These figures indicate that pond productivity has decreased as a consequence of an increase in disease outbreaks and thus development is not regarded as being sustainable.

Shrimp aquaculture development has resulted in severe environmental issues and requires several interventions in order to steer the sector in a more sustainable direction. Better management practices are one of the main interventions needed to be implemented.

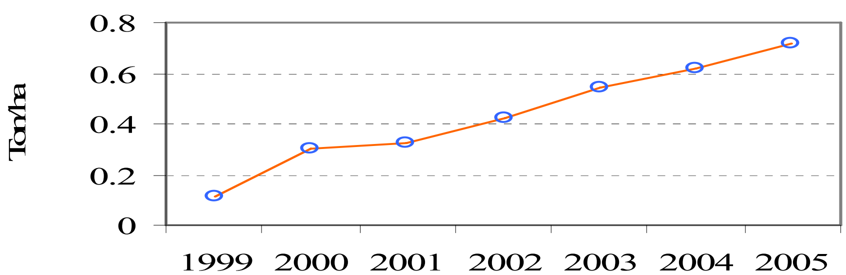
Coastal shrimp farming in south provinces

In shrimp farming systems, semi-intensive and intensive culture systems have been concerned for environmental issues in the Mekong Delta. The case study of shrimp commodity in the south of Viet Nam was scoped in Soc Trang, Bac Lieu and Ben Tre provinces since these coastal provinces have developed rapidly semi-intensive and intensive shrimp culture systems in recent years.

In order to assess existing shrimp farming activities; inputs and outputs of shrimp culture; and as well the environmental impacts by the shrimp culture activities, field trips and interviews for shrimp farmers were conducted in the concentrated semi-intensive and intensive shrimp culture areas of Soc Trang, Bac Lieu and Ben Tre provinces. In addition, secondary data and related studies were also used for the case study.

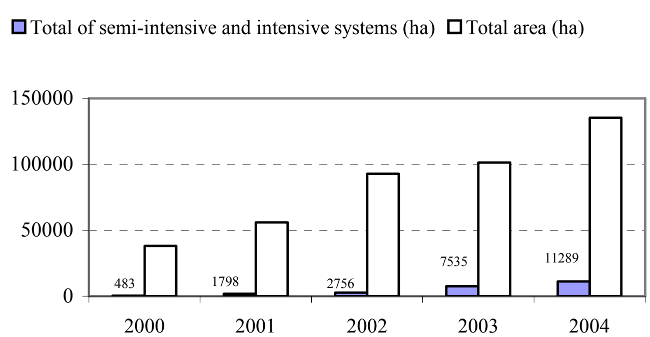
Soc Trang province is considered as the fastest shrimp culture development province in the Mekong Delta (DOFI Soc Trang, 2005a; MOFI, 2004a). Especially, semi-intensive and intensive shrimp culture area was increased rapidly from 5,241 ha in 2003 to 13,745 ha in 2004 (DOFI Soc Trang, 2005a). The export value from shrimp production was USD 25,3 millions in 1992 , increased USD 297 millions in 2004, and USD 306 millions in 2005 (Hai, 2005). Average shrimp yield increased significantly in recent years.

Figure 15 Average yield of cultured shrimp from 1999 to 2005 (DOFI, 2005a)



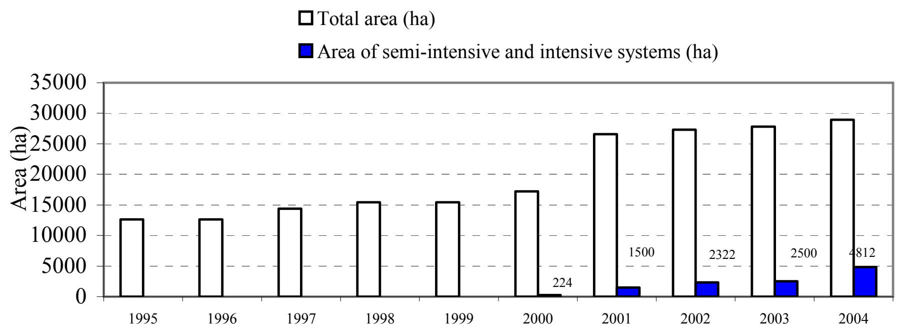
Bac Lieu province has 254.190 ha of total aquaculture area, in which shrimp culture area was accounted about 140,000 ha. Particularly, semi-intensive and intensive culture area has increased yearly and reached about 11,300 ha in 2005. Average shrimp production increased from 9,500 tones in 2000 to 72,209 tones in 2004 because of intensification and expanded area for shrimp culture in recent years (DOFI Bac Lieu, 2004b).

Figure 16 Total shrimp culture area and semi-intensive and intensive system in Bac Lieu province (DOFI Bac Lieu, 2004a)



In Ben Tre province, coastal aquaculture development is especially concentrated in three coastal districts as Binh Dai, Thanh Phu and Ba Tri, around 30,000 ha of total coastal aquaculture area in 2004 (DOFI Ben Tre, 2005). In these areas, semi-intensive and intensive shrimp culture area accounted about 4,800 ha. According to DoFI Ben Tre (2004), semi-intensive and intensive shrimp culture area has planned to increase from 2,500 ha in 2003 to and 15.000 ha in 2010.

Figure 17 Coastal shrimp culture Area in Ben Tre province (*Source*: DOFI Ben Tre, 2005)



The semi-intensive system pollutes around one third of the intensive systems mainly due to a lower feed input per hectare. If intensive systems are promoted then large investments must be made in effluent treatment ponds as well as solid waste deposit areas on the farm. This will result in a relative smaller production water surface which will have an adverse impact on the economic performance of the system.

Given the better economic performance including resilience of the semi-intensive shrimp system it is strongly suggested that development should concentrate on semi-intensive production systems due to its much lower pollution levels compared to the intensive system.

Table 23 Key pollutants from intensive and semi-intensive shrimp systems in Soc Trang province. The ratios between aquatic pollution and solid waste are based on Brigg and Funge-Smith (1994).

ENVIRONMENTAL INDICATORS	Intensive	Semi-intensive	Unit
ENVIRONMENTAL EFFLUENT BUDGET			
Aquatic pollution			
Nitrogen load (aquaculture)	176	54	kg/ha/year
Phosphorous load (aquaculture)	12	4	kg/ha/year
Solid waste			
Nitrogen load (aquaculture)	156	48	kg/ha/year
Phosphorous load (aquaculture)	100	31	kg/ha/year
Organic waste	5.422	1.662	kg/ha/year

Coastal shrimp farming in north provinces

The survival rate of shrimp culture depends on many factors, but two of the most important factors are disease and climate condition. In 2005, more than 40 % of shrimp farm in North Viet Nam was being affected by white-spot diseases, of which about 20 % of farm was totally loss. In addition, nature disasters are consequential to shrimp culture. In North, there were from 3-5 storms annually, this is negative effect to shrimp aquaculture. For example, in 2005, the storm No5 destroyed thousand of ha shrimp culture area in North and North Central, especially Hai Phong and Thanh Hoa provinces. In intensive system, the survival rate of shrimp was from 40 to 60 %, in semi-intensive system was from 30 to 50 % and extensive system ranges between 20-40 %. the above mentioned figures are for ponds that were not totally effected by white-spot disease and natural disasters.

FCR of shrimp culture varied depending on feed quality and feed management. The FCR of extensive pond is lower than that of Intensive and semi-intensive systems because of taking advantage of feed from wild by using directly water from the sea. The FCR of intensive and semi-intensive systems range between 1.2 and 1.5. The FCR of extensive was from 0.7 to 1.2.

Intensive and semi-intensive system are more risky than extensive system. Intensive system with high density stocking, limited water quality management and high financial investment are cause of risk, especially white-pot disease beak out in shrimp. In 2004, white-spot disease broke out in south central coastal provinces resulting on decreasing shrimp culture area in 2005 in this region.

Table 24 Various performance issues related to management and externalities

Management Performance & Risks	Intensive	Semi-intensive	Extensive
Survival rate (%)	40-60	30-50	30-40
FCR	1.6-2.1	1.6-2.1	0.7-1.4
Risk	High/Medium	High/Medium	Medium/Low

Table 25 Key pollutants from intensive and semi-intensive shrimp systems in Soc Trang province. (Assumption that amount of pollutants is a half compared to southern province since there is only 1 annual crop in the north)

ENVIRONMENTAL INDICATORS	**Intensive**	**Semi-intensive**	**Unit**
ENVIRONMENTAL EFFLUENT BUDGET			
Aquatic pollution			
Nitrogen load (aquaculture)	88	27	kg/ha/year
Phosphorous load (aquaculture)	6	2	kg/ha/year
Solid waste			
Nitrogen load (aquaculture)	78	24	kg/ha/year
Phosphorous load (aquaculture)	50	15.5	kg/ha/year
Organic waste	2.711	0.831	kg/ha/year

Location and farming siting

In general, shrimp culture ponds in the case study provinces were located in the coastal areas, where brackish water supplied favorably for shrimp culture. Although the semi-intensive and intensive shrimp culture area has developed rapidly in the provinces, the development has faced to a number of issues such as infrastructure for shrimp culture, especially canal system that may lead to self-pollution; lack of zoning for intensive shrimp culture area; shrimp pond design has not been standardized for reducing negative environmental impacts; lack of capital for investment of upgrading canal systems as well zoning for major shrimp culture areas in the provinces. Solutions for these issues has not still implemented at the current period.

Design and construction

In the scoped provinces, semi-intensive and intensive shrimp ponds are mainly located in inter-tidal and acid sulphate soil areas. This may cause water pH fluctuation in shrimp ponds, especially in the rainy season. On the other hand, water turbidity is high due to sedimentation in supply canals and shrimp ponds causing reduction in water supply and drainage in the culture areas. One main intervention to improve supply and drainage is to improve water supply and drainage infrastructure.

Seed supply, brood stock and post larvae

At present, seed stock demand is quite high and not sufficient for shrimp culture in the scoped provinces, despite shrimp post larvae has been imported from the central provinces (65-70% of total seed demand of the Mekong Delta) and the Mekong Delta's provinces 28.6% of total seed demand. Seed supply for hatcheries has not sufficient in terms of quantity and quality for shrimp farmers. Infected seed has been an out standing issue for provincial fisheries managers and shrimp farmers. Besides, brood stock supply for hatcheries has depended on wild brood stock source. Most brood stock for breeding in hatcheries is caught in the offshore area of Ca Mau province. Brood stock are bought and transported to hatcheries in the coastal provinces of the Mekong Delta and as well as central provinces. Such over-fishing of shrimp brood stock will reduce natural brood stock in further years. According to Sinh (2003), one fourth of the brood stock number died before selling at hatcheries. On the other hand, scarce and high price of brood stock that result in hatcheries have used the brood stock for breeding several times (2-6 times). This may lead to poor quality of post larvae for culture. In recent years, although attention has been paid to domesticated brood stock is considered and paid attention to replace wild brood stock source for breeding in hatcheries, it has not applied broadly in Viet Nam and the Mekong Delta.

Shrimp seed production has been strongly developed in Viet Nam in the last decade. In 2000, the number of shrimp hatcheries was 2,860, of which 2,520 were shrimp hatcheries with a production of 6 billion shrimp larvae (MOFI, 2000).

Table 26 shows the number of shrimp hatcheries and quantities of seed of shrimp in 2001. The total production of seed was 16 billion shrimp post-larvae (P15). Shrimp post-larvae production is mainly focused in central coastal provinces. Production in this region was about 12 billion and accounted for about 73.4 percent of the total production of the whole country (MOFI, 2000).

Table 26 Aquaculture seed production of shrimp and fish in 2001

Region	**Shrimp seed production**	
	Number of Hatcheries	**Output (mil. P15)**
Whole country	3,777	16,000
Northern Highland	3	38
Red River Delta	7	170
North Central Coast	31	296
South Central Coast	2,220	11,751
Central Highland	--	--
Southern East	211	1,117
Mekong River Delta	903	2,628

(Source: MOFI, 2001)

In 2001, 21 of 29 coastal provinces had shrimp seed production hatcheries with a total number of 3,777. The central coastal provinces produced a major proportion of shrimp post larvae. There were 2,661 shrimp hatcheries in these provinces with a total production of 10,095 million and the average capacity of each hatchery was 3.79 million post-larvae. Of those, Khanh Hoa Province had the highest number of 1,134 hatcheries with an average production of 3.47 million PL per hatchery (Ministry of Fisheries 2001b).

One problem is that 70% of the total cultured shrimp areas are in the Mekong Delta but the major seed production facilities are in the central area. Inter-province exports of shrimp post-larvae exceeded 15 billion PL_{15} (post larvae 15 days old) per year from 2000. Recent report indicated that the seed stock supply from Central region accounted for 70% of total seed production of Viet Nam, 28.6% from the South and 1.4% from the North of Viet Nam (Phuong et al., 2004).

Water use and impact

Shrimp culture industry has developed at present in the scoped provinces (Soc Trang, Bac Lieu and Ben Tre) causing several concerns on environmental problems by negative impacts from intensification level of shrimp culture. For example, effluent water from shrimp ponds has been not treated before discharge into rivers or canals. This waste water source may contain high concentration of nutrients and chemicals/drugs, and pathogens, which cause negative impacts on the coastal habitat and aquatic resources, especially for self-pollution in the local shrimp culture area rather than impact on other sectors.

In Soc Trang province case, most farmers lacked ponds for storage and treatment waste water. Waste water from shrimp ponds were discharged directly to public canals and rivers. For Bac Lieu province case, water environmental pollution was clearly caused by hatcheries (23% of total local hatcheries). The effluent water discharge from shrimp ponds impacts on surrounding and local area. In addition, using water source from the same canal due to limitation of supply and irrigation canal systems may lead to transition of shrimp pathogens in the locality. In contrary, for the Ben Tre province case, negative impacts by shrimp culture didn't happen due to better management and zoning for shrimp culture area. Of course, shrimp disease outbreak has also happened at small scale area. It is recognized that zoning for semi-intensive and intensive shrimp culture area, as well as improving supply and drainage canals, and good organizing for shrimp culture activities at local communities contributes significantly in successful shrimp culture development in the province.

Shrimp culture in coastal used brackish water. Brackish water of shrimp culture is supplied directly from the sea or river by tide to the inlet and reservoir then water is pumped to the cultured pond. Water of extensive pond is, normally, supplied direct from sea or river mouth. In some area, freshwater are supplied for shrimp culture in order to reduce salinity, however this is not popular in North and North Central.

An important issue is that the almost of shrimp water after usie was being discharged in to the surrounding environment. In some planned areas, used water was contained in reservoir for treatment, but this is very limited and only for intensive system. This is a cause of disease break out and environment pollution. Currently, water for shrimp aquaculture is not being monitored, except some pilot areas which water are monitoring by RIA1 in North and Central.

Waste and impacts

In general, effluent quality and management in semi-intensive and intensive shrimp farming areas has not been a major concern to the local communities in the scoped provinces. Water waste and sludge have not still managed well. Most shrimp farmers discharge water waste and event sludge directly into public rivers or canals, because most shrimp ponds do not have a waste treatment pond. Most shrimp farmers do not care much about good or poor water quality. However, they pump water into a sedimentation pond and treat the water before stocking shrimp seed.

The rough estimation of pollutant loads of effluent and waste of coastal shrimp aquaculture up to 2010 based on the Master Plan up to 2010.

ENVIRONMENTAL INDICATORS	Intensive (kg/ha/year)	Semi-intensive (kg/ha/year)	Total pollutant loads (tons/year)
ENVIRONMENTAL EFFLUENT BUDGET			
Aquatic pollution			
Nitrogen load (aquaculture)	176	54	***15960***
Phosphorous load (aquaculture)	12	4	***1120***
Solid waste			
Nitrogen load (aquaculture)	156	48	***14160***
Phosphorous load (aquaculture)	100	31	***9100***
Organic waste	5.422	1.662	***491.52***

Note: The calculation has been done for intensive and semi-intensive shrimp farming.

Feeds and feed management

Currently there are several kinds of feed have been used for shrimp culture. Most of the shrimp feeds have been produced by joint-venture companies in Viet Nam such as CP (Thailand), Grobest, Greenfeed, Cargill, Tomboy, Woosung and Anova.

Feed raw materials (including fishmeal) are administrated by the feed companies. Thus, amount and source of fishmeal (or replaced by plants source) for feed processing have not been proclaimed at present. Recent studies on replacing of plant based protein to fishmeal were conducted, but mostly applied to freshwater fish culture.

Although there is diversification of kinds of shrimp feed as the current status, an issue should be raised for the management of feeds quality and sources at provincial fishery sector. In fact, most shrimp farmers can not identify which kind of feed is good and how to know the quality of feed.

This is also an issue for feed management and provincial level and local shrimp community level.
For feed management, many shrimp farmers have paid attention to shrimp culture, especially for semi-intensive and intensive systems in recent years. Farmers' technical knowledge for feed management in shrimp culture has improved. However, practical feed management has still not successful by technical complexity in shrimp culture. Therefore, ineffective management for feeding in shrimp culture has raised an environmental issue and need to be considered for further development of shrimp culture in the coastal area of the Mekong Delta.

Disease issues and health management

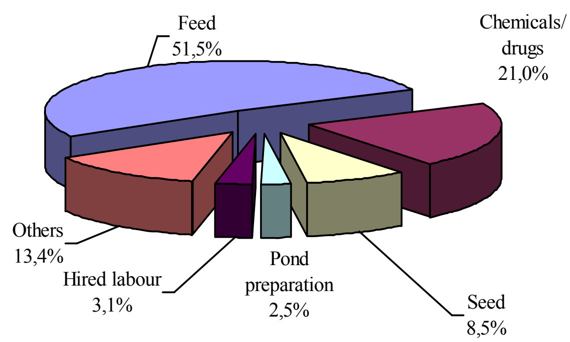
Shrimp disease has being an out-standing issue for shrimp culture in the Mekong Delta. There are several reasons of this issue. It may be concentrated at two major level of disease control:

- Management at provincial level, although provincial infection agency has made efforts in seed control in the province, importing and supplying shrimp seed from different several ways. This leads to plenty of difficulties in control seed closely. Besides, facilities and manpower have not yet met the need of shrimp seed quality and health management in the province.
- Management at shrimp farmer's level, most farmers is poor knowledge in seed quality control and health management. Besides, awareness of shrimp health management and environmental protection has being high level. In addition, most of them like to buy cheap price of seed regardless of good or poor quality of seed source.

Food safety and quality

According to recent studies show that most shrimp farmers has used many kinds of chemical and drug in their farm. The cost of chemicals/drugs was accounted about 21% in intensive shrimp production (**Figure 18**), despite farmers may not know well about the usages of chemicals/drugs. In fact many of the asked shrimp farmers did not exactly know how the chemicals/drugs worked effectively in their pond. Despite provincial aquatic resource infection agencies have made many efforts in chemicals/drugs controls there is still a lack of implementing existing rules. This may raised an issue for food safety and product quality control for future shrimp industry development in the coastal provinces of the Mekong Delta and in the north.

Figure 18 Production costs for intensive shrimp culture in the Mekong Delta (Nga 2004)



A sensitivity analysis of the impact of externalities upon the profitability of intensive and semi-intensive systems revealed that a reduction in farm-gate-value had the greatest impact for both systems (see Table 19). However, intensive systems are more vulnerable to market price fluctuations than semi-intensive systems e.g. a 20% price reduction in (FGV) lead to a reduction of 41% on Annual Net Profit (ANP) for the intensive systems compared to 29% for the semi-intensive. The same relationship was evident for increases in feed costs. Fuel price hikes had little impact on both production systems.

Socio-economic issues

Recently, shrimp farming has been the most important in aquaculture of Viet Nam, especially in the coastal provinces. The practice of shrimp culture industry has faced to the highest level of risks. However, high profit level and quick returns has attracted a large numbers of farmers which are following up shrimp culture. Statistical data (2001) shown that, an average of 36% of the total shrimp cultured areas of Viet Nam was infected by different diseases.

In 2002, this figures increased to 56.2% (268,854 ha). In 2003, about 36% (156,841 ha) of the total shrimp farmers in the Mekong Delta got some negative profit. On average, about 25-30% of the total shrimp farmers of Viet Nam get loss, every year (Sinh, 2004). Particularly, for ration rice-shrimp system is considered as a suitable system for several main shrimp provinces in the Mekong Delta, however, it is also facing with a big loss. For example, unsuccessful farmers of these systems in Soc Trang province increased up to 58% when a lot of these farmers stopped transplanting rice in the field in 2002. This number was 28.1% in 2003, with some improvement in the rotation of rice-shrimp and the water management. Many shrimp farmers of this farming system have gave up rice crop and followed up shrimp culture, event semi-intensive and intensive culture.

The shrimp disease outbreak in large scale recently has made a number of people jobless and even forced into selling land. In addition, 61.6% of shrimp households were indebted from loan, averaging

22.6 VND millions (US$ 1,413) per household, 51.6% of loaned households was lost in 2004; this caused high risk for bank activities (Sinh et al, 2005). If there is no solution for the biggest problem of shrimp disease outbreak, there will be a huge number of negative impacts on poor and poverty in society and the regional economy. Solutions for this need to be found out soon for sustainable shrimp culture development in the Mekong Delta.

In 2001, there were about 580,000 people working either directly or indirectly in aquaculture compared to 277,850 people in 1991 and 422,500 people in 1995. Aquaculture is an attractive sector in national economic development, contributing to solving unemployment, especially creating employment for people in rural and remote areas where labor is superfluous and has less chance to access other economic activities

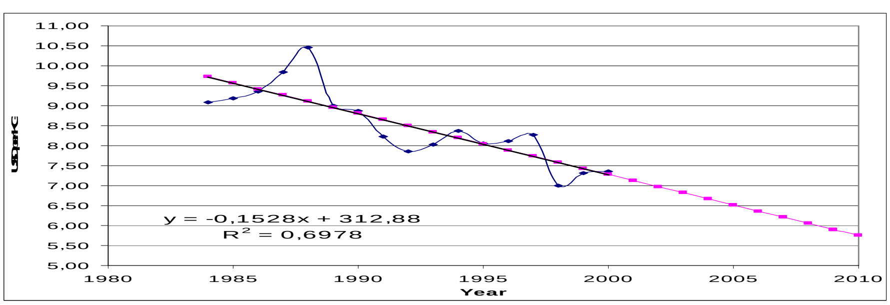
In general, women account for half of the labor force in Viet Nam. In rural and coastal areas, women are the major laborers in agricultural and aquaculture production, accounting for from 50 to 60 percent. In aquaculture processing about 80 percent of the labor are women. In coastal areas, due to the low catch of shoreline fishing, coastal people cannot rely purely on fishing and have to participate in other economic activities. In this context, aquaculture is a good livelihood option for women in specific coastal areas.

The results of the national survey in 2001 shows that 80.9 percent of total number of households in Viet Nam was involved in rural agriculture, forest and aquaculture, of which, 78.6 percent of households had the main income from agriculture, forestry or aquaculture sources. The economic differentiation of fisheries-related households is also evident. The richer households normally participate in offshore fishing; own processing enterprises or trading and supportive services. The number of rich aquaculture households is not high because aquaculture is unstable and sometime suffers from high risks, natural hazards, diseases and environmental pollution. The poor households normally participate in small-scale aquaculture and shoreline fishing. The lack of investment is one of the most difficult problems in their aquaculture development. Thus, poor people become a significant hired labor force for other aquaculture smallholders and companies.

Market issues

At present, the trend of shrimp price has decreased at farm gate level, and event export market (Christensen 2003- **Figure 19**), while production cost has not decreased. On the other hand, Viet Nam's shrimp product has faced to another big issue of trade barrier and anti-dumping price between Viet Nam and USA.

Figure 19 A prediction of international export market of shrimp product based on FAO statistics and are not size specific



(Christensen, 2003)

It should be noted that there can be considerable difference in prizes on shrimp according to size, time of year and species. This figure should therefore be read carefully and it is not a general tendency for all shrimp products produced.

In order to enhance the price of shrimp at farm gate and export market value, improving shrimp material quality, reducing production costs and especially organic shrimp culture should be considered soon by fisheries sector and shrimp farmers.

Institutional issues

Government institutions are responsible for managing and planning coastal shrimp production and promote quality and increase in production.

Extension services are provided through governmental (extension workers and hatchery) and privates based extension services. The latter is in the form of trade companies and voluntary groups of farmers. There's lack of skilled extension staff and access to relevant techniques/information.

Shrimp is a key sector in contributing to national export earnings and is, on a locale scale often seen as the most important sector in. In some coastal regions tourism is prioritized.

Several forms of farmer's organisations exist: groups, clubs, associations and cooperatives. Associations and cooperatives are being organised by commune people committee. Groups and clubs are unprompted forms of organisation or are being initiated with help from governmental project funding.

Farmers lack information about market opportunities and demands. Information is disseminated through radio, training courses, leaflets, middlemen and from farmer to farmer.

There is inadequate number of staff members in the aquaculture sector administration at provincial/district level. Staff members are typically graduates from fisheries/agriculture University or biological faculties of universities. There is lack of systematic monitoring of disease and environment issues in intensive fish culture areas (particularly concerning use of discharge water for fish culture). There is clearly a need for organized training and education of staff members

Summary of environmental issues and management practices/solutions for shrimp farming

Impacts	***Management practices/solutions***
Shrimp farming	
Impact 1. Pollution of water and land resources	• Develop regulations for the application of Decree No 67 (effluent taxes) to shrimp farming sector • Develop detailed planning guidelines • Implement guidelines at local level • Upgrade irrigation system in the shrimp farming areas where is using the former irrigation system of agriculture • Integration with other species (mollusk and seaweed farming follow Hai Phong example), • Using biological treatment of effluents (treatment ponds, enzymes, extractive species) • Develop BMP for responsible feeding practices and handling of wastes • Promote prawn/rice systems to reduce reliance on seawater and saline intrusions • Promote recirculation systems • Identify alternative uses for sludge
Impact 2. Depletion of wild aquatic reserves with high demand of quality seed	• Promote/develop programs for the domestication and production of SPF *P.monodon* broodstock • Develop stricter standards for hatchery management • Enforce compliance to standards to improve technology (maybe reduce number of hatcheries) • Develop a certification system for better quality hatcheries (healthy

	competition between hatcheries) • Promote use of better quality seed among farmers (BMP) • Aquatic Resources Protection to control more strictly compliance of hatcheries • Change in the catching practices of broodstock
Impact 3. Excessive use of (banned) chemicals with the environmental and Food safety and quality implication	• Awareness raising on environmental protection • Promoting the implementation of regulation through voluntary certification. Including the laboratories capacity (public and private) • Create the awareness of farmer and middlemen on market requirement • Improve the Post- harvest technology • Create the traceability system affordable by small scale producers • Human capacity building • Promote the application of BMP for food safety • Awareness raising and farmer training on safe chemicals usages •
Impact 4. Unsuitable siting of ponds	• Develop aquaculture plans with suitable water management (inflow/discharge) and protection of mangrove areas • Ensure minimum intact mangrove forest cover in farmed areas and include reforestation in plans • Approve and implement EIA Guideline • Research on the environmental carrying capacity for shrimp farming • Develop plan for rehabilitation of unused shrimp ponds (marine fish, etc.)
Impact 5. Disease outbreaks affecting both aquaculture and wild species	• SPF monodon stocks • Disseminate BMP for disease prevention and responsible health management (use of chemicals, etc.) • Develop and implement surveillance and warning system (following MOFI plan) • Capacity building for laboratories at province and district level
Impact 6. Introduction of exotic pathogens associated with exotic shrimp species	• Improving capacity for controlling transboundary movements • Develop capacity on IRA • Conduct and implement IRA before performing transboundary movements
Impact 7. Destruction of mangrove environments	• Establish protected areas • Promote replanting of mangroves to protect from erosion and stimulation of biodiversity

2.1.3 Guidelines for Better management

Location of aquaculture farms

Shrimp farms should be located within planned areas can help reducing a lot of environmental impacts on and of aquaculture. Follow are some

Management practices	**Criteria**
Build new shrimp farms above the inter-tidal zone	• No encroachment on the coastal fringe and its ecosystem
Avoiding damage mangroves forest or other	• Should not be located in protected areas

sensitive wetland habitats	
Avoiding the sulfate acid soil	• No FeS_2 in the soil layers
Do not locate farms on sandy soils or other areas where seepage or discharge of salt water may affect agricultural land or freshwater supplies	• No further development of sandy soil shrimp farming
All semi-intensive and intensive shrimp farming development must be subjected to environmental impact assessments and be part of a wider sector development plan	• Avoid adverse environmental impacts by using environmental carrying capacity as a development constraint

Design & construction of farms in ways that minimizes environmental damage

The good design and construction of shrimp farms will be decisive factors to reduce the environmental impacts and disease outbreak. Follow are some management practices.

Management practices	**Criteria**
Design of farm for intensive and semi-intensive farming	• 50% of land use area for shrimp pond • 20% of land use area for reservoirs • 20% of land use area for effluent treatment pond • 10% of land use area for sludge drying
Design of farm for improved extensive and extensive shrimp farming	• Remain at least 50 % of mangrove forest areas in the southern province • Remain at least 75% of mangrove forest areas in the northern provinces
Design of farm for organic-shrimp	• Remain at least 60% mangrove forest areas
Using biological treatment of effluents (treatment ponds, enzymes, extractive species	• Where possible use shrimp waste as input for value adding i.e. mollusk or seaweed culture and use phyto-remidiation rather than chemical treatment
Separate effluent discharge points from inlet canal to reduce self pollution and maintain bio-security	• Joint irrigation systems should be promoted in order to ensure that optimal effect of infrastructure development
Incorporate buffer areas and techniques and engineering practices that minimize erosion and salinisation during construction and operation	• Where possible use ecosystem restoration for erosion control and saline soil leaching i.e. mangrove in coastal areas; mellaleuca on saline highland
Integration with other species (mollusk and seaweed farming),	• Minimize inputs and wastes and maximize outputs possibly use rotational cropping
Promote prawn/rice systems to reduce reliance on seawater and saline intrusions	• Use of groundwater for culture is prohibited
Promote recirculation systems	• Minimize pollution loads
Identify alternative uses for sludge	• Use wastes as inputs for alternative aquaculture, agriculture or forestry

Seed supply, broodstock and post larvae

High efficient use of seed, broodstock and post larvae is key factor to mitigate the impacts on wild life and aquatic resource of shrimp farming. Follow are some management practices.

- Promote/develop programs for the domestication and production of SPF *P.monodon* broodstock
- Develop stricter standards for hatchery management
- Enforce compliance to standards to improve technology (maybe reduce number of hatcheries)
- Develop a certification system for better quality hatcheries (healthy competition between hatcheries)
- Promote use of better quality seed among farmers (BMP)
- Aquatic Resources Protection to control more strictly compliance of hatcheries
- Change in the catching practices of broodstock

Feeds and feed management

- Promote the formulated feed for shrimp farming together with daily checking and management.

Health management plan

Health management plan should be initiated in the sector level, which could help prevention of disease outbreak.

- SPF monodon stocks
- Disseminate BMP for disease prevention and responsible health management (use of chemicals, etc.)
- Develop and implement surveillance and warning system (following MOFI plan)
- Capacity building for laboratories at province and district level

Food safety and quality

- Awareness raising on environmental protection
- Promoting the implementation of regulation through voluntary certification. Including the laboratories capacity (public and private)
- Create the awareness of farmer and middlemen on market requirement
- Improve the Post- harvest technology
- Create the traceability system affordable by small scale producers
- Human capacity building
- Promote the application of BMP for food safety
- Awareness raising and farmer training on safe chemicals usages

Socio & economic issues

- Promoting the improved extensive and extensive shrimp farming and organic shrimp farming in southern provinces (Ca Mau) for poor as these systems are lower risk of economic loss and disease problem.
- Ensure economic resilient shrimp production systems are promoted to create stable incomes and jobs. This relates to all production systems.

Markets and demand

- Awareness raising on Technical Barriers to Trade and Environment Management ISO 14000 in shrimp farming and processing standards
- Promoting the traceability schemes for shrimp products

Institutional issues

Institutions (legislation, offices, organisations and norms) may facilitate sustainable aquaculture development and reduce the risks of unpredicted environmental or economic problems. The following general and immediate (specific) requirements are seen as important in promoting sustainability in the in the shrimp culture.

General institutional requirements:

- Decentralized, robust, transparent, and resilient management system working with applicable legislation and plans which are supported and understood by the affected stakeholders.
- Giving decision makers access to continuous updated and reliable data on production, natural resources, market and socio economic issues.
- Adjusting production and the development plans towards sustainability targets through incentive based measures and cross-sector planning.
- Considering the limited financial and human capacities in public administration and promoting a simplification of data collection on the sector and conduct participatory decision making.
- Ensuring that the implementation of legislations and development plans are adjustable to different administrative, socio economic and political contexts and that they are enforceable.

Immediate institutional requirements:

- Further investment in training of staff members in public aquaculture planning and research
- Ensure that planners and farmers have access to relevant and applicable aquaculture techniques and relevant information on GAP
- Invest in systematic monitoring of disease and environment issues in intensive fish culture areas (particularly concerning use of discharge water for fish culture)
- Keep expanding and strengthen the co-operation between existing farmer groups (various organisations) and governmental institutions
- Water pollution and disease out breaks should be reduced through better coordination of aquaculture planning with development in other sectors, participatory planning with stakeholders (empower farmers to organise), build awareness and incentives to follow GAP, promote certifications, invest in monitoring systems, train managers in handling pollution problems. Solving these problems require participation from numerous stakeholders: the farmers, DONRE, DARD, VASEP, Processors, RIA, Commercial seed producers
- Illegal productions should be limited by designing legislations which is enforceable, focus enforcement on heavy polluters and build awareness about benefits of complying with regulations. MOFI, DOFI, DONRE, RIA are key stakeholders in conducting this work.
- Supply of feed and quality seed should be improved through strategic coordination of public and private investments in seed production, implementing strategies for improving farmers access to seed and designing guidelines/legislation for sustainable supply feed sources

2.1.4 Implementation responsibilities

Shrimp commodities are major products and bring high export values for aquaculture in Viet Nam. There are a lot of stakeholders involved in this sector from hatching, grow-out, middlemen, processing and supply services. Environment management requires those stakeholders to have better practices in theirs business and the government role in managing all activities.

Public sectors

Ministry of Fishery should develop the guidelines, standards and other legal documents to facilitate the environment sound practices as well as the sustainable aquaculture planning. The departments of MOFI consists of NAFIQUAVED, Aquaculture, Science and Technology, VIFEP should be the key stakeholders to initiate the environmental friendly practices.

Provincial People Committees, DOFIs and DONREs should conduct the planning and implementing sustainable shrimp aquaculture master plan development, disseminating the better management practices, promoting in establishment of aquaculture associations in term of institutional and legal.

DOFI, Extension Center, Sub-department of Aquatic Resource protection, Sub- NAFIQUAVED in provinces should be play key role in promoting and conducting the work.

Private sectors

Private sectors includes middlemen, feed suppliers, hatchery owners, farmers will be the key stakeholders in implementation of better management practices.

2.2. Marine cage farming of grouper/cobia

2.2.1. Commodity Status and System Description

Brief overview

Marine cage farming has been developed in recent decades in Viet Nam. Most of cage farms are small in size except some foreign investment enterprises. The total production was 3,510 tons in 2005 produced in a total of 16,319 cages. Thus, the marine cage farming productions have increased rapidly since 1999 when the number of cages and total production were 346 cages and 52 tons, respectively. Nationally, Hai Phong, Quang Ninh, Bia Ria-Vung Tau and Kien Giang are the provinces with the largest production in marine finfish cage farming. Marine finfish cage culture in Hai Phong and Quang Ninh has in particular developed quickly despite no specific planning. In Quang Ninh province, there were 400 cages in 2000, but they increased to 5,700 in 2005 with a production of more than 1,300 tons. In 2000, Hai Phong city had 300 cages that produced 45 tons compared with a total of 6,000 cages and a production of 1,200 tons in 2005.

The increased production in marine cage culture has caused concerns of possible negative environmental impacts. As a response to such concerns, the People's Committee of Quang Ninh Province announced in 2004 that a certain number of cages farms would be moved to protect Ha Long Bay – the world heritage site. Thus a number of cage farms were moved to Cat Ba island thereby doubling the number of cages operating in this area. Environmental pollution had been recognized in Cat Ba cage farming areas in 2003 even before these additional cages were moved to the area from Ha Long Bay.

The major cultured finfish species are Cobia (*Rachycentron canadum* (Linnaeus, 1766)), Grouper (*Epinephelus tauvina* (Forskal, 1775)), Sea bass, Red Drum (*Lutjanus erythropterus* (Bloch, 1790)). Grouper is the major fish species cultured. Cage farms are operated mainly by small-scale enterprises in Ha Long, Quang Ninh province and Cat Ba, Hai Phong province. Whereas there are two big enterprises in Vung Tau province, one farm is a foreign investment company and another is state ownership enterprise.

Development Plans

According to the Master Plans for aquaculture, the target production in marine cage culture would increase to 100,000 tons in 2005 and 200,000 tons in 2010.

However, such production targets would be difficult to achieve as the production in 2005 was only 3,510 tons equaling only 1.8% of the 2010 target. Some issues that lead to the low production include lack of implementation of plans and an unrealistic master plan. The starting point is that marine cage farming has so far developed without any clear development plans. The production in cage farming is mainly done to meet the demand for consumption of live fish with a relative small market demand whereas fish are rarely produced to prepare frozen products due to the low prices on such products. Despite the slow development of marine cage culture the potential is huge in the coastal areas.

In order to achieve the set target, The Ministry of Fishery has introduced some development plans such as the planning for ocean farming up to 2010 in Quang Ninh – Hai Phong, the national program for seeds, and several science, technology, and human resources capacity building programs have been formulated. At present, RIA1 and RIA 2 are producing seeds of Cobia, Grouper, Sea bass, Red Drum and seem to be able to meet the current demands for seeds.

Location of production & Development

At present, marine finfish cage farming is mostly developed in the Northern coastal provinces in terms of production and number of cages including Quang Ninh and Hai Phong provinces, but also some southern provinces like Ba Ria - Vung Tau and Kien Giang provinces. The following list some of the major marine cage farming activities (Table 27).

Table 27 Location of marine finfish cage farming in 2005

Provinces	Number of cages	Production (ton)
Total National production	**16,319**	**3,510**
Quang Ninh	5,700	1,300
Hai Phong	6,000	1,200
Other provinces	1,010	4,619

Quang Ninh and Hai Phong provinces host a large part of the national marine cage farming activities producing about 70% of total national production.

Marine cage farming in the Northern costal provinces has developed in the recent years and attained some success. From 1999–2005, the area and number of marine cage culture increased rapidly with 300 cages and 41 rafts operating in 2000 compared with 7,697 cages and 531 rafts in 2005 (Table 28).

Table 28 The development of marine cage farming in the northern costal provinces (2000 -2005)

Year	Number of raft	Number of cage 3x3x3m	Production (ton)
2000	41	300	45
2001	105	910	70
2002	131	1,600	500
2003	165	1,864	720
2004	316	4,237	800
2005	531	7,697	1,200

At the first half of 2005, the number of cages and rafts in Cat Ba increased rapidly. This was in part due to the increased use of new cages and rafts and in part because farmers moved their rafts from Quang Ninh province to the area, making a total number of 411 rafts with over 6,000 cages (DARD of Quang Ninh, 2004). The farming activities are mainly concentrated in the bays of Cang Ca and Ben Beo.

The rapid development of cage farming in Ben Beo bay has been reported associated with contamination of the environment and negative impacts on the marine eco-system. Disease epidemics also have occurred with significant economic losses. However, further documentation is needed on this.

Development Plans

The Master Plan for fishery development includes development of a total area of 6,000 ha of which cage farming is about 16%. The plan for Tung Gau is of 2,400 ha, Soi Gianh is of 1,860 ha, Van Boi is of 1,000 ha. The development so far is concentrated around Cat Ba – Long Chau – Bach Long Vi in particular raising fish species of high economical value. Traditional marine farming is combined with so-called open farming following the plans of the Ministry of Fisheries for the coastal in Hai Phong and Quang Ninh provinces.

Table 29 Production targets of marine finfish cage farming in Master Plan for Hai Phong - Quang Ninh

Object	2005	2006	2007	2008	2009	2010	% 2010/2005
Production	1,500	1,800	2,100	2,400	2,800	3,000	100
Area (Ha)	1,500*	1,800	2,100	2,400	2,700	3,000*	

Sourses :Institute for Technology and Planning Aquaculture, Departments of Aquaculture, Departments of Agriculture and Rural Development and the report of Aquaculture (1999 – 2004).

Farming system design & production performance

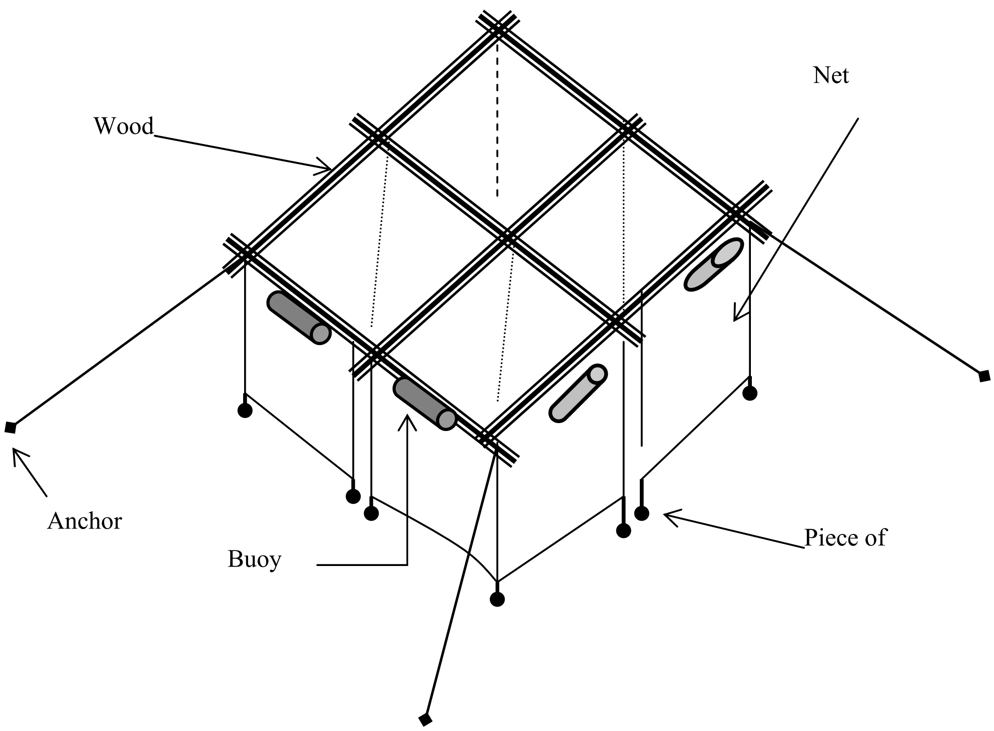
In Cat Ba, a typical cage design is made of 3 x 3 x3m size and be surrounded by nets, each household has from 5 to 50 cage based on economic condition. They have two kinds of cages with seed production and growth of the fish to reach market size. The productivity ranges from 7 to 15 kg/m^3/year.

A typical raft has the following design and features:
- It has a size of 2m x 2m x 2m or 3m x 3m x 3m.
- The net is made by silk thread or Polyetylen (PE) with mesh size of 2a = 0,5 - 1cm.
- The cages are fixed to a wooden frame. Lead or stones with a weight from 1.5 to 2kg fixed to the bottom of the net in each corner assure that the net is stretched out below the raft..

- The bottom and the sides of the frames are connected by ropes (

Figure 20)

Figure 20 A typical design of a small cage for marine finfish farming



- Cage is square or rectangle having a size of 3m x 3m x 3m or 5m x 5m x 4m.
- The sizes of the net mesh depend on the size of the species cultured:
  - Fish lengths of 16-30 cm, the size of net's mesh 2a = 2cm
  - Fish lengths of 31-50 cm, the size of net's mesh 2a = 5cm
  - Fish lengths above 50 cm, the size of net's mesh 2a = 8cm

Analysis of inputs and outputs

The initial investment includes the cost for building cages, buying motor boat, and other items. The average stat capital is around 290,000VND/m^3/cage.

With an average stocking density around 10 fish/ m^3 for Grouper, 7.0 fish/ m^3 for Cobia, 13.4 one/ m^3 for other, farmer will normally achieve an average production of about 4.4; 7.0; 7.8 kg/m^3/time. After the periods of time is about 1.4 year(612 days for Grouper, 375 days for Cobia, and 472 days for other), the size of commercial fish is about 2.5kg/one(Grouper is 1.5kg/one, Cobia is 4.3kg/one, and other is 1.6 kg/one.)

The main feed used is low value fish or trash fish, it is supplied for culture fish based on farmer's estimation and their affordable, so the Food Conversion Ratio (FCR) is at high level, the average is 13.6.

The demand for workers in cage farming is not high. According to the research results, farmers did not hire temporary worker, they have one fed and managed their cage. If the area of cage is 476m^3/one, the period of culture time is from 6 to 12 months, one farm has to have a worker fed and managed cage in 14 months.

Table 30 Average production performance parameters for 10 grouper farmers in Khanh Hoa province, central Viet Nam 2005. Data collected by the Viet Namese Institute for Fisheries Economics and Planning (2005)

PRODUCTION	***No. of units***	***Units***
Grouper performance per 127m^3 cage cluster		
Crops	1.0	*no/year*
No of stockings	1.0	*no/year*
Total stocked seed	430	*Seed/cage cluster/yr*
Stocking density	3	*Seed/m3/yr*
Yield	265	*kg/cage cluster/year*
Average size at harvest	1.0	*no/kg*
Survival rate	62%	*%*

In

Table 30, the average production performance for grouper farmers in Khanh Hoa is given as an example.

Major inputs - Water use

Most of cage farming areas is mainly located shallow areas in gulfs or small bays where they are protected from strong winds, waves, and tropical storms, but with the disadvantage of having a low exchange rate of water. The water exchange is mainly based on tidal exchange, but the often high densites of cage reduce the water exchange rate and environmental pollution, e.g. sediment deposits, from the cages is often high. In addition, farming may also be practiced in areas visited by tourists, e.g. around Cat Ba island, and tourist boats and other activities may negatively affect the cage farming in different ways.

According to the result of a study by Tran Luu Khanh (2003) in Ben Beo gulf (Cat Ba island) and Vungoan gulf (Halong bay) the contamination of organic and inorganic waste from raft's system did increase as a results of the increase in number of cages. Blooms of phytoplankton, including tosxic algae, have also caused problems, e.g. in Vungoan gulf.

Major input- Seed supply

Wild seed

Traditionally wild seed has been caught by local fishermen and subsequently cultured in cages. Initially, wild seed were abundant, but in recent years the demand has increased while the supply has been falling and not been able to meet the increasing demand.

Producing process in hatching farms

In recent years, RIA 1 and 2 have successfully developed the technique and experience to artificially breed and produce seed of a number of fish species important in marine cage culture. Such seed productions are now taking place, also together with private/state companies, in Hai Phong city, Quang Ninh, Khanh Hoa, Ba Ria and Vung Tau provinces. Production was about 800,000 seeds of Sea bass with sizes 3 - 4cm; 600,000 Grouper seeds with sizes 4 - 5cm; 500,000 Red Drum with sizes 5 cm; and 600,000 Cobia seeds with sizes 7 - 9cm. With recent improvements in hatching techniques and with the use of bloodstocks kept under culture conditions it is expected the breading and feeding of post larvae will be improved with increased quality of seed and reduced dependence on natural seed and broodstocks (MOFI, 2005c).

Fingerling prices vary in species. Red Drum fingerling fetches 5,000 VND/fish at average but often higher during the main stocking season. Prices for Cobia fingerling are about 12,000 VND/fish, and Grouper fetches around 15,000 VND/fish. In brief, fingerling prices vary during the season and are highest during the main stocking period.

Major input – feed and feed management

Feed used for the grouper and cobia is normally trash fish. Only around 1% of the farmers feed their fish with pelleted artificial feed. This is a serious environmental impact and can potentially lead to local environmental degradation. There is also a risk of transferring disease to the farmed fish from the trash fish.

The demands for trash fish in marine cage culture are together with other demands for such fish, e.g. for fish meal production, leading to a high pressure on such fish stocks with real risks for depletion. In 2005, the price of trash fish ranges from 1.000 to 3.000VND/kg depending on the season. The average of FCR for cobia and grouper is 13.6 when using trash fish.

Other input – use of antimicrobials and disinfectants

Relatively limited information was collected on the use of antimicrobials and disinfectants in marine cage culture. However, different means of prevention and treatment of diseases are necessary in marine cage culture. Thus, different types and application regimes are routinely applied. It is urgently needed to collect and analyse information about such usages as they are likely to have major negative environmental impact, but also represent occupational health risks for the farmers when preparing for treatment and applying treatments, e.g. from physical contact with the chemicals.

Major chemicals used include Formalin, Potassium per Manganese and Green Malachite used in different bath concentrations depending on conditions, species and the type of disease problem. E.g. 0.5 to 1L Formalin is typically used for 6 - 8 bath treatments of about 10 kg fish. At a farm with 100 cages and an average production of about 20 tons/year 3 – 5 L Formalin is used. All applied antimicrobials and disinfectants are discharged directly into the sea after usage.

The information to be collected on use of antimicrobials should be analyzed with an aim to come up with prudent use practices in marine cage culture.

A cage farm will usually have one or more boats used for washing nets and other farm management purposes. The operation of boats will lead to spills of oil, gasoline and other organic wastes.

Risks

Natural risks and disasters: The main natural hazards are storms and tropical low pressures; they could damage rafts, cages and release fish into the sea. In 2005, the damage caused by storms was considerable, there were many rafts broken especially the rafts were outside the gulf.

Social risks: social security, social contradiction, and competition for area affect social security in the coastal area.

Disease outbreak: this is the potential damage to cage farming; there are more and more dangerous diseases that are happened by high density cage and contaminated environment. That is bowel complaint by using spoilt food, parasitic disease, VNN disease. They create lots of damage for farmers.

Based on the 10 households interviewed in Khanh Hoa province in 2005 it is clear that grouper culture can be considered as a high risk business venture. The relative long culture period (high disease exposure period) and low annual net profit (low economic buffering) indicates that the economic resilience of the system is very low. There is a need to promote better feed utilization. In addition large scale commercial hatcheries needs to be established in order to reduce seed price which is currently heavily dependent on wild caught seed.

Market and market chain

The main market is fish sold alive to local restaurants or to nearby large cities in China or other large cities in nearby countries. The fish are transported alive to the restaurants. There are very few frozen products available for these species.

The prices fluctuate a lot on these species based on the culture season and the demand from restaurants. The prices of grouper also depend on the species of grouper. The slow growing species are expensive while the more common faster growing species are of half price. Below are given some prices but it should be kept in mind that the prices are fluctuating a lot and these are snapshot prices at the time of the fieldwork:

Table 31 Market sizes of some marine fishes

Species	Size	Prize
Snapper	1.2 kg/fish	50,000 VND/kg (~ 2.8 USD)
King fish	3.0 kg/fish	55,000 VND/kg (~ 3.0 USD)
Grouper (Orange spot)	1.5 – 2.0 kg/fish	140,000 VND/kg (~ 9.0 USD)
Red Drum	2.5 kg/fish	50,000 VND/kg (~2.8 USD)

Social and economic

In Haiphong and Quang Ninh provinces, cage farming is being developed rapidly and it is effective way to increase income for farmer, create job and reduce the pressure on catching. However, it still has some disadvantages such as: contaminating culture area, separating epidemic disease, creates lots of damage. In addition, it also invades marine conservation/protected area.

2.2.2 Environmental assessment

Location and sitting

The advantage of cage farming in Cat Ba is that the sites are out of wind, but the rate of water exchange is low. Tourist activities are being developed well in here so the amount of waste discharged into environment is significant and it also affects badly on the quality of water. Culture cage is laid in the place that has suitable water current. With the depth is 3m, surrounded by net, and the amount of fish inside cage itself makes the flow rate decrease by 35% in comparison with usual condition. If we use two rows of cage, the rate is decreased to 50%. Decreasing the flow rate makes reduce the exchange rate of water so the culture area is contaminated easily, especially in semi-diurnal tidal areas where the change of tide is low.

Design and construction

All cages are connected together to build up a raft in order to care and manage easily, but because of high density the exchange rate of water is prevented. In addition, it is very difficult to manage the food residues because of the cage instruction.
The current flow through the cage is prevented by its meshnet, so construction of the cage also affects the water current. If the speed of current is low, there are a lot of sedimentation.
The system of buoy and net prevents good water flow with increased sedimentation of small solid particles. Waste and residue of food that are settled on the bottom of cage is very difficult to collect.
In order to mitigate the environmental issues, follow are some recommendation for design and construction

- To build up the system of buoy and net to reduce the effect on current as well as possible.
- Using circle cage with plastic frame in open sea to reduce the pressure of current
- Sediment traps or net funnel systems could be used to collect wastes

Seed supply, broodstock & post larvae

Natural resources: It is being reduced by high density of catching. Besides, using destructable methods to catch low valuable fish also affects on natural resources of fish.

Artificial seed production: Currently the amount balances the demand of seed. Artificial seeds used in grow-out origins from national hatcheries as well as import from China depending on price and availability. Currently seed are imported from China due to the lower price. The adverse impact of this is that seed quality is very difficult to control, increasing the risk of production failure.

Using artificial seed not only reduces density of catching but also protects natural resources.
The main problem is ensuring the quality of artificial seed hence it is essential that seed production is based on selected broodstock. It is also essential that the feed given to the broodstock and seed is carefully screened to prevent epidemic diseases and ensure the quality of seed. Besides, there are some other things to be done:

- Research on domestication
- Develop stricter standards for hatchery management
- Enforce compliance to standards to improve technology
- Develop a certification system for better quality hatcheries (healthy competition between hatcheries)
- Promote use of better quality seed among farmers (BMP)
- Aquatic Resources Protection to control more strictly compliance of hatcheries
- Change in the catching practices of brood stock to reduce the pressure from catching in nature

Fish escaping from farms may mate with and degrade the genetic purity of wild stocks. Effects are often unknown and people are very concerned about this. Some recommendations regarding this are as follows:

- Manage the cages well in order to fish can not release into environment.
- Select the kind of fish to import so as to it can not affect on local species.
- Develop culture local fishes which have high economical value.

Water use and impact

Due to unplanned development of fisheries and limitation in human capacity, the water quality is badly impacted. The quality of water in cage farming area in Cat Ba is being affected by surrounding activities such as: Cage farming, hatching farm, tourism and domestic wastes. If these activities are well managed and a good water flow is ensured then waste sedimentation is likely to occur at a lower pace reducing the risk of eutrophication and oxygen depletion.

Besides, the marine cage farming also makes bad impacts on the environment due to waste discharge and sedimentation. Impacts of marine cages farming to water bodies can be limited by:

- Better planning within environmental carrying capacity
- BMP for responsible feeding
- Promote the cage rotation
- Water and sediment quality monitoring and warning to farmer.
- Promote open sea farming

Waste and impact

There is both a waste impact from the feed to the fish, the fish itself and from the humans working on the cages.

Also oil and waste from oil are increasing in the culture area due to transport's activities related to cage farming and to tourism. About 20 cages need one motor boat having power about 5 - 6cv. It is estimated that the oil discharged is about 0.2 - 0.5 kg/day based on the knowledge of farmers.

The effect of the waste is an eutrophication for surrounding ecosystem. This waste is made due to excess feed, which may lead to:

i) Algal blooms
Algae can grow excessively on the extra N and P present. The blooming of phytoplankton makes high density of algal, in which it is observed that there are about 28 kinds of toxic algal, they create "red tide" that will make the damage for cage farming in Cat Ba (Nguyen, 2004).

ii) Sediment enrichment and anoxia
All of nutrients in total or dissolved sharp in fastidious sediment includes: NO2-, NO3- and PO43- they have high density in the places around cage. After many years, cage farming has increased amount of sediment waste about 3 - 5 cm, which changes the quality of sea environment (Long, 2006).

iii) Poor water quality - due to waste build up
In cage farming area in Ben Beo Gulf (Cat Ba island), the amount of organic and inorganic which can contaminate environment are increasing rapidly with the increase of cage number.

Recommendation to minimize these environmental impacts are:

- Better planning within environmental carrying capacity
- Develop BMP for responsible feeding practices and handling of wastes
- Promote the cage rotation
- Water and sediment quality monitoring
- Promote open sea farming
- Polyculture of appropriate species may reduce fouling problems

Feed and feed management

The use of trash feed is the big issue in feed management. Trash feed is of high risk of contamination and it encourages destructive catch methods or illegal fishing (using bomb, mine or electricity). It is necessary to reduce the use of low value fish (Trash fish) for feed because:

- The supply is not stable and varies over time.
- The quality is difficult to control,

- Contaminates the environment easily (Poor FCR)
- Putting pressure on the surrounding biodiversity/resource

These disadvantages have an effect on the product, and farmers have understood the need to develop and change the feeding practices. Recommendations to limit these impacts are:

- Promote using the pellet feeding, change in regulation and policy allowing import of feed for marine species (first 5 years)
- Improve FCR
- Quality fish feed is important
- If using processed fish feeds, ensure that the FCR is as close to 1 as possible.
- Promote substitute fish meal and oil (cobia: high demand for energy) by using plant or other animal source may be helpful when trying to reduce stress on fisheries.
- Create farmer awareness of impacts of trash fish uses
- Research on pellet formulation
- Research and promote on adding values of trash fish (shifting to human consumption) for export.
- BMP for responsible feeding

Disease and health management

High stocking densities and contaminated environment are the main causes for aquatic animal diseases in marine fish farming. Besides the quality of feed and stocking seed are important factors.

The common diseases in marine fishes are:

- Viral disease: VNN (Viral nervous necrosis – VNN). It is the common disease for which grouper is easily infected. It has been a problem for many years and it occurs in all stages of the fish culture cycle.
- Bacterial disease: Mainly include *Vibrio vibrio spp* and *Pseudomonas. Sp* contaminated environment and non-ensured food are the main cause.
- Parasitic disease: Main infection from use of organic fertilizer and poor water quality.

The potential risk of disease outbreak is the infection of diseases from natural fish to cultured fish, which put the farmers in a potential dangerous situation. The risk of farms to farm infection in the same area when they have a disease outbreak is also evident. Often farmers throw the dead fish directly into the sea. During the period of the disease outbreak, there can be thousands of dead fish whereas a normal day there is only very few dead fish. Density of fish farms and poor hygienic conditions also often promote disease and parasite transfer. This can occur within farms, between farms and from cultured to wild stocks.

There is significant the amount of antibiotics and chemicals put into cage when disease outbreak and it affects dangerously on ecosystem. The common antibiotics used involved Rifamycin, Erythromycin, and Oxytetracyclin, they are mixed with feed or use to bath fish. Fish has been gradually adapted with antibiotic and it is therefore being use with increasing amount but the effect is very low. The antibiotics may stay in the environment and in the fish's body. Effects of antibiotics on other species, and the impact on the ecosystem as a whole, are often unknown and overuse can also lead to resistance.

Some common kind of chemicals used to "bath" fish to prevent parasitic disease is Formalin, $KMnO_4$, Green Malachite. The use of these chemicals has certain effects on the environment and of food safety. It should be noted that the use of Green Malachite is prohibited in Viet Nam.

Although some drugs may have effects, but the contaminated environment and the origin of seed are factors that farmers can not have control on. In order to prevent disease outbreak, we need to have specific management solutions from planning, feed management, improved science knowledge and skills, and the links between farmers in area, etc. Once the farmer's knowledge is still limited, then disease outbreak can happen any time in culture areas.

Generally, to avoid the disease outbreak, the farmers need to:

- Improve quality of water
  - Better planning within environmental carrying capacity
  - BMP for responsible feeding
  - Promote the cage rotation
  - Water and sediment quality monitoring
  - Promote open sea farming

- Restrict movement between farms
  - If movements between farms are reduced/restricted, disease transfer is less likely to occur
  - Disinfecting equipment and boats used between different sites can prevent disease transfer
  - This can also aid in less antibiotic use, saving money and preventing antibiotic resistance.

- Restrict chemical use
  - Reducing the use of antibiotics is crucial in maintaining healthy systems.

Food Safety and Quality

The food safety and quality would be affected by:

Pre harvest: Residue of antibiotic and chemical which are used to prevent epidemic disease.

Harvest and transport: Harvest process is not ensured; fish is scratched and bitten so it can get disease easily. Fish are not kept on ice immediately after harvest. The transportation equipments are not safe to transport alive or frozen fish. If the fish are not iced or they are scratched it is easy to get infections from virus and bacteria.

It is recommended to restrict chemical use: Develop and disseminate BMP/standards for responsible use of chemicals among farmers and HACCP application should be encouraged.

Economic and social issues

The result of the investigation process shows that: there are a lot of farms which can not take back money as much as they invest. The average is 143.500 VND/m^3 cage/time. However, all most of farms interview is not lost. There is about 32% of farms be break even (similar to 14 house), 32% of farms has profit is about 600.000 VND/m^3 cage/crop, and the rest is lost (about 36%). The main cause is high FCR, frequently disease outbreak so the survival rate and productivity are low.

The demand for worker in cage farming is limited. Arccording to the result of investigating, farms do not hire temporary worker, they typically have one worker to feed and manage the cages. If the area of cage is 476m^3/one, the period of culture time is from 6 to 12 months, so one farm has to have a worker to feed and managing cage in 144 months. So cage farming has good social effects as it creates lots of jobs for communities.

Environmental impacts	How to manage the impact	Who should manage the impacts
Impact on job and income generation, poverty alleviation	To encourage the development , support farmer with policy, fund, techniques, tax, etc. To make the policy in which farmer can use the water area in a	- MOFI - Local government - Department of Aquaculture department of fisheries resource conservation, fishery extension Center Department of environment and

	long time.	resources Local Banks

Market issues

Marine fish is a rather new commodity compared with others like shrimp or catfish but it has great potential to target big markets like EU, US or Japan with high nutrition and good for health. The culturing nature of the commodity attaches to the sea environment which is a big concern environment protection and genetic preservation. The quality of marine fish of Viet Nam is not large enough to set up a strong brand but it is a great potential to explore the market niche of green products – the commodity produced in environmentally responsible way. It is necessary that the target of 200,000 tones of marine fish will be supported with a range of environmental protection strategies.

Institutional issues

The co-operation between government institutions (Department of Aquaculture, RIA) and farmers has been improved over the years.

The system of extension workers from government to communes is working well. There are training courses organized to support farmers. Centre for extension fisheries in Hai Phong has many branches with staff that that observe, train, and demonstrate good aquaculture models. Additionally, there are several private companies providing training and information to farmers concerning feed, medicine and use of chemicals.

Governmental centres for monitoring and warning about environmental issues frequently inform and warn about the risks of contaminating the environment. Farmers are considered the most important stakeholder in ensuring environmentally sustainable marine cage production.

In the area of Cat Ba (Hai Phong), cage farming has transformed the livelihood of farmers. Cage farming is becoming one of most important occupations. Only tourism is seen as more important in the coastal areas.

Clusters of households have established farmer groups, but they are not seen as very successful. It is necessary to foster organisations of fish farmer clubs at district and commune level. It is seen as crucial that farmers are better organised as a means to share experiences and technologies.

The farmer's knowledge about market opportunities and demands is still limited. Farmers are not kept up to date. They mostly only rely on information from private commercial enterprises

Summary of major environmental issues of marine cage farming in Viet Nam

Farming these commodities in Viet Nam can cause some environmental issues as habitats degradation, water pollution, reduction of wild life and aquatic resource. Environmental pollution has been raising in recent years in Hai Phong, Ha Long, Phu Yen and Khanh Hoa provinces when the marine finfish cage farming have just obtained 1.8% of total production in 2010 and lobster production is nearly reach the target.

Although the marine cage farming has not caused as serious environmental pollution, disease outbreak and economic loss as shrimp farming, this aquaculture system could be considered as second most polluting system.

The major concerns come from unplanned development, stocking and feeding practices. With existing practices, the total quantity of trash fish will be used for marine cage could be 2,720,000 tons per year in 2010 if FCR is 13.6:1 in average. This is quite huge figure and unrealistic because the total fish production of Viet Nam were 1,547,160 tons and target number is 2,000,000 tons in 2010 (MOFI, 2006b). High trash fish usage is causing water pollution in marine cage as be sampled and analyzed by researches and the high demand of trash fish usage can make promptly depletion of aquatic resource as well as inefficient use. Therefore, the promoting better management practices and assisting infrastructure preparatory should be carrying out to prevent and minimize the environmental impacts as possible.

The prevalent of wild seed for marine aquaculture in Viet Nam is non-environmental friendly practices. The wild seed harvests have been depleted in recent years, e.g. the daily productivity of fishermen is decreased from 100 fingerlings/day to 10-20 fingerlings/day in Cat Ba and Ha Long marine areas. Special the survival rate is 62% in average, the rough estimation of seed supply 400 millions seeds per year as in Mater Plan while the seed production for marine finfish still is quite low. There are very few seeds of grouper, cobia seeds did not meet demand and farmer had been imported from China for farming in Hai Phong and Quang Ninh. These figure showed that there will be high pressure on wild seed fishing in case of there is no change in farming practices and hatching production.

Follow are the major environmental impacts and solution for marine finfish farming.

Impacts	***Management practices/solutions***
Marine cage farming of Grouper/Cobia/lobster	
Impact 1. Polluting water, biodiversity and sediment	• Better planning within environmental carrying capacity as well as trash fish resources needed as input for these production system • BMP for responsible feeding • Promote the cage rotation • Water and sediment quality monitoring • Promote open sea farming
Impact 2. Use of trash fish	• Promote using the pellet feeding, change in regulation and policy allowing import of feed for marine species (first five years • Promote substitute fish meal and oil (*cobia*: high demand for energy) by using plant or other animal source • Create farmer awareness of impacts of trash fish uses • Increase price of trash fish • Research on pellet formulation • Research and promote on adding values of trash fish (shifting to human consumption) for export
Impact 3. Impacts on wild broodstock and seed	• Research on domestication • Develop Broodstock center and conversion of shrimp hatcheries into multi-function •
Impact 4. Alternative income generation for communities in Marine Protected Areas	• Implement sea-ranching to reduce impacts to MPA's
Impact 5. Impact on landscape and world heritage other resource users (navigation, tourist, fishing)	• Promote open sea farming • Stakeholder consultation in planning • Cross sectoral planning
Impact 6. Importation of exotic pathogen	• Improving capacity for controlling transboundary movements • Develop capacity on IRA • Conduct and implement IRA before performing transboundary movements

2.2.3. Guidelines for better management

Site Selection for finfish marine cage.

Site selection should be considered follow practices

Practices	***Criteria***
Farm site	• Follow strictly the detail aquaculture planning • Avoid marine park, coral reef, sea grass bed and other protection areas by law • Navigation and spawning and nursing zones should be avoided • Avoid areas where water quality fluctuation is high such as estuarine region, particularly salinity • Avoid conflict of interest with other users such as fishermen, tourism, etc • Should be located far from effluent discharging gates of industrial and urban • Should place in areas which protect from strong wind and wave (e.g., lagoon, bay, etc) • Good security and easily accessible with basic infrastructure
Current	• Current speed is over 7 m/s
Salinity	• Should be higher than 20%o according to the fish tolerance
Transparency	• Should be higher 1m
Water condition	• Water depth – minimum 5 meter at low tide, ideally between 15-30 meter depth • Water current – should be at least 10 cm/second, and not more than 100 cm/second • Ideal water quality parameters • pH: 7.5 - 8.5 • Water temperature: 15 - 290c • DO:4 – 8 ppm • Nitrite NO2N: 0-0.05 ppm • Ammonia: <0.02 ppm • Salinity: optimum 22-34 ppt, some species: e.g. E. coioides can tolerate lower salinity

Farmers should have consulting with extension center, environment department for water quality information or sampling by quick sticks.

The place should be based strictly on the planning. The density should not be higher than we plan for each area, cage should not be put cross-lying because they prevent the following, the distance between cages is suitable to ensure transparent to reduce stagnant condition and settle down organic substances.

If there are a lot of cages in culture area, the distance between cage to cage should not be less than 20m, they should be about 120-150 m^2 cage per one hectare of water in average.

Design, construction and production system

Practices	*Criteria*
Structure of farm	• Reduce in using wood rate in structure of farm allowing more water exchange • Using the circle cages with wood or iron frame • Frame: made of bamboo, woods, PVC, HDPE (expensive)
Mesh size	• Mesh size: 8 mm for nursery of fingerling less than 10cm, • The length of fish is 16-30 cm, the size of net's mesh 2a = 2cm • The length of fish is 31-50 cm, the size of net's mesh 2a = 5cm • The length of fish is over than 50 cm, the size of net's mesh 2a = 8cm
Float	• Should be made of plastic drums, foam polyethylene (PE) wrapped by plastic (camverst) •
Size of cage	• Groupers/snappers/red drum: 5 x 5 x 3m; 3 x 3 x 3m; and 3 x 3 x 2m (mouse grouper) • Cobia: 6 x 6 x 2.5m; 12 x 6 x 2.5m; and polar cage • Cage size: 2 x 2 x 1m and 1.5 x 1.5 x 1m for nursery period
Type of cages	• Floating cage: could be used in closely and open sea • Fixed cages: could be used at present, but meet difficulties with salinity fluctuation and close to pollution sources • Polar cages: could be used in open sea • Submerged cages: could used in open sea
Tools for equipment	• Sediment traps or net funnel systems could be used to collect wastes • Scoop net (vot) • Bath container • Pressure jet gun • Aerator • Rubbish prevention nets • First aid kits/boxes • Farm recording book • Small boat • life vest • diving goggles
Daily farming practices	• Before feeding: o Checking nets and changing nets as necessary o Checking fish for abnormal swimming behaviors and discoloration o Preparing feeds

	o Feeding Separating the weak fish and removing dead
Net changing and cleaning	o Under normal farming conditions: - Mesh size of 8 mm – weekly - Mesh size of 25mm – every 2-4 weeks - Mesh size of 38 mm – every 4-6 weeks o Under special cases such as listed below, net should change immediately: - Diseases problems - Net tear or broken - Too much fouling o Net cleaning process: - Take net out - Washing net by jet gun or hand - Sun dry (2-3 days)
Housing, storage and operation areas	• Keep storage and processing places of trash fish separately from storages of net and other equipment. • Spaces for repairing, cleaning and storing net • Storage for other farm equipments • Fresh water storage drums or tanks

Seed supply, broodstock

Practices	***Criteria***
Wild seed conservation	• Establish the marine protected areas
Seed harvesting	• Prohibits using cyanic chemicals for catching
Promoting the produced seed	• Farmer should not use the wild caught fingerlings if you it can be avoided.
Hatchery produced fingerlings	• Minimum size: 10cm for hatchery produced fingerlings and 18-25 cm for wild caught fingerlings • Ideally obtain fingerling from hatchery, which has been tested for free from dangerous pathogen, e.g. Flexybacter, Iridovirus, Nerve necrosis virus VNN • Appearances: no abnormality and no physical damages • Fresh water bath for 5 minutes • Bathing with iodine in sea water (100 ppm) for 1- 3 hours • Holding in separated cage for 14 days before stocking (for quarantine), this holding cage should not be located at the center of the farm - downstream of prevailing water current • Check the transported holding water (salinity & temperature) • Acclimatize to farming water condition to reduce shock • Transport time from hatchery to grow-out site is suggested to

	be less than 3 hours by boat (in case of longer transport time, use oxygen bag)
Optimum stocking density	• Groupers/snappers/red drum: - Fingerlings: 400-500 pcs/m^3 - Juvenile to market size: 20-30 pcs/m^3 • Cobia: - Fingerlings: 70-80 pcs/m^3 - Juvenile to market size: 5-7 pcs/m^3
Nursery period	In the case of stocking smaller size fingerling (<5-6cm), nursing is necessary to grow small fingerling to 10cm for further grow-out (1-1.5 months nursery period) • Nursery System and practices: Stocking density: 400-500 pcs/m^3 for grouper/red drum/snapper
Biodiversity	• Introduction of exotic species should be avoided If new exotic species introduction is required, consult with DoFI, get approval, and proper introduction procedure should be followed

Feed and feed management

Using formulated food and produced food instead of using low valuable fish. The amount of food should be controled. Culture some kinds of oysters to prevent the blooming of algal when eutrophication happens.

Following are some better practices:

Nursery period:

Practices	***Criteria***
Feed, Feeding and Weaning	• Twice a day (morning & evening) with chopped fresh trash fish or farm-made feed, commercial feed (if available) • closely monitor feeding activity and feed to satiation • cleaning and gutting of trash fish is recommended • adding vitamin mix to the feed at 1% of total feed is recommended • closely monitoring the feeding to make sure no surplus of feed
Predator management	• Regular grading (weekly) is suggested to reduce cannibalism

Grow-out period:

Practices	***Criteria***
Traditional method – feeding trash fish	• Chopping fish for suitable size

	• Feed quantity should be about 5-8% total weigh of the school of fish, one or two time per day.
Promoting use of formulated feed	
Feed storage and quality control	• It should be supplied for fish immediately after producing. It can be kept in cellar or freezer, but it should not be over two days. • Feeding based on the demand of fish (3-4%) 1- 2time/day
Feeding practices	• It can affect on the growing rate and separating of fish. • Time to feed: It should be in the early morning (7-8h) or in the late afternoon (4-5 h) • We can use hand (or plaste, or showel) to feed. • We should feed in the centre of cage or in many places at the same time.
• Feed management	• Should stop feeding by observation of the symbol of fish in order to prevent the residue of food, waste, contaminate, and happens disease. • Should check daily the healthy of fish, and find out the solutions when disease outbreak happens. • Should find out and change the suitable dose of food in late times

Health management plan

The major of diseases in marine finfish cage farming

- Protozoan: *Crytocaryon*
- Extoparasite: *benedenian / Neo benedenian*
- Bacteria: Vibrio, Flexybacter
- Virus: Iridovirus, Nerve necrosis virus (VNN)

Following are some practice fo animal health management:

Practices	***Criteria***
Water quality monitoring	pH, DO, Salinity, transperancy
Practices to minimize risk of diseases transmission ways	• importing/buying fingerlings from certified disease free hatcheries/sources and tested dangerous disease pathogen • Checking the weak fish and bathing them in fresh water for 5 minutes, checking for parasite in the bath water. If you see parasite, bath all fish of that cage and change the net. • having fresh water bath for 5 minutes when changing the net • separating the sick fish and moving to separated cage • equipment used for sick fish should not be used for other non-infected cages without disinfection • sick fish should be treated properly according to the syndrome • dead fish should be taken out and do not discharge directly into surrounding areas

	• dead fish must not sell or use for feeding • Aeration system should be used to increase DO in water and bottom • Should have an extra cage to hold separately weak fish at downstream of water current
If suspect disease problem, what to do?	Acting quickly to stop spreading disease: • Treating the fish and changing the net at the same time • Consult and inform to other farmers about the disease and treatment • Consult and inform to extension workers, research institutes • • Collecting the infected fish as a sample • samples should be collected with gill and injured parts for big fish • the samples could be fresh one in case of short distance between farm and laboratory • sending samples to laboratory for disease pathogen detection • samples should be preserved in alcohol or formalin the fresh samples should be preserved by ice boxes

Food safety & quality

Practices	***Criteria***
Chemical usage	• Common Chemicals and Drugs Used in Marine Fish Farming • Limited using chemicals and drugs as much as possible. In case of disease issues, please refer to the banned lists
How to treat the waste water after chemical treatment	• Keeping the waste water in drum/tanks for few days allow oxygenation to neutralize the chemical and drug, Do not discharge waste water directly into natural water without dilution or neutralize • Diluting the waste water and/or neutralizing before discharging to sea water, but not discharge on sea grass or coral reefs • Do not discharge waste water directly into natural water without dilution or neutralize
Post harvest	• HACCP application

Economic and social

It is essential that cage culture contributes to the overall development of communities. The advantage of cage culture from a social perspective is that the use of trashfish links fishermens and aquaculture farmers livelihoods. This may reduce potential conflicts between the two stakeholders. Howver, if the demand for trashfish exceeds the sustainable utilisation level there is a danger that the feeding costs will increase. This will reduce the economic resilience of the systems which makes households more vulnerable to economic losses. It is essential that the dependcy on trashfish is reduced and substituted with other products, possible soybean based protein diets.

It is also essntial that jobs are created with specific focus on poor households. This can be both manual hired labour or small scale cage farms operated by owners. As fishery resources becomes more scares there will be a need to train and transfer fishermen into the aquaculture sector.

Market and demand

Farmers can combine in a group to find out the market to sell ther product, so they can not base on commercial private traders.

Companies, gorvernment institutors, producing factories should have suitable way to collect, buy and sell product, find the market to export to ensure suitable price for farmers.

Institutional issues

Key institutional and policy requirements:

- Keep investing in extension services (private and public). This is considered the most important activity to increase quality and quantity of the production
- Facilitate the establishment of farmer groups as a means to improve mutual communication between stakeholders and to disseminate information on GAP, new technologies and market opportunities.
- Upgrade farmers' access to information about market opportunities.
- Improve monitoring of production sites and the implementation of the governmental aquaculture plans

2.2.4. Implementation responsibilities

Institutions (legislation, offices, organisations and norms) may facilitate sustainable aquaculture development and reduce the risks of unpredicted environmental or economic problems. The following general and immediate (specific) requirements are seen as important in promoting sustainability in the in the marine cage culture.

General institutional requirements:

- Decentralized, robust, transparent, and resilient management system working with applicable legislation and plans which are supported and understood by the affected stakeholders.
- Giving decision makers access to continuous updated and reliable data on production, natural resources, market and socio economic issues.
- Adjusting production and the development plans towards sustainability targets through incentive based measures and cross-sector planning.
- Considering the limited financial and human capacities in public administration and promoting a simplification of data collection on the sector and conduct participatory decision making.
- Ensuring that the implementation of legislations and development plans are adjustable to different administrative, socio economic and political contexts and that they are enforceable.

Immediate institutional requirements:

- Keep investing in extension services (private and public). This is considered the most important activity to increase quality and quantity of the production

- Facilitate the establishment of farmer groups as a means to improve mutual communication between stakeholders and to disseminate information on GAP, new technologies and market opportunities. Extension workers and mass organisations are key stakeholders in this work.
- Upgrade farmer's access to information about market opportunities.
- Improve monitoring of production sites and the implementation of the governmental aquaculture plans
- Access to quality seed should be improved through
- Environmental pollution and disease out breaks should be reduced by building awareness and incentives to follow GAP, implement regulations on site location and design, better coordination of aquaculture planning with development in other sectors, participatory planning with stakeholders (empower farmers to organise), invest in monitoring systems, train managers in handling pollution problems. Solving these problems require participation from numerous stakeholders: the fish farmers, DOFI, Processors, RIA, Commercial seed producers.
- Supply of feed and quality seed should be improved through strategic coordination of public and private investments in seed production, implementing strategies for improving farmers' access to seed and designing guidelines/legislation for sustainable supply feed sources. DOFI, RIA and private seed enterprises are key stakeholders in this work.

2.3. Marine cage farming of lobsters

2.3.1 Commodity Status and System Description

Brief overview

Lobster farming was started incidentally in 1988-1990 when fishermen caught small lobsters in Phu Yen province, developed later in 1992 in Khanh Hoa province. Those lobsters were held in the cages with surviving and growing later on. The lobster farming has been rapid growing since 1992. For example, there were some dozen of cages in Song Cau district, Phu Yen province in 1992, the cages number were increased to 3,500 cages in 1999 and 7,500 ones in 2000.

For whole country, there were 7,289 cages in 1999, over double to 17,216 cages in 2000 and increased by nearly six times in 2005 with 43,516 cages. The total production was 425 tons in 1999 and increased to 1,795 tons in 2005, approximately 4 times. Khanh Hoa and Phu Yen are biggest provinces of lobster farming in Viet Nam.

As in history, the lobster in Viet Nam could be considering as a native species with major one are Ornate spiny lobster (Panulirus ornatus), Scalloped spiny lobster (Panulirus homarus) and Chinese spiny lobster (Panulirus stimpsoni). The Ornate lobster (Panulirus ornatus) is highest value in Viet Nam and became the prevalent species of growing in Khanh Hoa and Phu Yen. In 2005, lobster has been farming in Quang Ninh with 30 cages and 0.3 ton of production. Binh Dinh is highest volume of wild seed harvest. The farming here is focusing on nursing stage with production of 600,000-800,000 seeds per year for growing.

The Ornate spiny lives in the habitats from 25-30m of depth in the coral reefs, rocky mountain areas along coastline of central of Viet Nam. The average size of lobster is 20-25 cm of length; biggest one is 50 cm length and 4 kg of weight.

The Scalloped spiny lobster lives in the habitats from 1-90 m of depth, usually in water shed of 5 m of depth with the mixed sand and mud, stable salinity. The popular size is 20-25 cm of length, the biggest one could be 31 cm.

Lobster farming production will be increasing due to the high price and less risks of disease than Monodon farming. Some provinces have made plan of lobster farming as wells as institutional frame and incentive policies. Due to the availability of wild seed stretch from Quang Ngai to Binh Dinh coastlines, the lobster culture still has a big potential development.

Development Plans

The "Master Plan of Fishery Socio-Economic Development up to 2010", VIFEP- April 2002, indicated that 'marine and brackish water aquaculture will be high priority for exports, specially are shrimp, finfish and mollusks culturing. There are one alternative for lobster farming, the scope of production volume is 2000 tons in 2010 as same as production in 2000 and 2005. There are no changes or expansion in master plan since 2000 to 2010. In fact, the production volume did not reach the target set for 2000; even the volume production of 2005 was closed to the target in Master Plan.

The Master Plan has no specific planning and locations as well as potential development for lobster farming. This may be caused by low production volume in comparison to national one although this commodity can bring high benefit for community in south central provinces. As in history, lobster farming was developing incidentally in Phu Yen and Khanh Hoa led to unplanned development in those provinces. As consequences, the pollution and disease have been happened in Nha Trang Bay and forced Khanh Hoa People Committee to announce and move all lobster farming cages to Van

Phong bay in the end of 2004 with purpose of environmental protection in Nha Trang bay for tourism development.

At that time, the Master Plan of Aquaculture Development of Khanh Hoa province was also developed. By interviewing Khanh Hoa DOFI, the detail planning for lobster farming development in Khanh Hoa province is being developed. In order to have better management, Khanh Hoa DOFI has been drafting a Regulation on Environmental and Aquatic Resource Protection for Lobster Farming since 2005.

Location of production and development plans

The major production region is in southern central provinces including Khanh Hoa, Phu Yen, Ninh Thuan, Binh Dinh and Quang Ngai. In which, Khanh Hoa and Phu Yen provinces are farming commercial lobster. Other provinces have been harvesting and nursing from pre-juveniles to finger juveniles and selling to Khanh Hoa and Phu Yen.

The production volume in 2005 has been showed in table below:

Table 32 Production volume of lobster farming in 2005

Region/Province	Units	2005	Planned Target	Total cages
NATIONAL (Total)	Ton	1,795.3	2000	43,516
NORTH (Total)	Ton	*0.3*		
Quang Ninh	Ton	0.3		30
CENTRAL (TOTAL)	Ton	*1,795*		
Khanh Hoa	Ton	1,000		15,000
Phu Yen	Ton	750		15,000
Ninh Thuan	Ton	45		450
Binh Dinh	Ton	0		
Quang Ngai	Ton	0		

Note: Binh Dinh and Quang Ngai are doing the nursing, so did not count for production volume.

The total number of cages for lobster farming in Khanh Hoa is 26,600 cages equal to 260,000 m^2 of water surface including nursing cages in 2005 (DOFI Khanh Hoa, 2005).

In 2005, there are 30 lobster farming cages in Quang Ninh province, a trial with 10 kg/cage of productivity much lower than this one in the central provinces.

The lobsters died in several cages in 2001-2002 and recently in March 2006 in Van Phong Bay and Phu Yen provinces with unknown causative agent. It might be causing by bad water quality and growing practices in the general prediction. There are not really disease outbreak in lobster farming in Khanh Hoa and Phu Yen, though the death happened sometime in some places.

Steps to protect coral reefs are being taken in provinces such as Khanh Hoa, Hon Mun in Nha Trang Bay, Ran Trao in Van Phong bay in Khanh Hoa, and coral reef protected areas in Ninh Thuan provinces, with purpose of aquatic resources protection. If these initiatives help in developing standards for siting farms near coral reef areas, this may make an important advancement in environmental protection and sustainable use in lobster farming in central provinces.

Although the Master Plan of Fishery Sector has not identified specific zones for lobster farming, the ecological conditions in central provinces can indicate those provinces could be major areas for lobster farming in future. The production target is 2000 tones per year by 2010. The expansion of lobster farming in central provinces could be happened due to the high profit while *P.monodon* shrimp farming has been getting problem with disease outbreak (70-80% of shrimp ponds are deserted in Khanh Hoa this year). Though, the most constraint of lobster farming development in Khanh Hoa and Phu Yen provinces will be the availability of seed that heavily depends on the wild.

Farming System Design & Production Performance

Lobster farming has been developing and located in the clean areas without influences of urban and industrial wastes. The lobster is cultured in cages at places of 1.5-2 m of tidal magnitude in close bay with a little influence of waves and winds. The minimum water depth is 2.5 m at the low tidal. The benthic is usually sand, muddy sand and/or sand, muddy sand with death coral reef mixed shelter of dead mollusk.

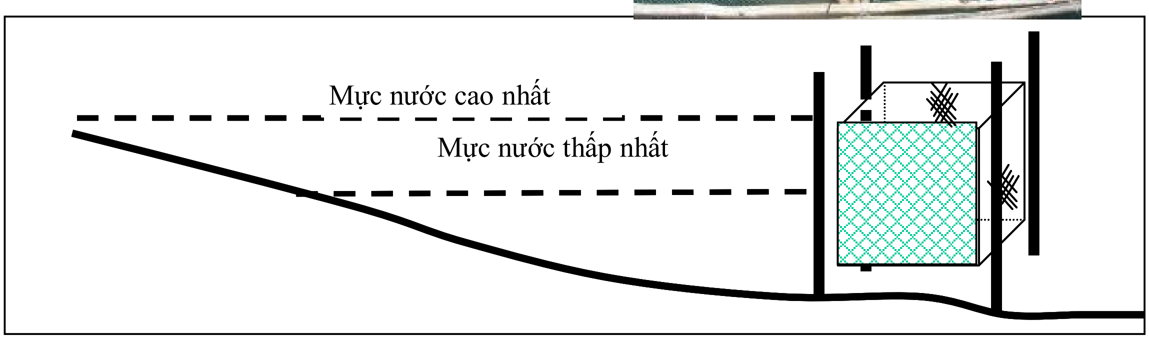
There are 3 types of farming system design, consists of fixed cage, sunk cage and floating cages. The prevailing types are fixed cage and floating cage. The size of cage varies depending on the farm owners, the common size are the 4m x 4 m; 3m x 4 m and 4m x 5 m. The smallest farm is clustered by 4 cages.

Type 1. Fixed cages

This type of cage is located at the place with 5-6 m of water depth at highest tidal time. This can cause the adverse effect to lobster when it is high temperature and difficult to moving to other places when disease and bad water quality happen. Usually these cages are located at the place with sandy and coral seabed.

The fixed cages are designed as follow pictures

Drawing of fixed cage for lobster farming



Source: MOFI/SUMA aquaculture profile

Cages are made by:

- Wood stake: the vertical wood state with 15-20 cm of diameter or 2x10 cm of formed stake, the length of stake depends on the water depth of farm sites. The wood stake must be 0.5 m higher than the water depth at highest tidal. The vertical stakes are stuck into seabed. The distance between 2 stakes are 1.5-2 m. The horizontal stake with 12-15 cm of diameter or 4x6 cm of formed stake. The horizontal stake is to form the frame of cages.

- The nets: The nets could be 1 or 2 layers. The nets are made of PE with 25-35 mm of size depending on the size of stocked seed. The nets at the bottom include another layer for holding the feed. The nursing cage has the smaller net size, less than 5 mm.

Type 2: Sunk cage

The sunken cage is designed as a cube rectangle with iron frame with ∅ 14-14mm. The iron frames are covered by the bitumen and nylon layer for longer lasting as well as preventing the microbial sticking on. The popular size is 3 x 2 x 2m or 3 x 3 x 2m. The cover is installed with plastic pipe with 10-15 cm of diameter for feeding. The cages are sunk at the place with 30-40 cm higher the seabed without fixed stake. This is easily to move to other places and could be fixed by casting anchor if located in the strong tidal and wind. This design is not used popularly now in Van Phong bay.

This type of cage usually locates at the place with muddy seabed, though this could also be located at the sandy one and directly on the seabed. Besides, this cage could be located at any water depth and could be changed accordingly to the water temperature, special is in the hot days.

Type 3: Floating cages

Floating cages are designed similar to fixed cages. The prevalent sizes are 4 x 4 m or 3 x 4m or 4 x 5m. The difference is the cages are stuck on the floats made of wood and fixed by anchors at the corners. The floating cages could be located at the high water depth and easily moved in case of bad quality of water environment or avoiding the typhoons. However, the cost of construction is higher than fixed one.

The picture above is an example of floating cages for lobster farming in Van Phong Bay.

Table 33 Typical farm level water surface-use for lobster culture

SURFACE WATER USED PER HECTARE	**Fixed cages**	**Sunk cages**	**Floating cages**
Number of cages per $1000m^2$	25	25	20
Average water surface per cage	13.5	13.5	27
Production area (water surface)	33.75 %	33.75 %	%

Table 34 Main inputs for lobster culture

INPUTS PER CAGE	**Unit**	**Fixed cages**	**Sunk cage**	**Floating cages**
Lobster nursing (pre-juveniles)	PL/cage/yr	300-400		
Lobster farming	PL/cage/		80-100-120	80-100
Volume of cage	M3	20	9-15	27
Stocking rate (pre-juveniles)	PL/m^3	15-20		
Stocking rate (juveniles)	PL/m^3	5-7	5-8	3-4
Feed	Kg/feed/cage	100-210	100-240	80-100
Labor (per m3 of production water volume)	Person/cage/yr	2.8	2.1	3.78
Labor cost (full time)	*'000 vnd/person/month	800	800	800
Labor cost (seasonal workers)	*000 vnd/person/crop	230	230	230

Table 35 Main outputs for lobster culture.

OUTPUTS PER HECTARE	**Unit**	**Fixed cage**	**Sunk cage**	**Floating cages**
Lobster	kg/cages/yr			
Typical harvest size (type 1)	Gram	1,000-1,900	1,000-1,900	1,000-1,900
Type 2	Gram	700-900 & over 1900	700-900 & over 1,900	700-900 & over 1,900
Farm Gate Value	*000 vnd/kg	400-600	400-600	400-600
Productivity	Kg/cages	40	40	40-60

The prices are fluctuated and depended on the season and demand – supply. The type 1 is the best farm gate price at any season, the different price between type 1 and type 2 is around 50,000 VND. The most expensive period is in Christmas holiday due to the crowded tourists as well as high demand from Taiwan and Hong Kong.

Table 36 Various performance issues related to management practices and externalities

Management Performance & Risks	**Unit**	**Fixed cage**	**Sunk cage**	**Floating cages**
Survival rate (pre-juvenile)	%	40-50-60	40-50-60	40-50-60
Survival rate (juvenile – over 100 g/PL)	%	95-97	95-97	95-97
Feed Conversion Ratio	Kg of feed/kg of lobster	20-30	20-30	20-30
Risk of 100% production failure		Low	Low	Low

Note: FCR 8-10 reported by Khanh Hoa DOFI, 20-28 is reported by Fishery Universiy, 26.3 in average is reported by SUMA profile..

Table 37 Main production performance parameters for a 'fixed' lobster cage culture in central Viet Nam (SUMA, 2005). The analysis is for a 20m^3 cage. It must be noted that this is usually part of at least a 4 cage cluster.

PRODUCTION	**One 20m^3 Unit**	
Lobster culture		
Crops per year	1.0	no/year
No of stockings per year	1.0	no/year
Seed size		
Total stocked seed per year	350	seed/cage/yr
Stocking density per year	18	seed/cage/yr
Yield per year	40	kg/cage/year
Average size at harvest	1.4	no/kg
Survival rate	16%	%

The survival rate is relatively low which may be attributed to the stocking of pre-juvenile lobster seed. Lobster seed are caught from the wild and this is considered a very wasteful use of a limited seed supply. It is suggested that pre-juveniles should be 'nursed' to a juvenile stage which is expected to produce more sturdy juveniles and thus increase survival rates.

The lobster farming in Khanh Hoa and Phu Yen provinces is considering as low risk in production failure because disease outbreak has not been happened seriously except scattered death in some cages. However, the death of lobster farming could be considered as high risk in term of economic aspect due to the high investment of the seed and feed.

Major inputs - Water use

Lobster has been farming in the marine water shed alongside to coastline with high and stable salinity. The major water use for lobster farming is marine water as the cages are located in the marine water from 5m to 90m of depth as the biology of lobster. The effluent of lobster farming is not clearly identified as one in the shrimp farming in the ponds. This is critical issue in environmental pollution control as well as in farming practices. The effluent come from marine cages is mostly caused by sea currents flowing through the cages. Wastes of feed are discharged directly to marine watersheds or surrounding environment without any control and management.

Environmental monitoring has been implementing in Khanh Hoa and Phu Yen for different purposes and conducted by different offices and stakeholders. Firstly, The National Environmental Monitoring Program has been conducted by Ministry of Natural Resource and Environment (MONRE), the secondly is environmental monitoring is sampled by Khanh Hoa Department of Natural Resource and Environment in provincial level and other researches are carried out by Nha Trang Fishery University, Nha Trang Research Institute of Oceanography and projects, though these are not frequent monitoring practices.

The tourism development in Nha Trang bay and industrial development in Van Phong bay have been pressuring on environmental issues to the coastal marine water quality[6]. There were conflicts between tourism and lobster farming in Nha Trang Bay. The effluents with high chemicals and drug usage without treatment come from shrimp farming ponds of inland are causing the problem for lobster farming.[7]

Research done by SUMA and RIA3 in 2003 indicated that water quality was deteriorated at the lobster farming areas as the high values of H_2S and NH_3 concentration of sediment and marine water[8]. These are indicators that organic matters decomposition under anaerobic condition at the bottom of lobster farming cages.

Major inputs - seed supply

Since the started point of lobster farming in Viet Nam, seed supply to lobster farming has been harvesting from wild. The major fishing grounds for PL are coastal areas of Khanh Hoa, Phu Yen, Binh Dinh, Quang Nam and Ninh Thuan. The wild seed is harvested by traps then transported to the nursing cages during within 5-12 hours on the boats and 3 hours on the cars with boxes. It is difficult to define the certain link to Marine Protected Areas in central provinces, though the coral reefs have been zoned to be protected in Khanh Hoa and Ninh Thuan.

Since the wild seeds are available in the coastal marine areas in those provinces, the lobster hatching has not been developed in Viet Nam although the scientists has been paying attention to work on this. The scarcity of wild seed has been rising as increased prices of seeds in recent years. The higher price of lobster seeds are caused by increased in production as there are many new comers to lobster farming when Tiger shrimp farming has been lost by disease outbreak and environment degradation in Khanh Hoa province.

The lobster hatching technology is still a curious question for this sector. The scarcity of wild seed could be predictable and foreseen in near future. Seed has been imported from Philippine since last year with 1000 PL and over 1,500 PL in four months of this year. All seeds have been tested and quarantined by provincial NADAREP and sub-office of NAFIQAVED at Tan Son Nhat airport.

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[6] Viet Nam Status of Environmental Report, 2005.
[7] Khanh Hoa DOFI report, 2005
[8] Water quality has been monitored in 2001 and 2002.

Major inputs - feeds and feed management

Trash fish is the most preferences of feeding to lobster farming in Viet Nam. The trash fish includes crustacean, mollusk and fish as in follow picture.

Those types of trash fish have been used in combination or separated type. Different from Tiger shrimp farming in Khanh Hoa and Phu Yen provinces, which are using the combination of pellets and trash fish (3 tons of pellets and 7.5 tons trash fish per ha per crop), the farmers do not use pellets for lobster farming.

There are some efforts on the trial and study on using the combination of pellets and trash fish in nursing stage. The trial has been lasted for 150 days and carried out by collaboration of RIA 3 and Bien Dong Fishery Cooperation in 2003. The results of this study did not support to push forth using pellets for feeding lobster. The survival rate of lobster was 97.67% in a first month with pellets combination, but the lobsters were died after 75th day.

Other inputs/resource use

Beside of major inputs like seed and feed, labor is another input in lobster farming. Labor is used in feed preparation, feeding and cage maintenance. This includes permanent and seasonal workers. Labor costs occupy 16-17% of total cost of production[9].

Risks

With those practices, lobster farming in Viet Nam is getting more risks in terms of environmental and disease aspects. Although there is not really disease outbreak, the scattered death of lobster in Phu Yen and Khanh Hoa provinces since 2001 was a first warning signal of risks. There is a potential dangerous that is unknown causative agent in some cages, for example, the death found in 16 lobster farms in March of 2006 in Phu Yen and others in Khanh Hoa.

In fact, lobster has been facing with different types of disease like Tiger shrimp. They consist of black gills, white spot on shelter, red body, contaminated sexual organ, white feeler and head breaking.

The design and location of cages has been getting natural risk, for example the low salinity during rainy season and high temperature in the hot days. Typhoons also can cause the high risk to lobster farming due to major lobster production areas are in southern central where there are high frequency of typhoon.

Economic risk is considering high because of high investment in seed and feed. The seed cost occupies over 43% and feed occupies 40% of total variable production cost[10]. The cost will be increased due to higher price of seed in recent years.

Lobster culture is heavily reliant on trash fish for feeding. Feed conversion ratios are very high indicating a poor utilization of the feed. It is expected that the price of trash fish will increase due to

[9] SUMA aquaculture profile, 2005.
[10] SUMA aquaculture profile,2005.

the high pressure on the fishing resource and high demand for fishmeal based protein (one of the main sectors demanding this is the shrimp sector). This will inevitably lead to higher prices in the future and the impact of this can be seen in the scenarios in

Table 38. A 20% increase in feed costs will reduce net profit by 4% per cage per year. This is a relative modest impact indicating that the system is resilient towards changes in this type of externality.

Seed costs accounts for the biggest operational cost of the system. Since lobster seed is caught in the wild prices are likely to increase as the resource becomes more scares. This is already happing due to the high fishing pressure on the resource and it is viewed as the single most restrictive parameter for further expansion of lobster culture. A 20% increase in seed costs will result in a 15% drop in net profit, thus this externality has a much higher impact. Research and development to hatchery produce lobster is essential if seed costs are to be maintained or reduced and also to avoid import of seed from other countries. The latter has the risk of introducing non native diseases.

Table 38 Sensitivity analysis of fixed cage lobster culture in central Viet Nam subjected to various externality scenarios. The first part of the table illustrates single a externality's impact upon Annual Net Profit i.e. increase in feed and seed costs. The second part of the table illustrates three multi-externality scenario's

Single Externality Scenarios					
Feed price	**Baseline 2006**	**20% increase**	**40% increase**	**60% increase**	**Unit**
Annual Net Profit (ANP)	9,590	9,182	8,774	8,366	**'000 vnd/cage/year*
Percentage impact ANP		-4%	-9%	-13%	
Seed price	**Baseline 2006**	**20% increase**	**40% increase**	**60% increase**	**Unit**
Annual Net Profit (ANP)	9,590	8,190	6,790	5,390	**'000 vnd/cage/year*
Percentage impact ANP		-15%	-29%	-44%	
Multi Externality Scenarios		**Feed price +20%**	**Feed price +40%**	**Feed price +60%**	
	Baseline 2006	**Seed price +20%**	**Seed price +40%**	**Seed price +60%**	**Unit**
Annual Net Profit (ANP)	9,590	7,782	5,974	4,166	**'000 vnd/cage/year*
Percentage impact ANP		-19%	-38%	-57%	

Given the multi-externality scenario where the system is exposed to shock of 60% feed and seed cost increases revealed that the system is still economically viable. This clearly indicates that the system is very resilient against externalities and can assume that productivity is stable. Lobster production is a highly profitable business venture.

Markets and market chains

Lobster is a highly priced commodity. In Viet Nam, lobster is cultured mostly in cages in Khanh Hoa and Phu Yen. Besides, there are some hundred of cages Ninh Thuan and Quang Ninh. Total number of cages in 2005 was 43,516, with the total production of 1,795 tones[11].

Most of the export volume goes through unofficial ways to markets like China, Taiwan, and Hong Kong. The official export quantity in 2005 for example was 1.1 ton only. In domestic market, lobster is consumed mainly in seafood restaurants.

The prices of lobster change depending on seasons and market demand but always maintain a high level. The peak time in a year is often Christmas or Traditional New year (Tet) holidays.

[11] MOFI, Statistical data from Aquaculture program 2000-2005

Table 39 Farm-gate prices, 2006 (Ngan,Khanh Hoa Data)

Sizes (kg/lobster)	Prices (VND 1000)
1-1.9	550-600
0.7-0.9 and > 1.9	500-550
0.5-0.7	450-500

Table 40 Domestic market prices, 2006 (Ngan,Khanh Hoa Data)

Sizes (kg/lobster)	Prices (VND 1000)
1-1.9	800-1,000
0.7-0.9 and > 1.9	750-900
0.5-0.7	600-700

There are two market chains corresponding to domestic consumption and export:
(1) Farmer → collector/middle men → domestic consumer and,
(2) Farmer → collector/middle men → exporter

The difference between farm-gate prices and domestic market prices is about VND 200,000-400,000 depending on sizes and seasons.

Social and economics

Lobster farming has been developing rapidly in Khanh Hoa and Phu Yen provinces because of high profit generation, which attracts the new-comers to get involved in lobster farming. The survey has been done by interviewing farmer during field trip indicated that the start up cost of lobster farming consists of cage construction, seed and feed. The construction costs are 1.6-1.8 modillion VND per cages equal to 16-18 millions VND per farm in average with ten cages, costs of seed are 6.6 – 7.2 million VND per cage equal to 66-72 million per farm, the costs of feed are rough 60-65 million per cage. The investment costs are quite high for poor involvement.

The finding of cost-benefit analysis is interpreted into the high economic elastic of lobster production system due to the high cost of seed and feed, consequently to influence of survival rate to the profit generation. The biggest influence of profit making is farm gate price of product and survival rate. The 10% change in survival rate or lobster price and seed price could lead to 54% and 18% change in profit generation, respectively[12].

The profit generation has been declined in recent years from 100% in first year down to 45% in last year causing by the increasing of seed and feed prices. Though the lobster farming is still of high profit compared with other coastal aquaculture modes of Viet Nam.

Job creation is considerable for poor in lobster farming. The monthly salary is 800,000 VND per month for permanent workers and 35,000 VND per day for seasonal workers. Besides, indirect impacts are creation of job and income for poor communities who are fishing the trash fish and seed for lobster farming.

[12] SUMA aquaculture profile, 2005.

Table 41 Labour indicators a 20m3 fixed lobster cage in central Viet Nam

LABOUR INDICATORS	**Fixed Lobster Cage ($20m^3$)**	**Units**
JOB INDICATORS		
Labour fixed	0.08	*man-months/cage/yr*
Labour harvest	0.00	*man-months/cage/yr*
Total labour	0.09	*man-months/cage/yr*
Investment per job	14,857.1	**'000 vnd/man year*

* Capital costs are used as the sole basis for comparing investments

One person will be able to manage around 10 cages in order to have a full time job. The system is not very labour demanding and feed and cleaning of the cages are the main duties which need to be performed. Due to the value of lobster, it is necessary to have a guard stationed on the cage cluster around the clock to avoid poaching.

Table 42 Economic performance indicators for fixed cage lobster culture in central Viet Nam assuming 1 crop per year. TVC= Total variable costs; TFC=Total fixed costs; NR=Net Profit; TOC=Total operating costs; CC=Capital Costs

ECONOMIC INDICATORS	**Fixed Lobster Cage ($20m^3$)**	
Net profit/ha/yr	9,590.0	*'000 vnd/cage/year
Total farm gross revenue (Farm Gate Value)	20,000.0	*'000 vnd/cage/year
Total operating costs (TVC+TFC)	10,410.0	*'000 vnd/cage/year
Value added (Net profit+labour costs)	9,660.0	*'000 vnd/cage/year
Benefit/cost (NR/TOC)	0.92	
Minimum start-up costs (TOC+CC)	11,710.0	*'000 vnd/cage/year

Given that the lobster cage is only $20m^3$, it has a high net profit per volume (500.000 vnd/m^3). The benefit-cost ratio is high indicating a good buffering effect against shocks i.e. disease outbreaks or externality impacts.

The minimum start-up cost is relatively high given that a least 4 cages are need in order to make a cluster. If a community invested in a joint operation, total operation costs and capital costs would be reduced due to large scale production. However, setting up a cooperative will require a high degree of trust within the community and does not seem to be the trend in Viet Nam.

2.3.2 Environmental Assessment

Lobster culture is a highly polluting business venture with a high risk of self-pollution because it is often conducted in shallow waters. Using wet-feed is the main cause of this and given the very inefficient utilization of the feed. It is suggested that formulated feeds with strong matrix-compositions should be developed. The private sector may budget with more research and development into lobster feed if the seed can be produced in hatcheries ensuring a continuous supply of feed. Hence, it is suggested that national research and development programmes should focus on getting lobster hatcheries commercialized.

Grow-out trials have been conducted in Khanh Hoa province where green mussels were grown on strings on the outer perimeter of the lobster cages. The green mussels shown good growth rates and once they were of an adequate size, they were used as input for the culture. Seaweed culture around a lobster producing area would also remove nutrients and provide an alternative income opportunity.

Location and farm siting

Lobster farming has been located in the southern central provinces where the wild seed are available and appropriate ecological condition exists for lobster culture. As a consequence lobster farms are located surrounding the coral reefs. If lobster farming was carefully planned and sited in areas with good water flows the adverse ecological impacts would be greatly reduced. Lobster cages were sited closely to the coral reef before the Hon Mun Marine Protected Areas was established. The buffer zone of Ran Trao coral reef has been used for lobster farming in Van Phong Bay.

Lobster cages sited close to coral reef may be advantage for farmed lobster, since the environmental conditions are optimal for growth. However, this has great adverse impact on the coral reef caused by sedimentation and water quality degradation. Poor water quality has been recognized in the lobster cages which located in the low current areas. Disease and death of lobster happened as consequence of bad practices.

Lobster farms development in unplanned areas in Khanh Hoa is causing environmental pollution at the culturing areas and potential impact on coral reef though the sea current. There is no sampling station for water quality monitoring to observe the off-site impacts caused by lobster farming in Khanh Hoa province. This will be missing of basic for lobster farm planning or adjustment in environmental friendly approach.

Otherwise, lobster farm location in the area having various economic development activities that may damage the business is one environmental issue that must be considered in planning process, as in the case of lobsters farming in Van Phong bay where the development of deep sea port will be the major impacts on lobster farming in future. The conflicts between master plan of different sectors are big issue when there is no coordination at higher level of decision – making.

Design and construction

The existing design and construction of lobster cage in Khanh Hoa and Phu Yen could bring different effective to production and influence to environment. In the earlier stage, there were two types of design of lobster farming are fixed cage and sunken cage as above description. The floating cages have just been developing since two recent years. Due to the characters of cage design types, the farmers choose the different types of bottom for their farms. This is causing some environmental issues.

The fixed cages design is located at place with sand and coral benthic when it is used as bottom of cages instead of artificial layer. This practice could damage the benthic habitat after some months of farming, especially for coral reef. The un-eaten feed is deposited to the benthic and creating a thick layer of organic sludge which are causing the bad water quality and damaging benthic habitat. The disease has been happening as a consequence.

After period of 1 or 2 years, the farmer brought sand for filling in the cage to create new bottom layer, this practice completely destroy all original habitat. The water depth is reduced by times leading to high temperature of water in the hot reason, again impacts on lobster growing. At present, there are many places used to locate fixed cages could not being used for lobster farming. Another disadvantage of fixed cages is low salinity in the rainy season because of fresh water come from shore.

The latest type of lobster cage is the floating one which is developed in recent years due to the deterioration of water quality in the shallow areas of previous lobster framing. Floating cages enables the farming in the deeper water areas and easily to move to other places when water quality is getting worse. Like above types of cages, lobster farming could impacts on water, sediment as well as the benthic by feeding practices.

Both sunken cages and floating cages could avoid the fresh water come from shore during rainy season. In additionally, the sunken cage is not easily for feeding management, there was death of worker happening while diving for un-eaten feed removing.

Seed supply, broodstock and post larvae

As in history of lobster farming in Viet Nam, the major seed supply is wild seed, which has been harvesting anywhere in southern central provinces from Thua Thien - Hue to Binh Thuan. Lobster farming sector is randomly specialized and zoned into two processes of nursing and growing. The major commercial production zones are in Khanh Hoa and Phu Yen, the remains specialize in nursing and selling to Khanh Hoa and Phu Yen provinces. Of course, there are still the nursing farms in those provinces and even two stages in several farms. The early development of lobster farming might be leading to creation of these zones.

Lobster farming in Khanh Hoa and Phu Yen has been developing rapidly leading to high demand of seed supply in recent years. Wild seed harvest becomes high pressure on coastal areas in central provinces.
The harvesting season lasts from November to next April; the highest productivity of harvesting is from January and February. There are some forms of harvests, by using nets, trap and diving, diving to capture the seed usually at the coral reef close to the coast.

Using nets of 2a=5mm size can catch the small seed and higher number of wild seed, this type cause the disturb of small wild seed come in the shallow water areas close to shore like bays or small bay. Consequently, it is causing the depletion of wild seed quickly, the survival rate of small PL is low in addition. Using trap and diving could have the bigger size of seed but lower productivity.

Otherwise, the nursing practices can contribute to decline the aquatic resource with low survival rate in this stage.

Seed supply does not meet the demand in the last year, approximate to 1000 PL has been imported from Philippine and 1550 PL is imported in January to April of 2006. This illustrated the high demand of seed supply.

Water Use and Impact

Impacts on water quality causing by the lobster farming has been recognized in Khanh Hoa and Phu Yen provinces since 2001 with death of lobster happening. There were some researches on water quality deterioration at the lobster farming sites.

Results of those researches has indicated that water quality has been deteriorating by time and increased in water depth at different lobster farming areas. The typical indicator of water quality is H_2S exceeding the TCVN 5943-1995 – the Viet Nam Environmental Standards on Coastal Water quality.

The National Environmental Monitoring System of MONRE also showed up the pollution of marine water quality in Nha Trang since 2002, 2003 and 2004. The major indicators of environmental pollution are Coliform and oil film in marine water [13]. Coliform indicator presents for biological pollution, which could come from organic matter decomposition and municipal waste from urban. It is difficult to define the pollution sources, presuming it comes from both inland and on-site activities.

Sediment sampling and analysis have been done in 2003 showed that H_2S and NH_3 parameters were exceeded the TCVN. This indicated that the sediment includes very high organic matters and those pollutants that were products of anaerobic decomposition process. The observation showed that sludge ratio was very high in bottom composition, occupied 78-19.5%.

[13] State of Environment Report -2005, MONRE.

As above discussion, there are no sampling sites for monitoring the impacts of lobster farming in Khanh Hoa provinces to provide the influences to off-site habitat and marine water quality.

Waste and impacts

The major waste is generated from lobster farming come from un-eaten feed and without removing them out of cages and marine water bodies. As results of this practice, the sludge accumulation at the bottom of lobster farming is big issues and polluting the water in turn. Results of the interviews with farmers at field showed that self pollution has been rising in most of lobster farming areas, especially with the fixed cages lobster farming which could not easily move to other places.

Feed and feed management

Feed and feed management play significant role causing environmental issues in lobster farming. Most of pollutants come from feeding practices. Using trash fish for lobster feeding is prevailing in anywhere in central provinces of Viet Nam. The results of some trials did not push forth to change in using trash fish to pellet.

High FCR of trash fish generated a lot of un-eaten feed and waste to bottom causing environmental issues like bad water quality, disease problem and influence to habitat at farming areas as discussed.

Disease issues and health management

The disease pandemic has not really happened in lobster farming like Tiger shrimp culture, as learned by interviewing local authorities and RIA 3 in Khanh Hoa province. People recognized the disease problem since lobster died in 2001. The researches indicated that it was mainly caused by bad water quality.

The first disease outbreak was appeared in March of 2001 with 20-30% death in one week in Phu Yen province. Since, the disease has been happened regularly in different farming areas in Khanh Hoa and Phu Yen provinces. The typical time of disease appearance is March and April. This March, lobsters in 16 cages were died in Phu Yen and this was found also in several cages in Cam Ranh.

The major factors and finding associated to disease occurrences are bacteria *Vibrio alginalyticus* on the lobster body. This is judged as a major factor causing the death of lobster. The antibiotic testing has shown that *Vibrio* resisted 10 types tested antibiotics used in experiment in 2005[14]. Other findings are high concentration of NH_3 and H_2S in water, fungus and parasites.

Another research of SUMA has recognized *Vibrio paraheamolyticus* at the lobster farming in 2003 in Phu Yen and Khanh Hoa provinces. This type of bacteria was prevailing with 8 types of lobster disease. The suggestion is that having Formal Aldehyd bath for lobster could help in reducing the death.

The transmission has not been recognized in farming areas, therefore this could not be considered as disease outbreak although disease occurrence become more regularly. However, the Extension Center of Khanh Hoa province sampled the lobster when disease occurred and some practices have been promoted for disease prevention. The regional center of Environment and Disease Monitoring and Warning under RIA 3 also has responded to disease when getting information from farming areas. Recommendations of those offices focused on the feeding management and farm site selection as well as the antibiotic usage.

[14] RIA 3 report, April 2005.

Food safety and quality

The major chemicals have been using for lobster diseases treatment are Formol Aldehyd, Formalin, Green Malachite, $CuSO_4$, CaO and antibiotics like Norfloxacin, Nalidixic acid, Ciprofloxacin, Oxytetracyline, etc.

Experiments of Formalin bath and antibiotics usage showed that these solutions are effective with small lobster and earlier recognition of diseases. The using of mixed chemicals in disease treatment can create the deterioration of water quality. This type of impacts will be stronger and more difficult to solve than organic matter generating by un-eaten feeds as this matter could be self disintegrated by the time. The more chemicals are put into the sea water, the higher COD concentration of marine water and deposits to the seabed observed, and the more degradation of farming areas occurred. The lesson learned from Tiger shrimp pond farming in Khanh Hoa this year.

Bacteria, fungus and parasites in the infected lobster could be transmitted to human health by fresh eating practices. There is no recognition of this transmission; however this might be the potential dangerous for human health.

Economic and social issues

Economic loss as a consequence of self pollution causing disease outbreaks is the biggest threat to sustainable development of lobster farming. The price of dead lobster is just one fourth or one fifth compared to live lobster. Economic looses are severe in case of disease outbreaks due to the high production costs mainly consisting of feed and seed. The major environmental issues and disease outbreaks occur when culture is done in shallow waters where fixed cages are located. This type of cage is used by the poorer people, who have limited capacital to invest. Some cages have been deserted and the owners have given up the farming last year in Van Ninh district, Khanh Hoa province.

Market issues

The major market of lobster is foreign market such as Taiwan, Hong Kong, China and domestic market consuming by tourists in Nha Trang. The most preference size is 1kg to 1.9 kg per lobster and all products are live lobster since there is no market for frozen or processed products. This preference of market implicates the high food safety requirement.

Institutional issues

Khanh Hoa province has advantageous natural conditions for aquaculture as well as benefited from the activities of research institutes, university, NGOs etc. However, the institutional issues there could not avoid the complex of system and the lacking of coordination of sectors and stakeholders like other provinces.

At the provincial level, DOFI and DONRE plays important role in managing lobster farming and environment. These offices have their own management system to respond to disease problems and environmental issues. However, these systems have been working for number purposes of management with limited resources and there is not enough concerns to lobster farming as this commodity would not be a strong priority of economic growth in Khanh Hoa province as well as at the higher level of decision-making.

Although, RIA 3 is in charge of Environment and Disease Monitoring and Warning system in central provinces from Da Nang to Binh Thuan under MOFI, the design of sampling sites of data collection does not have sampling site for disease and environment monitoring for lobster farming. Despite of including 1 sampling site in Nha Trang and 1 sampling site in Van Phong bay, those sampling site are not designed to monitoring the impacts of lobster farming as it is 5 km far from that areas. Disease response is a function of this institute when disease occurs with lobster in the region. This center should be strengthened in term of financial and technical aspects to meet their duties.

The major environmental issues in lobster farming in Viet Nam

The major concerns come from unplanned development, stocking of wild seed and current feeding practices. With existing practices, the total quantity of trash fish will be used for lobster marine cage could be 30,000 tons per year by 2010 given an average FCR of 15:1. The seed requirement will be 2.5 million seed if survival rate is 80%. Most of lobster seed comes from wild.

Follow are the major environmental impacts and solution for lobster farming.

Impacts	***Management practices/solutions***
Marine cage farming of lobster	
Impact 1. Polluting water, biodiversity and sediment	• Better planning within environmental carrying capacity • Avoid culture in shallow waters • BMP for responsible feeding • Promote the cage rotation • Water and sediment quality monitoring • Promote open sea farming
Impact 2. Use of trash fish	• Promote using the pellet feeding, change in regulation and policy allowing import of feed for marine species (first five year) • Promote substitute fish meal and oil (*cobia*: high demand for energy) by using plant or other animal source • Create farmer awareness of impacts of trash fish uses • Increase price of trash fish • Research on pellet formulation • Research and promote on adding values of trash fish (shifting to human consumption) for export
Impact 3. Impacts on wild broodstock and seed	• Research on domestication • Develop Broodstock center and conversion of shrimp hatcheries into multi-function
Impact 4. Alternative income generation for communities in Marine Protected Areas	• Controlled collection of lobster seed in the zones around MPA's (this will require community awareness programmes and must be incentive driven)
Impact 5. Impact on landscape and world heritage other resource users (navigation, tourist, fishing)	• Promote open sea farming • Stakeholder consultation in planning • Cross sectoral planning
Impact 6. Importation of exotic pathogen	• Improving capacity for controlling transboundary movements • Develop capacity on IRA • Conduct and implement IRA before performing transboundary movements

2.3.3 Guidelines for Better Management

Location of aquaculture farms

It is very important to:

- Locate lobster farms according to national planning and legal frameworks in environmentally suitable locations;
- Make efficient use of marine water resources and in ways that conserve biodiversity, ecologically sensitive habitats and ecosystem functions;
- Recognize that other users, people and species depend upon these same ecosystems.

Following are technical practices and criteria of location of lobster farms and/or zones:

Matrix of practices and criteria for lobster farming location

Practices	**Criteria**
Water current	• The bottom current should be 1-2cm/s
Water depth	• Water depth should be 4-8 m
Farm site/zones	• Lobster cages should be located in a bays or strait avoiding the influence strongly of typhoon, waves and winds • Far from discharging gates of effluent comes from urban and industrial sectors in inland • Shouldn't be located at or close to estuaries avoiding the fresh water during rainy season
Water quality	• Clean and meet Environmental Standards TCVN 5943-1995 (column b)
Benthic characters	• Clean benthic with sand or mud
Habitat	• Avoiding the coral areas even this is not protected areas aims to conserve the biodiversity of marine region

Design and construction of farms in ways that minimizes environmental damage

Development of lobster culture in central provinces of Viet Nam indicates clearly that design and construction can be a significantly influence to farm operation and environmental issues as above analysis..

Following are technical practices and criteria of design & construction f of lobster cages/farms and/or zones:

Matrix of practices and criteria for lobster farming location

Practices	**Criteria**
Type of cage design	• Floating cages should be the most preferences in lobster farming due to easily moving and operation in an environmental friendly practices
Nursing Cages	• Cage size should be 1.5x1.5x1.2 or 2 x 2 x 1.2 m. This size is better for operation and management. • Net size should be 2a=0.5-0.6cm and 1-1.5 cm, double layers
Growing cages	• Cage size should be 3x4x3m or 3x3x3m or 3x4x4m • Net size should be 2a=3-4cm
Farms	• The medium and appropriate size of farms should be 4-10 cages for better operation and management • Integrated culture should be applied including green mussels in lines, sea bass in several cages and or seaweed on the surface
Farm clusters and system	• Cluster farms should be integration of lobster cage, pearl cages and seaweed farms to reduce in water deterioration

Seed supply, broodstock and post larvae

Wild seed usage has been prevailing in lobster culture in Viet Nam. These practices contribute to wildlife depletion and reduction of seed availability.

Matrix of practices and criteria for seed supply

Practices	***Criteria***
Wild seed harvesting	• Using trap for seed capture is preference to release the small juveniles and do not disturb ecological process of lobster juveniles.
Wild seed transportation and preservation	• Using boxes with size are 30x40x25 or 60x70x45cm depends on the quantity. • Dry transportation: Keeping ice between boxes and seed should be

	preserved at 21-22oC with high humidity, created by seaweed or wet clothes, can increase the survival rate up to 95%. Duration: 5-7 hours • Water transportation: used for pre-juveniles transportation. Boxes are used, 5-7cm of seaweed or sand are fill into bottom of boxes. Temperature should be kept at 23-25oC. Duration should be 3-5 hours. Survival rate are 95-97%.
Nursing practices	• Balancing the pre-juveniles before stocking • Stocking rate should be 50-60 PL/m3 • Juveniles should be checked on 15th after stocking day about the size and quantity • Stocking rate should be reduced to 15-20 PL/m3 after 60 days of stocking; 12-15 PL/m3 after 90-100 days • 120 days or 4 months of nursing stage, juveniles should be moved to growing cages. •
Seed selection	• Seeds should be selected in a same size and good shape • Selecting the strong juveniles for stocking with full antennae, legs, abdomen and carapace parts
Stocking rate and practices in growing stage	• Selecting a same size and strong PL, weight should be 50-80 gram per PL • Stocking rate should be 5-7 PL/m3. • Reduce stocking rate to 4-5 PL/m3 when lobster gain 500-600 gram per PL.
Operation practices	• Daily checking PL and removing un-eaten feeds. • Periodically cleaning the cages • Keeping the female lobsters with eggs

Feed and feed management

Feed and feed management are major factor/source contribute to generation of waste during operation. Better management of feed could bring high effective for lobster production and pollution reduction in parallel.

Practices	***Criteria***
Nursing stage	• Good homemade processing trash fish by chopping and removing shelter. • Daily feed quantity should be 20-30% of pre-juveniles weight in the first 30days • Daily feed quantity should be 20-25% of PL weight later on
Growing stage	• Daily feed quantity should be 15-17% of weight of lobsters • Daily observing the lobster health and action • Daily removing the uneaten feeds and shelters • Periodically cleaning the cages • Checking lobster every 3 months • Using combination of fish + mollusk and crustacean could increase the survival rate and reduce the FCR to 14-15.

Health management plan

A health management should be designed and implemented in a preventive approach come along with different practices from location, design and construction, feeding practices and management, water quality management, etc as above guidance. Following are the guidance on specific activities.

- Design and setup a specific Disease and Environmental monitoring and warning system for lobster culture, including the sampling sites, reporting scheme, response action plan with specific responsibilities of farmer, DOFI, Nafiqaved, DONRE, and RIA3 . Having better coordination of those stakeholders to response the disease and environment issues in a unique approach.

- Water quality: *Vibrios, Coliform, H_2S, NH_3 , DO, BOD and heavy metal*
- Diseases: Red body, Black gills, Big head, Head breaking, worn out tale, shrunk lobster, viscid on gills.
- Frequency: water quality should be sample every 1 month for better predictions; disease should be observed daily to have earlier treatment.
- Farmer and/or farmer groups should establish the information channels on disease outbreak and treatment solution.

Food safety and quality

Although lobster has been exported to Taiwan, Hong Kong, China and domestic market with small volume without processing, food safety and quality must be paid attention to human health protection as this commodity is consumed for fresh eating specially. Beside lobster cage location should be avoiding far from contaminants source, chemical usage should be controlled. Following are guidance:

- Having unique extension materials on chemical usages in disease treatment
- Regularly inspecting chemical use at the lobster farming areas
- Regularly inspecting the residues on lobster products
- Certification scheme for lobster farming and trades

Economic and social issues

Lobster farming in Viet Nam hasn't been considered in application for poverty reduction as it requires high investment in seed and feed. However, it can contribute to poverty reduction and poor livelihood when wild seed harvest and trash fish fishing to supply for lobster culture might be done by the poor. Poor and women involvement should be well organized as cluster of this sector in central provinces.

Following are guidance to sustainable livelihood for poor and women:

- Promoting the better seed harvesting practices to ensure the wild life as a major income generation for poor
- Promoting trash fish processing for lobster culture as a livelihood and job creation for women and poor
- Creating jobs for poor in lobster culture

Cost-benefits of investment in environmental management could be considered as positive due to the low cost of environmental management excepting the cost of water quality monitoring. However, water quality monitoring is not only serves for benefit of lobster culture, but also for public benefit when this can help providing information for other development.

Markets and demand

Lobster is considering as a luxury product and consumers are rich people. Market demand might not be met as increased prices in recent years. It is proved that farm gate lobster price were 350,000 – 450,000 vnd/kg in 2003 increased to 450,000 – 600,000 vnd/kg in 2005.
The major markets are Asian countries and domestic market when these countries have been growing rapidly, special is Viet Nam economy.

The higher seed price and seed import indicates that lobster culture still be high profit generation, although producer surplus has been declined in recent years, e.g. the benefit cost ratio (BCR) was 2 in first years down to 1.45-1.5 in last year.

Institutional issues

Key institutional and policy requirements:

- Expand the level of extension services (private and public) in this commodity.
- Ensure that environmental problems in Lobster aquaculture production is monitored by skilled staff and not neglected in the provincial planning in priority to tourism and infrastructure projects (e.g. deep sea ports)
- Facilitate the establishment of farmers groups. These types of organisations are still weak.

2.3.4 Implementation responsibilities

Institutions (legislation, offices, organisations and norms) may facilitate sustainable aquaculture development and reduce the risks of unpredicted environmental or economic problems. The following general and immediate (specific) requirements are seen as important in promoting sustainability in the in the lobster culture.

General institutional requirements:

- Decentralized, robust, transparent, and resilient management system working with applicable legislation and plans which are supported and understood by the affected stakeholders.
- Giving decision makers access to continuous updated and reliable data on production, natural resources, market and socio economic issues.
- Adjusting production and the development plans towards sustainability targets through incentive based measures and cross-sector planning.
- Considering the limited financial and human capacities in public administration and promoting a simplification of data collection on the sector and conduct participatory decision making.
- Ensuring that the implementation of legislations and development plans are adjustable to different administrative, socio economic and political contexts and that they are enforceable.

Key institutional and policy requirements:

- Expand the level of extension services (private and public) in this commodity.
- Ensure that environmental problems in Lobster aquaculture production is monitored by skilled staff and not neglected in the provincial planning in priority to tourism and infrastructure projects (e.g. deep sea ports)
- Facilitate the establishment of farmers groups. These types of organisations are still weak.
- Supply of feed and quality seed should be improved through strategic coordination of public and private investments in seed production, implementing strategies for improving farmers' access to seed and designing guidelines/legislation for sustainable supply of seed sources (lobster juveniles). DOFI, RIA and private seed enterprises are key stakeholders in this work.
- Environmental pollution and disease out breaks should be reduced by building awareness and incentives to follow GAP, implement regulations on site location and design, better coordination of aquaculture planning with development in other sectors, participatory planning with stakeholders (empower farmers to organise), invest in monitoring systems, train managers in handling pollution problems. Solving these problems require participation from numerous stakeholders: the fish farmers, DOFI, Processors, RIA, Commercial seed producers.

2.4. Fresh water farming (Pangasius catfishes)

2.4.1 Commodity Status and System Description

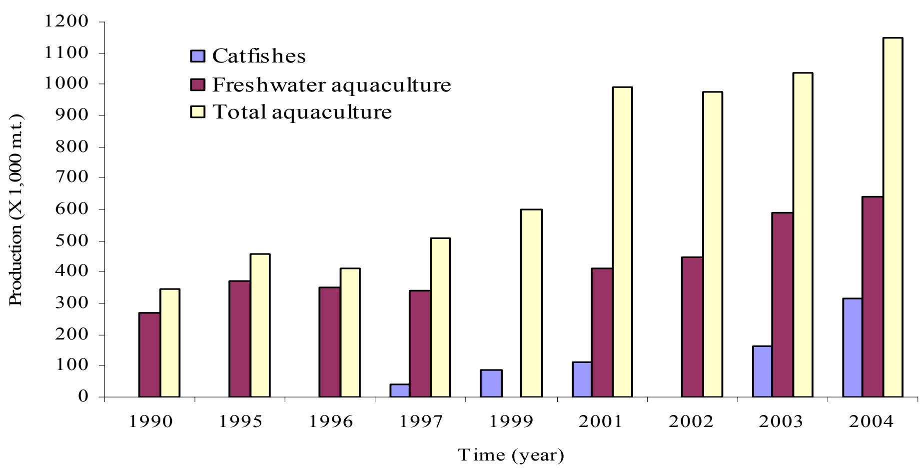
Brief overview

The Mekong river delta (MRD) in the southern part of Viet Nam covers 12% of the total area of the country and is a major player in Viet Namese aquaculture production. The Delta possesses approximately 650,000 ha of freshwater bodies, and freshwater surface can be enlarged up to 1.7 million ha during flooding period (Le, 2001; Tran and Nguyen, 2001). The MRD is by far the most productive region having highest potential for freshwater aquaculture development in Viet Nam due to its favorable environmental conditions. The total freshwater aquaculture production reaches 455,000 m.t., which is 71% of total national freshwater aquaculture production in 2004 (Do, 2005). Major culture species include Chinese and Indian carps, tilapia, snakehead fish and, most importantly, *Pangasius* catfishes.

Pangasius catfishes are the most important freshwater commodity produced in the MRD region in particular and throughout the country, which has enjoyed a very high growth in terms of both area and production.

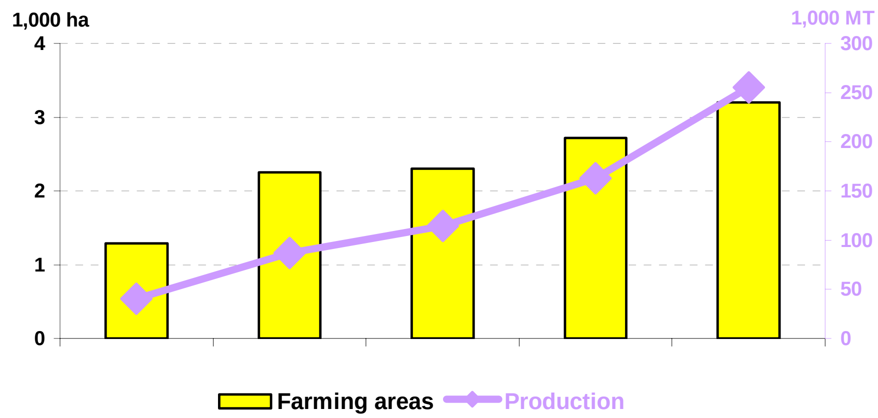
The total production of catfishes in 2004 was 315,000 m.t., 3.6 times as much as that in 1999 and shared approximately 56.0% of the total freshwater aquaculture production of the MRD.

Figure 21 Production of freshwater fishes and catfishes in the Mekong River Delta of Viet Nam from 1997 to 2004



Source: Tran, 2004; and Do, 2004

Figure 22 *Pangasius* area and production (1997-2004)



Source: Tran Thi Mieng, MOFI

There are two species of catfishes being cultured in Viet Nam, namely *Pangasius hypophthalmus* (tra) and *Pangasius bocourti* (basa). *Pangasius bocourti* used to be the main culture species in the early days, then culture of *Pangasius hypophthalmus* took over since the beginning of 2000, becoming the main cultured species and accounting for more than 95% of total aquaculture catfishes. At present the production of *Pangasius bocourti* remains only 3% of the total catfishes production.

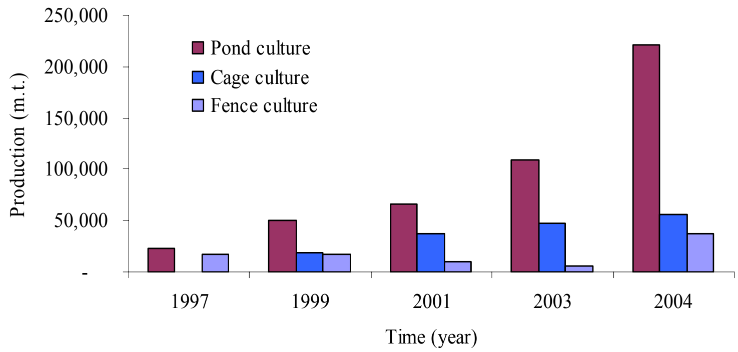
The catfishes are cultured in ponds, cages or fences with highly intensive management operations. The productivity of these systems depends on the stocking densities that are over 116-120 kg/m^3, 183-580 kg/m^2, and 345 kg/m^2 for cages, ponds and fences, respectively. Cages and ponds are the most important culture systems comprising 88% of total production, with 1,653 cages (Nguyen, 1998; Nguyen, 2004 and Tran, 2005). The stocking density in each cage varies between 80 and 130 individuals/m^3 (Nguyen, 1998; Nguyen, 2004 and Tran, 2005). Feed used in catfish cage culture are either commercial pellets, home-made feeds or the combination of both depending on culture location, stocking density and size of cultured fish.

Cage culture production in 2004 was 56,502 m.t. sharing about 17.8% of the total catfish production. About 6.5% of the total caged catfish production in 2004 was from *P. bocourti* (Tran, 2004 and Nguyen *et al*., 2004).

Pangasius hypophthalmus is the only catfish species produced in ponds. Its traditional practice is in the form of latrine ponds using wild fingerling. Since late 1990s the technology for catfish breeding was developed although wild seed is still largely preferred (Nguyen *et al.*, 2004 and Nguyen, 2004). Catfish production from pond culture has been increasing rapidly. The production of 2004 was 220,615 or 3.6 times as much as that of 1999 (MoFI, 2005c). Pond culture of catfish is expanding over all freshwater provinces of the MRD. The culture cycle for pond varies from 6-7 months. Normal stocking density is from 20-30 fish/m^2, but it can be very high as 60 individuals/m^2. Home-made feeds are popularly used for pond culture. The productivity of pond culture also depends on stocking density, location, feed use and level of water exchange. According to Nguyen *et al.* (2004) and Tran (2005), the productivity from catfish ponds was from 180-200 m.t./ha, but Le (2005) showed the productivity from her experiments was from 450-580 m.t./ha, with stocking density of 70 individuals/m^3.

Catfish culture in fence is a new practice, which has been developed along with pond culture since later 2003. *Pangasius hypophthalmus* is a species that has being been cultured in fence. The fence culture practice has grown rapidly from only 17 ha in 2001 to 176 ha in 2004. The production from fence culture reached over 37,882 m.t., which made up about 12% of national total catfish production in 2004. Farming practice in fence culture is also similar with pond and cage cultures in term of feed, feeding and culture period.

Figure 23 Production of different catfish culture systems in the MRD, Viet Nam



Source: Nguyen, et al., 2006

According to Nguyen et al. (2004), the production amounts from cage, pond and fence culture systems of *Pangasius* species were 46.9%, 42.7% and 5.3%, respectively. Ca tra (*Pangasius hypophthalmus*) has been considered as the major production of total catfish production in the MRD (Table 43). The export value of catfish products reached 300 millions USD, accounting for 12.5% of total export revenue from the fisheries sector of Viet Nam.

Table 43 Production share of *P. hypophthalmus* (tra) and *P. bocourti* (basa) in 2005

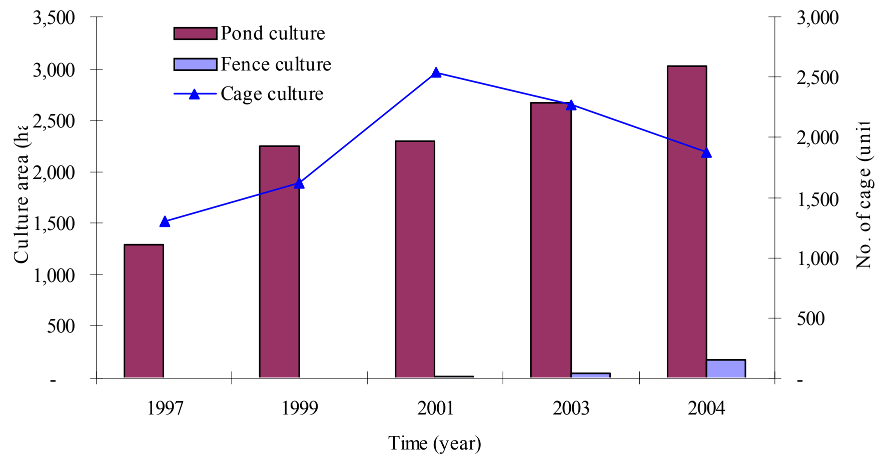
Species	Production (mt)	
	2004	2005
P. hypophthalmus (tra)	313,400	413,700
P. bocourti (basa)	1,600	1,300
Total	315,000	415,000

Source: Nguyen, et al., 2004

Development plans

The catfish culture systems (including pond, cage and fence) in the MRD are practiced at intensive level and rapid expansion, especially during the last few years.

Figure 24 Change in cultured areas and number of cages of catfishes by different farming systems in the Mekong river delta of Viet Nam (Tran, 2004)



Source: Tran, 2005

According to MoFI (2005c), it is estimated that Tra/Basa production will reach up to about 1 million m.t. in the MRD by 2010. Pond culture of catfish is expected to expand rapidly in order to meet the national target. Besides, fence culture may also expand. However, because the *Pangasius* culture development has been explosive without a controlled long-term Government development in place, it would appear that this overly rapid increase in production now exceeds the capacity of processing plants and the export demand (Hao, RIA2). The rapid and improperly planned development of this industry in the MRD raised also other issues related to seed, feeds, credits, and legal measure, etc. Therefore, recently, it was recommended that Tra/Basa production should not exceed 600,000 tones by the year of 2010.

Location of production and development plan

Major *Pangasius* production areas in the south of Viet Nam are An Giang, Dong Thap, Can Tho and Vinh Long provinces. These operate with different culture systems. Cage culture is conducted along the two branches of the Mekong River in Viet Nam, in which An Giang province is considered a main region of this culture system with 88 % of the total number of cages in the MRD. On the contrary, catfish ponds are located along the riverbanks and islands, where water exchange can be made easily, and this farming system is distributed across different provinces. Fence culture is installed around islands in the river branches where water is highly exchangeable.

Table 44 Production of tra and basa fish by provinces (2005)

Province	Pond area (ha)	Number of cage	Production (tones)
Can Tho	983	541	93,000
Dong Thap	-	2000	81,400
Vinh Long	131	274	31,500
Hau Giang	-	-	6,250
Soc Trang	(no data)	(no data)	15,000
An Giang	815	740	145,510
Total	**1,929**	**3,555**	**375,500**

Source: MOFI, Aquaculture program 1999-2005; L.X. Sinh, H.V. Hien, & D.M. Chung, Can Tho University, 2006

Farming system design and production performance

In cage culture of catfish, there are 3 sizes of cage of which small size is less than 300 m^3, medium size is 300-720 m^3 and large size is over 720 m^3 or even up to 1,200 m^3 (Tran, 2005). The medium size cages cover more than 50% of the total cages.

Large size: 1000 – 1,250 m^3 (10 x 25 x 5 m)

Medium size: 400 – 500 m^3 (6-8 x 15 x 5 m)

Small size: 150 – 250 m^3 (5 x 10 x 4 m).

In pond culture system, there are 2 groups of pond sizes which are 4,000 – 5000 m^2 and 1,000 – 2000 m^2 (2.5 – 3 m deep), average pond area was 4,441 m^2 per pond (300 – 12,600 m^2). According to culture systems, land use levels are different and described as following table:

Table 45 Land use

Land use per hectare	Cage	Pond	Fence
Total farm area	1,000 m^3 500 m^3 200 m^3	4,000 – 5,000 m^2	800 – 1000 m^2
Production area (%)			
Inlet water treatment pond (%)	0	100	0
Outlet water treatment pond (%)	0	0	0
Sludge deposit area (%)	0	0	0

Source: Minh's investigation

The sizes of catfish pond and cage design in An Giang province were reported recently and shown in the following table (

Table 46).

Table 46 Sizes of pond and cage

Sizes of pond/cage	Pond (m^2)		Cage (m^3)	
	Size	% of total ponds	Size	% of total cages
Large	> 3,000	30.0	> 720	36.7
Medium	1,000-3,000	53.3	288-720	56.7
Small	350-1,000	16.7	96-288	6.6

Source: Nhi, 2005

Most the fish cage and fence is built with wood. The depths of the pond and cage are 2.5-3 m and 4-5 m, respectively.

The catfish cage and pond construction and design are showed in the following pictures.

Figure 25 Cage of catfish culture (Minh's study data)

Figure 26 Pond of catfish culture (Minh's study data)

Pen culture is another potential system for catfish culture. The pen is a fixed enclosure built on the river embankment, in which the bottom is the bed of the water body. There are several common points between the two systems of culture especially in the environmental set-up of both systems, affecting site selection and culture operations. Another reason for the cost-saving aspect of the pen compared to cages is lower food losses: Part of the feed is likely to be lost uneaten, and drifted away in the current, but the loss here would be less than in floating cages, as much of it sinks to the bottom of the river, and can be eaten by the pangasius which is a bottom feeder. Because of these characteristics, pens are now a popular alternative to cages for Pangasius culture15.

Some main inputs for catfish culture systems were identified by percentage in total input values of each culture system (

Table 47).

Table 47 Input costs, yield and profit of catfish culture systems in Vinh Long, 2003

Items	Units	Cage culture		Pond culture	
		Average	**Std**	**Average**	**Std**
Total cost/m^{3}or /m^2/crop (TC)	'000 đ/m^3	790.5	401.5	169.6	172.3
% of total fixed cost in TC	%	36.1		14.5	
% of total variable cost in TVC	%	63.9		85.5	
Direct input cost (TVC)	%	100.0		100.0	
% fingerling	%	19.8		40.6	
% feed & chemical/drugs	%	75.6		55.3	
% labour TVC	%	4.5		4.1	
Yield/m^{3}or /m^2/crop	Kg/m^3	146.9	61.7	37.0	36.5
Profit/m^{3}or /m^2/crop	'000đ/m^3	836.6	773.4	139.6	307.0

Source: Minh et al., 2005

Total production costs included major items such as cost of labor, fingerling, feeds and others. The total production cost per hectare per year was very high varying from 712,903,325 VND of farm-

[15] GTZ, Pangasius farming practices in Viet Nam, Pg 10

made feed category to 3,894,692,167 VND of manufactured pelleted feed. The average feed cost of all categories shared 90.52% of the total variable costs, varying from 83.77% of farm-made feed category to 93.40% of manufactured pelleted feed category (Nguyen et al., 2006). The average production cost for 1 kilogram of fish is higher in the system feeding with pellet feed in both cage and pond culture systems. The production cost for home-made feed ranges VND 8,153-11,619/kg of fish while it ranges from VND 10,204 to 10,396 for 1 kg of fish produced with pellet feed in case of cage culture system. In pond culture system, the production cost for 1 kilogram of fish ranges from 7,000-10,600 VND for home-made feed and 8,000-11,000 VND for pellet feed in pond culture system (Le et al., 2005).

Some major inputs for catfish culture systems by different feed categories, 2005 (Nguyen et al., 2006)

Table 48 Total costs by items (value in VND)

Description	Category			All categories
	Manufactured pelleted feed	**Home-made & manufactured pellet feed**	**Farm-made feed**	
	Amount/ha/yr	**Amount/ha/yr**	**Amount/ha/yr**	**Amount/ha/yr**
Total costs	3,894,692,167	1,023,349,575	712,903,325	1,876,981,689
Total fixed costs	3,872,042	4,130,125	2,204,000	3,402,056
Total variable costs	3,890,820,125	1,019,219,450	710,699,325	1,873,579,633
1. Labor cost	5,994,500	3451200	1,821,750	3,755,817
2. Fingerlings	219,375,000	144,815,000	93,432,500	152,540,833
3. Feeds	3,634,107,500	858,363,000	595,352,200	1,695,940,900
4. Others	31,343,125	12,590,250	20,092,875	21,342,083

Source: Nguyen et al., 2006

According to Son et al. (2006), three most important components of production costs for catfish are: (i) feed, (ii) seed or fingerlings, and (iii) veterinary including chemicals and drugs. Results from the study show that chemicals/drugs for catfish shared about 5% of the total production costs per crop. Farmers now culture catfish year around and use more pellet feed and chemicals/drugs than before due to higher stocking density and more concerns about the water quality at the micro-region and diseases during off-season, especially flooding time.

Figure 27 Production cost components of Basa

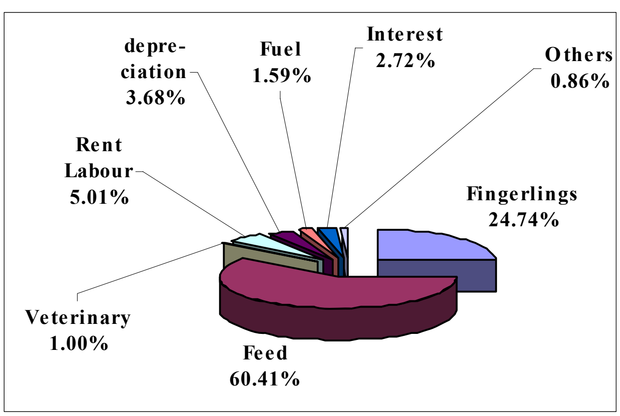
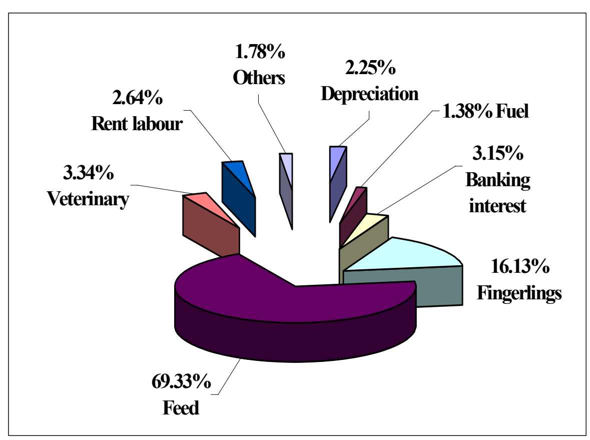


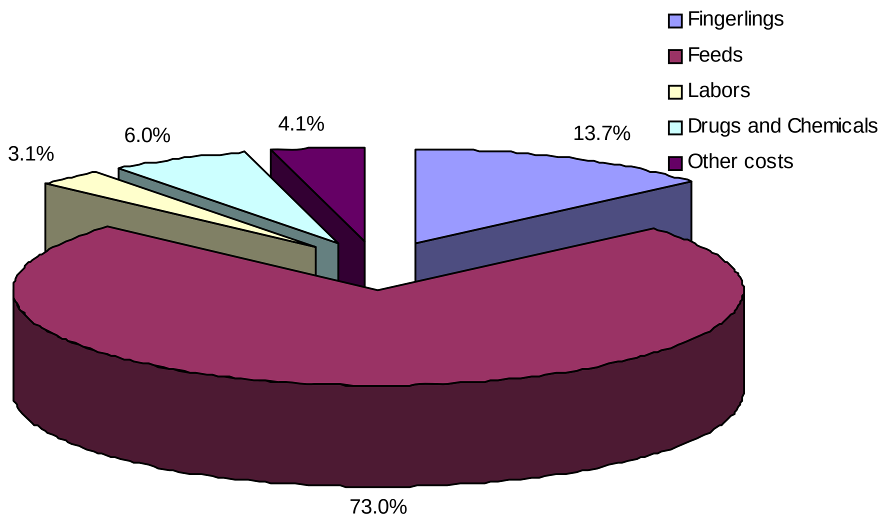
Figure 28 Production cost components of Tra



Sources: Son et al. (2003)

According to Nguyen et al. (2006), feed is the highest cost in catfish pond culture in the Mekong Delta.

Figure 29 The production costs of catfish culture in the Mekong Delta, 2005



Source: Nguyen et al. (2006)

With high average density (202 piece/m^3), the average FCR of 4, the average productivity is about 123 kg/m^3 of cage/crop. After a culturing period of around 1 year (generally 300 days, equal to 10 months), the harvest size of a fish is from 1-1.5 kilo/piece, 1.2 kilo/piece on average (
Table 49).

Table 49 Some technical features of catfish cage culture (n=3)

Technical variables	Unit	Average	Standard	Minimum	Maximum
Volume	m3	283.2	176.1	96.0	445.5
Productivity	kilo/crop/m3	122.6	20.4	109.4	146.1
FCR	Kilo of feed/kg	4.0	1.6	3.0	5.9
Harvest size	Kg	1.2	0.3	1.0	1.5
Number of crop	Crop/year	1.3			
Culturing time	Day/crop	300.0	90.0	210.0	390.0
Failure rate	%	100			
Survival rate	%	0.6	0.3	0.3	0.9
Stocking density	seed/m3	202.3	107.2	125.0	324.7

Source: Aquaculture profile report (SUMA, 2005)

According to GTZ, type of management of Pangasius farming practices in Viet Nam varies from one farm to another. In fact 98% of the farms in Mekong Delta are private – and run by the owner. Most of the owners have no academicals background in aquaculture. Some of the bigger farms hire competent technical managers but most learned through experience. Hence, most farms are poorly managed and lack basic monitoring and planning of their operation on such critical criteria as mortality and fish stock, inventory, inputs such as feed and medication or disease and pest. Very few farms actually consider these elements, let alone record them on a daily basis.

Major input-water use

Cage and fence culture systems base on river water of the MRD. The effluent water is discharged directly into the surrounding environment, i.e. the Mekong River. There are some problems with self-pollution due to uncontrolled development and not following planning. Water quality monitoring has not being conducted in the catfish culture systems. Public infrastructure does not meet the need to assist in supplying good quality water for catfish pond culture system. However, farmers have some basic equipment for water quality checking in their pond such as oxygen, pH, and temperature meters. The cage culture system has conflicted with navigation regarding water use.

Table 50 Water demand for catfish culture system. Suggest inputs are stated on a per hectare production area (water surface used for production or cage volume used for production)

Water demand	Unit	Cage	Pond	Fence
Freshwater demand	% of cage, fence & pond water volume	100	At least 50	100

Source: Minh et al., 2006

At present, many farmers like to culture catfish in pond due to being easer for control water quality. In the pond culture system, water is exchanged continuously by pumping from the river. The water supply and effluent from fish ponds is not treated by farmers.

In catfish culture systems, poor feeding practices lead to environmental pollution due to waste discharge from uneaten feed to the river. In pond culture, waste deposits on the pond bottom and the accumulated waste is often removed out of the pond after every harvest time. Part of the waste is released to the Mekong river during water exchange.

Waste loadings from cage feeding were significant. Yang *et al*. (2003) estimated that every year 204 cages operated in the study area would release into the environment about 295 m.t. of nitrogen; 75 m.t. of phosphorus; 8,730 m.t of organic matter and 10,978 m.t of suspended solids. There were about 1,872 cages in operation in 2004 (Tran, 2004), thus waste loading would increase by 9 times compared to the estimate of Yang *et al.* (2003). Such a loading would include 2,707 m.t. of nitrogen, 688 m.t. of phosphorus; 80,111 m.t of organic matter; and 100,822 m.t of suspended solids annually. Le (2005) presented that nutrient released from intensive culture of catfish ponds was estimated about 23.2g of nitrogen and 8.66g of phosphorus per kilogram of produced catfish. The production of pond cultured catfish in 2004 was approximately 220,000 m.t., therefore, the nitrogen and phosphorus released into water environment can be estimated as much as 5.1 and 1.9 thousand m.t., respectively.

Table 51 Used and lost nutrients from catfish cage culture (calculated from 204 cages in Dong Thap province)

Description	Total N	Total P	Total OM	SS
Total inputs from feeds (t/year)	416	88	10,706	-
Total outputs in fish (t/year)	121	13	1,976	-
Total wastes released (t/yr)	295	75	8,730	10,978
% lost	70.9	85.2	81.1	-
No significant differences of water quality measurements in cage culture areas and areas up and down cage culture areas				

Source: Nguyen et al., 2006

Major input- seed supply

Seed for aquaculture plays an important role, especially for the systems with higher level of intensification and those with new species. Seed production of aquatic species was considered one of the national programs for aquaculture extension from 2000 following the Decision 103/2000/QD-TTg dated 25/8/2000 by the Prime Minister about some policies to encourage the development of seed production for aquaculture. In 1995, the Ministry of Fisheries estimated that there would be about 275 freshwater hatcheries in Viet Nam to present producing more than 6 billion fry per year. Successful reproduction of the *Pangasius borcoti* has brought about a rapid development in both cultured areas and production of the species, especially in the Mekong River Delta. In 2002, about 10 billion fries and fingerlings were provided from 350 freshwater fish hatcheries. Every year now, the production of *Pangasius borcoti* is about 300 million. The program of seed production for aquaculture to 2010 was submitted in July 2004. According to it, more than 700 million fingerlings of catfish will be produced by 2010. In 2005, number of seed and fingerling of catfish was estimated as the following Table 52.

Catfish fingerling has been produced and supplied from the hatcheries in An Giang and Dong Thap provinces. Tan Chau (An Giang) and Hong Ngu districts have considered as the main catfish fingerling in the Mekong Delta. The sizes of catfish fingerling were stocked at 2.5-3 cm and 2-2.5 cm for cage and pond culture systems, respectively. The average stocking density of catfish for pond and cage culture systems were reported about 22.8 individuals per m^2 and 134 individuals per m^3, respectively (Nhi, 2005). Stocking density of fish varies depending on season, i.e. higher density in flooding season for cage culture. The recent investigation in An Giang province shows that, the stocking density for catfish pond culture is 40-60 individuals per m^2 in 2006. Catfish broodstock is cultured for breeding by hatcheries. Thus, broodstock source is available to produce and supply fingerling for catfish farmers.

Although the basa seed can be spawned artificially but the cost for artificial seed production is still high, the main source of seed is from the wild. The farmers can collect the wild seed from the rivers or buy seeds collected by others to culture. The survival rate from the stocking time to harvest time is around 30-90 %, the average rate is 60% (SUMA, 2005).

Table 52 Fingerling production in 2005

Item	Quantity
Larvae (newly hatched)	863,200,000
Fingerling	539,500,000

Source: Nguyen et al., 2006

According to Le et al. (2005), catfish fingerling size and price in pond culture system were smaller and cheaper (200-600 VDN per fish) than that of cage culture system (1,000-1,500 VND per fish). High seasonal demand for the fingerling led to insufficient seed supply from the end of 2003 to the beginning of 2005. This caused increasing double price of catfish fingerling (Sinh & Nga, 2004).
The unit price of fingerling was also reported by Nguyen et al. (2006) in the following table (Table 53). Most fingerling costs are the same to all categories of feed kind. Total fingerling costs per hectare depended on the stocking densities and farm size of each category.

Table 53 Average quantity and cost of fingerlings

Categories	Ave. no. of pcs	Price/piece	Total Cost
Manufactured pelleted feed	457,500	483	220,743,750
Home-made + manufactured pelleted feed	187,050	683	127,661,625
Farm-made feed	151,722	661	100,220,957
All categories	269,345	607	163,418,008

Major input- feeds and feed management

There are two kinds of feed have been used for catfish culture systems; these are manufactured pellet feed and farm-made feed.

There were 30 feed joint ventures between Viet Nam and foreign companies that provide about 500,000 tones of feed for aquaculture in 2000. In 2001, the number was 40 feed producers and 85,000 tones, covering 55% of the total feed amount needed for aquaculture. To meet the demand for feed of the aquaculture farmers, about 40,000 tones of feed were also imported from Thailand, Hong Kong and Taiwan, Province of China in 2001. The remaining was by un-identified or unregistered suppliers. Informal data show that there were about 120 types of feed traded in the market in 2003, but only about 70 types have been tested, registered and allowed for trading. The manufactured pellet feeds are produced in the form of floating pellets, while the farm-made feeds are sinking. There are around 10 companies involved in manufacturing pellet feeds for catfish. Major producers are Cargill, Proconco, Cataco, and Agifish.

The total pellet feeds produced from these companies were estimated from 100,000 to 150,000 tons in 2004 (Hien *et al*. 2005). The amount of catfish commercial pellet and farm-made feeds were 300,000 m.t. and 100,000 m.t in 2004, respectively. The nutritional quality of pellets (printed on the feed bag) is almost similar. The nutritional values, especially protein content were, depended on fish sizes. Pellet feeds for small size fish contents higher protein than that for large fish sizes (Table 54). However, Nguyen (2003) reported that the protein contents of manufactured pellet feed for catfish are lower than its requirement. The protein requirement for the optimum growth of catfish fingerlings was reported from 32.7-36.1% for large fingerling sizes. Practically, the feed producers limit protein level in order to reduce the selling price.

However, the main feed for catfish is farm-made. The farm-made feeds are prepared by cooking various feed ingredients such as rice bran, broken rice, trash fish and feed in the moisture form. The farmers often use feed moulding machine to produce moisture feed. The protein level of the farm-made feed is quite low, about 10.8%, only. The FCR, nevertheless, is rather high, from 3 – 5,9; with the average level of 4 (
Table 49).

Table 54 Average proximate composition (% dry matter basis) by type of feed

Composition (%)	Category		
	Manufactured pellet feed	Home-made & manufactured pellet feed*	Farm-made feed**
Moisture	11	10.6	60
Protein	23.1	24.9	10.8
Lipid	4.30	4.65	2.00
Ash	7.75	6.90	4
Fibre	5.60	7.30	-
NFE	-	-	-

Values of the pellets are recorded from feed bag
* *Values of the column are of the pellets used for the first 3 months.*
** *Values of the farm-made feed are from Tran (2005)*

According to Nguyen et al. (2006), feed formulation for catfish culture in An Giang and Dong Thap province was reported as the following table.

Table 55 Formulation of farm-made feeds

Ingredients	Ratio (%)
Rice bran	41.2-70.2
Trash fish	29.8-34.8
Broken rice	27-32

Source: CTU

Regarding to feed management, feeding practices were depended on the feed forms either manufactured pellet or farm-made feeds (Table 56). Broadcasting (25% of respondents), feeding frame (25% of respondents) and semi-auto feeding (55% of respondents) were used for manufactured pellet feeds while semi-auto feeding was the only feeding method for the categories of farm-made & manufactured pellet feeds and farm-made feeds. There has been improvement in feeding methods for catfish during the last few years. Nguyen (1998) reported that manual feeding method was mostly used for farm-made feeds during the period of 1990s. Feeding frequencies were varied by feed forms. The manufactured pellet feed category applied multiple feeding times (100% of farms), while 90% of farms of farm-made feed category fed one daily. The farm-made feed required time and labor for feed preparation (cooking, cooling, mixture, extruding,…) and feeding, therefore one feeding per day is normally applied to save labor costs.

Table 56 Feeding practice

Type of feed/ application method	Category						All categories	
	Manufactured pelleted feed		Farm-made & manufactured pelletled feeds		Farm-made feed			
	No.	%	No.	%	No.	%	No.	%
A. Manufactured pelleted feed								
1. Broadcasting	5	25	0	0			5	8.33
2. Feeding Tray	1	5	0	0			1	1.67
3. Feeding Bag	0	0	0	0			0	0.00
4. Feeding Frame	5	25	0	0			5	8.33
5. Demand Feeder	0	0	0	0			0	0.00
6. Automatic Feeding	0	0	0	0			0	0.00
7. Others (semi-automatic feeding machine)	9	45	20	100			29	48.3
Total	20	100	20	100	0	0	40	66.7
B. Farm-made feed								
1. Broadcasting	0	0	0	0	0	0	0	0.00
2. Feeding Tray	0	0	0	0	0	0	0	0.00
3. Feeding Bag	0	0	0	0	0	0	0	0.00
4. Feeding Frame	0	0	0	0	0	0	0	0.00
5. Demand Feeder	0	0	0	0	0	0	0	0.00
6. Automatic Feeding	0	0	0	0	0	0	0	0.00
7. Others (semi-automatic feeding machine)	0	0	0	0	20	100	20	33.3
Total	0	0	0	0	20	100	20	33.3
C. Feeding frequency								
More than twice daily	20	100	14	70	2	10	36	60
Once daily	0	0	6	30	18	90	24	40
Total	20	100	20	100	20	100	60	100

Source: Nguyen et al., 2006

In order to manage well catfish feeding and reduce environmental issue relate to catfish culture, it needs to shift the use of formulated pellets and home-made feeds to commercial pellets in order to reduce wastes load released into water environment. There were about 300,000 m.t. commercial pellets used in catfish farming in the MRD, and about two-third of total catfish production of 2005 was produced by using commercial pellets (Tran, 2005). This change shows a great reduction of waste loads from catfish farming into water environment.

Other inputs and use of resources

Development of aquaculture has created an increasing demand for seed, feed and especially for chemicals/drugs. There are a number of reasons for the increase in use of chemicals/drugs for aquaculture of which, the most important are: expansion of aquaculture, farmers' expectation, higher intensive level, extension, and marketing of the drug suppliers. In addition, markets of this input are very complicated that it is very difficult to determine or estimate the quantity supplied and traded. The most important concerns now are the safety level of these inputs, not only for the users and consumers but also for a better environment.

According to the study on Pangasius farming practices in Viet Nam by GTZ, drugs and chemicals are used in nearly all the steps of culture:

- Hatchery: Parentals are strong individuals and live on low inputs in terms of both feed and health treatment even though treatment is used when the fish is ill. However this has probably little influence on the final product (the larvae).

The incubation process is itself very short – a maximum of two days before larvae can be released into the ponds and principally requires clean water – no feed being necessary at this stage. However, the high rate of mortality at this stage makes it very tempting for the farmers to use disinfectant.

At the transportation level, the use of oxytetracyclin is also an issue.
- Pond improvement: between two cycles, the pond is dried, sediment is removed and lime is applied. All farmers visited seemed to apply these sanitation measures before restocking.

- Stocking: Some farms prepare the pond's water with such treatment as Copper sulfate and Oxy tetracycline.

- Nursing: The mortality rate at this stage is very high: 60 to 80% during the first month. Hence, water treatment - such as copper sulfate - and antibiotic use are common. The nursery stage is by far the most chemical intensive.

Some of the farms used high doses and without any knowledge of the used chemicals. In particular the use of chemicals which were not registered for aquaculture was observed: Human (Ba Liep, Huynh Van Ke) and livestock (Mr. Thuan) antibiotics sold at cheaper price. Observed practices and records showed that chemicals were applied almost daily, particularly in large nurseries. Only small-scale nurseries (such as Huynh Van Thien's) seemed not to use health treatments. According to them, the current selling price of fingerlings (around 80VND/pc compared to 140 the previous year) is too low for them to apply such expensive treatments.

- Fingerling: To lower mortality rates, farmers are intensively using chemicals, number of which are banned (copper sulfate), or not registered for aquaculture. Contrary to the final grow-out where the processors often come and test the fish prior to buying, there is no residue control on the fish at this stage, hence the nurseries do not bear the responsibility or the final product.
- Grow-out: Health and growth treatments are applied throughout the cycle. Addition of vitamin, amino-acid (Methyonin, Lysin) and probiotics – enzymes are common practices on Viet Namese farms. Use of antibiotic is recurrent and largely uncontrolled. Farmers have no knowledge of diseases nor of the products they are using. When asked why and when to use a product, they give vague answers. One symptom may correspond to different treatments or a treatment to different symptoms. It appears that most of the farmers use antibiotic following the advice of treatments salespersons. Only very well managed large scale farms use veterinary advice. Hence the misuse and overdosing of antibiotics and the use of banned antibiotics: Fluoroquinolones (such as Ciprofloxacin and Enrofloxacin) are commonly used although this product's family is banned in the US. But also in Viet Nam since February 2005. Furthermore, most farmers do not know the composition of the products, nor do they understand the concept of withdrawal period. In many cases, products are not in their original packaging and are sold in a transparent plastic bag which may – or may not – be hand-labeled.

The use of antibiotics and chemicals lead to some market concerns for food safety. For example, in difficult markets like the EU, Malachite Green (MG) and Leucomalachite Green (LMG) in cultured tra and basa fish used to be the main reason for rejected batches of tra and basa fish before 30 July 2005. However, Viet Namese government showed its decisive attitude in solving the problem of antibiotic residues and the measures taken have achieved very good results. After 30 July 2005 up to now, there has been no more rejected batch due to MG or LMG.[16]

Risk

Recent studies shown that, several risks in catfish culture were identified which consist of market (highest ranking), capital for operating cage and pond culture (37.5% of households); disease is the third issue for catfish culture (Fig. 6).

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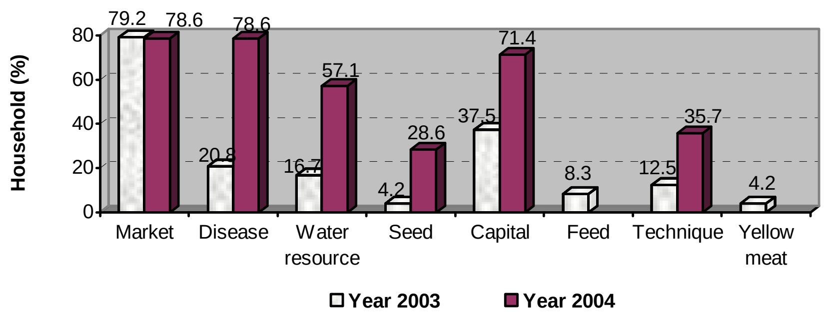
[16] NAFIQAVED - Report on control of antibiotics prohibited from use in fisheries production and trading in Viet Nam (2005)

Figure 30 Restrains for catfish culture in Vinh Long



Source: CTU, 2003, RIA2, 2004

Market and market chain

Most of the production of *Pangasius* is for export or in another word, international markets play an increasing important role to the development of catfish production. If in 1997, the total export amount of Viet Namese catfish was very modest, only few hundred tones with total export turnover of USD 1.6 million, the figures was 2,200 tones and USD 9 million in 1998. Despite the decrease in 3 years 1999-2001, the export quantity was 28,000 tones, equal to USD 87 million. The figures were 231 tones and USD 5 million in 2004 and 400,000 tones and USD 320 million in 2005 according to MOFI (12.8% of total export market share)[17].

Table 57 Market share of catfish for domestic and export markets (1997-2002)

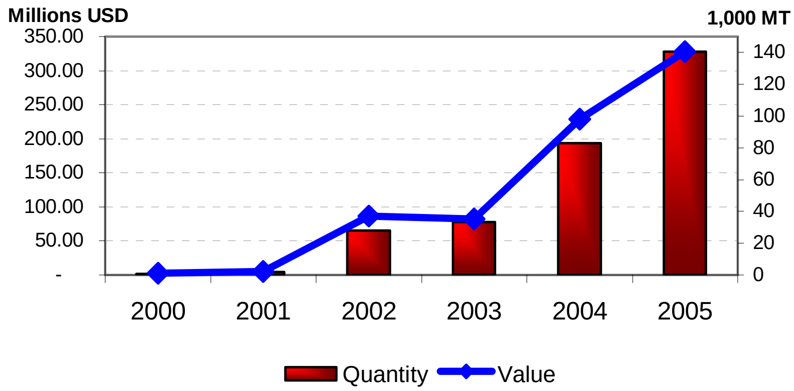
Description	1997	1998	1999	2000	2001	2002
Production of Tra fish (ton)	23250	45930	69335	98353	104078	136600
Production of Basa fish (ton)	17000	19670	17440	12093	10211	6290
Total production of Tra and Basa (ton)	40250	65600	86775	110446	114289	142890
Raw materials of Tra and Basa for export (ton)	14000	20902	42059	56990	85456	96008
Export of processed Tra and Basa (ton)	4000	5972	12017	16283	24416	27431
Market share for export (%)	35	32	48	52	75	67
Market share for domestic consumption (%)	65	68	52	48	25	33

Source: Ministry of Fisheries (1998-2002) and Departments of Agriculture &Rural Development (1998-2002) (summarized by Sinh, 2006)

Together with the high growth of production, the export value also increased quickly from $2.5 millions in 2000 to $350 million in 2005.

[17] Production and trade of fisheries commodities of Viet Nam (Part 2)

Figure 31 Viet Nam *Pangasius* Export

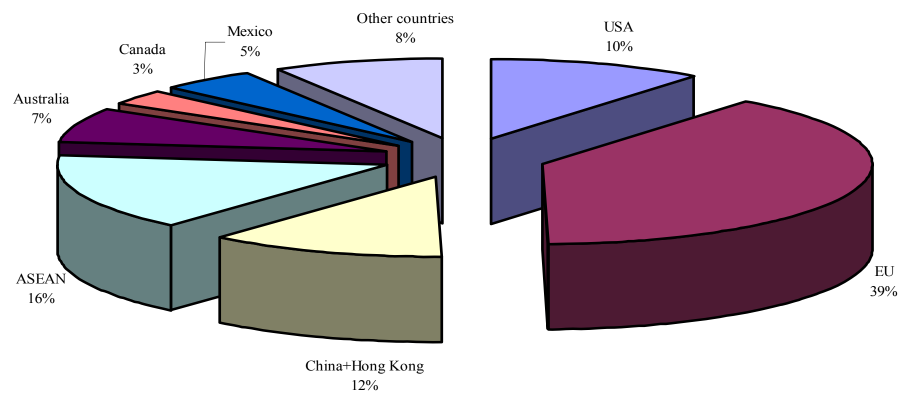


Source: Tran Thi Mieng, MOFI

The EU is the biggest market of Viet Namese basa fish with the total quantity of 75,291 tones (equal to 39% market share) in 2005. The US just consists of 10% of the basa market share since the export of basa to this market went down after the anti-dumping tariff imposition to Viet Nam basa fish in 2003. Except the US, the markets like EU, China, ASEAN, and Japan have significant growth rate in recent years. There are also new markets recently like Russia, Middle-East.

It is important to note that due to the debate on "dumping price" between US and Viet Nam, there has been a strong distortion of the market of catfish in the Mekong Delta of Viet Nam. At the mid year of 2003, price of Basa fish was about VND 8,000-9,000/kg and of tra fish was VND 7,000-8,000/kg and cage catfish farmers suffered too many problems. However, because of a number of forces and encouragement, new markets including domestic and new international markets for these kinds of catfish have been created and developed. This results in a spectacular increase in both production and price of these fish. Catfish is now cultured intensively not only in cages but also in ponds and pens along the main river. Price of fish is doubled compared to that of the same time of last year (in August 2004, the price is VND 15,000-17,000/kg for Basa fish and VND 13,000-14,000/kg for Tra fish).

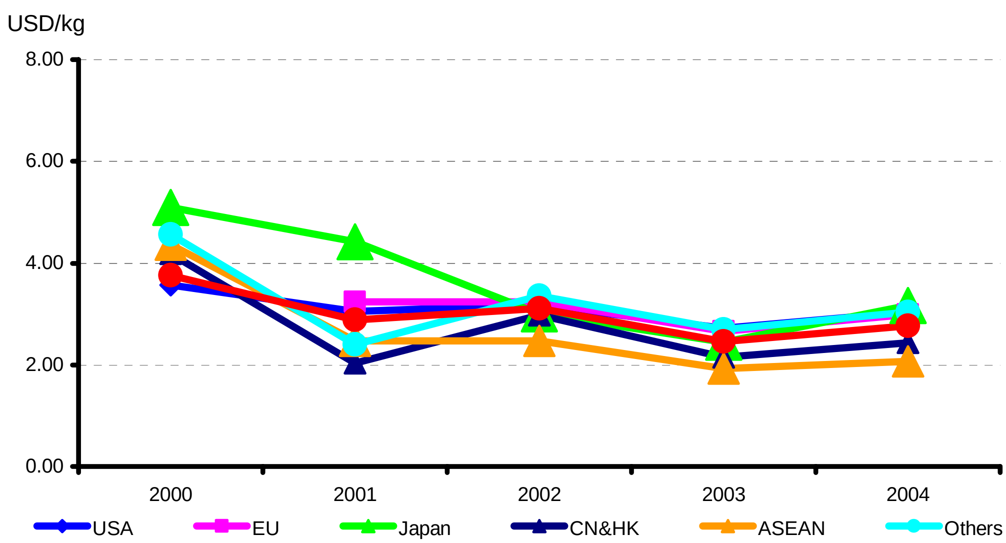
Figure 32 *Pangasius* export market share 2005 (volume)



Source: VASEP

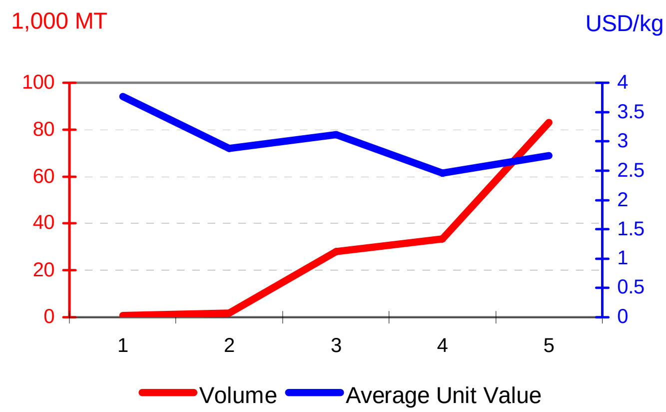
The greatest difficulty of *Pangasius* is the recession trend of prices.

Figure 33 *Pangasius* average export prices



Source: RIA2

Figure 34 *Pangasius*: Volume vs Price



Source: RIA2

This is a sign showing that the supply has overwhelmed the demand in the existing markets. However, as many people in the world to choose to eat more fish, especially white fillet fish without skin and prefer eating the value added product (Hao, RIA2), the Viet Namese basa still has opportunity to extend and widen it markets.

The Fisheries sector development has been pushed at a fast growth, fish quality, which is connected to environmental and aquatic resources protection, effectiveness and sustainability. Moreover, standardization of criteria for safe and clean aquaculture areas will be built and expended for implementation. Monitoring and quality controlling of aquaculture seeds, feeds and chemicals will be fulfilled better. The new approach on community-based management of aquaculture areas will also be further carried out. The issue of traceability or better culture practices for *Pangasius* farming is being considered so as to assure better products in terms of food safety. This also opens an opportunity for Viet Namese basa and tra fish to penetrate market niche of providing products produced in a more sustainable way. In line with the traceability efforts, as mentioned above, a national project on brand development for basa and tra fish has been approved since the beginning of 2006 for the purpose of further improving the quality of Viet Namese basa and tra fish commodity in the international market. Furthermore, there is significant potential to expand the local market for the commodity, particularly outside the Mekong delta region.

Basa and tra fish often goes from farmers to processors directly or through traders but unlike shrimp, processors directly collect most of the production. The tra and basa products are mostly for exports (around 80%) in many forms (raw materials, cooked, fillet, etc). Among the 20% of domestic consumption, around less than 10% are consumed in restaurants and more than 10% are consumed by families at home.

According to Sinh (2006), each ton of Tra fish traded in the market, the fish farmers might earn a total gross margin of VND 2,886,400. Also, in this case, the total marketing margin (MM) obtained by the actors along the marketing channels was VND 3,459,000, in which 10.85% was to trade-wholesalers 1 (TWs1); 1.28% was to TWs2. About 60.7% was for export and processing companies (EPCs); 21.6% for Restaurant & Eating Bars (REBs); and 5.57% for Retailers (Rs). In average, each fish farmer might gain a total profit around VND 100 million/farm in 7-8 months/farm from farming Tra fish in 2002. And it is clearly that the processing boosted more value to Tra fish products. EPCs got a highest distribution of total marketing margins per ton of live Tra fish traded (**Error! Reference source not found.**).

Almost 100% of Basa fish production produced by fish farmers was sold directly to EPCs (71.1%), and to TWs (28.9%). After being processed into fillet, Basa fish products were exported by EPCs to different international markets. Export summed up to 86.3% of the total production of Basa fish; 12.2% were sold to retailers, and the remaining of 1.5% was bought by REBs. For each ton of Ba sa fish sold in the market following the marketing channels in Figure 36, the fish farmers earned a total gross margin of VND 2,891,500. Also, in this case, the total marketing margin (MM) obtained by the actors along the marketing channels was 1,516,000 VND, in which 2% for TWs1; 10.3% for TWs2; 68.31% for EPCs; 11.61% for REBs; and 8.05% for Rs. In average, Basa fish farmers obtained a high profit of about VND 100 million for 12-13 months per crop per farm.

Figure 35 Marketing channels of Tra fish (Son et al.; 2003)

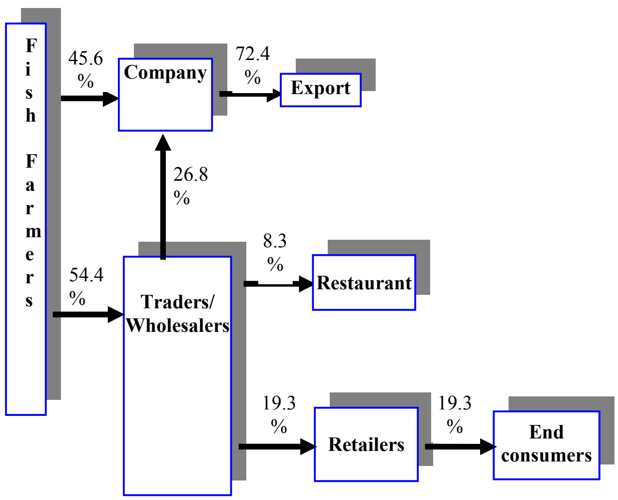
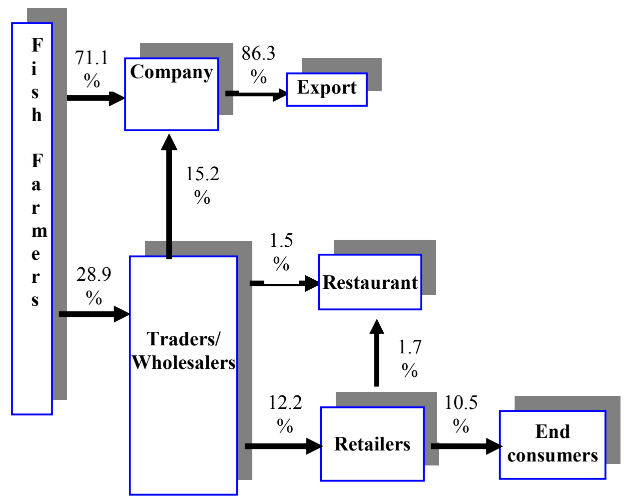


Figure 36 Marketing channels of Basa fish (Son et al.; 2003)



Note: Percentage (%) compared with total amount produced by fish farmers

Generally, the market size of *Pangasius* is around 1 to 1.2 kg per fish. The price of catfish has varied a lot in recent years in the Mekong Delta.

In 2001: 20,000 tones of filet product, equally 75,000 tones of catfish raw material. The price of catfish material was 5,000-6,000 VND/kg (for pond culture), and 9,000 – 10,000 VND/kg (for cage culture).

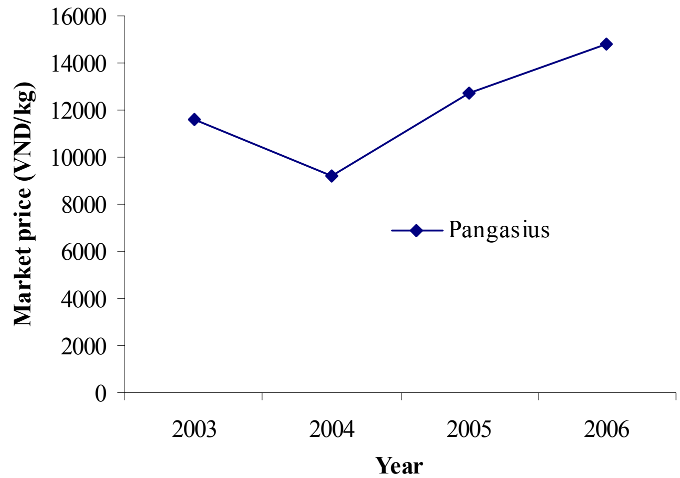
In 2002: 56,000 tones of filet product, equally 220,000 tones of catfish raw material. The price of catfish material was 10,000-11,000 VND/kg (for pond culture), and 13,000-15,000 VND/kg (for cage culture).

In 2003, total raw material of catfish was 300,000 tones, and the price was much various by this year. The price of tra fish (*P. hypophthalmus*) was from 5,000-9,000 VND/kg, and 10,000-15,000 VND/kg for basa fish (*P. bocourti*).

In 2004: The price of Tra fish (*P. hypophthalmus*) increased to 8,000-13,000 VND/kg, and 10,000-18,000 VND/kg for basa fish (*P. bocourti*).

From 2004, the farm-gate price has gone up from less than VND10,000/kilo (2004) to more than VND14,000/kilo (2006). This was explained by the higher demand of import markets for Viet Namese tra and basa recently.

Figure 37 Average farm-gate prices of *Pangasius* (VND/kilo)



Source: CTU

Higher demands of the markets not only help farmers to get higher farm-gate prices but also provide them a better position in selling their products. At present, the average difference of price from farm gate to processor and middle men are VND 200/kilo (CTU, 2006). Besides, the farmers can receive 30-50% of harvest value as deposit from processors before their harvest.

Economic and social issues

Tra and basa fish cage culture requires a high capital investment at the beginning to develop the cages (See

Table **58** & Table 59). This model, thus, is only suitable with the rich household with good financial capacity and is difficult to apply for the poor.

Table 58 Economic analysis of basa cage culture model (calculated on m^3/crop) (n=3)

Economic analysis	Unit	Average	Standard deviation	Minimum	Maximum
Capital cost	VND/m^3	1,036,987	344,692	645,833	1,296,296
Fixed cost	VND/m^3/crop	500,974	122,653	368,310	610,248
Variable cost	VND/m^3/crop	2,219,293	790,302	1,340,906	2,872,740
Total operational cost	VND/m^3/crop	2,720,266	912,588	1,709,216	3,482,988
Total revenue	VND/m^3/crop	1,685,220	154,837	1,531,250	1,840,909
Total income (Total revenue-Total cost)	VND/m^3/crop	-1,035,046	763,413	-1,642,079	-177,966
Labor cost	VND/m^3/crop	85,135	31,724	48,513	104,154
Added value	VND/m^3/crop	-949,911	772,338	-1,537,925	-75,227
Investment efficiency	%	-0,34	0,20	-0,47	-0,10
Total initial investment cost	VND/m^3	3,256,279	1,109,710	1,986,740	4,041,571
Fixed labor	Month/m^3/crop	0,08	0,03	0,05	0,10
Seasonal labor	Day/m^3/crop	0	1	0	1
Output price	VND/kilo	5,194	4,535	2,245	10,417
Feed price	VND/kilo	50	43	0	81
Seed price	VND/seed	13,867	1,206	12,600	15,000

Source: Aquaculture profile report (2005), (SUMA, 2005)

Table 59 Economic analysis of tra fish cage culture (calculated on m^3/crop) (n=7)

Economic analysis	Unit	Average	Standard deviation	Minimum	Maximum
Capital cost	VND/m^3	359,779	184,747	83,333	543,713
Fixed cost	VND/m^3/crop	119,949	54,931	43,966	179,278
Variable cost	VND/m^3/crop	533,671	459,046	2,667	1,128,669
Total operational cost	VND/m^3/crop	653,620	485,700	46,633	1,269,876
Total revenue	VND/m^3/crop	609,607	272,113	252,346	934,829
Total income (Total revenue-Total	VND/m^3/crop	-44,013	545,134	-813,723	720,034
Labor cost	VND/m^3/crop	15,369	6,153	9,224	27,425
Added value	VND/m^3/crop	-28,644	548,856	-797,915	738,810
Investment efficiency	%	2,28	5,88	-0,64	15,44
Total initial investment cost	VND/m^3	893,450	574,198	86,000	1,637,638
Fixed labor	Month/m^3/crop	0,02	0,01	0,01	0,02
Seasonal labor	Day/m^3/crop	0	0	0	0
Output price	VND/kilo	11,714	994	10,500	13,500
Feed price	VND/kilo	3,148	2,396	0	6,000
Seed price	VND/seed	779	521	0	1,350

Source: Aquaculture profile report (2005), (SUMA, 2005)

Although it requires a lot of capital, catfish cage culture doesn't require many laborers. There is often no seasonal labor and only 1-2 fixed labors required to take care the cages in 1 household. Those labors, however, don't spend the whole working time for the cages but are also responsible for other wok. According to the analysis, the fixed labor investment for basa fish cage culture is 0.08 month/m^3/cage (

Table **58**). With the average cage size of 283 m^3/cage (

Table **58**), culturing cycle of 10 month, in average, each household needs 23 months of fix labor. This cage culture, thus, bring social benefits (by providing jobs for the community), especially when the market is more favorable for the commodity and the cage culture brings better profit, more jobs will be created.

Table 60 Labor requirement for basa cage culture (n=3)

Economic analysis	Unit	Avarage	Standard deviation	Minimum	Maximum
Fixed labor	Month/m^3/crop	0.08	0.03	0.05	0.10
Seasonal labor	Day/m^3/crop	0.4	0.7	0.0	1.2

Source: Aquaculture profile report (2005),(SUMA, 2005)

2.4.2 Environmental assessment

Location and farm sitting

In cage catfish culture systems, most fish cage is located along river banks. The distance between cages is very near, i.e. 2-3 m (if the cages belong to one household) and 5-10 m (if the cages belong to different households). The density of cages is especially high in the area where there is strong water current. This, in fact, makes bad impact on the environment since the waste from the places is huge.

Although catfish cage culture was zoned for development, cages location seems to be not followed the zoning. Thus, the cages and their waste discharge may cause concerns on water environmental impacts, diseases, obstacle navigation and landscape of the area. The catfish cages have also received negative impacts from other farming activities, e.g. pesticides from rice cultivating community in the up-stream of the water source (river).

In catfish pond culture, in general, this kind of culture has not yet been planned in the many provinces at present. Ponds are located near by river banks and islands of the provinces like An Giang & Can Tho. The distance from ponds to river bank is around 30-50 m in average but in some cases, the pond is far away from the nearest water source which leads to difficulties in water exchange. Besides, in some cases, cages are sited close to waste of market, town sewage or agricultural farming communities. This has impacted the quality of water supply for the ponds.

There is not water discharge treatment system in the ponds. This is concerned problem because it causes pollution impacts of the river. Sediment from the fish ponds, however, is treated well by removal to gardens or other place.

Ponds, which are dug have more of an impact. However, the environment in this region is already partly degraded from non-aquaculture sources, and the area is heavily populated. In areas which are not directly adjacent to the river, ponds might divert water from other use – e.g. rice cultivation (GTZ).

Fence culture of catfish has been sited along river where water current is considered suitable for this type. Waste from feeds, especially farm-made feed, and chemical/drugs may also cause environmental issues. However, at present, there is no data on the environmental impacts of the fence culture system.

Sediment management is an issue in both ponds and pens. However, most of the surveyed farms use the sediment removed after each cycle to reinforce their banks – a good practice against erosion and floods. Only cages release organic waste in open water (GTZ).

It is strongly encouraged that all farms regardless of culture systems are registered. This can be done by giving each farmer a registration number. This would allow for planners to get an overview of the existing number of farms and production level. If ecosystem crashes or severe degradation the development in production tonnage and number of farms can be linked to this and as planners learn bout the dynamics of catfish development and the environmental status they can use this information in their planning for future development of the sector.

There is a need to make development plans which are based on the environments ability to assimilate and dilute wastes from grow-out. In addition it should be investigate how nutrients from aquaculture may be utilized as fertilizer in the agricultural sector.

Design and construction

The design and construction of catfish cages, ponds and fences is very dependent on the location and farm sitting.

The cages are made by wood or metal with a small floating house above for people taking care of the cages. In the high density of cages area, the floating houses and cages themselves become obstacles for navigation and river transportation. The cages are designed so as to be able to utilize as much as possible the river water current in keeping a continuous water exchange environment in the cages. This also means that there is continuously untreated waste discharged from the cages. The water supply for local community there is affected.

The catfish ponds are designed rather simply without storage or reservoir. The entire water surface is often utilized for stocking fish. Besides, there is often the same canal for water discharge and supply (Minh, 2006). The untreated water discharge goes directly to the common water canal, polluting other ponds and may even infect disease from one pond to another.

Broodstock and seed supply

Before 1997, catfish (tra/basa) fingerling relied on wild seed. Source of stock for the farmed species used to be unsustainable (see previous section) and deplete the wild fish stock. However, the reproduction of Hypophtalmus has been mastered and the needs for seeds are now fully covered by hatcheries (GTZ, 2005). But, as mentioned before, the wild seed is preferred because of lower price. With the growth speed of cat fish culture, the wild collected seed demand is increasing. There is not a study of wild seed exploitation and ecological effects of the activity. Some people say that it makes good impact while the other argue that this would cause wild seed exhaustion.

Water use and impact

In the Mekong delta, the water is polluted already by activities other than aquaculture activities and even though the carrying capacity of the river is high, factories and processors discharging effluents into the river, as well as agricultural activities contributes significantly to the degradation of water quality. Peaks of mortality are regularly observed during flood season probably because of run-offs from agriculture and urban waste water. This affects mostly cages and enclosures which are directly impacted by these sudden changes of water quality. To avoid such hazards, a GAP cages and pens should be sited in a suitable area, far enough from urban centers and intensive agricultural activities. One of the farms visited in My Hoa Hung was situated next to an oil factory processing catfish fat – which represents as much a risk in terms of chemical than biological contamination. But no monitoring had been done on the quality of water.

Other sources of chemical pollution are farm originated, empty feed bags, paper, cardboard, plastic, human waste, oil, fuel, wastewater, machines and disinfectant rinsing. Disposal of litter and especially empty antibiotic and disinfectant containers is deficient, and garbage has been repeatedly noticed during visits on the farms and their surroundings.

Machines are not properly maintained and oil leakage is a rule on all farms. This is a major concern in farms which locates machines above the fish holding area. In this respect, cages, with their home-made feed equipment and living quarters – and sewage from kitchen and workers -on top of the water are especially problematical.

However, it is difficult to control water quality for these systems. The cage and fence culture systems release amount of nutrients into the river, which, in turn, contributes in pollution issues. Rapid increasing in catfish production has created a great attention to environmental issues. Effluents from pond, cage and fence culture systems have been considered as potential causes for environmental degradation though comprehensive studies about the environmental issues related to catfish farming have not yet been conducted. Therefore, re-arrange or zoning for cage culture needs to be considered in the Mekong Delta, especially for An Giang and Dong Thap provinces. Recently, the number of catfish cages in the MRD has reduced from 2,539 cages in 2001 to 1,872 cages in 2004. This indicates that waste loads from catfish cage culture have decreased during the last few years.

Catfish pond culture has developed very quickly recently together with the more than ever amount of water pumped from the river to supply the ponds. But due to too rapid growth, there is not planning for this kind of culture. The ponds are built in the living area, of which effluent are not treated by farmers. This causes confliction in water use between people who needs water for living, for agriculture activities and for fish culture.

The levels of environmental impact from either catfish culture in cages, ponds or pens have not yet been quantified fully. However, Nguyen (2004) warned that the mortalities of catfish cultured in cages, ponds and fences have been increasing highly in the recent years, which were about 27.5%, 6.0% and 17.4%, respectively. Whereas, the mortality of catfish cultured in cage in 1995 was only 3-5% (Nguyen 1998). The increasing mortality has been observed to be related to the increase of stocking density, seed quality, diseases and water quality deterioration, of which deterioration of water quality has been considered as the most important cause.

Waste and impacts

Pollution in aquaculture is primarily linked to effluent management. At this point in time, effluents are not treated before discharge. Moreover, if this would theoretically be possible in pond systems, it will not be possible for cages and pens, which are essentially open net pens within the Mekong River Delta. Open systems like cage and pens can stand much higher densities - up to 10 times - than ponds. Hence they also produce much more waste both in terms of lost food and excreta. It should be noted than home-made feed is less stable and has worse FCRs than manufactured feed, which also leads to increased pollution. Concern for pollution from cage effluent, deterioration of water quality and fish disease outbreaks exists. Ammonia, nitrates, and organic matter released in fecal wastes could be absorbed at fairly high levels due to high water temperatures, thus fast growth of primary consumers. The Mekong River Delta however is less at risk than reservoirs or coastal areas. A study by the university of Can Tho in the Mekong River waters showed that there was no significant change in the water composition before Chau Doc and after Can Tho, despite the presence of more than 5000 cages – most of the cage production of catfish in Viet Nam. The waste is diluted in the flow of the Mekong. However, the impact could be felt soon as the intensification of farming continues. (*GTZ, Pangasius farming practices in Viet Nam*).

In fact, quality and management of effluent have not been monitored and controlled for the catfish culture areas in the Mekong Delta. This is an issue on water environment that need to be considered for long term development of catfish culture development in the MD. Sludge waste seems not have any negative impacts on environment but positive impact for orchard and agricultural cultivation thanks to nutrients from sludge. Catfish culture systems may receive mainly effluent from agricultural activities, especially pesticides. However, recent studies show that concentrations of pesticides and heavy metals have not found in the Mekong river where catfish cages are located in Vinh Long province (Table 61).

Table 61 Concentrations of pesticides and heavy metals in rivers of Vinh Long, 2003

Location	Heavy metals		Pesticides			
	Cd (ppb)	**Pb (ppb)**	**Họ Cúc**	**Clo source**	**Phospho source**	**Carbamate source**
Tra on market	0.91 ± 0.57	NF	NF	NF	NF	NF
Vinh Long market	0.90 ± 0.37	NF	NF	NF	NF	NF
Vung Liem	2.03 ± 1.20	NF	NF	NF	NF	NF
Tich Thien	-	-	NF	NF	NF	NF
Hieu Thanh	-	-	NF	NF	NF	NF

Notes: NF = not found

Source: CTU, 2004

Feeds and feed management

In 2002, about 99% of catfish farmers used home-made feed. Trash fish (freshwater and marine fish) often cover 20-30% of total weight of raw materials for making the home-made feed. Because insufficient trash fish supply and environmental issues, catfish farmers have gradually increased using commercial pellet. In 2004, there were 18 companies producing 100,000 tones of commercial feed for fish culture in the Mekong Delta while feed demand for tra/basa fish was estimated about 400,000 tones of which 300,000 tones of home-made feed (Sinh, 2006). In 2005, all catfish farmers still used home-made feed but there were 66.7% and 55.5% of the total cage and pond culture farmers in traditional area of An Giang province used commercial feed for 3-4 first weeks, respectively (Nhi, 2005). Home-made feed was used by 100% of catfish farmers (both cage and pond culture) in the middle months of crop and commercial pellet feed used by 71.4% and 85.7% of cage and pond culture farmers, respectively (Le et al., 2006). It also estimated that about 100,000-120,000 tones of marine trash fish were used for tra/basa fish culture in the Mekong Delta in 2004 (Sinh, 2006). However, some concerns exist about the source of the trash fish in home-made feed. Primarily composed of by-catch, trash fish used as feed comes from the nearshore and riverine fisheries, which are considered fully exploited. Uses for trash fish includes direct human uses, mainly as fish sauce, livestock feed, and aquaculture feed. Trash fish, being of a variety of species including juvenile fish, are also an important componet of marine ecosystems and their unsustainable removal can lead to tropho-dynamic disruption, as well as overall decrease in average marine trophic levels (i.e. "fishing down the food web"). Where more weight in trash fish is required than is produced from farmed products, this amounts to an overall net loss of fish protein. Competition for the use, and overexploitation is reflected by raising prices. In the future, it is likely that only high value aquaculture use like grouper or shrimp will be able to afford trash fish (GTZ).

According to recent overview by CTU, commercial feeds will be used more and more by catfish pond culture farmers if the price of catfish increasing. This may lead to a huge demand and concern on insufficiency of fishmeal for feed processing.

At present, there are not any substitutes to existing fishmeal based protein for tra/basa fish feeds. It raises a need to research for in development plant based substitutes to fishmeal for feed processing of catfish in further. To improve the quality of feed, especially home-made feeds, recently, studies on nutritional requirements and feeds for catfishes has been carried out intensively during the last few years at universities and research institutions. There research has provided knowledge for better formulation of feeds for catfishes as well as to improve feed utilization of catfishes leading to the reduction of waste loads from feeds.

Over-feeding caused pollution from residue, especially with home-made feed. This becomes a critical problem for cage culture as the uneaten feed cannot accumulate on the bottom like in pond culture to be removed later. This is waste that may cause pollution for the water area.

Tra and basa is often cultured in monopoly method, therefore, the un-eatened feed is not cleaned by any other species. This may lead to the question of finding suitable species to culture with tra and basa.

Disease issues and health management

Catfish diseases have been considered the second major problem (under the first ranking of market) in the culture systems in the Mekong Delta. This issue seems to be difficult to control and treat effectively for catfish farmers. Disease prevention is considered as a main point for health management at present. Some current diseases of catfish were summarized in recent years in the Mekong Delta (Table 62).

Table 62 Common diseases in catfish farming

Name of disease	Levels of occurrence
Haemorrage diseases	high level
Baccillary necrosis of Pangasius	high level (causing highest level losses)
Pop-eye disease	Medium level
Jaundice disease	Medium level

Source: CTU, 2006

Due to no water treatment and lacking knowledge of farmers, dead fish, and diseased fish are released directly to public canals and rivers. This is one of the causes of disease infection from one pond to another.

Escape of fish sometimes occurs during floods, if the water level reaches the height of the pond's banks. In the case of Hypophtalmus aquaculture in Viet Nam, the impact of escapes is minimal, as the fish are native to the region. In addition, the early stages of artificial hatcheries means that fish produced are still ecologically and genetically similar to wild stocks since artificial selection is used minimally. That being said, as husbandry techniques improve, and hatcheries begin selecting for traits favorable to aquaculture, escapes may become a concern (GTZ, 2005).

Due to the open culture system, risk of disease and parasite transfer to wild stocks would be possible. Recently, the bacteria Edwardsiella ictaluri, a disease native to North America and ictalurid catfish, was identified in farmed tra cultured in the Mekong River Delta. This is the first instance of this disease being observed in pangasiids. It remains unclear as to whether the bacteria are introduced or local but previously unknown, however transmission of pest could be an issue in the future (GTZ, 2005).

Food safety and quality

In order to ensure aquatic products safety and quality, MoFI issued the list of chemicals/drugs that are permitted, limited and prohibited for aquaculture in 2002. Ten anti-biotics were banned and Malachite Green was also added in the prohibited list in 2003. In 2005, the prohibited list consisted of 17 anti-biotics and 34 of limited chemicals/drugs.

There was 83% of catfish farmers used chemicals/drugs due to poor water quality. However, this number has reduced in recent years (Tuan, 2004). Despite there has been many kinds of chemicals/drugs has banned by MoFI, recent reports by Chinh (2005) show that 30% and 15.6% of total culturing fish and harvested fish samples were infected with malachite green, respectively. Infected fish samples by Quinilone (Enro & Cipro) group were 13.3% of total culturing fish and 4.67% of total harvested fish samples in An Giang and Can Tho province in 2004. This raises an issue for food safety and quality, and need to be controlled by provincial fisheries managers.

Part of the chemicals/drugs applied for catfish cage/pond culture are discharged in to the river water source, which causes problem for environment and water quality, thus health of people in the surrounding area. This also a problem for wild species.

Socio-economic issues

Recent studies by Nhi (2005) show the net profit and profit: cost ratio between farming areas in An Giang province. Net profit per kg of fish and profit: cost ratio of cage culture fish in new area was VND 1,340 per kg and 17.9% better than that of traditional culture area, i.e. VND 183 per kg of fish and 2.2%, respectively.

Market price variation of tra/basa fish has strong impacts on socio-economic aspects in the culture areas such as employment, debt and land selling etc. Recent reports show that total number of successful catfish farmers was reduced from 87% in 2001 to 76.4% in 2004 (Tuan, 2004). There was 30% of total catfish cage culture farmers got negative profit while that number was 20% for pond culture farmers in 2004. The main reason was increasing of major input costs while decreasing price of outputs. According to Agriculture and Rural Development (2005), not less than 50% of catfish farmers obtained negative profit in 2005.

However, other successful farmers could obtain positive profit from catfish culture. It may depend on their technique and management, especially kind of used feed and feed management. According to

Nguyen et al., (2006), the total return varied by different feed categories. The category of manufactured pellet feed was the highest (VND 4,443,600,000 per crop), while the lowest return was the category of respondents used farm-made feed (VND 929,123,750 per ha per crop). The differentiation of gross return was due to the volume of fish harvested (Table 63).

Table 63 Annual gross returns per hectare

Items	Value
Manufactured pelleted feed	
1. Volume (kg)	**423,200**
2. Price/kg (VND)	**10,500**
3. Total return (VND)	**4,443,600,000**
Home-made + manufactured pelleted feed	
1. Volume (kg)	**142,990**
2. Price/kg (VND)	**8,610**
3. Total return (VND)	**1,231,143,900**
Farm-made feed	
1. Volume (kg)	**104,690**
2. Price/kg (VND)	**8,875**
3. Total return (VND)	**929,123,750**
All categories	
1. Volume (kg)	**223,627**
2. Price/kg (VND)	**9,328**
3. Total return (VND)	**2,086,064,089**

Source: Nguyen et al., 2006

This level of net return of manufactured pellet use farmers is about 2.2 -fold and 2.03 time higher compared to farm-made feed category and home-made & manufactured pellet feed, respectively.

Table 64 Annual net returns (per farm)

Category	Local currency (VND)			Foreign currency (US$)		
	Gross return	Total cost	Net return	Gross return	Total cost	Net return
Manufactured pelleted feed	**4,255,775,000**	**3,894,692,167**	**361,082,834**	**267,777**	**245,057**	**22,719**
Home-made & manufactured pelleted feed	**1,201,207,000**	**1,023,349,575**	**177,857,425**	**75,581**	**64,389**	**11,190**
Farm-made feed	**876,775,000**	**712,903,325**	**163,871,675**	**55,168**	**44,856**	**10,311**
All categories	**2,111,252,334**	**1,876,981,689**	**234,270,644**	**132,842**	**118,101**	**14,740**

Note: 1 USD = 15,893 VND Source: Nguyen et al., 2006

The losses of catfish culture in recent years makes farmers less invested in catfish culture as it is very risky and requires a lot of investment. The farmers even reduce labor working in catfish cages and ponds. The low investment makes things worse since ponds or cages are not improved, no reservoirs or waste treatment pond constructed and no good selection of seed.

Welfare situation in Viet Nam and in aquaculture in particular is rather good. Aquaculture in Viet Nam is not associated with particular child rights abuse. Children might help on the family farm but rarely on a full-time basis. On all the farms visited no worker under 16 was noticed (GTZ, 2005). The workers living quarters on the fish farm were habitable and sound, with basic services such as toilet and kitchen. Wages seem to be higher than in other sectors; however it remains to be seen if farms comply with all legal requirements, including use of contract for permanent workers.

Safety standards on the farm are quite poor. In particular, of all visited farms, only one, TTagr, had a first-aid kit – which was actually not complete. First-aid training, safety and emergency regulation were missing (GTZ, 2005).

Resource access

No major disputes and conflicts seem associated with the practice of pangasius aquaculture.

Farmers usually grant poor fishermen access to the surrounding of the cages and enclosure, where the abundance of feed attracts wild fish. Part of this is ca linh – the fresh water trash fish used as feed – which can sometime be sold for 15.000 VND/kg (GTZ, 2005). Hence conflicts with the traditional users of the river and the embankment are avoided.

Management

Management of the farms is poor. There are no requirements for starting an aquaculture system nor siting, or discharge consent regulation, hence minimum management standard do not exist and have to be voluntarily implemented.

Training and competence of the staff is low. Even at management level, technical or academic background is lacking. This translates into poor management tools. No records of monitoring or activities are kept. For instance, only two of the visited farms had mortality records (GTZ, 2005).

Hence, feed ratio and FCR can not be accurately calculated by most of the farmers, who simply feed according to experience and observed behavior of the fish. This results in waste and inefficient feeding practices. Feed input was however recorded in a few (bigger) farms, usually when the owner did not manage the farm (pointing to financial control rather than good farming practice).

Similarly, no medicine administration records were kept in all but the same two farms. Some farmers did keep purchase records but none had chemical product inventory.

Market issues

Market is an important factor encouraging or discouraging the environment protection of catfish culture.

In the past, Bocourti was the primary fish for export into Asian markets, as hypophthalmus was thought to be dirty and of poor quality – considered as a latrine fish due to the direct positioning of latrines over the rearing ponds. Due to the ease of production, hypophthalmus production was cleaned up and exporting has picked up together with the growth of catfish culture areas of difference systems, especially pond culture. This pond culture system tends to be lower technology, with high use of homemade feeds, dependence on natural feeds in ponds. These practices tend to give the meat a muddy flavor and yellowish color, not favored by the export market, thus cage aquaculture was the preferred method of operation for export. This fact resulted in the increase in number of cages – a more environmental threatening form of culture -compared with that of ponds.

However, in 2005, due to low price which no longer could cover the expenses of the cage culturing system, pangasius tended to be replaced inside the cages by other fish of higher market value such as

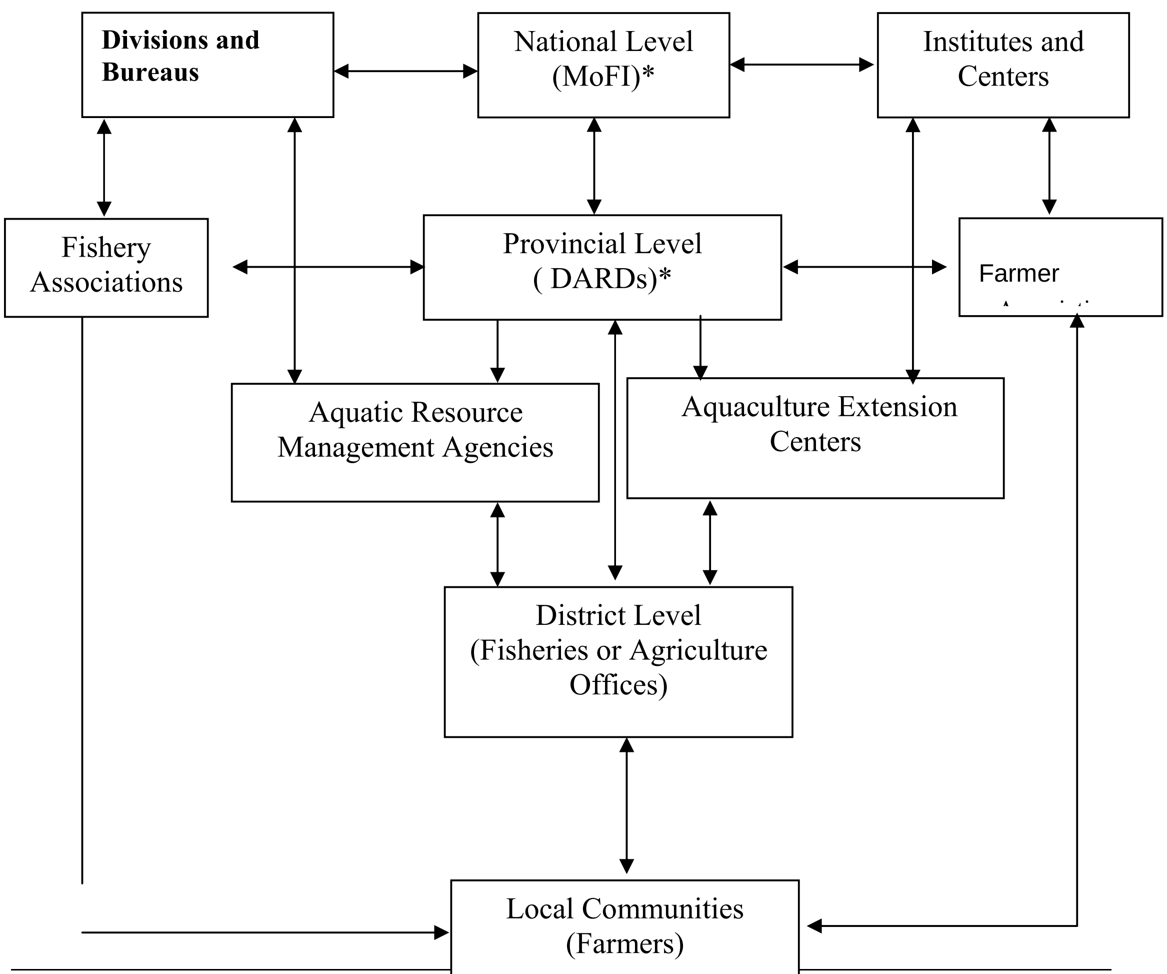
Tilapia, Colossoma Brachypomum (Ca Chim, an imported species close to the piranha). In fact, 1200 cages have been deserted in 2006 according to An Giang People Committees' announcement.

The unexpected thing is, in 2006, the price of catfish for both yellow and white meat type is increasing dramatically. The farm-gate price of white meat tra fish is VND 14,000 – 14,500/kilo, of yellow meat of VND is 12,500-13,500/kilo and the export price increases from USD 3.2 to 3.4/kilo (Viet Nam Economy, 8 June 2006). This, again, orients farmers to culture catfish (in all systems) in the next crop, which, then, may lead to over-production, price drop and improper use of land and water resources unless good planning is implemented.

In another matter, as catfish is mainly an exported commodity, the environmental protection requirements of the import markets/ consumers also have impacts on the catfish producers' behaviors. In fact, at present, the high requirements from big markets like the EU, US demand the farmers to produce in a more responsible way without banned anti-biotics and good food safety. The increasing demands for products produced in environmentally responsible ways can be the motivation for farmers to apply better management practices (BMP/GAP) in catfish production. There are also opportunities for farmers to gain higher prices once their outputs are qualified as BMP/GAP products.

Institutional issues

The Ministry of Fisheries which plays the most important role to combine the relation of fields of action in aquaculture industry is a governmental organization which fulfills functions of the state management and under administration of the Government. There are three administrative levels of fisheries sector: central (national), provincial and district levels. The institutional organization of the fisheries sector includes under divisions and specialized institutions and associations.



***MoFI: Ministry of Fisheries**

DoFI: Department of Fisheries

DARD: Department of Agriculture and Rural Development

Institutional framework of the Viet Nam's Fisheries Sector

The supportive divisions assist the Ministry to fulfill its state management function. They are division of aquaculture, division of collective and individual economic sectors, division of plan and finance, division of science and technology, division of international relations, division of legislation, division of personnel organization, bureau of capture fishery and aquatic resources management, bureau of quality management, sanity safety and fisheries veterinary and ministerial inspectors and ministerial offices.

The specialized institutions support the Ministry in terms of research and development. They are Institute for Fisheries Economic and Planning, Research Institute for Aquaculture No. 1 (based in the North); Research Institute for Aquaculture No. 2 (based in the South), Research Institute for Aquaculture No. 3 (based in the Central) and National Fisheries Extension Center and Information Center.

The union and associations support the development of the fisheries sector which is Labor Union of Viet Nam's Fisheries Sector, Viet Nam's Fisheries Association and Viet Nam Association of Seafood Exporters and Producers.

The Viet Nam's fishery governing law has been adjusted in recent years and it has just been issued in July 1st, 2004 by the President of the Socialist and Republic of Viet Nam. The fisheries law consists of 10 chapters and 62 Articles. These chapters are about: general regulations; protection and development of aquatic resources; capture fishery; aquaculture regulations; regulations of fishing boat and fisheries services; regulations on processing, trading, export and import of aquatic products; regulations on international cooperation for fisheries operations; regulations on governmental administration for fishery; regulations on reward and punishments and regulations on clause of implementation. There are also numbers of decrees, decisions, etc issued at governmental and ministerial levels on specific tasks to support the management of the fisheries sector.

The research institutes for aquaculture, institute for fisheries economic and planning and others have been assigned by the Ministry of Fisheries to conduct research on national aquaculture development. Besides, universities and local authorities have also carried out several applied research on aquaculture. The researches have focused on aquatic seed production, improvement on aquaculture technology, feeds for aquaculture, and technological improvement on reservation of aquatic products, aquaculture environment, and other urgent issues in aquaculture practices.

The Viet Namese scientists who specialize in aquaculture have studied and perfected the artificial seed production processes for major aquatic species that are important for export.

Applied researches on freshwater aquaculture in Viet Nam include artificial seed production, fingerling rearing and grow-out of some indigenous species in the Mekong River Delta. In addition, there has been an advanced research on the application of technological advantages in catfishes (ca tra and basa) seed production and grow-out.

In terms of education and training, according to MoFI (2005c), there was 156 staffs who was trained and obtained bachelor degree of aquaculture in 2004; 1,278 staff at intermediate level in fisheries (including aquaculture); and 2,876 skilled workers who were trained in 2004. There are 18 staffs who have participated in master or doctor programs in other countries. Many fisheries staffs took short training courses in Viet Nam and abroad.

In the last few years, aquaculture increased quickly with various culture systems (pond, fence, and cage) without programming. In addition, changeable weather such as high temperature, cold and drought lead to increasing of fish diseases and affected to the environmental condition. Although, the research institute of aquaculture and scientists who have studied, determined and provided managers and processor respond to disease and environmental pollution in aquaculture such as water exchange, using chemical to solve problems. Besides, farmers have also used active techniques of treatment to limit the increasing of diseases according to the study "environment survey and determination factors of disease in catfish and giant freshwater prawn" have carried out by the coordination between division of science and technology and Can Tho University (DARD, 2006).

2.4.3 Guidelines for Better management

Catfish farming has been adjusted by market impacts rather than environmental issues, though the environmental pollution still be implication hinder to the farming while the production cost is high with chemical and trash feed uses. These led to 1200 cages has been deserted in 2006 as An Giang People Committees' announcement. There are number farmers having converted cages farming to pond farming as first system met problem of water quality and disease.

Environmental policy, including wildlife and conservation policy should be implemented and based on an environmental risk assessment taking into account the prior use of the land or site and all potential environmental impacts. The major prediction of environmental issues and suggested management solutions are showed in follow matrix.

Impacts	***Management practices/solutions***
Catfish farming for pond farming	
Impact 1. Impacts on water and soil environment	• Enforce regulation on building up the treatment pond before discharging to water bodies • Establish the voluntary certification scheme to promote responsible for reducing water pollution • Promote polyculture with kissing gourami • Creating awareness in import country market of catfish using the pellets in catfish farming • Promote the BMP for controlling overfeeding • Promote sludge using for cultivation • Effluent from catfish pond should be discharging to rice integrated system. • Create monitoring system for environmental pollution • Implement credit scheme for better investment and farm management (especially feed) • Farm originated waste such as empty feed bags, paper, cardboard, plastic, human waste, oil, fuel, wastewater, machines and disinfectant rinsing shall be contained and properly disposed of. In particular, disposal of litter and especially empty antibiotic will have to be implemented and containment facilities for oil should be built. • Pond site chosen must be directly adjacent to the river, so as to not divert water from other use. • Sediment should be removed and used to reinforce the banks of the farm – never released in the river.
Impact 2. Impacts on market price and livelihoods	• Develop better plans to balance supply and demand (stable production). Ex 1200 cages have been deserted in 2006. • Create awareness on market issues among farmers • Create awareness of customers about the sustainability produced catfish, which, in turn, will demand the farmers to target the niche of the market for better price.
Impact 3. Use of (banned) chemicals	• Develop and disseminate BMP/standards for responsible use of

on environment and health	chemicals among farmers • Increase control of chemicals suppliers • Monitoring, documentation and recording practices (inputs such as feed and treatments, mortality, inventories, invoices and accounting) have to be implemented.
Impact 4. Impact on wild stocks	• The height of the pond's banks should be higher than the highest recorded water level in the area so as to prevent escape of fish during floods. • Spread of disease should be monitored by a veterinary. • No trash fish from the nearshore and riverine fisheries, which are considered fully exploited should be used in the fish feed.
Cage and fence farming of catfish	•
Impact 1. Impact on water environment	• Promote the responsible feeding, feed removal • Better planning for number of cages and optimal location (current vs overfeeding) within environmental carrying capacity • BMP for responsible for chemicals uses • Promote using pellet for feeding • water quality shall be monitored on intake and/or outlet for oxygen, pH and carbon dioxide parameters and ammonia. • Farm originated waste such as empty feed bags, paper, cardboard, plastic, human waste, oil, fuel, wastewater, machines and disinfectant rinsing shall be contained and properly disposed of. In particular, disposal of litter and especially empty antibiotic will have to be implemented and containment facilities for oil should be built. • Sewage from toilets, kitchen and laundry should not contaminate the water. All farms should have septic tanks – a legal requirement for aquaculture farms in Viet Nam.
Impact 2. Impact on other users of water resources (navigation, fishing, water supply for living)	• Better planning (cross sectoral) • Promoting the pond catfish farming as an alternative
Impact 3. Impact on market and livelihood	• Develop better plans to balance supply and demand (stable production). Ex 1200 cages have been deserted in 2006. • Create awareness on market issues among farmers • Create awareness of customers about the sustainability produced catfish, which, in turn, will demand the farmers to target the niche of the market for better price.
Impact 4. Use of (banned) chemicals on environment and health	• Develop and disseminate BMP/standards for responsible use of chemicals among farmers • Increase control of chemicals suppliers • Monitoring, documentation and recording practices (inputs such as feed and treatments, mortality, inventories, invoices and accounting) have to be implemented.
Impact 5. Impact on wild stocks	• Banks and nets should be monitored and maintained to avoid rupture. • Spread of disease should be monitored by a veterinary. • No trash fish from the nearshore and riverine fisheries, which are considered fully exploited should be used in the fish feed.

2.5. Freshwater pond culture of carps/grass carp

2.5.1 Freshwater Fish Culture Status and System Description

Brief overview

Freshwater aquaculture has long historical development in Viet Nam. It has developed from catching wild fish and since then gradually moved to more and more aquaculture based production. In the early day, fish culture was mainly developed in the low land area and along branches of rivers, with a majority of Chinese carp which provided food for domestic consumption. With the introduction of new species such as Tilapia, Indian and grass carp, freshwater aquaculture is well developing and becoming a significant source of income contributing to national economy as well as a considerable source of protein for Viet Namese people (MOFI, 1996).

Presently, a lot of freshwater fish species are cultured in Viet Nam. Conventional cultured species are Silver carp, Grass carp, Common carp, Indian carp (Rohu and Mrigal). Common carp (*Cyprinus capio L.*) is a major species of traditional aquaculture. Since 1970s, minor Hungarian and Indonesian common carp were introduced to Viet Nam. The hybridization of three strains of local common carp and Hungarian and Indonesian strains now becomes valuable fish in fresh water aquaculture (Tuan, P.A and B.T. Tuyet, 2002).

Similar to common cap and silver carp, grass carp (*Ctenopharyngodon idellus*) was also officially introduced to Viet Nam in 1958. This is an herbivorous species that suitable with condition of farmers so it was rapidly and popularly stocked in Viet Nam. Silver carp (*Hypophthalmichthys molitrix*) is also a popular species in the North of Viet Nam. Research Institute officially introduced it into Viet Nam first time in 1964 for Aquaculture No. 1 (Tuan, P.A and B.T. Tuyet, 2002). In addition, Indian carp includes rohu (*Labeo rohita)* and mrigal (*Cirrhina mrigala)* were introduced to Viet Nam in early 1980s by Mekong River Committee (Ha, 1999).

Besides these species, catfish such as Tra and Basa are dominance species culture in Mekong delta and become main freshwater fish product for export. Tilapia is also considered as potential cultured species for large scale production and exportation. Moreover, different local species are also farmed. Especially, under development of breeding and culture technologies, most of culture species now are artificially bred to provide fish seed for producers. However, freshwater aquaculture is mostly for domestic consumption and it is considered a good option for food security and poverty alleviation. However, freshwater carps are almost farmed at low commercial level for local and domestic consumption

In 2004, total freshwater aquaculture area of Viet Nam was 335,760 ha, it was 2.7% higher than that in 2003 (MOFI, 2005c) The total freshwater culture production was about 639,700 ton, of which there were 300,000 ton and 20,000 ton of catfish and tilapia respectively. The national production of freshwater fish culture is present in table below:

Table 65. Production and area of freshwater fish culture from 2000-2005 (MOFI, 2002; 2004a and 2005c)

Year	**Production**	**Area**
2000	388,110	310,000
2001	429,100	408,700
2002	450,000	425,000
2003	589,091	327,092
2004	639,700	335,760
2005 plan	850,000	370,000

The transferred areas from low productive lands to aquaculture were about 55,300ha in 2004 and it was 7.8 % higher than in 2003 (MOFI, 2005c). There were 500 freshwater fish hatcheries which produced 15 billion fry fish in 2004, of which 3 billion fry fish were catfish larvae. Besides, the seed production of other freshwater species such as freshwater prawn and Tilapia is dramatically increasing. Only 35 million monosex Tilapia was produced in 2002 but the figure was 180 million fingerlings in 2004.

Development Plans

Aquaculture practices play currently an important role for economic development in Viet Nam. It creates job, income for fish farmer and contributes to poverty reduction. Therefore, Viet Namese government pays much attention to encourage aquaculture development. A number of policies and programs have been issued to create favorable environment conditions for aquaculture. Hereunder are some of these programs, policies:

- Decision No 224/199/QD-TTg of Viet Namese prime minister dated 8/12/1999 approved the aquaculture development program
- Decision coded 103/2000/QD-TTg dated 25/08/2000 stipulating financial and credit policies for promotion of aquaculture seed production
- The Decision 03/2000/NQ-CP dated 2/2/2000 of the government on farm economic policies, including policies on finance and credit
- Decree No. 15/CP dated 19/3/1996 stipulating on management, production and trading of animal feed in Viet Nam. Moreover, The Circular Letter No. 2/1998/TT-BTS of the MoF dated 14/3/1998 guiding on implementation of Decree No. 15/CP.
- Decision coding 112/2004/QD/TTg of Viet Namese government approved the seed production development program to 2010

Besides these governmental policies, provinces have issued their detail policies to encourage the development of aquaculture practices and relevant service activities. MOFI (2004b) reported that cities and provinces released the total of 265 documents in 2004 including resolutions, directions for aquaculture development. These resolutions and directions mention on land uses, investment, finance and risk support policies.

Location of production and development plans

The major production region of freshwater fish is Mekong delta. With the culture area made up 37% the total freshwater fish area, its production count for 62,9% the total fish production of the whole country. The highest fish production is An Giang province with production of 151,391 ton in 2004. Can Tho and Dong Thap was ranked second and third with production of 80,000 ton and 72,500 ton respectively. Tra and Basa fish are dominance culture species in these areas. Their productivity may attain 300,000 ton/ha/culture cycles.

Besides the Mekong delta, Red river delta was also main freshwater production with total fish production of 141,076 ton. The fish production by regions is presented in table below:

Table 66 Fish production by regions in 2004 (MOFI *2005c*)

Region/Province	**Units**	**2004**	**Higher than 2003**	**Main production province**
NORTH (highland)	Ton	37,557	18.1	Phu Tho
Red river delta	Ton	141,076	13.5	
North CENTRAL	Ton	34,634	26.6	

SOUTH central	Ton	9,500	28.5	
Tay Nguyen	Ton	8,991	32.2	Daclac
South east	Ton	41,789	17.2	
Mekong delta	ton	464,148	-	An Giang

Farming system design and production performance

The various farming system of freshwater fish culture is existing in Northern part of Viet Nam. Of which six freshwater aquaculture farming types are common, including household pond culture, rice cum fish, VAC, specializing area, reservoir fish culture and wastewater aquaculture. However, those above cultured systems are not clearly different in some cases where there are water poultry cum fish, sty cum fish and VAC with added wastewater.

Farming system design

Rice cum fish

Rice cum fish is seen mainly in low land area of coastal provinces. Rice fields submerged most of the time in the year are in tendency of being converted to rice cum fish or fish pond. The cultured area is relatively large; the minimum area is about 1000m^2.

Rice fish culture consist of three models are integrated (fish and rice), rotated culture (one fish crop and one rice crop) and the third crop (two rice crops and one fish crop). The latter one is a specific rice-fish pattern in Nghe An province. After harvesting the autumn-summer rice crop, the water depth of sunken rice field is raised high by rain water source or irrigated network supply and then fish is stocked. The culture period usually lasts 4 months, from September to January of the coming year. In that period, food is not supplemented to fish, except for a few farmers who stocked grass carp.

The main culture species in this model is Common carp (*Cyprinus carpio*) which makes up for 50-60 %; others are Grass carp, Rohu, Mrigal and Tilapia. As for the third crop, the proportion of grass carp and Common carp is nearly equal with proportion of 40%. In prawn-rice culture model, Giant prawn is major culture species. Prawn is not fed in the whole culture period.

Fish stocked density in rice field is quite low. It is about 120 p/500m^2in integrated culture, 150-180 p/500m^2 in rotated culture and 40-60 p/500m^2 in the third crop. Fish stocked size varies model to model but it is usually a relatively large size from which fish can be harvested after a short cultured period. In Nghe An, the fish stocked size is about 50-100 g/p in integrated and rotated culture and 125-200 g/p in the third crop. To have fish with suitable size, farmers reared fingerlings in small earthen ponds before stocked them into rice field.

Household's Pond culture

The pond size at household's level is relatively small. It usually varies from 200 to 500 m^2. The average water depth rarely exceed 1 meter, even at some coastal and high land areas, fish pond bottom can be dried up in the summer.

Fish stocked density is relatively low and varies from 0.5 to 1.5 p/m2. Farmers usually stock different species into ponds in which the traditional species of Common carp and Grass carp and Silver carp, Rohu, Mrigal, are very common. The proportion of fish stock is unable to determine exactly because farmers relies on their own personal experience. Stocking time is the beginning of the year and normally starts at April (common calendar) but harvest time usually conducts all year around. All species are not stocked at the same time. Stocking depends on fish breeding season; fingerling source and service and farmers' need. Common carp usually releases into pond firstly and then grass carp and

Tilapia. The average fish productivity of fish pond culture is about 1.5 ton/ha and varies from region to region.

VAC system

Integrated fish culture called VAC (**V-Garden, A-pond and C-piggery**) is very popular in North and central part of Viet Nam. Ponds in VAC system are often located in the households or newly established farms. The pig sties are usually built in pond edges from which a part of pig's urine and manure or other waste matters can be released directly to fish pond. Each sty has at least 5-6 pigs therefore the amount of waste matter discharges into pond very abundant. Pig is usually fed with vegetable and commercial food of some food companies. Duck is generally cultivated in pond or kept at a part of pond by a duck-pen. Consequently, all duck manure and its waste matter such as redundant food is totally released into pond.

Figure 38 Pig sty on pond bank

Figure 39 Pig sty on pond bank seen from behind. Untreated manure is discharged into pond

This culture model is normally carried out in areas with available water source, especially with irrigated network source. Fish pond area varies from 400 to 1000 m^2 and water depth is relatively high. Stocking density is about 1.5-2.5 p/m^2. Fish cultured species is usually omnivorous species and low oxygen demand such as Common carp (*Cyprinus carpio*), Tilapia (*Oreochromis niloticus*), Mrigal (*Cirrhinus mrigala*) and Rohu (*Labeo rohita*). To utilize the natural food, Silver carp (*Hypophthalmichthys molitrix*) and Bighead carp (*Aristichthys nobilis*) can be added in integrated model of Pig-fish. And because of abundant of debris organic matter and natural food, commercial food does not supplement into pond. The fish productivity of this model is quite high and about 3 tons per ha.

Wastewater aquaculture

This culture model is common in sub urban of main cities such as Nam Dinh and Hanoi. Fish ponds normally receive waster water which discharge from agriculture, industry and human activities of city. The waste water contains a large portion of organic matter such Nitrogen and phosphorus which are suitable for aquatic species growth and development. Thus, cultured species are normally omnivorous/detritus and low oxy demand such as Common carp (*Cyprinus carpio*), Tilapia (*Oreochromis niloticus*), Mrigal (*Cirrhinus mrigala*) and Rohu (*Labeo rohita*), Silver carp

(*Hypophthalmichthys molitrix*) and Bighead carp (*Aristichthys nobilis*). The productivity of fish cultured model at Thanh Tri-Hanoi is presented in the table below:

Figure 40 Waste water aquaculture ponds in Nam Dinh (Photo: Mai Van Tai, 2004)

Table 67 Productivity of fish culture models in Thanh Tri district-Hanoi city in period of 2000-2002 (Hanoi agricultural extension center, 2003)

Culture system	**Year 2000**	**Year 2001**	**Year 2002**
Household pond	4.0	4.5	5.0
Lake/dam	3.0	3.5	4.0
Rice-fish	1.6	1.7	1.8
Wastewater reservoir/dam	4.0	5.5	7.5
Average	3.3	3.6	4.2

Intensive culture

In terms of monoculture in freshwater fish culture, monosex Tilapia is a main cultured species in most areas of Northern part of Viet Nam. Almost tilapia intensive models, stocking density varies from 3-5 p/$m^{2.}$ Fish is fed with commercial feed, farm-make food such as dry or moist feed. Culture period is about from 3-5 months and productivity varies from 8-15 ton/ha, depending on farmers' investment and stocking density.

Production performance

Land-use

Since freshwater aquaculture in northern and central part of Viet Nam has low intensified level, thus almost fish farms have no inlet and outlet water treatment pond. Production area counts for over 98% of total farm area. The typical farm land-use is shown in table below:

Table 68 Typical farm level land-use for freshwater aquaculture

LAND-USE PER HECTARE	**Household' pond**	**Rice cum fish**	**Reservoir**	**Intensive culture**	**VAC**
Total farm area	100%	100%	100%	100%	100%
Production area (water surface)	98.6-98.8%	98.7%	89.8%	98.7%	98.5%
Sludge deposit area (land surface)	1.2-1.4%	1.3%	1.2	1.3%	1.3%
Area for other purposes	0%	0%	0%	0%	0.2%

Table 69 Main inputs for fish culture.

INPUTS PER HECTARE	Unit	Household' pond	Rice cum fish	Reservoir	Intensive culture	VAC
fish seed	p/m^2	0.5-1.5	<0.5	<0.5	3-5	2.0-2.5
Feed	Kg/ha/yr	0	0	0	15000	0
Maintenance	*'000 vnd/ha/yr					
Labor (per ha production water surface)	Person/ha/yr	1	1		1-2	1-2
Labor cost	*'000 vnd/ha/yr					

Moreover, fish stocking density is relatively low, with number varied from 0.1 to2.0 p/m2 except for intensive tilapia culture. Chemical, drug , fuel and feed costs are not required, therefore operational costs are mainly seed and maintenance (see table below):

Table 70 Main outputs for freshwater culture

INPUTS PER HECTARE	Unit	Household' pond	Rice cum fish	Reservoir	Intensive culture	VAC
Fish yield	ton/ha/yr	1.5-1.8	0.3-0.5	<0.1	10-12	>3.0
Typical harvest size	g/kg	0.6-2.0	0.5-1.2	0.2-3.0	0.3-0.5	0.8-2.0
Farm Gate Value	*000 vnd/kg	10-15	12-13	10-35	13-15	12-14

Major inputs - Water use

Water resources for aquaculture activities differ from regions to culture models and are mainly supplied from rivers via irrigation canal system. This system links rice fields, residence areas, pasture lands, industrial areas. Water is much more available in rainy season (March to September) and sometimes there is flood in the provinces. In addition, rain water and the surface run off water from households or deliberate discharge from domestic use are water sources for stagnant ponds in resident areas. Also, wastewater discharged from the city is used for aquaculture activities in urban areas of city such as Hanoi and Nam Dinh.

Freshwater fish culture practice is rarely exchange water in the whole culture period. Once fish is harvested, effluent water is discharged directly into surrounding area such as canal, irrigation system or other ponds without treatment. However, there is not much information on water quality monitoring program of freshwater aquaculture. These programs focus mainly on coastal aquaculture, especially shrimp culture, because of high potential risk of organic contamination.

At present, irrigation systems were built for agricultural practice purposes, hence water demand for aquaculture practices have not paid much attention. As a result, conflicts between fish farmer and agricultural farmer in sharing water resource sometimes occur. During dry season, water is used for irrigating paddy fields after transplanting rice, therefore in some ponds the water level decreased so drastically, that farmers had to sell fish ahead of schedule. Moreover, water source may contain toxic residues, heavy metal or organic load which is contaminated from agriculture and industry activities. Steinbronn *et all* (2005) showed up the negative impacts of using pesticides, chemical residues in agriculture practices to fish in pond, notably rice cum fish or ponds received effluent water from rice field. He pointed out that pesticides might enter ponds with the water-flow and through leaching as well as with the weeds and duckweed, which are both collected from rice fields and frequently used as fish feed. In addition, wastewater from industrial, urban activities is released into river of canal without treatment may negative impact on fish health.

Major inputs - seed supply

Broodstock of freshwater fish nowadays originates from fish culture in pond. Each hatchery has its own brook-stock selection program to maintain the seed quality and quantity. In addition, aquaculture research institutes are carrying out fish selection program to improve and conserve fish genes. At present, RIA1 is conducting selection programs with two major target species are common carp and Tilapia. Otherwise, MOFI is funding for conservation and maintenance fish genes program. The results of these research programs may scatter through extension channels or transfer to fish hatcheries.

Major fish hatcheries are located in lowland area where water source is naturally supplied to pond through water canal, river branches and irrigation system. Hatcheries normally consist of reservoir, broods-tock ponds, grow-out ponds and rearing larvae pond and canal system to supply water for production activities. In addition, the hatcheries which produce fry fish usually have hatching and rearing larvae system. Hatcheries usually build nearby water canal not only to reduce operational cost from pumping water but also to supply seed with high quality to main fish production areas. The data indicate that there are 60% fish seed hatcheries in Nghe an province are established along the branches of Lam river and main fish production areas such as Quynh Luu, Dien Chau or Nam Dan districts. Subsequently, fish fingerling may meet the farmers' demand, reduce the price and assure the seed quality by not transporting from long distance.

The fish fingerling price differs from time and fish size. It is estimated that fish seed price in starting stocking season is higher than that in late one. In addition, larger fish size is higher price. However, the fingerling price is slightly decreasing in recent years (see table below)

Table 71 Fingerling prices of some major freshwater fish in Nghe An in recent years

	Fish size	**2000**	**2002**	**2003**	**2004**	**2005**	**2006**
Common carp	40-100 p/kg	45,000	42,000	35,000	30,000	28,000	25,000
Grass carp	60-100 p/kg	45,000	40,000	30,000	28,000	26,000	25,000
Indian & silver carp	150-250 p/kg	35,000	32,000	30,000	25,000	23,000	20,000
Tilapia	240-270p/kg	60,000	60,000	55,000	52,000	50,000	50,000

Major inputs - feeds and feed management

Freshwater fish culture in North and central part of Viet Nam rarely supplement feeds into pond for fish culture except for intensive Tilapia culture. In VAC culture system, Pig sties or duck fence are often constructed on pond banks so their waste is washed off into fish ponds. It supplies a huge source of organic matter to fish pond. Besides, vegetable, brewery and agriculture by products like rice bran, maize, sweet potato, and waste from abattoirs also are used as feed for cultured fish. Banana, cassava leaf, grass or vegetable is supplemented to fish pond not only as food for grass carp but also as green manure for other aquatic species. Also, the use of untreated organic manure of Pig, Cow, Buffalo and Human is very popular. These manures are scattered infrequently into pond. Its amount is difficult to determine because farmers usually rely on their experience.

There are various kinds of food such as commercial feed, hand-made feed (dry and moist feed) are using as feed in intensive Tilapia culture. These feed differ from protein content and price. It is estimated that there are over 10 companies which are producing tilapia feed notably Conco, Cargill, Concord, Globest, Con nai vang, Halan and Laithieu. Commercial feed prices currently are 5,300;

5,800 and 6,500 VND/kg with protein content of 18, 20 and 25 % respectively. There is a little information on FCR of commercial feed. It may vary from 1.5-1.7. The feed price trend is quite stable in recent years

Moist and dry feed are making in Tilapia farm in order to reduce the operation cost. Fish is usually fed these kinds of feed two-three months before fish is harvested. The price varies from 3,800-4,500 VND/kg. Fishmeal originates from various sources as importing from Indonesia, Malaysia and Peru or purchasing from Viet Namese fish port and middle man. Thus the fishmeal source fluctuates time to time, for example in winter season almost fishmeal is imported.

Other inputs/resource use

Other resources used in fish culture are lime, manure and drug. Drug and chemical may use to treat fish diseases or environment pollution.

Risks

There are not many risks on freshwater fish culture because this culture practice has low input and intensify, compared to other commodities such as marine or shrimp culture. Its production is quite sustainable and likely to contribute to poverty reduction.

Diseases and health management

The freshwater culture normally is poly-culture with low input and there is a limited food supply to fish pond as well as low stocking density. Therefore, disease outbreak rarely occurs. The most serious disease of freshwater fish species is red-spot disease which causes mass mortality of grass carp especially in high fish density pond or/and low temperature. Other pathogens are bacteria and fungal that cause diseases on silver carp, big head carp and Tra/basa. Some researches on strategy of diseases and health management in fish farming have carried out by researches institutes. Otherwise, vaccination method is ongoing study on target species such as grass carp and common carp.

Food safety

Since the profit from most freshwater fish is fairly low, farmers don’t have incentive or money to buy many chemicals or antibiotics to use in the ponds. This is an advantage regarding food safety since no residues from chemical will be presented.

Most freshwater fishes are consumed by local markets and are often not taken to a processing facility but taken directly to the markets where they are sold. When fresh water fishes are not properly cooked or frozen after harvest there is a risk of transferring fishborne zonotic parasites (transmission from fish to human). The risk is especially significant in areas where raw fish or under cooked fish is eaten. An example is Nam Dinh province in the Northern Viet Nam. In Nam Dinh more than 25% of the male adult population infected with 1 or more species of fishborne zoonotic parasites. In provinces where raw fresh water fishes are not seen as a delicacy, the infection rates are much lower (under 1%)

Waste water fed aquaculture is another risk for food safety. It has been reported that fish cultured in fish-fed-waste water may contain heavy metal, anti-biotic and other toxic. It is well documented that farmers working in peri urban waste water fed aquaculture systems have more frequently ski problems and infections than the norm.

Markets and market chains

Fresh water pond culture is one of the traditional aquaculture methods of Viet Nam. They are one of the species cultured in small fresh water ponds. Most of the species can be artificially spawned. The average productivity is about 3 tones/ha. The most common species are common carp, grass carp, tilapia, Indian carp, silver carp and bighead carp.

Most of the fresh water fish species other than tra and basa are consumed domestically in the form of fresh, unprocessed fish except tilapia which recently (since 2002) has been cultured for export. However, the production of this species in 2004 was only 20,000-30,000 tones. The total value of export is USD 120,000 in the form of frozen fillet (while the Chinese export value was over USD 85 million). Tilapia is expected to be one of the key export commodities of Viet Nam in the coming time. However, at present, the size of tilapia is still smaller than the export requirement. The target of the fisheries sector in the near future is to increase the tilapia production up to 120,000 - 150,000 tones, of which 2/3 will be exported. It is planned that by 2010, Viet Nam can produce 200,000 tones of commercial tilapia, of which 50% will be exported (MOFI, 2006c).

The prices of fresh water carps and tilapia in general are quite stable, even slightly increase except for silver carp and bighead carp and are expected to be higher as the demand of substitutes for poultry and cattle meat due to avian flu and foot and mouth disease epidemics.

Table 72 Common carp prices (2003-2006) *Unit: VND 1000 (Khoi, RIA1 2006)*

Year / Size	**2003**	**2004**	**2005**	**2006**
<1,0 kilo	11-12	11-12.0	12.0	12-12,5
1-2 kilos	12-13.5	13-14	14.0-14.5	14.0-15.0
>2 kilo	14-15	15.0	15.0-15.5	16.0-18.0

Prices of Indian carp (often with 2 market sizes: <1,0 kilo or >1,0 kilo) are normally lower than that of common carp from VND 1000-2000 of the same size.

Table 73 Tilapia prices (2003-2006) Unit: VND 1000 (Khoi, RIA1 2006)

Year / Size	**2003**	**2004**	**2005**	**2006**
<0,3 kilo	10-11	10-11	10.0-11.0	10-12
0,3-0,4 kilos	11-12.0	12.5-13.0	12.0-13.0	13-14
>0,5 kilo	14.0	14.0-15.0	15.0-15.5	16.0-16.5

Table 74 Grass carp prices (2003-2006) Unit: VND 1000 (Khoi, RIA1 2006)

Year / Size	**2003**	**2004**	**2005**	**2006**
<1,0 kilo	11-12	13-13.4	13-15	13-14
1-2 kilos	14-15	15-16	15-17	16-18
2-3 kilos	18-20	20-22	25-30	20-25

Other less common species like silver carp and bighead carp are priced at VND 7,000-8,000/kilo (for <1,0 kilo in size) and VND 11,000-12,000 (for >1 kilo in size) As mentioned before, the market characteristic of these commodities is domestic consumption in fresh form, processors do not involve in market chain of freshwater fish products in North and central region of Viet Nam. There are two kinds of chain:

(1) Farmer → consumer (local market, quantity is not much) and,
(2) Farmer → middle man (collector) →seller (market) → consumer
or Farmer → seller (market) → consumer.

Within the market chain, for common carp, grass carp and tilapia, the price at farm gate is lower than that at town/city and high land markets from 3000-5000 VND/kg. For Indian carp and other species, the difference is about VND 2,000-3,000/kilo (Nghe An). In the main fish production areas, the prices are 2000-2500 VND/kilo different.

Social and economics

The resilience of the freshwater fish culture is very high, comparing with other commodities such shrimp or marine fish culture. The freshwater fish culture models are usually polyculture systems with a combination of different fish species cultured with individual habitant preferences within the water column. Besides, fish culture has low input, fish species variety, easy culture technique and pond management, then risk of loss is rarely occurred. As a result, it leads to a sustainable pond production. Therefore, freshwater fish culture is suitable for poor farmer in rural areas and for poverty alleviation purposes. Market access is one of the main constraints for sustainable development of this commodity and in certain cases lack of market access has resulted in farmers generating a net loss due to low farm gate values.

2.5.2 Environmental Assessment

Location and farm siting

Freshwater farm location plays an important role in fish pond management and practices. Farms are typically situated along rivers, river branches, water canal, and irrigation canals which have favorable condition with regard to available water resources. However, water quality should be monitored because water source may contain toxic residues, pesticides or organic matter which is discharged from agriculture, industry sources or residence areas without treatment. Flood may threat the fish pond in the raining or flooding season. In addition, fish may escape from culture pond and has negative impacts on biodiversity of wild fish population.

Farms which originate from rice field may share the water resource with agricultural practice. These farms normally locate far from resident areas and then reduce the negative impact of human activities and conflict among community. However, activities in the paddy fields, such as the application of pesticides, may negatively affect ponds. Water shortages in ponds may occur, when paddy fields start to be irrigated. Farm located in residence areas may receive water waste from human, animal raise activities. Water source is usually from rain or groundwater. These farms are hard to manage because of limited water source and security issues.

Farms located in low land area have many positive points such as water source availability, easy transportation, nearby hatcheries and feed and drug agents. Conversely, flooding and water source pollution may impact to the production result. In high land mountain or coastal areas, farms usually receive the pure water source, but water shortages in ponds may occur. Addition, farm operational cost may increase because transported cost of feed and seed.

Issues / Threats / Conflicts	Geographic location	Examples of solutions/mediation measures/actions
• flooding • pollution	Low land area	▪ Build pond rationally ▪ Harvest fish before flooding season ▪ Having reservoir to mitigate the polluted impact
• Shortage of water source • Lack of feed and seed	High land area	▪ Farm build along river or canal ▪ Government have assist seed price policy ▪ Use agriculture by-product and local material to make home-made feed
• low quality fish product • human health	Peti-urban area	▪ Use fish cum rice or fish cum vegetable model ▪ Inspection fish product before taking to market

Design and Construction

Almost freshwater ponds are designed in rich soil, clay or sandy soils. Clay and rich soil may well maintain water level in the whole culture period. Sandy soils are easy to construct pond but they are week in maintaining water level in pond. As a result, it is difficult for farmer to handle the pond, especially in dry season. The special design of sandy soils pond should be followed:

- lining the bottom and bank pond by nylon or HP piece
- pond bank constructed by cement and rock if water source is available
- pond depth exceed 1.5m, if pond is not lined, create canal in bottom for fish

Seed supply, broodstock and post larvae

In freshwater seed production hatcheries, spawners usually select from fish culture population or through fish selection program. Generally, the hatchery has its own brook stock selection program to ensure the quality and quantity of seed production. To avoid the inbreeding phenomenon, spawners can be supplied to hatcheries from research institutes, national centers for freshwater seed production or via fish selection program or project. For example, hybrid common carp and Tilapia (Gift strain) can be obtained at RIA1.

Currently, the hatchery infrastructure is efficient for producing conventional fish species such grass carp, silver and bighead carp, common carp and Indian carp. However some hatcheries need to invest the capital for setting up the monosex tilapia hatching and system.

The fingerling quality of freshwater fish is related to brook-stock and seed quality inspection. The inbreeding phenomenon sometimes occurs in hatcheries, it leads to degrade the quality of fingerling after few spawner generations. Therefore it is essential to invest to selection and gene conversation program. In addition, brood stock have to inspect for pathogen, especially virus and bacteria agent. Therefore the investment will focus on facilities and equipments for fish health laboratory. That will ensure the high quality of fish seed.

Water use and impact

Fish pond rarely exchanges water in its culture period. Water effluent to surrounding area only occurs when fish is harvested. Presently the negative impacts of fish pond effluent to water surface quality are not recorded.

However, the water quality in fish pond is influenced by many sector such as industrial sectors, agriculture and urban development. There is a high potential of fecal contamination in water resources supplied for aquaculture activities from human and animal activities in resident areas. On the way to ponds, water is contaminated by feces of dogs, cats, ducks. Duck raising on canals is a custom in some area of red river and Mekong delta. Ponds and canals are often used as washing places including vegetable, slaughtered animals. Ponds or rice cum fish fields get fecal contamination from manures from rice farming. Waste water aquaculture certainly causes high fecal contamination.

In relation to fecal contamination resulted from on farm activities, it is noted that domesticated animals are raised as integrated economic activities beside aquaculture of the households with grow-out ponds, hatcheries and nursing. Pig are most common 2-400 pieces/household, duck 20-1000 pieces/household, Swan 2-200 pieces/household and chicken 10-30 pieces/household. Most of pigs are grown in sties located in the pond banks while duck and chicken in captivity or in ponds or gardens or fields. Dogs and cats are also raised in houses or farms and they are not in captivity. Thus, the potential for fecal contamination resulted from growing terrestrial species on farms is very high.

In addition, manure of pig, duck, bird and chicken is widely used in all aquaculture farming types including rice cum fish, VAC, specializing farming areas. In general, pig manure is used more than others in amount possibly by its high quantity available. Pig manure is mainly put directly into ponds from pig sties by flushing effluents or by transportation from within or outside the households without decomposition. Night soil and bird manure are used mainly in nursing rather than in growth our ponds. Bird manure is used in a manner of placing a sack of the manure at a corner of a nursing pond. In particular, nursing ponds and some grow-out ponds, domestic waste or latrine flush are discharged into aquaculture ponds. However, most of ponds are in residence areas so human manure is treated via septic tank before being discharged into ponds.

Waste and impacts

Pond usually prepares before stocking fish and one of important tasks is to remove sludge and solid waste from fish pond. There is not available information on the quality of effluent matter from fish pond. It may contain much proportion of Nitrogen, phosphorus and carbon.

Sludge and solid waste is used with different purposes. The waste may shift from pond bottom to its bank in order to raise the pond bank depth. It can be used as manure in VAC system or fish cum vegetable and fruit.

Feed and feed management

As mentioned above, most of the fish culture models do not use commercial feed or farm-made feed, except for Tilapia monoculture, therefore the fishmeal demand for freshwater fish pellet is not so high. Fishmeal can currently come from various sources such as international market (Indonesian, Malaysia and Peru) or local market. When semi-intensive and intensive culture area expand, the demand for pellet food will increase. However there is still sufficient fishmeal to supply the increasing demand of the dry pellets. Substituting plant protein to fishmeal protein and using food processors by-product are the best approach to resolve the lack of fishmeal for fish pellet in the future. Soybean is being used currently as a plant protein to substitutes to existing fishmeal based protein. Other candidate is pea been, but it is on-going research.

The government has issued a number of policies and regulations to stipulate the feed production. The government issued Decree No. 15/CP dated 19/3/1996 stipulating on management, production and trading of animal feed in Viet Nam (DARPC, 2000, p346-354). Moreover, The Circular Letter No. 2/1998/TT-BTS of the MoF dated 14/3/1998 guiding on implementation of Decree No. 15/CP, and the proposed fishery law also regulates aquaculture feed and raw materials for feed producing. However, there are not many researches on substituting other protein source to fishmeal, though farmers are using pea bean and soybean as plant protein source to substitute animal protein.

Disease issues and health management

The main characteristics of freshwater fish culture are poly-culture and low intensify. Thus this production is quite sustainable with low risk of disease outbreak and crop loss. In addition, the uses of vaccine, biological product and herb are encouraging to control diseases and protect environment.

Food safety and quality

There are not many chemical and drug used in freshwater aquaculture practices, thus the negative impacts of their uses to environment are also very limited.

The food safety aspects of fresh water aquaculture related to fishborne zoonotic parasites do not have a direct negative impact on the surrounding environments.

Economic and Social Issues

Almost fish farmers are living in rural area. Their main income comes from agriculture practices, husbandry and services. They are quite poor and developing aquaculture is new approach to create more jobs and income. However, when fish crops are lost because of water pollution, diseases outbreak or bad management, it may lead to economic lost which have negative impact on farmers' livelihood. The investment for freshwater fish culture is modest compared to other commodities such as marine fish culture or shrimp culture, but economic loss may have severe impact due to the fragile rural inland household economies. Farmers will have no income to support their families nor capital to invest for next culture crop. Some of them do not have the ability to pay the interest rates of the loan to the banks resulting in indebtedness and return to poverty. Thus the conflict between rich people and poor one in community may occur.

Market issues

As major market for Carps and Grass Carps fresh water farming in pond is domestic one, farmers and authorities have not paid attention to the food safety and quality as well as the management. However, market demands could effect on this farming system as high demand of human food when avian influenza and pig disease problem have been happening in Viet Nam.

Recently more export markets have been found for Tilapia fillet products that brings a good signal for Tilapia farming in country. This species can be cultured as an alternated crop after shrimp farming in the northern provinces and it is in fact has developed in Nghe An, Ha Tinh and others provinces in the north. In Quynh Loc – Nghe An province, the converting shrimp pond to Tilapia farming has happened as shrimp farming met difficulty of brackish water supply and brought loss to farmers. Tilaphia is also an extra products of shrimp farming in the south provinces where Tilapias has been cultured in effluent treatment ponds in Ca Mau provinces. The farming system can bring benefit to the poor as well as sound environment perspectives.

Institutional issues

Decentralized government institutions are taking greater responsibility in managing the resources and transfering technology to farmers.

Extension services is provided by provincial and district extension centers and by freshwater hatcheries. Hatcheries provide seed rearing or grow-out fish culture techniques to fish farmers. Generally, there's a lack of skilled staff in the extension service and dissemination of methods for transferring fish culture techniques is insufficient.

DOFI is responsible and co-operate with DONRE and the center for disease and environmental monitoring (RIA)s. The provincial extension center introduces the environmental management and disease prevention and treatment to fish farmer.

The freshwater aquaculture in e.g. Nghean (the area that was studied), which mostly consists of carps is only considered important in rural development, where it contributes to poverty reduction. Generally the environment protection program in the province focus more on brackish water aquaculture than on freshwater.

Information about market opportunities and demands is provided through radio, training course, leaflet. However, farmers are still not sufficiently informed

There is an inadequate number of staff members in the aquaculture sector administration at provincial/district level. There's lack of key skills and knowledge concerning environmental management in freshwater aquaculture culture. There is lack of systematic monitoring of disease and environment issues in intensive fish culture areas (particularly concerning use of discharged water for fish culture).

Summary of environmental issues of fresh water farming in ponds

Fresh water pond culture also brings positive impacts to environment and social aspects. Most of environmental issues in fresh water culture in pond come from outsides as this commodities culture depends on the intake water quality, which are getting problems of land based pollution as above analysis.

The major positive impacts are supplementary of the household's income and foods supply for rural areas. This commodities development would be well matched of all provinces condition in Viet Nam and pro-poor.

Impacts	*Management practices/solutions*
Fresh water pond culture of carps/tilapias, paddy	
Impact 1. Efficient use of resource	• Promote in rural areas with limited resource
Impact 2. Supplementary of the household income and foods supply	• Promote the polyculture system • Promote as a solution for poverty alleviation and food security • Promote fresh water culture in mountain regions as a diversified food supply and nutrient
Impact 3. Impact on human health	• Better planning to avoid the contaminated water intakes for fish farming • Cross sectoral planning, especially with the agricultural sector • Support research on risk factors • Develop BMP based risk factors identified • Awareness raising on raw fish eating in communities
Impact 4. Impact on rice field conversion	• Promote the integrated or rotation of rice- prawn farming as a alternative of rice converting from rice field to prawn farming

2.5.3 Guidelines for Better Management

Location of freshwater fish farms

Fish farm should be located in areas which meet these demands:

Practice	*Criteria*
Water quality	• Available water source and meet Environment standards TCVN 5942-1995 (column b) on surface water quality standards
Soil condition	• Locating in flat areas and soils should be clay or rich soil; and • Meet the Environment standards TCVN 5941-1995 on pesticides residues in the soil
Social aspects	• Good security
Services supply	• Convenient transportation, nearby food and seed supply age
Others	• Far from industrial zone, polluted areas by human and agriculture practices

Design & construction of farms in ways that minimizes environmental damage

Intensive freshwater fish pond:

Practice	***Criteria***
Water supply	• Locate areas which receive water from river branches or irrigation canal •
Farm size	• More than 10000 m2
Farm design	• Fish farm should have reservoir (inlet water treatment pond) and outlet pond to reduce negative impact of water source and water effluent •
Farm structures	• Build growth-out ponds, 1-2 nursing ponds, houses for protection and store/make feed • Build the canal system to supply water to ponds • Pond banks are constructed by stone and cement • Pond area is quite large enough and vary from 500-5000m2 • Pond depth must be higher than 1.5 m. pond
Individual household and pond	• Build a canal system in farm or design each pond has sluice gate to connect with irrigation system • Production area is from 2000-1000ha, Pond sizes varies from 500-50000m2 • Pond depth is from 1.2-1.8m • Pond banks design solidly to avoid water leaking

Seed supply, brood-stock and fingerling

Practice	***Criteria***
Seed supply	• Seed inspects before release to pond
Genetic diversity	• Use pure strains for spawning and avoid inbreeding

Feeds and feed management

Practice	***Criteria***
Feed supply	• Use commercial food with high quality. Moist and wet feed have to store in refrigerator before feeding
Substitute feed	• "Green feed" such as Banana, cassava leaf, grass or vegetable is supplemented to fish pond as food for grass as well as green manure have to remove frequently to a void water contamination.
Feed management	• Feed size and protein content have to adjust to corresponding to fish mouth size and fish stage • Use feeding tray in fish pond to monitor fish feeding ability and remove redundant food

Health Management Plan

Practice	*Criteria*
At farm level ***Environmental check list***	• Recording feed, feeding and water quality parameter, weather everyday • Check water color, water depth and fish movement in pond everyday • Exchange water if high turbidity or water contamination • Manure has to treat before supplementing into pond • Intensive fish farm or fish-fed wastewater pond have environmental tools such as pH or Oxygen
At the farm clusters	• Building the network for monitoring and early warning environment and diseases • Monitoring environmental parameters and diseases at main production areas, intensive fish culture areas. Sample should collect frequently or unscheduled time. • Establish the information channels to inform farmer immediately if environmental pollution or disease outbreak. • Monitor the environmental factor such as: organic: Nitrogen, phosphorus, pesticide residues, heavy meter • Monitor Disease: parasite, bacteria and virus • Establish the fish farmer group in order to manage water source and disease • Train farmer through extension training about environmental management in fish pond, prevention and treatment fish diseases.

Food safety and quality

- Avoid using forbidden chemical and drug in aquaculture.
- Stipulate the use of probiotic/ biological product in environment management and disease treatment.
- Avoid using “night soil”
- Implement better management practices to break the cycle of the zoonotic parasites

Economic and social issues

- Promote polyculture in poor rural areas
- Form the fish culture groups to share culture technique, experience and water source
- Revolve community trust funds to improve capital access
- Establish regulations for different groups who are using the same resources such as water and land
- Promote and stipulate woman participates the aquaculture activities

Markets and demand

- Harvest fish at commercial size
- Keep fishes alive to get the highest value of fish
- Harvest fishes which get the commercial size in polyculture pond and supplement new seed into pond. For intensive fish culture harvest, is only done when fish size meet market’s demand

Institutional issues

Key institutional and policy requirements:

- Further investment in training of staff members in public aquaculture planning and research
- Ensure that planners and farmers have access to relevant and applicable aquaculture techniques and relevant information on GAP
- Facilitate the establishment of farmer groups as a means to improve mutual communication with farmers and disseminate information on GAP, new technologies and market opportunities
- Ensure that environmental problems in freshwater aquaculture production is monitored by skilled staff and not neglected in priority to brackish water production.

2.5.4 Implementation responsibilities

Institutions (legislation, offices, organisations and norms) may facilitate sustainable aquaculture development and reduce the risks of unpredicted environmental or economic problems. The following general and immediate (specific) requirements are seen as important in promoting sustainability in the in the fresh water culture.

General institutional requirements:

- Decentralized, robust, transparent, and resilient management system working with applicable legislation and plans which are supported and understood by the affected stakeholders.
- Giving decision makers access to continuous updated and reliable data on production, natural resources, market and socio economic issues.
- Adjusting production and the development plans towards sustainability targets through incentive based measures and cross-sector planning.
- Considering the limited financial and human capacities in public administration and promoting a simplification of data collection on the sector and conduct participatory decision making.
- Ensuring that the implementation of legislations and development plans are adjustable to different administrative, socio economic and political contexts and that they are enforceable.

Immediate institutional requirements:

- Further investment in training of staff members in public aquaculture planning and research
- Ensure that planners and farmers have access to relevant and applicable aquaculture techniques and relevant information on GAP
- Facilitate the establishment of farmer groups as a means to improve mutual communication with farmers and disseminate information on GAP, new technologies and market opportunities. Extension workers and mass organisations are key stakeholders in this work.
- Ensure that environmental problems in freshwater aquaculture production is monitored by skilled staff and not neglected in priority to brackish water production
- Supply of feed and quality seed should be improved through strategic coordination of public and private investments in seed production, implementing strategies for improving farmer's access to seed – particularly in poor rural areas. Improve farmers’ access to credit. DOFI, RIA, VBARD and private seed enterprises, are key stakeholders in this work.
- Farmer's access to information about market opportunities should be improved through participatory planning and sharing of experience from successful entrepreneurs.

2.6. Freshwater cage culture of carps

2.6.1 System description

Brief overview

The potential for fresh water cage aquaculture and its environmental impacts and implications are demonstrated through the following case study report of fresh water cage culture in Tuyen Quang province.

Tuyen Quang province is located in a mountainous area and has a large potential for aquaculture development. The province has more than 10,500 ha of water surface in which small water bodies (ponds, lakes) cover 1,461 ha and reservoirs used for irrigation (>5ha) cover 230 ha. Tuyen Quang province has an interfacing river/stream system with three large rivers running through the province: Lo, Gam and Pho Day Rivers with a total length of 400 km. People have a long tradition and are well-experienced in different types of fish culture. Rice-cum-fish and cage culture systems were introduced here for about 10-years ago.

Cage culture in the Lo River was introduced in 1978 and has developed rapidly. The case study found that 121 cage culture systems were operating including 77 grass carp cages, 28 cages of Goouch (*Bagrius bagrius)* and 6 cages of ca Bong (*Spinibarbus denticulatus)*. The provincial capital of Tuyen Quang hosted a total of 66 cage culture systems including 41 cages of grass carp, 13 cages of Goouch (*Bagrius bagrius)* and 12 cages of ca Bong (*Spinibarbus denticulatus)*. The Chiem Hoa district has 26 cage culture systems; Ham Yen district has 15 cage systems; and Son Duong district has 14 cage culture systems. Most of these district cage systems raise grass carp.

Cage culture development programme of Tuyen Quang province

The Ministry of Fisheries has a policy to develop reservoir fisheries with the focus on cage culture. According to the programme, the production target for fishes cultured in reservoir is 228,000 tons by 2010, in which 20-25% of fish production should be high value species. Also by 2010, the number of cages should be increased to a total of 30,000 cages including 10,000 cages with a size of 100-200 m^3 with an expected average productivity of 15-20 tons/cage; and 20,000 cages sized 20-30m^3 with an expected yield of 0.8 ton/cage. The planned future expansion of reservoir cage culture would create new jobs for 75,000 people. Total investments needed would be around 300 billion VND and 2 billion fingerlings and 330,000 tons of pelleted feeds per year would also be needed.

The People's Committee of Tuyen Quang province has put strong priority and ownership of the development of aquaculture as illustrated by the formulation of strategy for aquaculture development in the period 1991-1995. Further, this is documented by the definition of the Party Committee Congress to "Strongly develop fish culture in ponds/lakes and cage culture in rivers and streams". In 1994, the People's Committee approved 02 projects funded by HCR and 327 programmes with a total investment of about 450 million Viet Namese Dong (VND) in order to expand the size of cage culture activities in the provincial area. A credit scheme was established enabling every household to borrow from 2.0-2.5 million VND to create 1-2 cages. As a result the total number of cages in the province increased to 714 at the end of 1994. The Provincial People's Committee has allocated fund to implement research on identification of the causes of major diseases and formulation of recommendations for treating such diseases. In 1997, the People's Committee approved a project titled "Development of cage aquaculture" in 1997 - 2000 including the construction of a total of 1,000 cages at a total cost of 11 billion VND (equivalent to $800,000) which financed by the Bank for Poor People. The project manager is Tuyen Quang Fisheries Company. However, due to primarily limited aquaculture experience in diseases control, several farmers experienced economic loss and the number of operating cages were therefore increased gradually between 400-480 during the project period (see). According to the Department of Agriculture and Rural Development, project funds could not be allocated as planned. There were only a total of 121 cages operating which is a 30% reduction compared with that in 2000. Main reasons for this slow development are the disease problems in grass carp culture and lack of fingerlings of some species such as ca Bong (*Spinibarbus denticulatus)* and Goouch (*Bagrius bagrius)*. Also the exploitation of sand and other construction materials in the rivers have caused pollution problems mainly in the dry season. This has been seen as having a negative effect on the development of cage aquaculture in Tuyen Quang province.

In 1982, there were 217 cages in Tuyen Quang town. However, these activities came to a sudden stop when the cage culture activities were hit by major disease outbreaks. In 1992, some households restarted cage culture activities with 9 households doing cage culture in bamboo and wooden cages in Tuyen Quang town with a size of about 10 m^3. Main stocked species were grass carp with stocking density of about 700-800-1000 fish/cage with a size about 4-6 cm. Fish production yield per cage ranged from 100-200 kg.

Fish culture area and development plan

Cages are mainly located along the Lo river side and in small reservoirs in some districts. Along the riverside in Tuyen Quang town, the cages were distributed downriver and anchored to the riverbank. In some small reservoirs, the cages are normally placed close to the riverbank which eases the management. As mentioned above, the plans of Tuyen Quang province are to expand the cage culture area along the Lo river side. However, presently the total number of cages and the area used for culture have decreased with culture areas located mainly under the Nong Tien bridge and Tuyen Quang town.

Design for farming system and productivity

During the period 1997-2000, the total number of cages in Tuyen Quang province reached about 50% of the planned target with productivity ranging between 250-300 kg/cage. The farmers have increased knowledge on all culture management aspects from the stocking of fingerlings to growth out and fish harvest. However, it is uncertain to what extend the farmers adopt to new developed technologies for diseases treatment and feed management .

The dimension of the cages in Tuyen Quang's Rivers are typically 4–4.5 x 2–2.5 x 1–1.3 m^3 with 60 - 70% of cage structures submerged in water which protects the cages and fish from floods. The slot of the cage are made of wood and bamboo with sizes ranging from 1.0 – 1.5 allowing for adequate water exchange. Some households have started to use plastic pipes for cage construction because the smooth plastic surface reduces the algal growth. Though the growth of algal is beneficial as algal may slow down water movements.

The productivity depends on the fish species and farming area. The fish species cultured depend to a large extend on which species of fingerlings are available for stocking. Grass carp fingerlings are widely available and is the most commonly culture species in cage culture with productivities between 250-300 kg of marketable fish per cage (25-30kg/m^3). This yield can be obtained typically after a two year culture period with fish sizes at harvest of about 4-6 kg. Fish yields of ca Bong (*Spinibarbus denticulatus)* and Goouch (*Bagrius bagrius)* are lower and range from 150-200 kg/cage following 2-3 year culture periods.

Growth rates vary among different species. Grass carp can obtain a weight of 4-6 kg after 2 years culture of fingerlings sized 0.5-1.0 kg (+ 3 years), whilst ca Bong (*Spinibarbus denticulatus)* and Goouch (*Bagrius bagrius)* can obtain a weight of about 2.5-3.0 kg after 3 years culture.

Cultured species

Grass carp is the traditional cultured species in fresh water cage culture. This species needs good quality water where grass also is well adequate for their feeding. Grass carps grow fast, has high quality of meat and generate a good income. However, grass carp is also relative susceptible to diseases including red spot disease, different types of ulcerations, particularly in the early of rainy season. Fingerlings of large sizes are often stocked to overcome disease problems. Other fish species may be cultured with grass carp, e.g. Goouch (*Bagrius bagrius)*, ca Lang (*Mystus guttatus)*, ca Bong (*Spinibarbus denticulatus)*, and false black laner (*Bagrichthuys macropterus*) to reduce the stocking density of grass carps thereby reducing disease risks.

Mortalities range between 6-10% in households stocking fingerlings sized about 0.3 kg/fish during September to October when the water quality is good (high water transparency). Growth rates of the fish range from 100-130 gram/month. Fingerlings sized of 20 – 30 g/fish usually obtain a weight around 0.6 -0.8 kg/fish at harvest time. If fish is stocked in the rainy season, there is a high risk of mortality mainly caused by low water quality.

Bagarius rutilus is a indigenous species that lives in the streams or rivers with high water current and gravel bottom. The fish feeds on insects, shrimp/prawn, and small fish species. Fish bred in natural conditions has low growth rates and obtain a weight about 2.5-3.0 kg/fish after 3 years. The meat is off a good quality and high value. Goouch (*Bagrius bagrius)* is the main species of this genus cultured in cages in Tuyen Quang province.

Spinibarbus denticulatus is a fish species that lives in rivers or streams throughout the province. It prefers clear waters and feeds on grass and plants. The fish show a low growth rate with sizes of 3.0 kg obtained after 3-4 years culture. The meat is tasty and the fish can be culture in cages and ponds. Thus, this is a very important species in particular suitable for culture in running water systems.

Table 75 Statistical data on the number of cages used for culture and fish yields (1994-2000)

Year	Total number of cages in the province	Average productivity (kg/cage)	Fish production of cage culture (kg)	Note*
1994	714	128	91,400	93
1995	401	207	83,000	- 130
1996	378	224	84,600	-155
1997	404	265	107,000	-202
1998	450	288	129,000	-220
1999	478	270	129,000	-240
2000	478	299	145,000	-245
Total			**770,200**	

(*: the fish production of Tuyen Quang town)

Major investment – water sources

The main water sources is the Lo River and to a less extend some other small reservoirs (less than 100 ha).

Cage culture is practiced in open aquaculture system with the level of water exchange depending mainly on water velocity and the construction of the cages. There has not yet been done any environment impact assessment of cage culture, but possible negative impacts appears minor due to the low number of cages. However, the problems with fish diseases may negatively affect the environment, e.g. through transfer of pathogens and impact of chemicals used for diseases treatment.

Major investment – fish seed

The number of grass carps needed annually for stocking of the 80 cages are about 8,000-10,000 fish. Such numbers can quite easy be provided from the current hatcheries in Tuyen Quang.

Table 76 The total number of cages under the project funded by the Bank for Poor People in the period 1997 – 2000

Area	**Total**		**Years**							
	No. of cages	**Fund (million VND)**	**1997**		**1998**		**1999**		**2000**	
			No. of cages	**Fund (million VND)**	**No. of cages**	**Fund (million VND)**	**No. of cages**	**Fund (million VND)**	**No. of cages**	**Fund (million VND)**
Tuyen Quang town	171	474.5	111	310.5	24	74			36	90
Yen Son	116	450	-	-	50	190	50	190	16	70
Son Duong	15	39.5			15	39.5				
Ham Yen	47	127	47	127						
Chiem hoa	12	29		12	29					
Na hang	5	20			5	20				
Total	**366**	**1,140**	**158**	**437.5**	**106**	**352.5**	**50**	**190**	**52**	**160**

Other fish species (*Bagarius rutilu, Spinibarbus denticulatuss*)

As mentioned above, the fingerlings of the two other commonly cultured species are mostly collected from nature. *Bagarius rutilu* and *Spinibarbus denticulatuss* are distrubuted to farmers. The fish seed is caught in nature and stocked in special ponds before they are provided to the farmers. With this practice, it will be difficult to provide sufficient number of seeds to meet the demand of the planned expansion and intensive culture.

Characteristics of seeds

Seed harvesting season of *Bagarius rutilu* and *Spinibarbus denticulatuss* is just after the rainy season around September-October. In general, fish yields are low which partly explains the slow development of aquaculture of these species. Thus, lack of fish seed is a major constraint for future development of culture of these species.

Generally, the seed of *Bagarius rutilu* and *Spinibarbus denticulatuss* are caught by local fishermen in the middle and downstream parts of the Lo and Gam river.

Due to the short time of breeding, changes of environmental condition, high fishing efforts and using of illegal fishing materials, the sources and supply of *Bagarius rutilu* and *Spinibarbus denticulatuss* are decreased. This is compared with grass carp where the fingerling can be obtained from the hatcheries making fish seed available throughout the year. Larger fish seeds are generally of better quality and have better survival rate.

Fish seed prices vary with season and species. Price of grass carp is always lower than others because it is sold at the farms. The prices of grass carp vary from 5,000-10,000 VND/fish with sizes of 15-20 cm equaling 50-100 g/fish. The prices of *Bagarius rutilu* and *Spinibarbus denticulatuss* are higher depending on sizes and season with prices up to 20,000-30,000 VND /fish at a size of 10-15 cm.

Major investment - Feeds

Feed for different fish species consist mainly of pelleted feed, home-made feed, and trash fish. Up to date, most of the households do not use commercial pellet feeds. The main feed item for grass carp and *Spinibarbus denticulatuss* are grass or different types of vegetable leaves collected from forests, rice fields and home gardens. During the dry season, the farmers use dried cassava. Feed for *Bagarius rutilu* consist mainly of small fish, worms and snails.

It is so difficult to calculate the feed price because farmers mostly collects it themselves. Based on farmer interveiws, the food conversion ratio of grass carp is around 20-30 kg grass/1 kg fish, whilst there is no similar information for *Bagarius rutilu*.

Inputs and other used resources

Farmers almost do not have other inputs (such as chemical, supplemented materials) except for feeds.

Risks

Fish diseases are the basic risks of cage culture, particularly grass carp. There are four main type of grass carp diseases:

- Body ulcerated, fish scale lost, oedema,
- “Happy died” no effect to the fish shape but bleeding inside.
- Pop eyes, haemorrhage mouth and gills.
- Gill rotten with a lot of mud.

Aeromonas bacteria is a primary disease-causing pathogen. The second most important pathogen is the group of viruses with less disease problems associated with parasites. The diseases mainly occur in the early period of the rainy season that is characterized by climatic changes and low water qualities (e.g. pollution of river water by wastewater discharge).

The following provide some basic information about the economic impact of diseases in cage culture based on information obtained from 61 households surveyed at the end of December 1994:

- Households earning money = 27/61 (44.2%)
- Breakeven households = 5/61 (8.2%)
- Incur losses households = 29/61 (49.6%)

The households that make money from this mainly because they have not experienced any major disease problems because fish diseases, water pollution and floods are the main reasons affecting to the production of the households. The conclusions are as follows:

- Low quality of fish seed (too small fish sizes and poor health conditions), high stocking densities and stocking fish before the rainy season leads to fish disease problems.

- Poor economy is also associated with limited knowledge on cage culture; inadequate fish feed and in some cases also floods.

- The densities of cages is to high in areas close to households leading to build up of fish feces and decomposition of grass and leaves on the bottom resulting in environmental pollution.

Natural risks and disasters
Flood is the most experienced disasters which can brake and drift the cages. Floods occur approximately every 5-6 years.

Market and market constraints

The market prices for harvested cage cultured fish varies depending on size, seasons and fish quality. For example, if the size of grass carp is above 2.5-3.0 kg it can be sold during Tet holiday for around 25,000-30,000VND/kg compared with a price in autumn-winter period ranging from 18,000-20,000VND/kg. Normally, prices of *Bagarius rutilu* and *Spinibarbus denticulatuss* are high because of high consumer demands. Price of *Spinibarbus denticulatus* usually varies from 90,000-100,000VND/kg, whilst price of *Bagarius rutilu* can get up to 120-140,000 VND/kg.

Annual grass carp production is around 24-30 tons with productions of *Bagarius rutilu* and *Spinibarbus denticulatus* ranging from 3-5 tons for each species. They are sold at mainly local markets. The buyers normally are restaurants and hotels which purchase fish directly from the cage owners. For grass carp, retail sellers in the local market buy fish from cage owners and sell in the market.

Social and economical issues

The contradiction with other industry to use water resources

Cage culture in reservoirs usually leads to conflicts with other water resource users, e.g. farmers using water for irrigation purposes. The location of cages may also lead to conflicts with the transport sector and the construction sector (exploitation of sand). In particular the exploitation of sand seems to cause environmental pollution mainly during the dry season. Several households have complained in writing asking the authorities for stopping the exploitation of sand.

Investment and investment rate

The provincial project (1994-1997) anticipated that each household would borrow 2.0-2.5 million VND for investment in cage aquaculture. In the period from 1997-2000, it was planned that each farmer would borrow up to 9-11 million VND. However, the actual average borrowing rate in 1997-2000 for a household was about 3 million VND.

This project aimed to support the people living in remote areas and increase their job opportunities as well as to increase revenue and to contribute to elimination of hunger and reduction of poverty. However, the number of beneficiaries in this period did not reach the planned target because the range of different factors described above.
As mentioned above due to a reduction of credit lending and decrease in the number of cages, the economic income of participating farmers was not as planned. However, it is noted that about 30% of the households which obtained credits have continued to get revenue from cage culture.

2.6.2 Environment assessment

Sites and cage culture area

Following the regulations on cage culture activities in freshwater area, the area used for cage culture should not exceed 2% of the total water surface area and cage farms should be located at least 200 m apart. Formerly, the number of cages in Tuyen Quang was very high and quite intensive with a lot of active farmers. This caused pollution and a deterioration of water quality. Presently, the number of cages is quite low with cages being distributed along the riverside (Tuyen Quang town) not following the general regulations. The currently used sites have a high water current and only limited environmental pollution takes place.

Number of cages in reservoirs is still very low and it is therefore difficult to assess the environmental impacts of cage fish culture in reservoirs. Table 77 lists the environmental impacts elated to cage culture activities.

Table 77 Environmental impacts of cage culture

The risk to impact/ pollution	Impact objects	Impact region	Impact levels	Solutions/ Recommendations	Institution /related individual responsible
Continuous cage installed	Fish culture in cages	Cages located in downstream	Could be effect	The distant between cages: 20-25m to increase water current	Fishery Center issues the regulation and check
Feed is grass	Cultured species, benthos	River/reservoir bottom		Move the cage location	Fishery center guide the technology
Small flood to river/ reservoirs	Fish culture in cages	Rivers and reservoirs	Diseases	Fish stock after rainy season	Fishery center guide the technology, extension training

Design and construction

The materials themselves, i.e. bamboo and wood, will have little environmental impact. However, some environmental impacts may be caused by high demands for bamboo and wood

Fingerling and broodstock supply

Except grass carp, fingerlings of *Bagarius rutilu* and *Spinibarbus denticulatus* must be collected from the wild which may lead to depletion of such wild resources. One way of reducing the need for wild seed would be to artificially breed the species in question However, research is need on this.

Hatcheries systems and related issues to fish seed quality, resources:

Ministry of Fisheries have contributed together with provinces to build the hatchery centers to promote research on utilization of indigenous species for aquaculture purposes and restoration of resources. Presently, Tuyen Quang province is improving the provincial fishery center and also upgrading hatcheries to supply enough fry to meet the provincial requirements.

Water use and impacts

The presently used water resources originate from rivers and less so from reservoirs. Although river water due to its movements are preferably compared with water in reservoirs, though rivers also receive urban and industrial waste waters. So far it is unknown to what extend other activities and industries affects the cage culture practices, but also to what extend cage culture may affect other activities.

Residue, waste and impacts

The current number of operating cages is low and little environmental impact can be expected. However, this is likely to change if more cage culture farms are established as planned. There are no efficient methods to improve the environment or control of residue of fishes in cages. However, farmers often use different simple means of preventing influx of wastes in cages and inform each other on how to prevent disease in their cages.

Feed and feeding regime

The feed for grass carp and *Spinibarbus denticulatuss* is grass, leaves, and dried–chopped cassava. *Bagarius rutilu* needs snails, prawn, crabs chopped in small pieces or worms collected along the river. The residues of grass or leaves are usually collected after feeding for later use as feed. In general, feed residues consist of grass, leaves, and other waste that fish cannot digest. Farmers rarely use chemicals. Normally, fish is fed only once daily in the afternoon. The amount of grass/leaves/others to be fed is based on farmers experiences. Farmers usually stock similar species and seed densities of fish in cages.

Disease problems and health management

Actually, fish disease usually occurs to fish cages, particularly the cages of grass carp in the early part of the rainy season just after stocking the fingerlings. There are a lot of heavy rains to wash away the residue on land to the river. This causes a change in many environmental factors. Bacteria and viruses are the disease agents mainly causing epidemic disease in grass carp. Haemorraghic disease may occur in grass carp caused by Grasscarp reovirus and may be associated with up to 70-100% mortalities for the fry and 40-50% mortalities for marketable fish. Ulcers are often caused by *Aeromonas hydrophila* with mortality rates around 40-50% for all fish sizes. Parasites (mainly lice) occur less frequent but can cause mortalities although less rare than disease caused by bacteria and viruses. Disease outbreaks are quite common in grass carp cage culture and have been a major factor for the reduction of numbers of operating grass carp farmers. This is illustrated by disease episodes in 1998-2000 when 67% households involved in cage culture in Tuyen Quang provinces (over 400 cages) did partial or completely stop operation.

For the *Bagarius rutilu* and *Spinibarbus denticulatuss* group, fish disease is not a problem because the number of cages is not much and stocking density is low.

Food safety and quality

Chemicals are rarely used to treat cage cultured fish and few if any problems can be expected with accumulation of such chemicals. The occurrence of fishborne zoonotic parasites in cage cultured fish is unknown. These parasites represent a real risk to food safety and human health and their distribution on cage cultured fish should be assessed. Overall, there is little to argue that food safety should be of higher importance in cage culture fish compared to other types of cultured fish.

Economy and social issues

As mentioned there are conflicts between community groups, esp. those exploiting sand in the river and farmers engaging in cage culture. Such conflicts may be solved with the intervention the authorities and setting up arrangements of divisions of season and areas of sand exploitation and region of cage culture.

For the transportation, there will have some conflicts if the number of cages increasing and block the river. It is therefore needed to make plan and move cages into reservoir to avoid the conflicts between stakeholders.

Market issues

Market issues are currently not a problem as the volume of fish produced in cage culture is low and basically only meet the local market needs. It is needed to develop a market strategy if cage fish culture is to be expanded . Tuyen Quang is on the national road No. 2 and located only 160km far from Hanoi. Therefore, Hanoi will be an important market for fish product of cage culture in Tuyen Quang. On the other hand, the aquaculture development plan focuses on diversified cultured species to meet Hanoi market needs or export demand. Market issues must be considered systematically and aquaculture development must be planned carefully to be able to link producers to processors and consumer.

2.6.3 Guidelines for Better Management

Selected location for cage culture

In the near future, the selected site is Na Hang reservoir, 90km far from Tuyen Quang town and the upper areas of rivers flowing through Tuyen Quang. The number of cages in the reservoir is planned to reach 60-70% of total cages whilst the number of cages along the river is to be reduced and stabilized at 30-40%.

Three species will be cultured including *Bagarius rutilu*, *Hemibagrus guttatus* and tilapia. *Bagarius rutilu*, *Hemibagrus guttatus* will provide 100 tons of fish production to meet the demand of Hanoi market. These two species will be cultured in the upstream and section of Lo River flowing through Tuyen Quang town. Tilapia will increase the fish production up to 1,000 tons and will be cultured mainly in the reservoir.

Design and construct the fish culture area in order to minimize the environment impacts

The fish culture area in Na Hang reservoir will be planned in the downstream, 500-600m of the distant to the bank, 30-50m depths to the intensive fish culture area The system of cages here are net cages with the groups of 40-50 cages each (each cage capacity is 1000-1500m^3). The distant between cages should be 200m in order to not obstacle to implementation procedures, safety for transportation and prevention of fish diseases.

For Tuyen Quang town, there is a need to make the wooden cages with every 10 cages for a group and 10-15m distant of parallel located in order to be better exchange water.

Fingerling and broodstock supply

Fingerling of the 3 species will be produced at the hatcheries of provincial fishery center and other 02 provincial hatcheries. Actually, RIA1 already have had broodstock of three species. The research results of breeding technologies on tilapia and *Bagarius rutilu* were successful. The research on *Hemibagrus guttatus* is on-going project and hopefully it will be successful in the future. RIA1 technology needs to transfer to provincial level.

Feed and feeding regime

Feed for tilapia is very popular in Viet Nam and will be introduced to fish culture area to reduce the risks of water quality pollution and to increase the stability of aquaculture activities.

Bagarius rutilu and *Hemibagrus guttatus* can temporary use the feed of marine fish species. In the future, it is a must to carry out research on feed use efficiency. Feeding regime and management can follow the procedure of marine culture.

Health Care Management Plan

Implement environment and fish disease warning system for the fish culture area.
Establish a mechanism for the coordination of group of households or farmers to manage fish culture area.
Apply participatory method in farming management.
Investigate other technological solutions to improve the environment conditions in cage culture of fish.

Food quality and security

Control carefully the culture environment and feed during fish culture period.
Regularly supervise the disease occurring in the area.
Determine the potential factor of pollution, disease agents to eliminate.

Economy and Social issues

Identify model and organize production activities to have economic efficiency.
Calculate the inputs; create the services plan and provide inputs such as seed, feed, chemical.

Market and needs

Assess the needs of market about product types, quality and quantity of goods, consumers.
Propose the production project and consume products following market needs.

Institution and Policy

Build and strengthen the hatcheries, fishery centers, environmental and fish disease warning centers. These organizations need to join in the discussion period with the farmers in order to cooperate closely with them. These organizations also have the responsibilities to support farmers to implement the technology process.

2.7. Coastal mollusk farming

2.7.1 System description

Brief overview

Coastal mollusk culture started early in Viet Nam as the species are available in the wild at the tidal flats stretched from the north to the south coastal provinces. This culture practice was implemented in Viet Nam since the early 1970s in Ben Tre province after which the system was transferred to Tien Giang in 1987 and Tra Vinh in 1995. In Nam Dinh province, the mollusk cultured was introduced in 1990s but it faced with high natural risk and low prices. Up to 7 to 8 years ago when there was trading expansion between Viet Nam and China and high demand of the mollusk of Chinese market, farmers were more attracted to the business.

At present, mollusk production has reached 114,570 tons (MOFI, 2005d) and 118,945 tons (MOFI, 2004a), in which 95% of total production is clam. In recent years, the Ben Tre clam seeds have been experimentally stocked in Thai Binh and Nam Dinh with good results.

Clam is a new commercial commodity in Viet Nam and is the highest value commodity in the exported mollusk group. It is produced mainly in Ben Tre (Ngheu Ben Tre - *Meretrix lyrata* (Sowerby, 1851)) consisting of 90%. The rest production is local clams (Ngao dau-*Meretrix meretrix* Linnd, 1758). Before 1980, clam was collected from the nature with total production of 300-400 tons/year and increased to 700/800 tons/year in 1982-1986.

There are three native culture clams species in Viet Nam, The species 'cultured' are Meretrix meretrix both in south and north, *M. lusoria* only in north, while M. lyrata is only natural distributed in the south. The name and main culture area of these species present in Table 78.

Table 78 Name and distributed area of culture clams species

Viet Namese name	English name	Scientific name	Culture areas
Ngheu Ben Tre	Hard Clam	Meretrix lyrata (Sowerby, 1851)	Ben Tre, Tra Vinh, Tien Giang, , Soc Trang
Ngao dau or ngao vạng	Asiatic Hard Clam	Meretrix meretrix Linnd, 1758	Nghe An, Thanh Hoa, Thai Binh, Nam Dinh, Ben Tre, Tien Giang.
Ngao Vân	Poker Chip Venus	Meretrix lusoria (Roding, 1798)	Nghe An

		
Ngheu Ben Tre - Hard Clam	Ngao dau - Asiatic Hard Clam	Ngao van- Poker Chip Venus

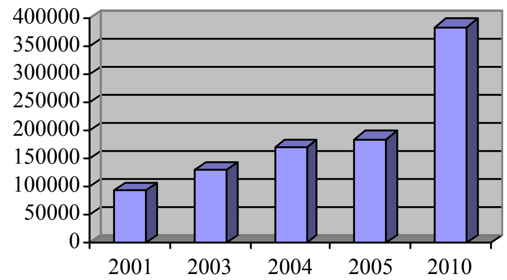
At the beginning of clams farming in Nam Dinh province, the province used only local Asiatic Hard Clam. In 1998 the Hard Clam (Ngeu Ben tre) was experimental cultured in this area. This clam species is rapidly adapted with local environmental condition. In recently years, Hard Clam production is distributed up to 90% of total clams production in Nam Dinh province.

According to Nam Dinh provincial statistical data, the present status of clam culture area about 700 ha of which 450 and 250 ha in Giao Thuy and Nghia Hung districts, respectively. The total production of clams has reported to be 10,500 tons in 2005. Average productivity is about 15 tons/ha/year. Although, clams culture area limited, the production is still increasing year by year.

Development Plans

Master plan of aquaculture development indicates the plan for clam production to 2010 as follow figure:

Figure 41 The clams production (ton/year)



Source: Annual report of 2003 and 2004, Aquaculture Department, Ministry of Fisheries and Orientation for Viet Nam Aquaculture Development up to 2010 year.

The real production was nearly 64% of target production of 180,000 tons in 2005.

Location of Production & Development Plans

The major clam culturing provinces in Viet Nam are showed below

Table 79 Clam framing location in Viet Nam

Provinces	*Area*	*Production*
Total	**12,417**	**118,945**
Part 1+2	**3,420**	**21,677**
Quang Ninh	1,300	5,500
Hai Phong	620	1,077
Thai Binh	800	6,100
Nam Dinh	700	9,000
Part 3.	**596**	**6,110**
Thanh Hoa	500	3,105
Nghe An	60	1,000
Ha Tinh		1,800
Thua Thien - Hue	36	205
Part 4.	**40**	**1,834**
Da Nang	3	4
Binh Dinh	30	35
Khanh Hoa		1,780
Ninh Thuan	7	15
Part 5.	**700**	**22,000**
Ho Chi Minh	700	22,000
Part 6.	**7,661**	**67,324**
Tien Giang	2,150	17,000
Ben Tre	4,075	42,012
Tra Vinh	1,000	5,000
Bac Lieu	276	2,157
Kien Giang	160	1,155

Source: MOFI Annual report,2004

Among those coastal provinces, there are two provinces with highest production including Nam Dinh province in the North with production of 9,000 tons and Ben Tre in the South with the production of 42,012 tons.

There are two other coastal districts in the north nearby Nam Dinh. However, the intertidal areas that suitable for clams farming are distributed in Giao Thuy and Nghia Hung with about of 700 ha. The production target for clams culture of Nam Dinh province in 2005 is 9,500 tons. As mention above, total production of clams in 2005 was up to 10,500 tons. The reasons are: (1) high stocking density due to natural clams seed is available in 2004; (2) Natural conditions in term of temperature, salinity of sea water, rainfall etc are suitable for clam grow-out.

Farming System Design & Production Performance

Clams culture is suitable on sand flats in the intertidal zone with sunlight exposure less than 8 hours per day. It should be noted that the species can be grown in the non-intertidal zone but this will have implication on the quality of the product and it is required that clams are moved to the intertidal zone for a period of time prior to harvest.

The species need a fine sand (70-90%) substrate. It must be noted that they cannot survive in a mud substrate or in standing water but requires a continuously current.

In Nam Dinh, the substrates are typically chosen based on already existing (natural) clam beds. Culture beds are typically located near the river mouths with a small inclination and weak wave action thus reducing risk of moving the clams to other areas, especially when they are small. The area used is typically the lower and middle parts of the tidal flat.

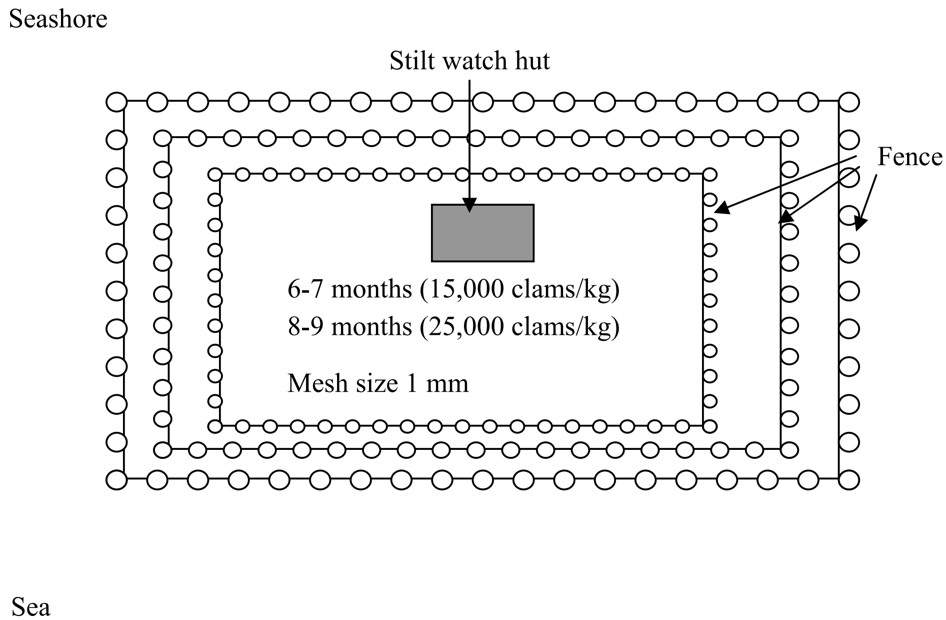
Clams farming design system is simple. Bamboo/wood stakes and nylon net to prevent clams escaping away enclose the culture bed areas (see picture).

There are two stages of clam culture including nursery and grow out. Following is the typical design of clam farm:

Nursery system

In the nursery phase 2-3 fences surrounds each other in order to prevent the clam seed from escaping. When the seed are stocked at high densities they tend to excrete a fluid which attaches a buoyant string to their shell and the current, waves and wind may move them by this practices. Hence, a fine mesh size is needed. A secondary effect of the fence is the buoyant string upon contact with the fine nylon mesh, sticks to the net and the string breaks of the clam shell hindering this from moving further. When clams become bigger (in the grow-out system) they can no longer be moved by this action and therefore only one fence is needed. The fences are approximately 30 cm height and are inundated during high tide. A stilt hut is placed in the middle of the culture area in order to allow the farmer observe and protect the clam.

Figure 42 Design of the hard-clam nursery system



Grow-out system

The grow-out system is somewhat larger than the nursery system. This system only has a single fence and only in the direction of the wind, wave and current. This is to prevent clam seed to be carried away. Like the nursery system the fence is only around 30 cm in height. There is a stilt hut to allow the farmer to observe the culture area. The grow-out farm is located further from the seashore than the nursery farm. The fence is buried a few cm into the sand sediment.

Figure 43 Design of the hard-clam grow-out system

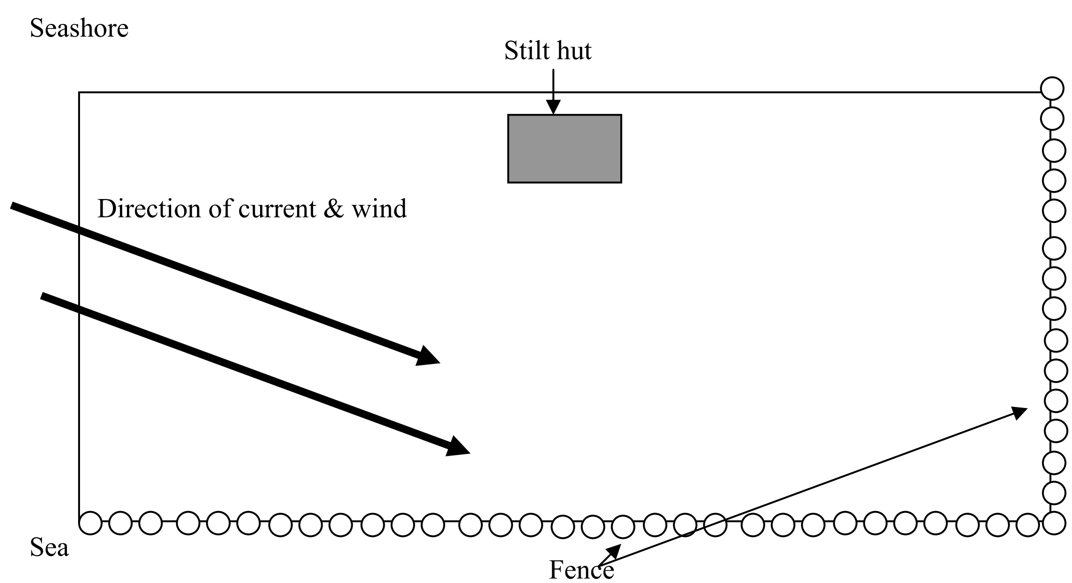


Table 80 Aquaculture Equipment Grow-out System

Equipment	Cost
Stilt house/hut	1,000,000 vnd/hut
Fine nylon mesh fence	5,000,000 vnd/ha

Hard Clam spat is collected from the natural ecosystem and stocked between July to August in nursery systems in Ben Tre province. Some farms do not have nursery systems but buy the larger clam seed from nursery systems after 6-7 month nursery grow-out.

Stocking density is about fluctuates 750-13,000 seed/m2 depending on the investment ability of farmer and seed availability.

Usually, clams seed are stocked in natural breeding season from May to at the end of July in Nam Dinh Province. During the culture period, the clams tend to move/be moved from higher elevation to the lower. In order to improve survival rate and growth rate monitoring of density, thinning and re-stocking to low-density areas are carried out regularly.

The often-used densities for clams in the north are: If size is 3,000-6,000 seed/kg (0.5-1.0 mm) the density of 'sowing' is 300-500 seed/m^2 (600-750 kg/ha); and if size is 2,000-3,000 seed/kg (3.0-8.5 mm), density is 200-250 clams/m^2 (600-700 kg/ha).

The culture period depends on the locality, the seed size and the market size targeted and varies from 6 to 30 months. Clam culture period in general (in the north) will be 18 months if stocking seed of 5,000-7,000 pieces/kg, 12 months if stocking 3,000-4,000 pieces/kg, 8 months if stocking 1,000 pieces/kg and 6 months if stocking 300-400 pieces/kg.

The clams are harvested year around when having the sizes of 30 to 70 pieces/kg. In Nam Dinh clams are graded into three sizes: 30-40 pieces/kg, 40-50 pieces/kg and 50-70 pieces/kg.

Productivity is depending on the biotic conditions and the seeding density. In well-managed, farms a clam yield from 15-20 tons/ha is achieved. Even 33 tons/ha has been reported, but likewise also sometimes yields are down at 4 tons/ha.

Table 81 Main production performance parameters for clam production in North Viet Nam (information is based on SUMA, 2004)

	40 tons productivity	30 tons productivity	20 tons productivity	
Farm area	10,000	10,000	10,000	***m2***
Water area	10,000	10,000	10,000	***m2***
Stocking density per crop (indv./m2)	700	700	700	***seed/m2***
Seed size per kg	3,000	3,000	3,000	***seed/kg***
Seed size	0.3	0.3	0.3	***g/seed stocked***
Total stocked seed per ha	10,200,000	10,200,000	10,200,000	***seed/ha/crop***
Total stocked biomass of clam seed	3,400	3,400	3,400	***kg/ha/crop***
Grow-out production period	12	12	12	***months/crop***
Average harvest size	45	45	45	***cockle/kg***
Average harvest size	22.2	22.2	22.2	***g/seed harvested***
Harvest yield (kg/ha/crop)	40,000	30,000	20,000	***kg/ha/crop***
Annual harvest yield per ha (kg/ha/year)	40,000	30,000	20,000	***kg/ha/year***
Harvested individuals per crop	1,800,000	1,350,000	900,000	***cockle/ha/crop***
Survival rate per crop (%)	18	13	9	***%***

40 tons clam/ha/yr have been reported as the average productivity in a 2005 survey of clam culture in Northern Viet Nam. However the variation in collected data was rather high and therefore performance indicators are also calculated for productivity of 20-30 tons clam/ha/yr (Table 81). It is clear from the table that survival rates are low and there would be amber opportunity to improve this in order to increase the efficiency of seed input in the production chain.

Major inputs - Water use

Clam culture areas are usually located at intertidal flats along the coastline and near the river mouths. Water used for clams farming is depending on the natural condition. There are some water and sediment sampling sites of monitoring under MONRE in Red river mouth, these monitoring are not designed for clam culture.

Major inputs - seed supply

Regarding to clams seed produce, there will be 10 hatcheries for mollusk producing to 2010. At present clams seed are manly collected from nature. In general, natural clam seed production is enough for local demand in Nam Dinh province; especially in 2003 clam seeds were transfer to other provinces. The clam seed prices in 2005 are as below

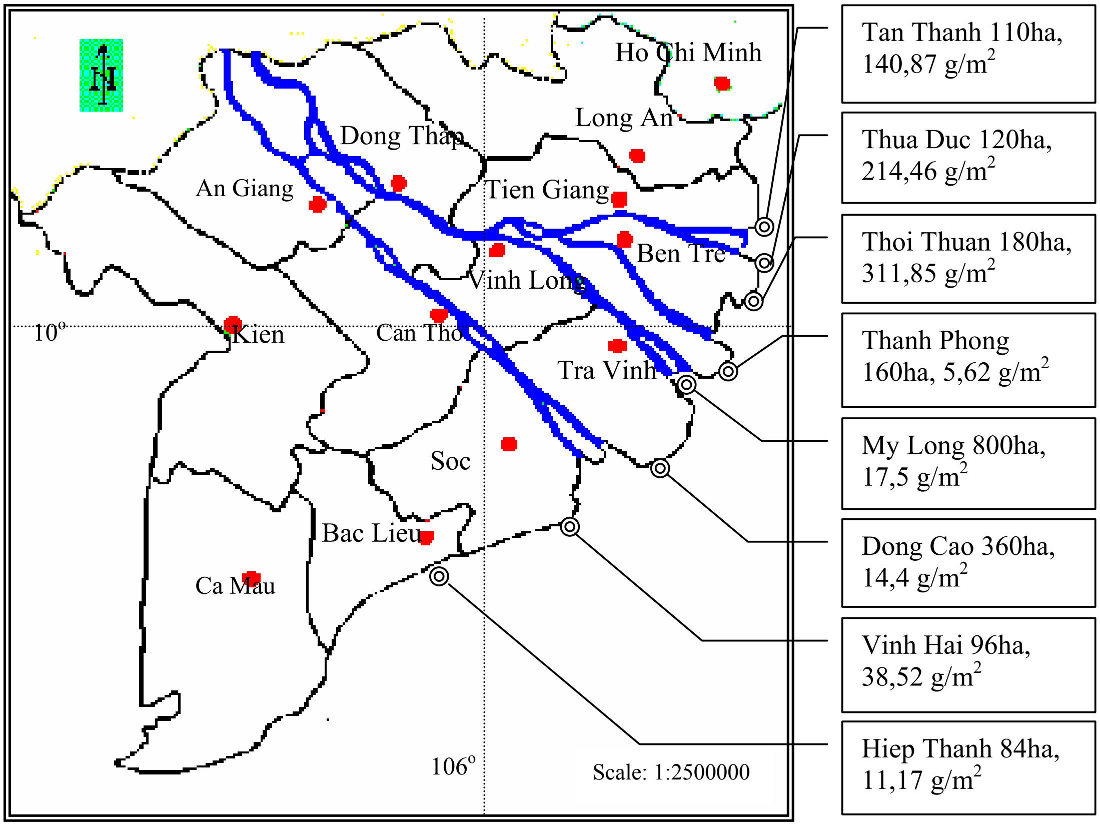
Table 82 Major input of clam culture – seed price

Clams seed size (piece/ kg)	Price (VND 1,000/kg)
150,000	1,200-1,500
3,000	50
800-1,000	36
100-300	12

Source: Survey data, 2006

In Ben Tre province, seed will have to be collected and bought on site of Ben Tre and neighboring provinces where the spawning season is from April to June (Tien Giang) and July to August further south on the coastline (see Figure 44).

Figure 44 Clam seed density along the East coast of the Lower Mekong Delta, Viet Nam. Data was collected from October 1995



Major inputs - feeds and feed management

Basically, clams culture use natural food. Clams culture areas in Nam Dinh province connect with three rivers namely Day, Vop and Ninh Co. Ben Tre provinces is located at the Mekong river mouth. These are all good nutrients and suspended solids sources to develop natural food.

- Clams mainly filtrate the water for particulate organic matter (POM) and to a less extend phytoplankton, which are less abundant in the water body due to the high turbidity.
- There are no feed inputs and clam culture removes and bind nitrogen from the ecosystem
- It should be noted that approximate 23 kg N can theoretically be bound in clam protein/ha/yr

Other inputs/resource use

The other inputs, though these are major input as well, consists of some equipment and construction cost as below:

Hard Clam culture in Ben Tre:

Table 83 Aquaculture Equipment Grow-out System

Equipment	Cost
Stilt house/hut	1,000,000 vnd/hut
Fine nylon mesh fence	5,000,000 vnd/ha

For clams farming in Nam Dinh Province

- Construction (bamboo\wood, net, guard house etc) 40- 50 VND million per ha
- Preparation of culture beds: 30- 40 VND million per ha
- Land tax: 4 VND million per ha
- Labor cost for harvesting: 350 000 VND per 1 ton

Risks

Clams farming depends very much on environmental conditions. The risks of clams culture activity may cause by typhoon, water fluctuations such as salinity, temperature etc. For example, about 5,000 tons red clam seed died in May 2003 in Tien Hai district, Thai Binh Province. High salinity and stocking density may cause this problem (Viet Namnet, 2003).

Seed cost is by far the highest input cost in clam production. Since no additional feed is given, the sensitivity analysis is merely conducted for an increase in seed costs. Given a productivity of 40 tons clam/ha/yr the production systems will still be economically viable at an increase of seed cost of 30% (see 81). However, if the productivity drops to 30 tons clam/ha/yr break-even will be around a 20% seed cost increase. The 20 tons clam/ha/yr is not economically viable given the baseline information.

If productivity can be stabilized around 40 tons clam/ha/yr and there is an amble supply of seed available, the system is regarded to be a good business opportunity. However, if there is doubt about the availability and quality of seed which may lead to increased production costs or if the productivity is reduced due to disease outbreaks, the system is not regarded to be very resilient an thus it would not be economically viable.

Optimal siting will be essential in order to ensure that there is a good supply of feed naturally available in order to reach the high productivities.

Table 84 Sensitivity analysis of clam culture in North Viet Nam 2006 subjected to seed price increase. The table illustrates single a externality's impact upon Annual Net Profit i.e. seed cost

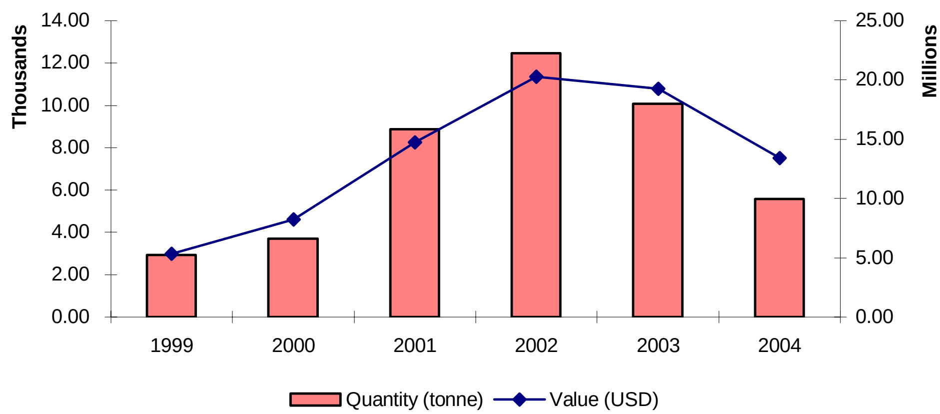
Single Externality Scenarios				
Baseline	**40 ton yield**	**30 ton yield**	**20 ton yield**	**Unit**
Annual Net Profit (ANP)	115,200	35,950	-43,300	**'000 vnd/ha/year*
10% Seed Cost Increase				**Unit**
Annual Net Profit (ANP)	98,200	18,950	-60,300	**'000 vnd/ha/year*
Percentage impact ANP	-15%	-47%	-39%	
20% Seed Cost Increase				**Unit**
Annual Net Profit (ANP)	81,200	1,950	-77,300	**'000 vnd/ha/year*
Percentage impact ANP	-30%	-95%	-79%	
30% Seed Cost Increase				**Unit**
Annual Net Profit (ANP)	64,200	-15,050	-94,300	*'000 vnd/ha/year
Percentage impact ANP	-44%	-142%	-118%	

Markets and market chains

- Export value and markets

Clam is no longer a supplemental food for people in the coastal areas of Tien Giang, Ben Tra, Tra Vinh, Soc Trang and Ca Mau but becomes a potential export commodity with total export quantity of 2000-3000 tones/year[18] since 1999. There are 4 provinces with largest amount of export including Ho Chi Minh city, Tien Giang, Ben Tre and Kien Giang. The total export quantity was about 200,000 tones/year. The export value increased from 5.3 million tones in 1999 to the peak of 12,458 tones (equal to $20 million) in 2002. The frozen clam meat export of Viet Nam has increased by 50% in quantity and 63% in value compared with 2000 (MOFI, 2006c).

Figure 45 Viet Nam's clam export



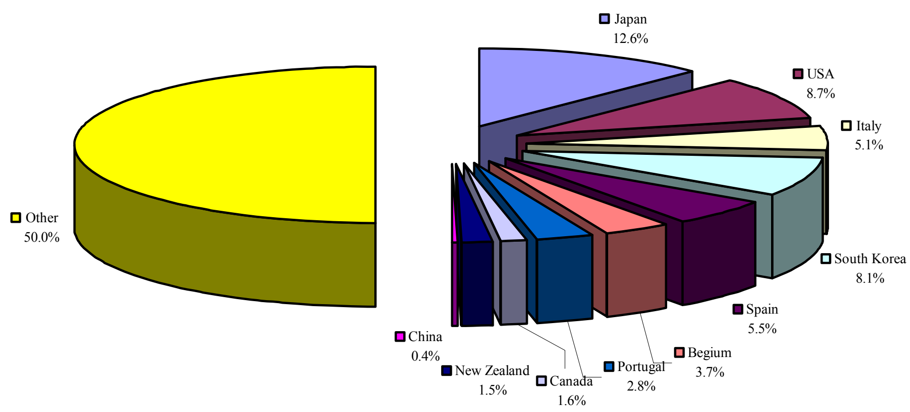
Data source: Viet Namese Custom Statistics

Viet Namese clam products has been exported to more than 10 countries and territories. The biggest market is Japan as this is one of Japanese traditional food. Besides, in the Asia, clam products have some other consumers like South Korea, China, Taiwan, Hong Kong and Thailand. Though the official data show a modest value of export to China but the actual amount is much larger since most of the clam export to China goes through unofficial way (Thanh, RIA1). It is predicted that there will be favorable and stable market growth for this commodity, especially Japan, the US and some other Asian countries like South Korea and China (MOFI, 2006c).

Like shrimp and catfish, there is also an effort to develop a brand for the Viet Namese clam. Ben Tre – the largest clam area – has promoted "Ngheu Ben Tre"[19] commercial brand. Initial steps have been implemented successfully. This is a great progress to introduce Ben Tre clam products to international market in the near future.

[18] http://www.binhthuan.gov.vn/khtt/nongnghiep/ngunghiep/Motsoloaica
[19] See more at www.bentre.gov.vn

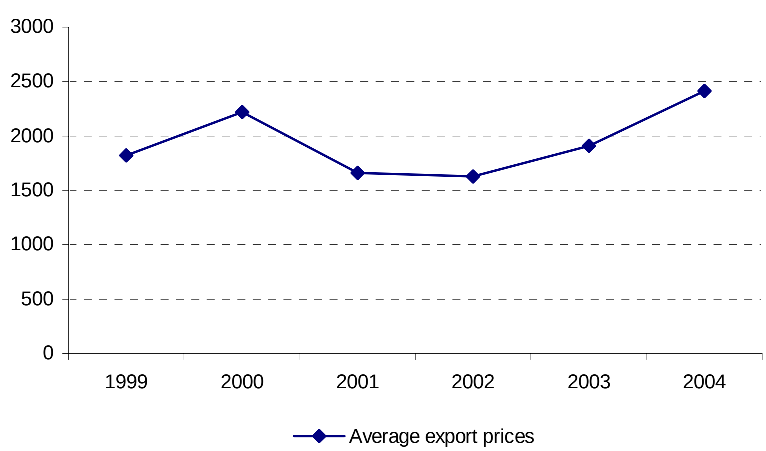
Figure 46 Market share of Viet Namese clam (2004)



Data source: Viet Namese Custom Statistics

Together with the high increase in market share, the prices of clam also enjoy a progressing trend. In 2002 when Viet Nam started to export clam, the price of frozen clam meat was about USD 1,800-1,900/tonne. The price in the end of 2005 was about USD 3,200-3,500/tonne (Ha, 2005).

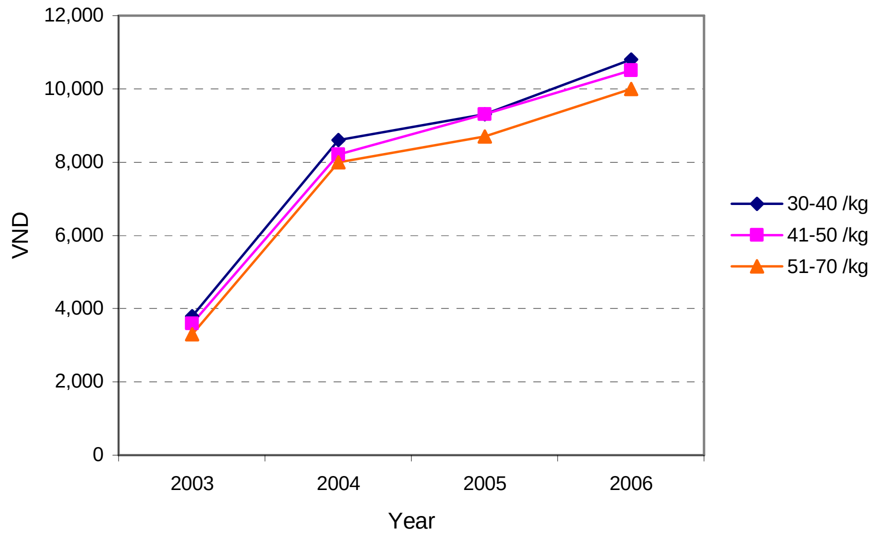
Figure 47 Average export price of clam



Data source: Viet Namese Custom Statistics

The farm-gate prices also stayed a high level in recent years. Before, the price was only VND 2,000-3,000/kilo, but now, the prices always stay at over VND 10,000-11,000/kilo. The supply however is always lower than demand of the markets (Thanh, RIA1). This is a great potential for producers to open their culturing areas.

Figure 48 Average farm-gate price of marketable clams by market sizes

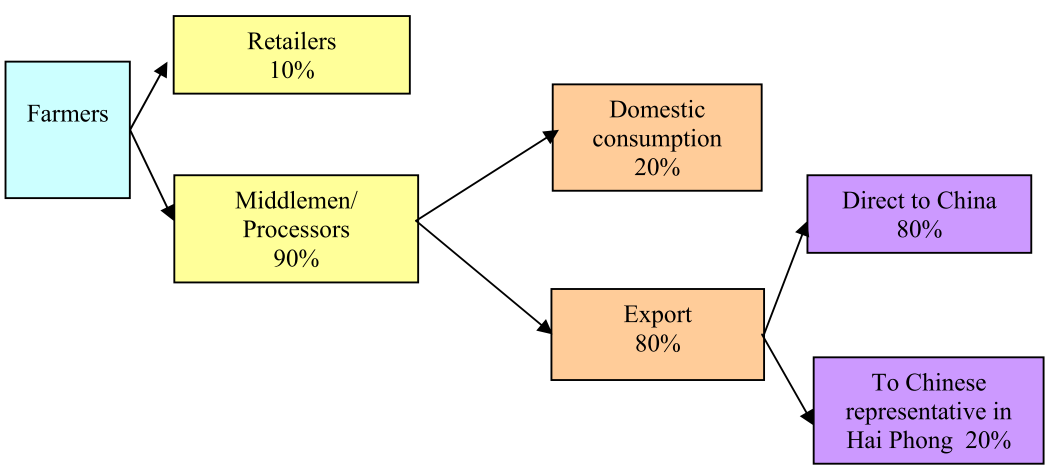


Source: Thanh (RIA1)

- Market chain

Below is an example of the clam market chain in Nam Dinh, one of the clam areas of Viet Nam. Most of the products here, after processing, goes to China. This is explained by the fact that compared with other provinces, Nam Dinh is close to China – the biggest market in the world for clam consumption.

Figure 49 Claim market chain (Nam Dinh province)



Source: Thanh, RIA1

In the market chain, the difference between the farm-gate and processor/wholesaler price is about VND 200/kilo. Similar is the difference between processor and importer. The domestic end-consumer (for example in Da Nang) pays VND 1,000 higher than the processor's prices. (Clam price in Nam Dinh, Thanh RIA1).

Socio - economics

In general it is difficult for poor households to engage in clam culture, mainly due to the high investment requirement (Table 85). Poor households are typically hired as manual labour during the harvest periods which is very labour intensive. They can involve in this activity in term of seasonally work during harvesting times with about 200 man days/ha (SUMA, 2005). In the clam harvesting season a laborer can earn 70-80,000 VND per day or 350 VND thousands per 1 ton clams (Thanh, 2006).

Table 85 Investment for grow-out clams

Unit: 1000 VND/ha/crop

Item	Mean	Min	Max
Capital cost	44,291	2,600	200,000
Fix cost	77,454	7,849	329,300
Available cost	145,829	26,000	345,000
Total input	223,283	46,541	631,300
Total output	332,409	18,000	850,000
Profit	109,126	2,579	518,325

Source: SUMA, 2005

Table 86 Labour indicators for clam production in North Viet Nam assuming one crop per year

LABOUR INDICATORS	40 tons productivity	30 tons productivity	20 tons productivity	Units
JOB INDICATORS				
Annual man-power requirement (labour/ha/year)	2.6	2.1	1.6	*labour/ha/year*
Annual fixed man-power	0.5	0.5	0.5	*labour/ha/year*
Annual variable man-power	2.0	1.5	1.0	*labour/ha/year*
Investment per job	17,042	21,228	28,139	*´000 vnd/ha/year*

* Capital costs are used as the sole basis for comparing investments

Clam production is quite labour intensive producing around 2.5 jobs/ha/yr (see Table 86). The majority of the labour is seasonal and is required at harvest. It is mainly the landless and poorest within or around the community which are hired to harvest the clam and it provides an important income opportunity for such groups. The culture practice requires little skill and the main fixed labour input is required to maintain the perimeter fence as well as guard the crop.

Assuming production can be stabilized around 40 tons clams/ha/yr the system is able to generate a net profit of around 115 mill vnd/ha/yr (Table 87). The benefit-cost ratio is acceptable at 0.6 which leaves a fair buffering in case of changes in seed costs or farm gate value. However, if the productivity drops below 30 tons clams/ha/yr the system looses it buffer and become very vulnerable to externality impacts. Hence, it is very important that production is stabilized which will require special attention to siting production in areas with optimal culture condition and ensure that Best-Management-Practices are followed. It is suggested that the survival rate of stocked clams may be increased if clams are stocked in enclosed nurseries before being dispersed in the grow-out enclosures.

Table 87 Economic performance indicators for clam production in North Viet Nam assuming 1 crop per year. TVC= Total variable costs; TFC=Total fixed costs; NR=Net Profit; TOC=Total operating costs; CC=Capital Costs

ECONOMIC INDICATORS	40 tons productivity	30 tons productivity	20 tons productivity	Units
Net profit/ha/yr	115,200	35,950	-43,300	*´000 vnd/ha/year*
Gross revenue (calculated using FGV)	333,800	250,350	166,900	*´000 vnd/ha/year*
Total operating costs (TVC+TFC)	191,800	187,600	183,400	*´000 vnd/ha/year*
Value added (Net profit+labour costs)	135,000	51,550	-31,900	*´000 vnd/ha/year*

Cost/Benefit (NR/TOC)	0.60	0.19	(0.24)	
Tax	4,000	4,000	4,000	***´000 vnd/ha/year***
Minimum start-up costs (TOC+CC)	262,600	258,400	254,200	***´000 vnd/ha/year***

Minimum start-up costs are high mainly due to the high cost of seed. If high quality seed can be produced in hatcheries it is likely that the price will be reduced as has been observed for other species cultured in Viet Nam i.e. tiger shrimp. The investment needs are considered to be too high for poor households to engage in this type of culture other than providing seasonal manual harvest labour.

2.7.2 Environmental Assessment

From an environmental point of view clam culture can be regarded as a 'clean production' system. The high productivity will remove nutrients indirectly from the aquatic ecosystem by filter feeding on algae (which directly uptakes nutrients via photosynthesis). This poses a restriction for the expansion of clam culture in nutrient deficient environments. However, in many of the Viet Namese coastal regions suitable for clam culture high polluting aquaculture is also being conducted. This ensures a continuous supply of nutrients providing good culture conditions for clam culture. In certain areas clam/mollusc culture main even be promoted in order to reduce the negative impact of nutrients from i.e. shrimp or lobster culture. This will reduce the risk of eutrophication and development of toxic algae blooms which is a major food safety issue in clam culture. Thorough environmental production assessments must be made prior to designing development plans for this type of aquaculture in coastal areas.

Mussels, clams and cockles can also be culture in nutrient rich ponds and have good potential for removing nutrients from a shrimp pond between crops. In addition some of the nutrient rich solid waste from shrimp culture may be used as fertiliser to create algae blooms with in the pond environmental. This will reduce the amount of waste produced during shrimp culture and may be able increase the pond life-span by reducing the nutrient loading on this.

Table 88 Key nutrient uptake potential for clam culture in North Viet Nam calculated on the basis of the protein content in clams. This is a very conservative estimate since metabolic functions are not included.

ENVIRONMENTAL INDICATORS	**40 tons productivity**	**30 tons productivity**	**20 tons productivity**	**Units**
Aquatic pollution				
Nitrogen uptake (mangrove/aquaculture)	48.1	36.1	24.0	***kg/ha/year***
Phosphorous uptake (mangrove/aquaculture)	6.0	4.5	3.0	***kg/ha/year***
Solid waste uptake	568.2	426.1	284.1	***kg/ha/year***

Location and farm siting

The clam culture beds are typically chosen based on already existing (natural) clam beds in both grow-out and natural seed collecting in almost culture areas. However, this farming impact to local clam development. In case of clam culture in Nam Dinh Province, local clam resources are declining tendency when Hard Clam (import from Ben Tre) production predominated.

Design and construction

Bamboo/wood stakes and nylon net enclose the culture bed can be an obstacle to clams post-larva moving to existing (natural) nursing clam beds. This is caused of natural seed production reducing in some areas when culture site expended.

Seed supply broodstock & post larvae

Since clam seed are not evenly distributed by nature in every province, farmers often have to buy them from other provinces. The seed availability is one of the major constraints for the farming. In the south seed of clam mainly comes from Ben Tre and Tien Giang in sizes varying from 500 to 100,000 pieces per kg. In the north natural seed of clam is available in Nam Dinh province.

To overcome the constraint in lack of seed supply some local governments have applied management measures on their seed beds. The natural clam seed bed management in Thoi Thuan commune, Binh Dai district of Ben Tre province is an example: The natural seed bed is managed by a local cooperative and seeds only harvested when they reach the size of 5,000 pcs/kg or bigger. A salary will be paid for labour, security guard and administrative board. Thereafter the rest of the income is spent as follow: 39% will be paid for different type of taxes. The remaining 61% is split by 20% going to a local government fund and the other 80% will be equally divided to local people. Due to this management method, seed production has increased remarkably a. In 2002, seed price at the size of 5,000 pcs/kg was 19,000 VND/kg.

Water use and impact

Discharging freshwater from rivers directly impact to mollusk farming including clams in term of providing nutritional sources and reducing salinity. In the last few years, Vop river flows are impeded by shrimp farming construction along this river.

Presently, water quality are not be influenced by industrial sectors, agriculture, urban development, hatcheries, tourist, etc due to these activities are not developed in near by the clams culture sites in Nam Dinh province.

Waste and impacts

Clams farming systems do not released waste to environment.

Feeds and feed management

No supplemental feed for clams farming

Disease issues and health management

Till now no diseases making any major impact on farming performance have been reported in Viet Nam, but localized mortalities have occurred and often are attributed to sudden changes in abiotic conditions such as salinity drop.

Food safety and quality

To attain export permit of mollusk products to e.g. EU a monitoring program has to be in place, and Viet Nam is one of the few Asian countries in addition to Japan, Thailand and Republic of Korea allowed to export bivalves to EU. According to Infofish 3/2003 maybe soon also imports from Indonesia of *Meretrix* sp. will be permitted, if the Indonesians can make a mapping of the production areas, set up laboratories for phytoplankton analysis, start fortnightly phytoplankton, ASP (amnesic shellfish poisoning) and DSP (diarrheic shellfish poisoning) monitoring and draft a procedure for opening and closing of harvesting areas. The Viet Namese export to EU was closed during 1998-99 due to lack of a functioning monitoring system, but now this is in place in several main farming areas as Thai Binh, Nam Dinh, Binh Thuan, Ho Chi Minh City, Ben Tre, Tra Vinh, Kien Giang and Tien Giang provinces.

Economic and Social Issues

Till now no diseases making any major impact on farming performance have been reported in Viet Nam, but localised mortalities have occurred and often are attributed to sudden changes in a biotic condition. For example, high salinity and stocking density may be caused of about 5,000 tons red clams seed died in May 2003 in Tien Hai district, Thai Binh Province equivalent with 20 VND billions lost. Similar with this problem, a larger amount of clam seed died in early of May, 2006 in Giao Thuy district, Nam Dinh province due to high salinity. It is estimate that VND billions lost.

Market issues

Export market promotion and effort to develop band name for "Ngheu Ben Tre" has been bring the positive effects to the farmer, specially is the poor who would be involved in the clam culture. The higher prices at farm gate would encourage the farmer expanding clam culture as the production did not meet the target plan in 2005.

This is not only bringing positive impacts in term of social and economic effectiveness, but also environmental benefit in coastal aquaculture sector of Viet Nam. This commodities development would be as an alternative for poverty alleviation and livelihoods when other commodities farming would be high risk and lost.

Institutional issues

Decentralization of public management does not seem to have happened in the planning of this commodity. However, this may vary between provinces.

In Nam Dinh the Provincial Fishery Extension Centre and three extension sub-centres organize training courses and workshops.

The environmental and aquatic disease laboratory was set up in 2005 under Fisheries Resources Conservation sub-Departments in Nam Dinh Province. The laboratory monitors shrimp diseases and control water quality.

Clam farming is seen as an important sector due to employment, income generation and its environmental sustainability

The Clam culture Association in Giao Thuy district was established in May, 2006. It will start running next month. The Association is the only existing structure that contributes to enhancing farmers' knowledge about market opportunities. The Association also facilitates the farmers sharing of experiences.

At present, there are no clear set of rules for clam farming. Managers have difficulty in directing clam production according to the local aquaculture plans and farmers operate autonomously depending on their investments and access to land and water.

The facilities for management have been improved due to a new environmental and aquatic disease laboratory have been set up. The staff members in administration lack knowledge about management and specifically about control of water quality and fish disease

Summary of environmental issues of clam farming in Viet Nam

The majority of environmental and social issues connected to clam farming are related to positive environmental aspects as well as poverty alleviation potential in the coastal zones. However, using wild seed for farming is being major a concern a constraint for future development of clam culture if there is no change in seed supply model. Beside, social conflicts with regard to natural resource access in coastal zones become a concern since the legal framework is not available for land management for tidal flats.

This commodities culture has a high development potential, a high market demand together with positive impacts on social and poverty alleviation in coastal areas in Viet Nam. However, it will require better planning and management practices. Pollution of coastal water is the main threat to the sustainable development of this commodity.

Impacts	***Management practices/solutions***
Clam farming	
Impact 1. Removal of pollution in water	• Promote the clam culture as a polyculture/integrated system • Promote clam culture in treatment of effluent

Impact 2. Reduce the pollution of sediment	• Promote the clam culture as a polyculture/integrated system • Promote clam culture in treatment of effluent
Impact 3. Food safety and quality	• Better planning or zoning for clam farming avoiding polluted site of heavy metals, pesticides • Promote certification scheme for food safety • BMP for pre and post harvest
Impact 4. Impacts on livelihoods by providing sustainable incomes because of high demand	• Building hatcheries, • Building depuration center (public and private) • Researches on technology local species • Promote mollusk culture as a sustainable AIG activity in connection with Marine Protected Area and other community development strategies
Impact 4. Impacts on wild resources	• Conserve the mangrove forest and natural recruitment • Develop and disseminate hatchery technology • Promote hatchery development
Impact 5. Social conflicts among farmers	• Improving the land/water surface allocation • Promoting community-based management of resources
Impact 6. Impact on job and income generation, poverty alleviation	• Ensure workers welfare and safety • Avoid use of child labor
Impact 7. Alternative income generation for communities in poverty alleviation	• Ensure transparency in mud-flat allocation

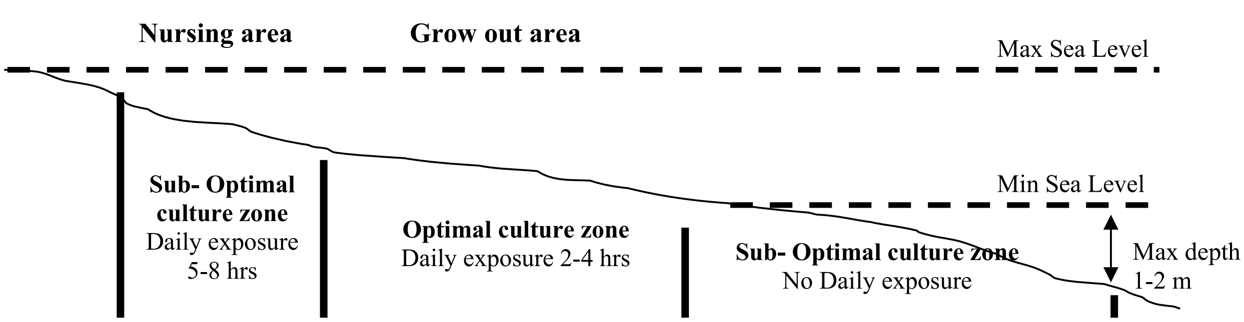
2.7.3 Guidelines for Better Management

Location of aquaculture farms

In considering the positive impacts of mollusk farming and ecological tolerance of this species, the mollusk farming should be located in a way that would be environmental sound.

Locate mollusk farms according to national planning and legal frameworks in environmentally suitable locations, making efficient use of marine water resources and in ways that conserve biodiversity, ecologically sensitive habitats and ecosystem functions, recognizing that other users, people and species depend upon these same ecosystems.

Figure 50 Suitable culture zones for hard clam



Following are technical practices and criteria of location of mollusk farms and/or zones:

Matrix of practices and criteria for mollusk farming location

Practices	***Criteria***
Benthic characters	• a fine sand (70-90%) substrate

Farm site/zones	• Intertidal flat, whit water exposure should be less than 8 hours, optimal zone is daily exposure 2-4 hours
Water depth	• Maximum is 1-2 m
Benthic and habitat	• Avoiding the contaminated areas and spawning grounds, this is not protected areas aims to conserve the biodiversity of marine

Design and construction of farms in ways that minimizes environmental damage

Mollusk culture in coastal provinces of Viet Nam has been performing with simple designs & construction from the north to the south. However, these designs would bring some considerable impacts to environment includes wild spawning areas and navigation.

Preparation of the culture system is simple as the fence has to be constructed as well as the stilt hut.

Matrix of practices and criteria for lobster farming location

Practices	**Criteria**
Farms	• Avoiding the fish spawning ground • Avoiding the navigation channels
Cluster of farms and system	• Mollusk culture should be designed as a nutrition removal for effluent discharging from other system like shrimp farming as integrated system in a downstream of the sea and river flows.

Seed supply, broodstock and post larvae

Wild seed usage has been prevailing in mollusk culture in Viet Nam. These practices contribute to wildlife depletion and reduction of seed availability.

Matrix of practices and criteria for seed supply

Practices	***Criteria***
Wild seed conserve	Conserve the mangrove forest and natural recruitment Develop and disseminate hatchery technology
Change in using wild seed to artificial feed	Promote hatchery development
Nursing practices	Density: 300-500 seed/m^2 – size is 3,000-6,000 seed/kg Duration: 6-7 months
Growing practices	Density: 200-250 clams/m^2 – size is 2,000-3,000 seed/kg Duration: 18 months, would be shorter when seed size is bigger, fluctuated from 6-30 months

The clams are harvested year around when having the sizes of 30 to 70 pieces/kg. In Nam Dinh clams are graded into three sizes: 30-40 pieces/kg, 40-50 pieces/kg and 50-70 pieces/kg.

Productivity is depending on the abiotic conditions and the seeding density. In well-managed farms a clam yield from 15-20 tons/ha is achieved. Even 33 tons/ha has been reported, but likewise also sometimes yields are down at 4 tons/ha.

Feeds and feed management

No feed and feeding in mollusk culture, however Turbid water is a must as it contains much feed for the clams to filter feed on.

Matrix of practices and criteria for seed supply

Practices	***Criteria***
Water quality	• Clams mainly filtrates the water for particulate organic matter (POM) and to a less extend phytoplankton, which are less abundant in the water body due to the high turbidity.
Nutrition	• It should be noted that approximate 23 kg N can theoretically be bound in clam protein/ha/yr

Health management plan

Health management should be designed and implemented in a preventive approach come along with different practices from location, design and construction, feeding practices and management, water quality management, etc as above guidance. Following are the guidance on specific activities.

- To high levels of effluent and siltation have an adverse effect on survival if the bottom substrate changes considerably
- If clams are covered by too much sediment they will die.
- Predators such as snails, crabs, marine fish and starfish pose a threat to clam culture. Farmers will actively remove these species if found on the flats during low tides.
- Concerning marine fish (especially rays) the farmers often have fishing nets surrounding the culture area and this gives them an extra income.

Food safety and quality

Viet Nam Mollusk has bee exporting to the EU market (Ben Tre), therefore food safety and quality has been well controlling in Ben Tre. However, this issue has not been paying attention to due to no market requirement as the major market is China.

- Better planning or zoning for clam farming avoiding polluted site of heavy metals, pesticides
- Promote certification scheme for food safety
- BMP for pre and post harvest, includes development of depuration

Economic and social issues

Mollusk farming in Viet Nam hasn't been considered in application for poor as it requires high investment in construction. However, it can contribute to poverty reduction and poor livelihood when wild seed harvest and job creation. Poor and women involvement should be well organized as cluster of this sector in coastal provinces.

Following are guidance to sustainable livelihood for poor and women:

- Promoting the better seed harvesting practices to ensure the wild life as a major income generation for poor
- Creating jobs for poor in lobster culture

Markets and demand

Concerning marine fish (especially rays) the farmers often have fishing nets surrounding the culture area and this gives them an extra income.

Institutional issues

Key institutional and policy requirements:

- Further investment in training of staff members in public aquaculture planning and research

- Relevant and transparent regulations for coastal mollusc production must be developed and designed
- Facilitate the establishment of farmers groups as a means to improve mutual communication with farmers

2.7.4 Implementation responsibilities

Institutions (legislation, offices, organisations and norms) may facilitate sustainable aquaculture development and reduce the risks of unpredicted environmental or economic problems. The following general and immediate (specific) requirements are seen as important in promoting sustainability in the in the coastal mollusc culture.

General institutional requirements:

- Decentralized, robust, transparent, and resilient management system working with applicable legislation and plans which are supported and understood by the affected stakeholders.
- Giving decision makers access to continuous updated and reliable data on production, natural resources, market and socio economic issues.
- Adjusting production and the development plans towards sustainability targets through incentive based measures and cross-sector planning.
- Considering the limited financial and human capacities in public administration and promoting a simplification of data collection on the sector and conduct participatory decision making.
- Ensuring that the implementation of legislations and development plans are adjustable to different administrative, socio economic and political contexts and that they are enforceable.

Immediate institutional requirements:

- Further investment in training of staff members in public aquaculture planning and research
- Relevant and transparent regulations for coastal mollusc production must be developed and designed.
- Facilitate the establishment of farmers groups as a means to improve mutual communication with farmers and disseminate information on GAP, new technologies and market opportunities. Extension workers and mass organisations are key stakeholders in this work.

2.8. Coastal seaweed farming (Gracilaria & Kapaphycus)

2.8.1 Commodity Status and System Description

Brief overview

Seaweed culture in Viet Nam has been developed since early of 1990s, before these years *Gracilaria* has been grown naturally in Dinh Vu island, Hai Phong city as a native species. In present, there are two major areas for seaweed farming; one is in the Northern provinces of Hai Phong and Thai Binh; the other is in the southern and central provinces of Ninh Thuan, Phu Yen and Khanh Hoa provinces. Two major seaweed species are cultured in these areas; *Gracilaria* (give species) in the north and *Kapaphycus alvarezii* in the south central provinces.

The total production in 2005 was 20,260 tons of dry products, in which there were 16,665 tons of *Gracilaria* and 3,959 tons of *Kapaphycus*. *Kapaphycus* is an exotic species which was introduced into Viet Nam in 1993 by the cooperative research between Nha Trang Sub-Institute of Material, Kochi Biological Institute and USA Biological Institute, while the *Gracilaria* is local species where are available in the brackish water or estuaries in north and promoted to be cultured in 1990s.

Kapaphycus culture has been developing rapid since 2000; the production of this type seaweed culture in Ninh Thuan has increased by 1,650 times in comparison to production of 2005. This might be resulted by the ecological tolerance of this species is well matched with environmental condition in Viet Nam central provinces as well as the benefit generation.

The production of *Kapaphycus* will be increasing to meet market demand growth and pro-poor culture for communities in coastal areas of central provinces because this species is easy to be cultured and has potential market demand for export and domestic consumption.

The *Gracilaria* culture in the Northern provinces has been facing with fluctuation of China market demands. This seaweed species is used for abalone feeding in southern provinces of China, though this import is not stable. The major products are consumed in domestic market for pharmaceutical, cookies and candy, cosmetic factories.

Development Plans

Despite of rapid development of seaweed culture in central provinces and high production in Northern provinces, the seaweed culture hasn't considered in the Master Plan in the sectoral level. It might be interpreted that seaweed has not been considered as major products due to its low prices and export values.

However, seaweed culture is considered in the Fishery Development Master Plan at the provincial level like in Hai Phong and Ninh Thuan. Unfortunately, the biggest seaweed culture in Hai Phong will be lost because of industrial development. Fishery sector is sometime of lower priority in coastal areas.

Location of production and development plans

Hai Phong province has highest production of *Gracilaria* and Ninh Thuan province has the highest production of *Kapaphycus*

Table 89 Seaweed production in 2005 of Viet Nam

Region/Province	Units	2005	Planned Target	Main land for conversion
NORTH (TOTAL)	ha			
Hai Phong	Tons of dry product	12,700		Brackish water at the estuaries
CENTRAL (TOTAL)				
Ninh Thuan	Tons of dry product	1,285		Lagoon, and open sea
Khanh Hoa	Tons of dry product	1,310		Open sea

Beside those provinces, *Gracilaria* is also cultured in Quang Ninh, Thai Binh, Nam Dinh and Thanh Hoa provinces; and *Kapaphycus* is cultured in Phu Yen and Binh Thuan provinces.

Farming System Design & Production Performance

Gracilaria culture: There are three seaweed culture systems in Hai Phong including the monoculture system, integrated culture with crab and integrated culture with brackish fish. In addition, farmers have cultured seaweed in Intensive/Semi-intensive and Extensive shrimp ponds right after Tiger shrimp harvested when the winter are not suitable for shrimp farming in the North.

Seaweed culture in Hai Phong consists of:

(1) Single culture system: 1,634 ha

(2) Integrated culture with crab: 1,600 ha

(3) Integrated culture with fish and in shrimp ponds: 4,532 ha

The design of all system simple pond as in the picture.

There are no difference between system in term of input and outputs of seaweed. There are two crops in a year, the first one lasts from December to May of next year, and the second one are cultured integrating with fish, crabs. The productivity is 50-60 tons of fresh products per crop for 1 ha.

The major inputs of *Gracilaria* culture are labor forces for maintenance, seed culturing and harvesting. The seed are available in nature, though in order to have enough quantity, the farmers have to grow the seed. The biggest input is labor cost for harvesting, farmers usually hire seasonal workers with 40,000-50,000 vnd/day. When the price is quite low, farmers did not harvest or sharing products for worker.

Table 90 Major input and outputs of different *Gracilaria* seaweed culture systems

INPUTS PER HECTARE	**Unit**	**Design 1**	**Design 2**	**Design 3**
Start up cost	*000 vnd/0.5ha per crop	30,000	30,000	30,000
Labor cost for maintenance – permanent workers	*000vnd/ 1 ha per crop	7,500	7,500	7,500
Labor cost for harvest – Seasonal workers	*000 vnd/0.5ha per crop	5000	5,000	5,000
Production	Ton of fresh product	40	50	55-60
Revenue	*000 vnd/0.5ha per crop	20,000	22,500	27,500-30,000
Profit – added values	*000 vnd/0.5ha per crop	4,500	7,000	14,500

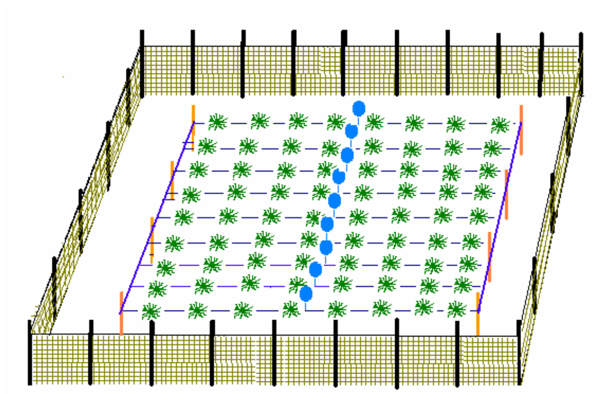
Note: price is 500 vnd/kg of fresh products in average, some part of products got higher prices.

Beside, there is an amount of integrated culture areas; fish and crab are main products which can bring higher profit and seaweed become the sub-products of those culture system.

***Kapaphycus* culture:** *Kapaphycus* has been culturing with three systems in Ninh Thuan Provinces.

Total area of seaweed culture in Ninh Thuan is 9,600 ha in lagoon and marine water shed in coastal areas.

(1) seaweed culture in pond or lagoon with surrounding net. Design of this system as next figure



(2) seaweed culture in pond or lagoon without surrounding net.

Design of this system is the same, but removing the surrounding net.

(3) seaweed culture in open sea: seaweed is stuck on the lines, floating, sticks and anchors.

Table 91 Major input and outputs of different *Kapaphycus* seaweed culture systems

INPUTS PER HECTARE	**Unit**	**Design 1**	**Design 2**	**Design 3**
Start up cost (line, anchors, floating, etc)	*000 vnd/0.5ha per crop	500	8,000	5,000
Seed	*000 vnd/0.5ha per crop	5,000	5,000	5,000
Labor cost for maintenance	*000 vnd/0.5ha per crop	5,000	5,000	5,000
Labor cost for harvest	*000 vnd/0.5ha per crop	500	1,000	1,000
Production	Ton of fresh product	35	46	53
Revenue	*000 vnd/0.5ha per crop	34,400	45,600	51,200
Profit – added values	*000 vnd/0.5ha per crop	23,400	26,600	35,200

There are two crops a year, the first one lasts from September to March, and second one lasts from April to September or October. September and October are the months for seed growing only.

Major inputs - Water use

Gracilaria* culture*: this species lives in brackish water with salinity is from 15%o to 30%o, usually in the estuaries. Seaweed culturing farms are located at those areas and the tidal flats. The major input for seaweed culture is brackish water by exchanging according to the tidal regimes.

This is also not necessary to have any special design or treatment for water use before taking into the farms. However, the risk might be coming from the intake water quality as water might contain the contaminations from urban and industry as seaweed culture areas located at the downstream of river, special is a strongly industrialization city .

***Kapaphycus* culture:** The major water use for *Kapaphycus* culture is marine water with higher salinity and high transparency as in central coastal zones through tidal magnitude and regimes.

Ninh Thuan province is not strongly industrial development province like Hai Phong and Khanh Hoa. Water quality for seaweed culture hasn’t been influenced much by urban and industrial sectors at present. Otherwise, seaweed culture in Dam Nai is considered as solution for environmental quality improvement when water shed has been receiving effluent from shrimp farming, resident areas and agriculture.

Water quality monitoring has been carrying in some places for other purposes such as the industrial and urban pollution control and/or for environmental status report, though the information of water quality monitoring has been sharing to DOFI in Ninh Thuan, monthly. This can help providing the good information for aquaculture sector in general.

Major inputs - seed supply

Another important input for seaweed culture is seed for culture. Seed supply for seaweed culture in both north provinces and south central provinces do not meet any constraints as these species has been growing rapidly in the natural condition without any special conservation.

Gracilaria* culture*: farmers need to grow of natural seaweed in some areas before stocking. This type of seaweed is in the Red List Book on Flora of Viet Nam. This species was grown naturally in the Nam Trieu and Bach Dang estuaries, Hai Phong city. It is brought to culture in other places in Hai Phong, but this resulted in low productivity of culture and low contents of ‘Agar-Agar’ in the seaweed.

Kapaphycus culture: September and October are the months for seed growing only. The farmer has to buy seed with price of 3,500 vnd/kg in 2005 and 2006. The seed growing is mainly culturing in the pond or lagoon.

This species blooms in the coastal areas in Ninh Thuan Province as well when the poor can harvest in the wild according to the tidal regime, twice a month for 10 days.

Major inputs - feeds and feed management

No feed has been used for seaweed culture and nutrients for growth just come from natural sources.

Other inputs/resource use

The other input for seaweed culture is labor forces for maintenance, management and harvest. Most of labor forces are household members; there are wages for seasonal workers in harvesting time only.

Risks

The risks for seaweed culture mainly come from natural hazards and poor water quality caused by urban, industrial sector and others. Typhoon in last 2005 brought a big loss of seaweed production in Hai Phong, Thai Binh and Nam Dinh provinces for whole year.

Sometimes in the April and May there are some disease problem for *Kapaphycus* culture in Ninh Thuan provinces. There is recognition of influence of shrimp pond effluents to the seaweed culture. The assumption on causative agent is the high temperature of marine water.

A sensitivity analysis of the impact of externalities i.e. such as price reduction due to reduced international prices, increase in seed price due to reduce natural availability, upon the profitability of seaweed farming (system 3-Kapaphycus) revealed that a reduction in farm-gate-value had the greatest impact. A 20% reduction in (FGV) leads to a reduction of 31% on Annual Net Profit (ANP). An increase in seed price had less impact on the ANP i.e. a 20% increase in seed price lead to a 6% decrease in ANP.

Table 92 Sensitivity analysis of seaweed culture in central Viet Nam based on 2005 survey conducted by The Viet Namese Institute for Fisheries Economics and Planning. The first part of the table illustrates single externality's impact upon Annual Net Profit i.e. drop in farm-gate value and increase in seed costs. The second part of the table illustrates three multi-externality scenarios

Single Externality Scenarios					
Farm gate value	**Baseline 2006**	**20% reduction**	**30% reduction**	**40% reduction**	**Unit**
Annual Net Profit (ANP)	62,280	42,680	32,880	23,080	**'000 vnd/ha/year*
Percentage impact ANP		-31%	-47%	-63%	
Seed price	**Baseline 2006**	**20% increase**	**40% increase**	**60% increase**	**Unit**
Annual Net Profit (ANP)	62,280	58,640	55,000	51,360	**'000 vnd/ha/year*
Percentage impact ANP		-6%	-12%	-18%	
Multi Externality Scenarios		**FGV -20%**	**FGV -30%**	**FGV -40%**	
	Baseline 2006	**Seed price +20%**	**Seed price +40%**	**Seed price +60%**	**Unit**
Annual Net Profit (ANP)	62,280	39,040	25,600	12,160	*'000 vnd/ha/year
Percentage impact ANP		-37%	-59%	-80%	

Creating scenarios in which FGV was reduced whilst the cost of seed increased clearly revealed that seaweed culture systems are very resilient to externalities. Even in the worst-case scenario the system was economically viable, generating an ANP of 12 mill vnd/ha/yr.

Whilst FGV have experiences and increase in the last years (mainly due to increased demand by abalone farmer in China – *Gracilaria*, it is likely that prices will reduce once production volume increase considerably. Even so, the high economic resilience of the system makes it a potential candidate to promote to poorer households which does not have access to land i.e. fishing communities, however, further analysis needs to be made to in order to compare the return on labor and added value with other income generating options.

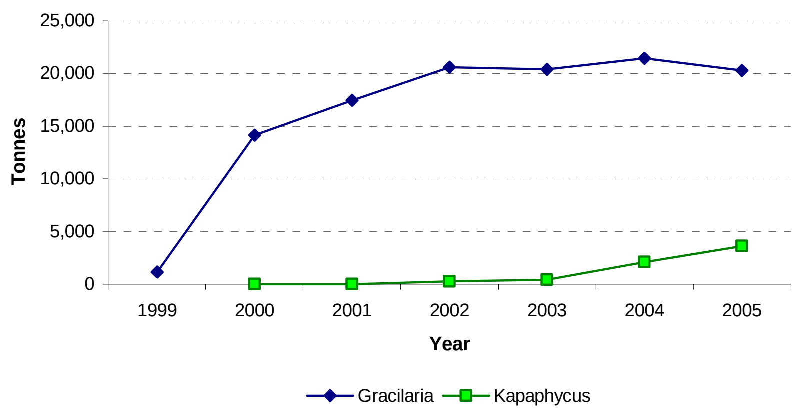
Markets and market chains

Seaweed is a special commodity not only because of its economic value but also of its ability to improve the environment. There are two main commercial seaweeds in Viet Nam: *Gracilaria* and *Kapaphycus*. The former is more popular than the latter with 85% of total seaweed production (2005).

Gracilaria is consumed domestically through factories to produce Agar-Agar products, medicines, Cosmetics, Candy and Cookies and a small amount are directly consumed as food. The major market is Ho Chi Minh city. In export markets, China is the biggest consumer for this product.

The markets for *Kapaphycus* are China, Taiwan, Hong Kong, Japan and America. There is domestic market demand for special seaweed called “white seaweed”, the semi-dry of *Kapaphycus* product. The dry product of this seaweed is one third weight in comparison to fresh one. The price of this is VND 20,000/kilo for dry type and this product are consumed in Ho Chi Minh and Da Lat for food supply (Ngan, 2006).

Figure 51 Seaweed production (1999-2005) (put at beginning)



Source: MOFI, Statistical data from Aquaculture program 2000-2005

Before, the prices of seaweed were very low. However, since 2003, when the seaweed has been known as a commercial commodity, the price has increased and stayed at a stable level. *Kapaphycus,* for example, has been increased from VND 2,000-3,000/ kilo in 2002 to 7,000 for dry products (Ngan, 2006). It is predicted that there will be a high demand for *Kapaphycus* seaweed in exporting markets as the prices has been increasing in recent years. Similar is *Gracilaria* because of the higher demand for this as abalone feeding in the southern provinces of China in 2006.

Table 93 *Gracilaria* farm-gate prices (fresh product) (Ngan, Hai Phong Data)

Year	Price (VND/kilo)
2003	450-550
2004	450-550
2005	400-500
2006	800-1,000

Table 94 *Kapaphycus f*arm-gate prices (dry product) (Ngan, Ninh Thuan Data)

Year	Price (VND/kilo)
2003	7,000
2004	7,500-8,000
2005	8,000
2006	8,500

The market chain of seaweed is simple but there is still difference between the market chain of G*racilaria* and that of K*apaphycus* since the former is consumed in both domestic and export markets while the latter is for export mainly.

Figure 52 Market chain for *kapaphycus* (Ngan, Ninh Thuan Data)

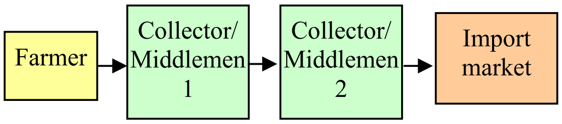
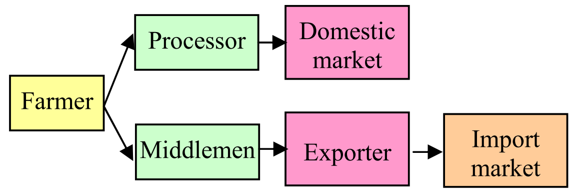


Figure 53 Market chain for *gracilaria* (Ngan, Hai Phong Data)



In general, the difference between farm-gate price and middlemen/ domestic market is VND 500-1000 after each chain. Table 95 shows an example of price difference in market chain of *kapaphycus.*

Table 95 Price difference in market chain (*kapaphycus*)

Year	Unit	Farm gate price	Midlemen 1	Exporter/middlemen 2
2006	VND/kg of dry product	8,500	9,000	10,000

Source: Ngan, Ninh Thuan data

Social and economics

In general, seaweed culture with low investment and easily culturing is quite suitable for poor in both the north and the south central province. This aquaculture system can bring high profit generation in term of cost and benefit analysis. Kapaphycus culture is considering as the end and the means of poverty alleviation in Ninh Thuan province and even wild harvest can bring income for the poor without culture. Ninh Thuan authorities suppose that is the sustainable livelihood for their people in coastal zone, specially is that sandy soil shrimp farming turn out causing lost and a lots of hectare have been deserted recent years.

Table 96 Labour indicators for seaweed production in Central Viet Nam assuming 1 crop per year

LABOUR INDICATORS	**Units**	**GROW-OUT**
JOB INDICATORS		
Labour fixed	*man-months/ha/yr*	2.00
Labour harvest	*man-months/ha/yr*	0.17
Total labour	*man-months/ha/yr*	2.17
Investment per job	**'000 vnd/man year*	5,539

* Capital costs are used as the sole basis for comparing investments

Seaweed demands a relative high labour input which can be carried out by unskilled labour. The investment per job is very low and it is seen as a good system to promote to poorer communities in demand of alternative livelihood opportunities. Seaweed culture will require user-rights to water surfaces and is particularly suitable to a community who does not have land-user rights i.e. fishing communities.

Table 97 Economic performance indicators for seaweed production in Central Viet Nam province assuming 1 crop per year. TVC= Total variable costs; TFC=Total fixed costs; NR=Net Profit; TOC=Total operating costs; CC=Capital Costs

ECONOMIC INDICATORS		
Net profit/ha/yr	62,280.0	***'000 vnd/ha/year**
Total farm gross revenue (Farm Gate Value)	98,000.0	***'000 vnd/ha/year**
Total operating costs (TVC+TFC)	35,720.0	***'000 vnd/ha/year**
Value added (Net profit+labour costs)	73,280.0	***'000 vnd/ha/year**
Benefit/cost (NR/TOC)	1.74	
Minimum start-up costs (TOC+CC)	47,720.0	***'000 vnd/ha/year**

The net profit is quite high for this commodity given that it is a simple raw product which is used as raw material to produce agar or in the past couple of years as abalone feed in Southern China. The operating costs are relative low compared to the gross revenue. The high B/C ration for the system also indicates that this system has a higher degree of economic resilience which makes it suitable to promote to capital poor communities who cannot afford entering into 'high-risk' business ventures.

2.8.2 Environmental Assessment

Although *Kapaphycus* is exotic species and introduced to Viet Nam since 1993, it has been growing rapidly by the years in term of biomass and production as farmer in central provinces is considering this species as a sustainable livelihood for poverty reduction. There is no study on biological impact on the local species and no judgment on whether this is invasive species or not.

Appearance of wild *Kapaphycus* without culturing might be the evidence of rapid and ecological appropriate condition for this species in the southern central coastal zone. There is no recognition and/or research on invasive to native species.

Location and farm siting

Location and farm siting of seaweed farming is very important when the major environment impacts on seaweed culture come from urban and industrial sectors while this aquaculture would not be influencing to environment. However, it is not easy for farm site selection far from pollution source and meeting the ecological tolerance of this species, for example is Gracilaria culture in Hai Phong.

This seaweed farm of nearly 1000 ha areas will be disappeared in the near future when Dinh Vu Economic zone will be full constructed. The second big seaweed farms in Cat Hai island will be shrunk as the deep seaport will be built there. Those biggest seaweed culture areas would be lost in future.

Kapaphycus culture in Ninh Thuan province has not been facing with this problem as this province did not rapidly developing in term of industrial sectors and urban expansion. However, seaweed culture in Dam Nai is considered as solution of environmental improvement when there is phenomenon of water pollution caused by shrimp farming and resident areas in the banks.

Design & Construction

Design and construction of seaweed farm would not be influencing to surrounding environment as this is environmental friendly production.

Water Use & Impact

Water uses for seaweed culture is taken by exchanging according to the tidal regime. Though, water uses depend heavily the water quality in the region as seaweed farms usually located at estuaries, lagoon and marine water shed close to the coast.

The outside impacts on seaweed culture have been recognizing that the leachate from landfill and effluent from factories caused problem for seaweed farm in Dinh Vu where these farms located closely to.

Waste & impacts

Effluent and waste wouldn't be problem for environment in seaweed culture as it is considering as nutrition removal for water shed. There are some systems of integrated culture with fish, crab or alternated crop in shrimp ponds indicating the positive effects of seaweed culture in this aspect.

Feeds & Feed Management

There is no requirement of feed for seaweed culture.

Disease issues and health management

- ***Gracilaria*** culture: Disease is not problem during this species culture excepting the breaking when seaweed hasn't been harvest in time. This might be explained that is caused by overloaded biomass in the system rather than the disease problem.
- ***Kapaphycus*** culture: seaweed culture in recent years has been facing with some disease issues such as soften and white spot, and symbiosis as farmer called is "dog fur". Two types of this disease are causing the decline of biomass and no growth for a long time. Both diseases are judged that is caused by the high temperature of water while farmer recognized these in the shallow water depth farms or earlier stocking with hot climate condition.

Seed quality is considered as a possible factor that might be influencing to the disease issues. Because of this is first time farmer recognized the symbiosis when seed come from Dam Nai.

The sole solution for solving disease issue is early harvesting seaweed; this can help compensating the investment cost for farmers.

Food Safety & Quality

No chemical using in disease treatment of seaweed excepting earlier harvesting of products. The most concerns of food safety & quality is contaminant come from industrial sector and urban development. There is no evidence of violation of food safety or impact on human health caused by unsafe of seaweed products. This might be lacking of controlling of seaweed products as not required by the exporting market.

Economic and Social Issues

Unfortunately, the seaweed culture in Ninh Thuan has been developing without sustainable planning, there are some social conflicts between users in the costal zone like conflict of fishermen and seaweed culturing farmer for shipping site, farmer to farmer. Those conflicts have been solving out at the community level through meeting held by the commune authorities.

The major conflicts of seaweed culture in Hai Phong are water uses quality, which might be influenced by other sectors effluent discharging. Like other commodities, Gracilarias seaweed culture areas will be lost as in the long term master plan of this city.

Economic lost in seaweed culture could be considered as not big as in shrimp or other commodities culture. The farmer can harvest seaweed earlier for investment costs when seaweed is getting disease issues.

The significant issues for seaweed culture in Hai Phong are land lost for other sector development while this species culture would be livelihood for poor with low investment.

Market issues

The major market for Kapaphycus culture is exporting to Hong Kong, Taiwan, Japan and USA. The high demand of these markets has been impacting on price in recent years.

Institutional issues

Kapaphycus culturing in Ninh Thuan province has been doing by farmers with strong extension services and support of DOFI. In the first stage, 1990s there was no market for *Kapaphycus* and this was wildly growing in lagoon. One enterprise in Ho Chi Minh city was developing market and encourages farmers to culture this species. In present, the farmers have been organized to culture *Kapaphycus* according to the marine surface water and land allocation of commune people committees. The early of this year, Ninh Thuan province has been developed the Master Plan for Seaweed and Babylonia culturing as the new alternative of livelihood for poor in Ninh Thuan. There is no farmer group or association on seaweed farming. The major important market information source comes from middlemen.

Gracilaria culture in Hai Phong has been carried out by the farmers and one state ownership enterprise on aquaculture in Dinh Vu peninsula, where is no belong to any administrative commune and this areas is under management of City People Committee. Seaweed farming there just is temporary when Dinh Vu industrial zone still not be filled in present. Another seaweed farming area is Cat Hai island, Cat Hai district. However, the newest decision on Cat Hai island development is removal of all residents and activities to develop the terminal sea port areas.

At central level, there is no specific plan and/or target figure of seaweed culturing in present.

Environmental management in aquaculture would be high appreciated in term of good coordination of Ninh Thuan Department of Natural Resource and Environment and Ninh Thuan Department of Fishery when they are sharing information monthly despite this information is not serving for seaweed culture. However, these could help providing the environmental status for aquaculture planning process.

Environment management in aquaculture has not been working considerably in Hai Phong as this city has other development priorities as well as hot-posts in environmental issues with rapid growth of industrial sectors, urban expansion and sea port expansion in near future while Department of Natural Resource and Environment is incapable to work out on all these issues.

Summary of environmental issues of seaweed farming in Viet nam (*Kapaphycus and Gracilaria)*

Seaweed farming has been considering as the environmental sound culturing when the *Kapaphycus* are cultured as integrated system with lobster in Khanh Hoa province and Dam Nai lagoon where are receiving the effluent shrimp pond in the banks. The *Glacilaria* are cultured as the alternated crop after shrimp farming in the Hai Phong. The polyculture system in brackish water of sea bass, tilapias and seaweed has been prevailing in Hai Phong. All these aquaculture system can bring benefits in terms of economic and environment. Although the seaweed farming in Ninh Thuan provinces can bring livelihood for poor in Ninh Thuan with high profit generation caused by high demand market, the seaweed farming in Hai Phong are facing problem with low farm gate prices because of unstable market as well as the effects of other sectors development.

Impacts	*Management practices/solutions*
Seaweed farming	
Impact 1. Removal of pollution in water	• Promote the as a polyculture/integrated system • Promote seaweed culture in treatment of effluent(Ex in Dam Nai lagoon)
Impact 2. Reduce the pollution of sediment	• Promote the seaweed culture as a polyculture/integrated system • Promote seaweed culture in treatment of effluent
Impact 3. Impacts on livelihoods by providing sustainable incomes because of high demand, job and	• Researches on technology local species • Promote seaweed culture as a sustainable AIG activity in

income generation, poverty alleviation	connection with Marine Protected Area and other community development strategies
Impact 5. Import exotic species	• Research on risk and invasive of Kapaphycus species

2.8.3 Guidelines for Better Management

This section focuses on providing guidance in Viet Namese and English on environmentally sound planning and operational management of each key aquaculture system prior to development of an area/region.

Better management principles and practices should consider the management actions required for each major environmental issue. The following headings are for guidance only. New ones may be added, or removed depending on the commodity/farming system.

Location of aquaculture farms

Despite the fact that the National Master Plan is lacking a plan for seaweed culture at national level, provincial master plan adjustment should be paying attention to planning for seaweed culture in suitable locations. Location of seaweed farms should be located in the planned areas to avoid the adverse impacts on seaweed culture from other sectors.

With regard to zoning development of seaweed culture it is important to ensure the supply of nutrients. This makes it an ideal candidate to grow in shrimp effluent recipients which will ensure a free nutrient supply and seaweed culture will contribute to reducing the risk of eutrophication. By zoning seaweed in recipients receiving shrimp effluent it will be possible to increase the environmental carrying capacity and hence the production potential for polluting aquaculture systems.

Following are technical practices and criteria of design & construction of seaweed farms and/or zones:

Matrix of seaweed culture for farm location or zones

No	Practices	Criteria
1	Salinity	• Kapaphycus: 20-35‰ • Gracilaria: 15-30‰, optimal is 26‰
2	Water depth	• Kapaphycus: at least is 6m in the marine water shed, 1-2m in the ponds/lagoon during the cooler temperature • Gracilaria: 1.5 m
3	Farm site/zones	• Kapaphycus: ponds, lagoon, marine water • Gracilaria: brackish water in the estuaries, ponds and tidal flats
4	Water quality	• Clean and meet Environmental Standards TCVN 5943-1995 (column b)
5	Benthic characters	• Clean benthic with sand or mud
5	Habitat	• Avoiding the coral areas even this is not protected areas aims to conserve the biodiversity of marine

Design & construction of farms in ways that minimizes environmental damage

Design and construction of farms could bring higher productivity and biomass in seaweed culture for both species of seaweed in the north and central provinces.

Following are technical practices and criteria of design & construction f of seaweed farms and/or zones:

Matrix of seaweed culture for design and construction of seaweed farm and/or zones:

No	Practices	Criteria/systems
1	Kapaphycus:	• Design 1: the farm is surrounded by the net can bring higher productivity, this design could be used in the lagoon and shallow water depth and could be used for seed growing • Design 3: the farm is built by the lines, sticks and anchor. This design brings highest profit as high productivity.
2	Gracilaria	• Integrated culture system could bring high profit generation as higher total production and diversification of products. • The seaweed culture is the next crop after shrimp farming can help improving environmental condition.

Seed supply, broodstock and post larvae

Although *Kapaphycus* is exotic species and introduced to Viet Nam since 1993, it has been growing rapidly by the years in term of biomass and production as farmer in central provinces is considering this species as a sustainable livelihood for poverty reduction. There is no study on biological impact on the local species and no judgment on whether this is invasive species or not.

Appearance of wild *Kapaphycus* without culturing might be the evidence of rapid and ecological appropriate condition for this species in the southern central coastal zone. There is no recognition and/or research on invasive to native species.

Feeds and feed management

No feeding usage in the seaweed culture, therefore no specific management practices are necessary.

Health Management

The most important factors could influence to the disease issues for Kapaphycus culture is water temperature, and the floating creatures in the sea current. The right stocking season would bring the effectiveness of health prevention.

Food Safety & Quality

Food safety and quality could be ensured by avoiding the contaminant generation source such as urban, industrial sector.

Economic and Social Issues

Seaweed culture could be considered as a good livelihood for the poor, though seaweed planning should be solving the conflicts with other users in the coastal zones through participation approach.

Markets and demand

The white seaweed (semi-dry products) consumption in the domestic market would be expanding in future. The ratio of fresh and white seaweed products is 3:1 while this is 8:1 for fresh and dry products, the prices of white seaweed products is 20,000 vnd/kg. This change in consumption model and market expanding could help farmer makes higher profit and more efficient use of resource.

Institutional issues

Key institutional and policy requirements:

- Improving sustainability of long term Master Plan for whole province help aquaculture will be sustainable in term of land use and investment.

- DOFI should be ensured that environmental problems from other sectors are coordinated with the development of seaweed aquaculture during aquaculture planning and decision –making process in provincial level.
- Aquaculture farmer association should be established to have better enforcement to other polluters in land base which could bring adverse impacts to seaweed farming as well as market development issues.
- Extension network should be strengthened to help implementation of better management and seaweed farmers in culture and disease response (early harvesting to avoid the loss)
- Improve monitoring of production sites and the implementation of the governmental aquaculture plans through setting up baseline database and data updating yearly through staff of communes, provincial statistic offices system, aquaculture associations and extension workers networks.
- Improve communication between the Department of Natural Resource and Environment (DONRE) and Department of Fishery (DOFI) to ensure that environmental issues in aquaculture are considered in the overall environmental planning.

2.8.4 Implementation responsibilities

Institutions (legislation, offices, organisations and norms) may facilitate sustainable aquaculture development and reduce the risks of unpredicted environmental or economic problems. The following general and immediate (specific) requirements are seen as important in promoting sustainability in the seaweed culture.

- Provincial People Committees should plays important role in coordination of different sector to have better cross sectoral master plan for long term.
- DOFIs play important role in aquaculture planning at provincial should have better practices to ensure the sustainability of aquaculture plan.
- DOFIs and aquaculture associations should enforce other sectors to reduce the environment influences on seaweed culture.
- Water quality monitoring should be done by DONRE and shared to DOFI and aquaculture association and farmers
- Better management practices for seaweed planning and extension material for seaweed culture should be developed.
- Provincial Fishery Extension Centers and aquaculture associations should be strengthened and capacity building to disseminating the BMP.

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Annex 2: List of participants in workshop and study team members

Participation in the workshop/stakeholder consultation hosted by MOFI on 24 June 2006 on Environmental Management in Aquaculture investments in Vietnam.

	Name	Position	Workplace
1	Le Thanh Luu	Director	RIA1
2	Bui Van Dien	Officer	RIA1
3	Dinh Van Thanh	Officer	RIA1
4	Doan Thanh Loan	Officer	RIA1
5	Le Van Khoi	Officer	RIA1
6	Le Xuan Suc	Officer	RIA1
7	Nguyen Huy Dien	Vice director	NAFEC
8	Pham Trong Yen	Vice director	DIC/MOFI
9	Bui Huu Manh	Officer	NAFIQAVED/MOFI
10	Ngo Phuong Hoa	Officer	NAFIQAVED/MOFI
11	Nguyen Thi Chinh	Officer	DPF/MOFI
12	Nguyen Tien Long	Officer	DoST/MOFI
13	Vu Thi Hong Ngan	Officer	VIFEP/MOFI
20	Le Thanh Phuong	Director of Fisheries College	CTU
21	Truong Hoang Minh	Officer	CTU
14	Michael Phillips	Environmental Specialist	NACA
15	Flavio Corsin	Aquatic Animal Health Specialist	NACA
16	Tran Thi Thu Ngan	Environmental Specialist	NACA
17	Nguyen Hai Ha	Officer	NACA
18	Jesper Clausen	Officer	FAO
19	Tham Ngoc Diep	Officer	WWF

Study team members

	Name	Position	Workplace
1	Le Thanh Luu	Director	RIA1
2	Bui Van Dien	Officer	RIA1
3	Dinh Van Thanh	Officer	RIA1
4	Doan Thanh Loan	Officer	RIA1
5	Le Van Khoi	Officer	RIA1
6	Le Xuan Suc	Officer	RIA1
7	Le Thanh Phuong	Director of Fisheries College	CTU
8	Truong Hoang Minh	Officer	CTU
9	Michael Phillips	Environmental Specialist	NACA
10	Flavio Corsin	Aquatic animal health specialist	NACA
11	Tran Thi Thu Ngan	Environmental specialist	NACA
12	Nguyen Hai Ha	Officer	NACA
13	Jesper Clausen	Officer	FAO
14	Tham Ngoc Diep	Officer	WWF
15	Christoph Mathiesen	Institutional specialist	IFM
16	Anders Dalsgaard	Food safety and public health specialist	KVL
17	Stig Møller Christensen	Planning specialist	

Annex 3: GOV regulations relevant to aquaculture

General regulations related to aquaculture development and management

- **Law of Fisheries** No.17/2003/QH11 dated 26/11/2003 by the Congress of Vietnam.
- **Veterinary ordinance 2004**
- **Veterinary ordinance amendment in 2005**
- **Decree 86/2001/ND-CP** dated 16/11/2001 by the Government on the conditions to operate the business in fisheries and aquaculture and **Circular 02/2002/TT-BTS** dated 6 December 2002 of Ministry of Fishery guiding the implementation of Decree 86/2001/ND-CP
- **Decree No. 43/2003/ND-CP** of the government dated 2 May 2003 promugating regulation of functions, responsibilities and organizational structure of the Ministry of Fisheries.
- **Decree No. 70/2003/ND-CP** of the government dated 17 June 2003 promulgating regulation of penalization of administrative violation in fisheries sector
- **Decree No. 27/2005/ND-CP** of the Government on 8 March 2005 providing guidelines for implementation of Fisheries Law
- **Decree 59/2005/ND-CP** dated May 4, 2005, governing production and trading conditions in some fishery areas
- **Directive No. 32/1998** on overall planning for socio-economic development
- **Decision 251/1998/QD-TTg** dated 25/12/1998 by the Prime Minister to approve the development program for the export of aquatic products to 2005(decision was amended to extent the program toward 2010 and oriented toward 2020)
- **Decision No 224/1999/QD-TTg** of the Prime Minister on 08 December 1999 approving aquaculture Development Programs towards 2010
- **Decision no 112/2004/QĐ-TTg** dated 23/6/2004 by the Prime Minister approving National programme on seed production supplying for fisheries sector
- **Decision 131/2004/QD - TTg** of the Prime Minister dated on 16 July 2004 approving National programme on fisheries resources protection and development
- **Decision No.22/2004/ QD-BTS** dated 15 September 2004 of the Ministry of Fishery regulating the promulgation of Branch Standards and Decision No. 06/2005/QD-BTS of February 17, 2005 promulgating branch standards
- **Decision No. 33/2005/QD-BTS** of December 23, 2005 approving the program on fisheries mechanical engineering development to 2010 and orientations to 2020
- **Decision No 10/2006/QD-TTg** of the Prime Minister on 11th January 2006 approving the Master Plan for Fisheries Development to 2010 and orientations towards 2020
- **Circular 02/2004/TT-BTS** of the Ministry of fisheries on 22 March 2004 guiding the implementation of the Decree No. 70/2003/ND-CP
- **Circular N° 03/2006/TT-BTS** by the Minister of Fisheries on 12 April 2006 guiding the implementation of Fishery sector development master plan up to 2010 and outlook of 2020.

Regulations on use of land, forest land and water bodies

- **Land Law No.13/2003/QH11** dated 26/11/2003 by the Congress of Vietnam
- **Law on forest protection and development No. 29/2004/QH11** dated 3 December 2004 by the Congress of Vietnam
- **Law on water resource** No. /2003 by the Congress of Vietnam
- **Decree 09/NQ/CP** dated 15/6/2000 by the Government on economic restructuring and marketing of agricultural products and Circular 05 of Ministry of fisheries on 3 November 2000 guiding the implementation of the Decree 09
- **Decree 181/2004/ND-CP** dated 29/10/2004 by the government provided the detail guiding for the implementation of new Land Law.
- **Decree 182/2004** dated 29/10/2004 by the government on the fees charged to the violation in land/water bodies manaegement
- **Decree 142/2005/ND-CP** of the Government on collecting fee for renting land and watersurface
- **Decision 773-TTg** of 21/12/1994 approved the Program to exploit deserted land, alluvial ground at riversides, coastal areas and plain's water surface.
- **Decision 04/2002/QD-BTS** dated 24/12/2001 by the Ministry of Fisheries on the regulations to manage the environment in the concerntrated shrimp farming areas.
- **Decision 264/2003/QD-TTg** dated 24/12/2001 by the Prime Minister about some solutions on the use and management of the lands in the state-managed agricultural and forestry enterprises.
- **Circular 82/2000/TT-BTC** dated 14/8/2000 by the Ministry of Finance to instruct the land and financial policies to encourage farming economy development.

Regulations on seed, feed, chemical substance, antibiotics and bio-microorganism, and quality management of aquatic products

- **Ordinance on food hygiene and safety** passed on August 7, 2003
- **Decree No. 93/CP** dated 27 November 1993 by the Government on veterinary tasks on aquatic animals and aquatic products and **Circular 02/TS-TT** dated 25 June 1994 by Ministry of Fishery guiding the implemantation of Decree No. 93/CP
- **Decree 1091/1999/QD-BKHCNMT** dated 22/6/1999 by the Ministry of Science-Technology and Environment on the government investigation of the imported and exported goods.
- **Decree 08/2000/QD-BTS** dated 7/1/2000 by the Ministry of Fisheries to regulate the investigation and approval of the quality of aquatic products.
- **Decision 865-QĐ/NC** of the Minister of MOFI dated 23/10/1996 on promulgation of the document "Planning and re-arranging the aquaculture hatcheries in the period of 1996 – 2000";
- **Decision 103/2000/QD-TTg** dated 25/8/2000 by the Prime Minister about some policies to encourage the development of seed production for aquaculture. This was guided in details through Circular 04/2000/TT-BTS dated 3/11/2000 by the Ministry of Fisheries.

- **Decision No 01/2002/QD-BTS** of the Minister of MOFI dated 22/01/2002 on prohibiting the use of some chemical substances and antibiotics in fisheries production and trading with particular emphasis on shrimp production
- **Decision No. 03/2002/QD-BTS** of January 23, 2002 promulgating the regulation on management of aquatic veterinary drugs
- **Decision 15/2002/QĐ-BTS** dated 17/5/2002 promulgated the regulations to control the excess use of harmful chemicals and medicine residuals in fisheries and aquaculture products, including shrimp products,
- **Decision 18/2002/QD-BTS** dated 03/6/2002 promulgated the regulations on testing the aquaculture seed, food, medicine, chemical substances and bio-microorganism used in aquaculture including shrimp production;
- **Decision No 07/2005/QD-BTS** of the Minister of MOFI dated 24/02/2005 on prohibiting the use of some chemical substances and antibiotics in fisheries production and trading. This Decision is replacing the Decision No 01/2002/QD-BTS on the mentioned matters.
- **Decision No 26/2005/QD-BTS** of the Minister of MOFI dated 18/08/2005 on prohibiting the use of Fluoroquinoloness antibiotics in fisheries products exported to the United States and North America.
- **Decision 176/QD-BTS** dated March 01, 2006 on releasing the temporary regulations on the management of white leg (*P.vannamei*) shrimp culture.
- **Decision 06/2006/QD-BTS** dated April 10, 2006 on releasing the regulations on the management of safe shrimp culture zones and enterprises
- **Circular No 03/2005/CT-BTS** dated 07/03/2005 by MOFI on strengthening the control of antibiotics and substances used in processing and trading of foodstuffs of aquactic animal origin
- **National standard N° TCVN 6986: 2001 -** Water quality standards for industrial effluent discharged into coastal waters for the purpose of the aquatic animal life protection.
- **Sector standard N° 28 TCN 96-1996 -** Technical requirements for monodon broodstock.
- **Sector standard N° 28 TCN-102: 1997 and amendment in 2004 -** Compound pellet feeds for black tiger shrimp (*Penaeus monodon*)
- **Sector standard N° 28 TCN 101: 1997 -** The procedure for testing fisheries commodities.
- **Sector standard N° 28 TCN 099: 1996 & Amendment in 28 TCN 124: 1998 -** Quality requirements for Postlarvae 15 marine shrimp.
- **Sector standard N° 28 TCN-125: 1998 -** Black tiger shrimp nursery technique (PL15 to PL45).
- **Sector standard N° 28 TCN-111: 1998 -** The procedure of disease prevention for cage cultured freshwater fish.
- **Sector standard N° 28 TCN-171: 2001 -** The procedure for intensive culture of black tiger shrimp (*Penaeus monodon*).
- **Sector standard N° 28 TCN 167: 2001 -** Technical requirements for broodstocks of Basa catfish and Basa Bocourti.
- **Sector standard N° 28 TCN 168: 2001 -** Technical requirements for fry of Basa catfish and Basa Bocourti.
- **Sector standard N° 28 TCN 169: 2001 -** Technical requirements for small fingerlings of Basa catfish and Basa Bocourti.
- **Sector standard N° 28 TCN 170: 2001 -** Technical requirements for fingerlings of Basa catfish and Basa Bocourti.

- **Sector standard N^o 28 TCN 176: 2002 & Amendment in 2004 -** Floating cage culture of Basa bocourti, Basa catfish – Conditions for food safety.
- **Sector standard N^o 28 TCN 187 : 2004** - Compound pellet feed for Macrobrachium
- **Sector standard N^o 28 TCN 188 : 2004 -** Compound pellet feed for Pangasianodon hypophthalmus and Pangasius bocourti.
- **Sector standard N^o 28 TCN 189 : 2004 -** Compound pellet feed for tilapia
- **Sector standard N^o 28 TCN 190 : 2004 & Sector standard N^o 28 TCN 191: 2004 -** Shrimp farming area - Conditions for food safety.
- **Sector standard N^o 28 TCN 192 : 2004** – fish raft culture area- Conditions for food safety
- **Sector standard N^o 28 TCN 193 : 2004** – Bivalve mollusk collection area – Conditions for food safety
- **Sector standard N^o 28 TCN 202: 2004 -** The procedure for diagnosis of white spot disease in Penaeid shrimp by Polymerase Chain Reaction (PCR).
- **Sector standard N^o 28 TCN 211: 2004 -** The procedure for the intensive grow-out of Ba sa catfish.
- **Sector standard N^o 28 TCN 212: 2004 -** The procedure for seed production of Ba sa bocourti.
- **Sector standard N^o 28 TCN 213: 2004 -** The procedure for seed production of Ba sa catfish.
- **Sector standard N^o 28 TCN 214: 2004 -** The procedure for intensive grow-out of Ba sa bocourti.
- **Sector standard N^o 28 TCN 092: 2005 -** Marine shrimp hatchery – Technical and Sanitary requirements.
- **Sector standard N^o 28 TCN 220: 2005 -** Macrobrachium hatchery – Technical and Sanitary requirements.

Regulations on marketing and export of aquatic products

- **Decree 178/1999/QD-TTg** issued by the Prime Minister about the regulations on labelling of goods traded in domestic markets and imported/ exported. This was detailed by Circular 34/1999/TT-TTg dated 15/12/1999 and **Circular no 03/2000/TT-BTS** on 22/9/2000 providing guidance to implement Decision 178/1999/QĐ-TTg from The Prime Minister on 30/8/1999 which promulgated the regulations on labling fisheries products for market;
- **Decree 95/2000/QD-TTg** dated 15/8/2000 by the Prime Minister on the revision of regulations in Decree 178/1999/QD-TTg on the labelling of goods traded.
- **Decision No.650/2000/QD-BTS** of August 4, 2000 promulgating the regulation on the state inspection and certification of aquatic goods quality (replaced for the decision of MOFI 08/2000/QD-BTS dated 07/1/2000 with similar objectives).
- **Decision 61/QĐ-TTg** dated 17/1/2002 of Prime Minister on support aquatic products market development

Regulations on environment and natural resource protection relating to aquaculture

- **Law on Environmental Protection** passed on December 27, 1993.
- **Ordinance** on protection and development of aquatic resources dated 25 April 1989 by State Council
- **Decree 175/CP** of the Government dated October 18, 1994 guiding the implementation of the Law on environmental protection
- **Decree No. 26/CP** dated 26/4/1996 if the Government on administration punishment to environment protection violations
- **Decree No. 67/2003/ND-CP** of the government on environmental protection charges applying to waste water.
- **Decree 109/2003/ND-CP** dated 23 September 2003 of the Government regarding the sustainable exploitation of wetlands.
- **Decision N^{o} 06/2006/QD-BTS** dated 10 April 2006 of Ministry of Fishery promugating regulation of Safe Shrimp Aquaculture Zones and Farms.
- **Circular 04/TS-TT** dated 30 August 1990 of Ministry of Fishery guiding the implementation of the Ordinance on protection and development of aquatic resources dated 25 April 1989 by State Council and **Decree No.195/HDBT** dated 2 June 1990 by Council of Ministries on protection and development of aquatic resources
- **Circular No 490/1998/TT-BKHCNMT** dated 29 April 1998 of MOSTE on making and evaluating environmental impact assessment reports with regard to investment projects
- **Circular 01/2000/TT-BTS** dated 28 April 2000 of Ministry of Fishery amending and supplementing Circular Circular 04/TS-TT dated 30 August 1990 of Ministry of Fishery guiding the implementation of the Act on protection and development of aquatic resources dated 25 April 1989 by State Council and **Decree No.195/HDBT** dated 2 June 1990 by Council of Ministries on protection and development of aquatic resources
- **Circular 02** dated 6 December 2002 of Ministry of Fishery concerning conditions to operate business in fishery and aquaculture.

Annex 4: Synthesis table of commodity specific environmental management actions

The following table summarizes the major better management recommendations for each commodity/farming system report. More specific details are available in the commodity reports.

a) Shrimp farming

Management recommendations	Shrimp farming
Farm siting/location	• Build new shrimp farms above the inter-tidal zone • Avoid damage to mangrove forest or other sensitive wetland habitats • Avoid building farms on acid sulphate soil • Do not locate farms on sandy soil areas • New semi-intensive/intensive shrimp farm developments should be subject to EIA and/or within designated suitable areas • Efficiency of extensive intertidal farms should be improved
System design and construction	• Separate effluent discharge points from inlet canal to reduce self pollution and maintain bio-security • Minimize erosion and salinisation during construction and operation. • Reduce waste and improve efficiency of resource use through integrated farming and system design and management • Integration with other species (mollusk and seaweed farming), • Promote prawn/rice systems to reduce reliance on seawater and saline intrusion in rice farming areas • Take measures to minimize release of waste (eg garbage, oil) to the coastal environment
Water/sediment management	• Reduce water use through reduced water exchange and recycling • Dispose of sludge in environmentally sound manner. Identify alternative uses for sludge • Treat effluent water to reduce impacts on natural habitats.
Seed management	• Use domesticated shrimp stocks where possible. • Promote production of SPF *P.monodon* broodstock • Develop stricter standards for hatchery management and shrimp quality. • Develop a certification system for better quality hatcheries (healthy competition between hatcheries) • Raise awareness and promote use of better quality seed among shrimp farmers • Improve the catching practices of shrimp broodstock. • Exotic species (eg *P.vannamei*) only cultured when from disease free sources, and measures taken to minimize risk of escapes from farms.
Feed management	• Use formulated feed of suitable quality and size • Promote regular feed checking reduce waste and improve FCR through better feed management.
Health/disease control	• Use of SPF *P.monodon* stocks. In absence of SPF stocks, use quality, tested, PLs. • Management on disease prevention and responsible health management rather than chemical use • Develop and implement surveillance and warning system • Build capacity for health management, monitoring and surveillance at province and district levels
Food safety	• No use of banned chemicals • No prophylactic use of chemicals. • Practice preventative health management and proper diagnosis of disease problems. • Maintenance of sanitary conditions on farms and handling and post-harvest treatment of harvested shrimp. • Awareness of farmer and middlemen on market requirements

Social benefits and employment	• Promote improved extensive and extensive shrimp farming and organic shrimp farming in southern provinces (Ca Mau) for poor as these systems are lower risk of economic loss and disease problem. • Provide training to farmers and employees in BMPs • Minimize conflicts and ensure benefits to the local communities

b) Marine fish and lobster cage farming

Management recommendations	Marine fish farming	Lobster farming
Farm siting/location	• Avoid marine park, coral reef, sea grass bed and other legally protected areas • Navigation and spawning and nursing zones should be avoided as cage sites • Avoid conflict of interest with other users such as fishermen, tourism, etc • Locate farms away from industrial/urban discharge points • Place in areas protected from strong wind/wave or use cages suitable for more exposed conditions • Ensure security with accessibility and basic infrastructure • Site farms in areas zoned/designated as suitable for marine fish farming	• Avoid marine park, coral reef, sea grass bed and other legally protected areas • Locate in sheltered areas avoiding the influence of strong waves/winds. • Locate farms away from industrial/urban discharge points • Select marine areas with good water qulaiyt and avoid estuarine areas with salinity fluctuations • Clean benthic areas with sand or mud • Avoid coral areas even if not a protected area to conserve marine biodiversity • Avoid conflict of interest with other users such as fishermen, tourism, etc
System design and construction	• Floating cages should be strong enough to withstand wind and currents without damage • Do not cluster all the farms in a given area. Leave space for rotation. • Promote integration with seaweeds and mollusks to reduce wastes and improve efficiency of farm operations • Take measures to minimize release of waste (eg garbage, oil) to the marine environment	• Floating cages preferred in lobster farming due to easily moving and operation in an environmental friendly practices • Size of farms should be 4-10 cages for better operation and management • Integrated culture should be applied including green mussels in lines, sea bass in several cages and or seaweed on the surface • Take measures to minimize release of waste (eg garbage, oil) to the marine environment
Water/sediment management	• Ensure water quality is suitable for cultured species • Allow sufficient space within aquaculture areas to rotate farms to minimize waste build up. • Avoid areas with poor water circulation • Conduct monitoring to ensure maintenance of water and sediment quality	• Avoid areas where water quality fluctuation is high such as estuarine region, particularly salinity. • Allow sufficient space within aquaculture areas to rotate farms to minimize waste build up. • Conduct monitoring to ensure maintenance of water and sediment quality
Seed management	• Use hatchery reared fish where possible. • Avoid use of wild caught juveniles caught using destructive fishing methods • Develop stricter standards for hatchery management and quality of hatchery fish seed. • Introduction of exotic species should be avoided. If necessary, consult and get approval from appropriate	• Use methods for capture wild seed that improve survival and reduce ecological impacts (eg traps for capture of wild seed) • Transport techniques that reduce stress and improve survival. • Use good quality seed and stocking rates that ensure optimal survival • Keeping female lobsters with eggs to allow release of eggs to the environment.

	authorities.	
Feed management	• Reduce use of raw trash fish. • Improve efficiency of feed use through use of moist or formulated diets • Promote regular feed checking reduce waste through better feed management. • Removal of waste feed to avoid contamination of environment. • Cleaning of cages to maintain a healthy environment.	• Daily checking of lobsters and removal and safe disposal of un-eaten feeds. • Periodic cleaning of cages to maintain a healthy environment • Good homemade processing trash fish by chopping and removing shelter. • Using combination of fish and mollusks to increase the survival rate and reduce the FCR.
Health/disease control	• Conduct regular health checks and undertake regular fresh water bath. • Undertake regular environmental monitoring and maintain environmental conditions to optimum. • Move only healthy animals • Treat sick fish properly, according to the syndrome. • Remove dead fish and discharge accordingly.Report diseases to local authorities to enable quick responses to outbreaks • Farmer and/or farmer groups establish the information channels on disease outbreak and methods of treatment.	• Conduct regular health checks • Maintain environmental conditions to optimum • Move only healthy animals • Undertake regular environmental monitoring • Report diseases to local authorities to enable quick responses to outbreaks • Farmer and/or farmer groups establish the information channels on disease outbreak and treatment solution.
Food safety	• Siting away from potential sources of contamination • No use of banned chemicals • No prophylactic use of chemicals. • Practice preventative health management and proper diagnosis of disease problems. • No discharge of un-neutralised waste water after chemical treatment. • Maintenance of sanitary conditions on farms and handling of harvested fish. • Awareness of farmer and middlemen on market requirements	• Siting away from potential sources of contamination • No use of banned chemicals • No prophylactic use of chemicals. • Practice preventative health management and proper diagnosis of disease problems. • Maintenance of sanitary conditions on farms and handling of harvested lobsters. • Awareness of farmer and middlemen on market requirements
Social benefits and employment	• Local government should have detailed planning and farmers should register their operation. • Develop cage culture groups to share culture techniques, experience and water source • Use revolving funds to improve access to capital • Provide training to workers in better farm management	• Local government should have detailed planning and farmers should register their operation. • Develop cage culture groups to share culture techniques, experience and water source • Use revolving funds to improve access to capital • Provide training to workers in better farm management

c) Coastal mollusk farming

Management recommendations	Mollusk
Farm siting/location	• Locate farms away from industrial/urban discharge points • Avoid sites with conflict of interest with other users such as fishermen, tourism, etc
System design and construction	• Minimise overstocking and keep farming within carrying capacity
Water/sediment management	• Ensure farm sites do no suffer from build up of waste sediment
Seed management	• Use hatchery reared mollusk seed where possible. • Develop stricter standards for hatchery management and quality of hatchery mollusk seed.
Feed management	• Not appropriate for filter feeding mollusks • For marine gastropods (eg *Babylonia*), take measures to reduce waste and improve efficiency of feed use.
Health/disease control	• Conduct regular health checks
Food safety	• Regular testing of mollusks to ensure maintenance of food safety requirements. • Maintenance of sanitary conditions on farms and handling of harvested mollusks.
Social benefits and employment	• Mollusc farms provide good opportunities for poor people due to being low risk. • Support access of poor people to mollusk farming technology

d) Coastal seaweed farming

Management recommendations	Seaweed farming
Farm siting/location	• Locate farms away from industrial/urban discharge points • Avoid conflict of interest with other users such as fishermen, tourism, etc • Encourage integrated seafarming to increase carrying capacity of coastal environments for aquaculture
System design and construction	• Minimise overstocking and keep farming within carrying capacity • Dispose of any wastes (garbage, old lines/rafts) in an environmentally safe manner
Water/sediment management	• Ensure farm sites do no suffer from build up of waste
Seed management	• Use quality and disease free seaweed plants
Feed management	• Not appropriate for seaweeds
Health/disease control	• Conduct regular health checks
Food safety	• Maintenance of sanitary conditions on farms and handling of harvested mollusks.
Social benefits and employment	• Seaweed promoted for poor people in coastal areas • Support access of poor people to seaweed farming technology

e) Catfish (*Pangasius*) cage and pond farming

Management recommendations	Catfish cage farming	Catfish pond farming
Siting/location	• Site farms only within suitable areas. • Better planning is required to define the suitable areas for catfish farming and carrying capacity. • Locate farms away from industrial/urban discharge points • Avoid sites with conflict of interest with other users such as fishermen, tourism, etc	• Site farms only within areas with sufficient water supply.
System design, construction and	• Cages/nets should be inspected regularly	• Promote polyculture with kissing

interactions with wildlife/habitats	and maintained to avoid damage and loss of stock	gourami • Effluent from catfish pond should be discharging to rice integrated system. • Take measures to reduce farm waste (eg empty feed bags and other garbage and organic wastes) • The height of the pond's banks should be higher than the highest recorded water level in the area so as to prevent escape of fish during floods.
Water and sediment management	• Take measures to reduce farm waste (eg empty feed bags and other garbage and organic wastes) • Monitor environmental conditions	• Enforce regulation on building up the treatment pond before discharging to water bodies • Promote sludge using for cultivation • Create monitoring system for environmental pollution • Pond site chosen must be directly adjacent to the river, so as to not divert water from other use. • Sediment should be removed and used to reinforce the banks of the farm – never released in the river.
Seed management	• Use quality seed from hatcheries, not wild seed • Inspect seed before release to cages	• Use quality seed from hatcheries, not wild seed • Inspect seed before release to ponds
Feed management	• Restrict use of trash fish from nearshore and riverine fisheries, which are considered fully exploited. • Preference to formulated diets to reduce waste • Feed efficiently to reduce waste and FCR	• Restrict use of trash fish from nearshore and riverine fisheries, which are considered fully exploited. • Preference to formulated diets to reduce waste • Feed efficiently to reduce waste and FCR
Health/disease control	• Implement health management measures that reduce stress • Maintain biosecurity and risks of disease introduction • Reduce risks of spread of disease through removal and correct disposal of dead fish. • Ensure responsible use of veterinary drugs and chemicals	• Implement health management measures that reduce stress • Maintain biosecurity and risks of disease introduction (easier to accomplish for pond farms) • Reduce risks of spread of disease through removal and correct disposal of dead fish. • Ensure responsible use of veterinary drugs and chemicals
Food safety	• Develop and disseminate BMP/standards for responsible use of chemicals among farmers • Purchase properly labeled chemicals from reliable suppliers • Monitoring, documentation and recording practices (inputs such as feed and treatments, mortality, inventories, invoices and accounting) have to be implemented. • Sewage from toilets, kitchen and laundry should not contaminate the water. All farms should have sceptic tanks – a legal requirements for aquaculture farms in Vietnam. • Ensure sanitary harvest and handling of catfish from pond to processor	• Develop and disseminate BMP/standards for responsible use of chemicals among farmers • Purchase properly labeled chemicals from reliable suppliers • Monitoring, documentation and recording practices (inputs such as feed and treatments, mortality, inventories, invoices and accounting) have to be implemented. • Sewage from toilets, kitchen and laundry should not contaminate the water. All farms should have sceptic tanks – a legal requirements for aquaculture farms in Vietnam. • Ensure sanitary harvest and handling of catfish from pond to processor

Social benefits and employment	• Create equitable links between farmers and processors to better balance supply and demand. • Create awareness on market issues among farmers • Create awareness of customers about the sustainably produced catfish, which, in turn, will demand the farmers to target the niche of the market for better price.	• Create equitable links between farmers and processors to better balance supply and demand. • Create awareness on market issues among farmers • Create awareness of customers about the sustainably produced catfish, which, in turn, will demand the farmers to target the niche of the market for better price.

f) Carp cage and pond farming

Management recommendations	**Carp cage farming**	**Carp pond farming**
Siting/location	• Locate farms away from industrial/urban discharge points • Avoid conflict of interest with other users such as fishermen, tourism, etc	• Locate farms in flat areas with suitable soils (clay/rich soil) • Avoid pesticide contaminated soils and water supplies (water and soils should meet Environment standards) • Locate farms away from industrial zone, polluted areas by human and agriculture practices.
System design, construction and interactions with wildlife/habitats	• Construct cages and nets with sufficiently strong material to reduce damage from wind and water currents and reduce risks of losing fish stock.	• Use integrated farming systems (such as VAC) making efficient use of on and off-farm resources • Build pond dykes solidly to avoid water loss through seepage • Ensure adequate water supply.
Water management	• Take measures to reduce farm waste (eg empty feed bags and other garbage and organic wastes) • Monitor environmental conditions • Move cages around to avoid waste build up in particular locations	• Ensure water quality is sufficient and meets Environment standards TCVN 5942-1995 (column b) on surface water quality standards • Intensive pond farms should have inlet and outlet and treatment facilities to avoid water pollution
Seed management	• Use quality seed of known species • Inspect seed before release to ponds • Do not stock exotic species unless approved by government	• Use quality seed of known species • Inspect seed before release to ponds • Do not stock exotic species unless approved by government
Feed management	• Feed efficiently by observation of fish behaviour and adjusting size and protein content of diet to fish size • Use feeding tray in fish pond to monitor fish feeding ability and remove redundant food	• Feed efficiently by observation of fish behaviour and adjusting size and protein content of diet to fish size • Use feeding tray in fish pond to monitor fish feeding ability and remove redundant food
Health/disease control	• Maintain healthy cage environment to reduce stress on fish • Monitor the environment • Ensure fish seed are free from disease.	• Maintain healthy pond environments to reduce stress on fish • Monitor the environment • Ensure fish seed are free from disease.
Food safety	• Do not use banned chemicals and drug in aquaculture.	• Do not use banned chemicals and drug in aquaculture. • Stipulate the use of probiotic/

		biological product in environment management and disease treatment. • Avoid using "night soil" • Implement better management practices to break the cycle of the zoonotic parasites
Social benefits and employment	• Develop fish culture groups to share culture techniques, experience and water source • Revolving community trust funds to improve capital access • Establishing regulations for different groups who are using the same resources such as water and land • Promoting an stipulating woman participates the aquaculture activities	• Promote polyculture culture in poor rural areas • Develop fish culture groups to share culture techniques, experience and water source • Revolving community trust funds to improve capital access • Establishing regulations for different groups who are using the same resources such as water and land • Promoting an stipulating woman participates the aquaculture activities