

Aquaculture and environmental issues in the region of Nai Lagoon, Ninh Hai district, Ninh Thuan province, Viet Nam

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During recent years, aquaculture in Viet Nam has grown rapidly in terms of area, type of culture, productivity, yield as well as economic results. For diversification purposes, many species have cultured at different localities. However, spontaneous development without adequate planning, management controls or awareness of environment conservation have led to problems such as conflicts among users, environmental degradation and outbreaks of disease, resulting in difficulties for aquaculture development in general.

Nai Lagoon located in the northeast of Phan Rang city, belongs to the administrative area of Ninh Hai district, Ninh Thuan Province. Nai Lagoon supplies aquatic resources that form the basis of the livelihoods of most of the people living around it. Like other coastal lagoons, due to the heavy pressure of livelihood activities, particularly aquaculture, Nai Lagoon has been at risk of gradual degradation of its environmental quality and resources, thereby compromising the livelihoods of local communities.

Under these circumstances, sustainable aquaculture development together with coastal ecosystem and environment conservation, based on the involvement of local communities, as adopted by many countries and local governments throughout the world, appears vital.

In order to develop community-based environment conservation at Nai Lagoon, it is necessary to understand the status of aquaculture and relevant problems. This paper focuses on aquaculture development and environmental issues at Nai Lagoon in recent times.

Methodology

Rapid Rural Appraisal (RRA) methods and questionnaire surveys were used to collect data from targeted households of five communities around the lagoon. RRA method was applied to obtain general information on the study area and to direct the questionnaire survey. Information in the questionnaire survey focused on culture status (cultured



Interview with a farmer.

species, type, area and economic performance), environmental issues emerging during recent years and orientation for sustainable aquaculture. The number of aquaculture households randomly interviewed was selected based on the relative ratio of households growing different species. The number of interviewed households is shown in Table 1.

The study attempted to assess the current situation of aquaculture in the region of Nai Lagoon in terms of cultured species and economic performance. Social assessments were undertaken in order to understand awareness, attitudes and opinions of aquaculture households about fisheries extension activities and environmental issues. Data was analysed for each item using MS Excel software.

In addition, secondary data was summarised in order to understand natural conditions, social-economic situation, environmental issues, mechanisms for aquaculture management and orientation of aquaculture in the region of Nai Lagoon.

Results and discussion

Overview of natural conditions of Nai Lagoon

Nai Lagoon is a coastal bay about 700 ha in area. The maximum depth of the lagoon is about 2.5 m depending on tide. Tidal amplitude fluctuates from 0.7 to 2.5 m. Rainfall is rather low, usually around 700 – 800 mm with the wet season from August to November, often flooding at this time causing losses for shrimp farmers. The lagoon often features a strong current throughout the wet season and salinity may fall. The volume of fresh water annually supplied to Nai Lagoon ranges from 350 to 400 million m³. However, seventy percent of the volume often reached for three months of rainy season. For that reason, fresh water supplied for agriculture and shrimp culture was limited in dry season leading to many difficulties for these activities.

The lagoon is connected with the sea by a narrow canal (Ta Khac Thuong et al, 2001) of 2 km in length, 3-5 m in depth and 100-400 m in width. However, the canal has filled up somewhat leading

Table 1. Number of aquaculture households interviewed.

Cultured species	Number of households	Ratio (%)
Black tiger shrimp	30	43
Seaweed	15	22
Crab	10	14
Molluscs	8	11
Marine fish	7	10
Total	70	100

Table 2. Area and yield of shrimp culture at Nai Lagoon.

Year	Area (ha)	Yield (Tonnes)	Productivity (tonnes/ha)
1992	469	620	1.32
1995	552	523	0.94
1998	548	947	0.57
1999	607	1,183	1.95
2000	673	1,412	2.1
2002	898	1,162	1.29
2003	898	1,143	1.27
2004	773	2,221	2.87

(Source: Reports of 2004 and 2005, Provincial Fisheries Department of Ninh Thuan province).

Table 3. Some species cultured at communes around Nai Lagoon.

Commune	Cultured species					
	Black tiger shrimp	Swimming crab	Snail (<i>Babylonia areolata</i>)	Blood cockle	Seaweed	Fish
Khanh Hai	+				+	
Tri Hai	+	+			+	+
Ho Hai	+	+			+	+
Tan Hai	+		+	+		
Phuong Hai	+	+			+	+

Table 4. Economic results of each species culture activities.

Cultured species	Culture period (months)	Profit (VND/ha/month)
Babylon snail	4	74,116,750
Black tiger shrimp	4	41,562,500
Fin fish	8	16,250,000 – 17,500,000
Seaweed	5	2,111,000
Swimming crab	12	1,300,000 – 1,500,000

to a decrease in water exchange and increased sedimentation within the lagoon.

Overview of social – economic situation of communities around the lagoon area

According to the administrative division, five communes of Tan Hai, Ho Hai, Phuong Hai, Tri Hai and Khanh Hai belonging to Ninh Hai district are located around Nai Lagoon. The total population of these five communes was around 64,300 people accounting for 54% of the district population. Up to December 2004, the population density was at 423 people/km², which is rather high in comparison to district population

density (215 people/km²) (Provincial Fishery Department of Ninh Thuan province, 2004). The population is biased towards young people with more than 50% under 18 year old, a high birth rate (crude birth rate was about 3%) and number of people per household (average of 6-7). Moreover, the local unemployment rate is high at more than 30%. In recent years, literacy standards have improved but are still at low levels in comparison to urban areas. Resolving the unemployment problems, increasing living standards and improving the lagoon environment are challenges for the local government. In recent times, livelihood activities of most local people were mainly based on resources of Nai Lagoon such as shrimp culture, aquatic

resource exploitation, and salt production. Nai Lagoon is the largest area for aquaculture in Ninh Thuan province with around 900 ha of pond area.

Recent situation of aquaculture in the region surrounding Nai Lagoon

Aquaculture at Nai Lagoon started in 1980 mainly with extensive systems. The main products were marine fish and sand-shrimp (*Metapenaeus* sp.). The area of aquaculture increased to 80 ha with the introduction of black tiger shrimp culture in 1987 using improved extensive systems. In 1993, the Peoples Committee of Ninh Thuan Province issued a policy to develop infrastructure for 500 ha of aquaculture in the region and aquaculture activities changed from this time. After 1995, culture techniques changed to semi-intensive type with large investments of seed, shrimp feed, equipment and application of technological advances. The year 2000 was the peak of shrimp culture activities of Ninh Thuan Province in general and Nai Lagoon in particular in terms of productivity and economic performance. Aquaculture has stabilized at around 900 ha of pond area at present.

However, due to failure of black tiger shrimp culture in recent years, other species have been farmed instead. Up to July 2005, there were 120.5 ha used for culturing other species with 267 participating households. Of these, the area used for seaweed culture (*Kappaphicus alvarezii*) was largest (133.8 ha). In fact, most of households were at the stage of looking for suitable alternative culture species. Species cultured in the area are summarized in table 3.

Basing on surveyed data, economic performance calculated for one ha showed that high profit were associated with the farming of black tiger shrimp, babylon snail, finfish and seaweed.

The results of culture (table 4) have shown that culture of snails, shrimp and fish can give high profit. In fact, shrimp farming was high-risk activity so snail and finfish have been the new trade-off for culture activity at the lagoon. However, the main difficulty has been the lack of culture technique for these species for farmers, especially for babylon snail. Therefore, the Fishery Extension Center of Ninh Thuan province should in future seek to assist farmers in this regard, together with capital provision policy.

Black tiger shrimp culture (*Penaeus monodon*)

Together with high profit, the area used for shrimp culture has increased. Over the period from 1989 to 1999, shrimp culture area increased by 105.74% (an average of 10.57% annually). However, in the period from 2000 to 2005, the area used for shrimp culture has decreased. The ponds remain, however the area actually used has fallen from 898 ha (2003) to 773.2 ha (2004), to only 325 ha in 2005 (Fishery Department of Ninh Thuan province, 2005). While area under culture was still increasing in 2002 the productivity and yield had begun to fall, with yield down 250 tons and productivity falling by 800 kg/ha, reaching a low of just 1,270 kg/ha in 2003. This was one reason for the rapid subsequent decline in culture area and switch into other species by many farmers; another reason was that farmers lacked capital to continue shrimp farming.

Seaweed culture (*Kappaphicus alvarezii*)

In 2003, with assistance from the Provincial Fishery Department of Ninh Thuan, the Peoples Committee completed preparation of a project to provide opportunities for employment and "hunger eradication - poverty alleviation" for shrimp farmers around Nai Lagoon. The area planned for seaweed culture was 20% total area of Nai lagoon (from 160 to 200 ha) (People Committee of Ninh Hai district, 2004). Seaweed culture was piloted in a 4.8 ha area at Khanh Hai Commune, increasing to 37.8 ha in 2004 and 133.8 ha in 2005.

Seaweed was farmed using the method of a single line stretched over the lagoon bottom. This method was popularly applied and evaluated as having advantages over other methods. Seaweed was often cultured from May to September and from October to March of following year in areas of water exchange with salinity of 28 – 30 ppt, less waves and no direct influence by fresh water. However, in the sub-crop season, weather was often unstable and floods, storms and high temperatures had some negative impacts the development of seaweed culture.

Table 5. Assessing extension activity in the region of Nai Lagoon (n=70).

Item	Opinion	Ratio (%)
Aquaculture workshops		
Participating	40	57
Not participating	30	43
Results		
Good	28	40
Fair	7	10
Bad	5	7
No opinion	30	43

Table 6. Decreasing environmental quality – causes and solutions (n=70).

Item	Opinion	Ratio (%)
Environmental quality		
a. Good	1	1.4
b. Acceptable	6	8.6
c. Bad	63	90
Cause of pollution		
a. Freely discharging waste	43	61
b. Lack of treatment systems	2	5.7
c. Low awareness of culturists	13	19
d. Other	10	14.3
Way of improvement		
a. Seed testing before stocking	2	3
b. Improving pond environment	2	3
c. Enhancing community awareness	52	74
d. Other	14	20

Swimming crab culture (*Portunus spp.*)

Swimming crab culture has not been widely developed due to lack of seed. However, difficulties in shrimp culture have led some households to use their shrimp ponds for swimming crab culture. Most of these households were poor. In addition to swimming crab culture, their livelihood activity was fishing in the lagoon so they could catch natural seed to supplement during culture cycles. Other households could buy seed from fishers. For that reason, most of interviewees (90%) revealed that seed quality was not good and rather scarce. In general, swimming crab culture at the Nai Lagoon was mainly "harvesting and stocking in rotation".

Most cases of swimming crab culture were carried out at Hon Thien – Ho Hai commune. Culture area in 2004 was only 6.3 ha with 16 households and average culture area was 0.35 ha/household. Culture density was rather low at the average of 1.32 inds/m² with average seed size of 20 – 30

individuals/kg. Productivity of swimming crab culture at Nai Lagoon was about 1.16 tons/ha/year.

Mollusc culture

Due to problems encountered with shrimp culture, the Fisheries Department proposed diversifying culture species in order to improve the culture area environment and develop sustainable aquaculture. As new species, snail and blood cockle were reared.

Babylon snail farming (*Babylonia areolata*): Babylon snail was a cultured species of economic value, especially for export purpose. In 2003, the Fishery Extension Center of Ninh Thuan Province carried out snail culture successfully in earthen ponds. From this time, it started to be reared by farmers. Crops started from February to June and from September to December. The price of seed was rather high and all households revealed this to be the main difficulty. At the present, six households conduct snail farming in ponds at Tan An village - Tri Hai commune with total area of 2.8 ha. Furthermore, nine households culture snail in the

lagoon area (cage culture) at Khanh Hai commune. However, all of these households have suffered high mortality rates without identified reasons. The potential problem of snail rearing was fresh feed. This could easily pollute the lagoon environment if snail culture further develops.

Blood cockle culture (*Arca ranosa*): Since 1997 some farmers started blood cockle culture in the littoral area of the lagoon but results were not good. Up to June, 2005 there were only two households conducting blood cockle rearing at Hon Thien, Ho Hai commune with 2 ha pond area and 0.5 ha littoral area (fence culture). The culture period lasts for seven months (from August to April of the following year). However, due to high mortality rate without known reasons, yield only reached 0.4 tons/ha. In recent times, there has been no hatchery seed so wild seed of blood cockle caught from the lagoon was used. Due to overexploitation, natural seed of blood cockle became gradually scarce, negatively affecting natural resources of blood cockle in Nai Lagoon. Together with the development of seaweed culture, waters area used for exploiting blood cockle seed was narrowed leading to conflict between the two activities. According to the policy of Provincial Fishery Department, the area of blood cockle culture should not be increased due to low economic performance and environmental impact of the waste from blood cockle farming.

Fish farming

Fish farming was one option to diversify culture species in order to reduce the dependence on shrimp culture activity with negatively environmental impacts. Fish farming at Nai Lagoon started from 2004. Cultured species included sea-bass (*Lates calcarifer*), snapper (*Lutjanus* spp.) and tilapia (*Oreochromis* spp.). The culture season of fish depended on seed availability. Moreover, the Fishery Extension Center of Ninh Thuan Province has piloted model of co-culture of black tiger shrimp and milkfish in order to improve environmental conditions and enhance economic performance. Fish farming helped to provide more jobs, increased income for farmers, and improve pond environment. According to farmers, the economic performance of fish farming was positive. However, data was limited for detailed analysis.

Environmental problems caused by aquaculture activities at Nai Lagoon

In recent time, problems of environmental pollution and degradation at Nai Lagoon were at alarm levels. Of these, waste from culture activities was the most important problem that needed to be solved. Negative factors for the environment of Nai Lagoon from aquaculture activities included:

Chemicals

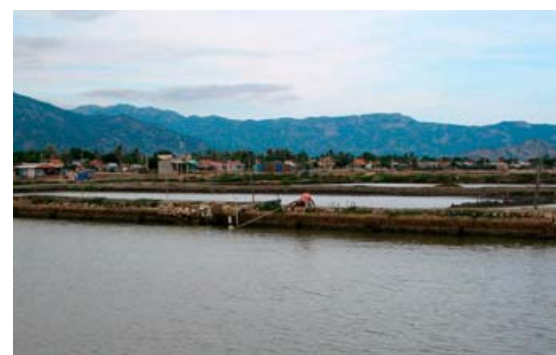
For aquaculture production, all households used chemicals for a variety of purposes including cleaning the pond bottom, water quality management and sterilization, probiotics and tonics. These chemicals affected not only the ecosystem in culture pond but also natural ecosystem when they were released into outside environment.

Organic wastes

Large amounts of dissolved and solid wastes generated from aquaculture activities have been mentioned in a number of documents. So far, in general, aquaculture systems in the region have developed spontaneously without planning. Hence, there was lack of dedicated systems for water supply-discharge. Therefore, water discharge was loaded into the lagoon without any treatment, leading to pollution of the lagoon. Some parameters were higher than regulated criteria for aquaculture such as dissolved oxygen, NH_3 , biological oxygen demand and total bacterial counts. For that reason, there should be necessary measures to control these wastes. In recent time, in order to avoid environmental pollution caused from low quality feed, the Fishery Extension Center and Fishery Department has often tested feed samples from shrimp feed services. In addition, fisheries extension programs were undertaken to educate farmers about feeding rates and regimes. The seaweed culture program was also one of solutions for this problem.

Fisheries extension activities and awareness of local people about environmental issues

Yearly, under guideline of the Provincial Fishery Department, the Fishery Extension Center collaborating with District People Committee, Commune People Committees, and shrimp feed agents organised aquaculture workshops.



Above, below: Shrimp ponds in the Nai Lagoon area.



However, survey results showed that only 57% of aquaculture households did attend. Forty percent of interviewees evaluated the workshops as helpful. By this way, they learned culture techniques such as feeding methods and disease prevention. However, 7% of interviewees thought that fishery extension activities did not have any effect.

Assessing environmental quality, 90% interviewed opinions showed that it was bad but 1.4% thought that it was good. According to aquaculturists, causes of pollution were freely discharging waste (61%), low awareness of local people (19%), lack of waste treatment systems (5.7%) and other causes such as unplanned development and unsuitable time culture. In order to improve environmental quality, they suggested to enhance community awareness. Seventy four percent interviewed opinions thought that responsible culturists should not discharge waste freely, particularly in case of infected shrimp ponds by disease.

At present there are some communes (Luong Cach, Tri Thuy) that have introduced fees for environmental cleaning. However, the fee for aquaculture activity was not applied due to lack of policy. Environmental fees might be new for local managers and farmers.

However, it could be a useful tool to regulate local economic development if it were used in the right way. According to our survey, 63% of interviewees agreed that it is necessary to apply an environmental fee. The basic issue was to identify appropriate sum of money and use the fee for right purpose. For aquaculture, environmental fee policy aims at ensuring the fairness between resource users and others. This fee could be calculated based on profit from aquaculture activity. This fee also forbids resource users to be responsible for their activities. In case of disease breaking out, this fee would be the fund to help farmers to resolve the problem.

Mechanisms for management of aquaculture activity

Among authorities/offices at any level

Aquaculture activity was under direct management of the Provincial Fishery Department, the Fishery Extension Center and Aquatic Resources Preservation Office (responsible for culture techniques, environmental conditions and disease warnings), the Provincial Peoples Committee (generally promulgating policy, planning development and regulating management) and the District and Commune Peoples Committees (implementing guidelines).

In principle, aquaculture ecosystems are the un-detachable part of aquatic ecosystem that are not only directly related to but also affected by terrestrial ecosystems. Thus aquaculture is affected by other economic activities, especially agriculture. However, the connection among economic branches was still loose and not decentralized completely. The Provincial Fishery Department was responsible for aquaculture but canal and irrigation systems are under management of the Provincial Department of Agriculture and Rural Development. Under this circumstance, the Fishery Department was only in charge of professional techniques so it could not manage wastes from agricultural activity (mainly fertilizers and pesticides). Moreover, at district and commune levels, there was not any office responsible for aquaculture so management activities were ineffective. Trying to resolve these issues, the Fishery Department of Ninh Thuan Province established Ninh Hai Station of Aquaculture Management in order to better manage aquaculture activity at the district level.

Among farmers conducting aquaculture

Before 2004, all localities around the lagoon established aquaculture self-management groups in order to control environmental cleaning and disease warnings. On a voluntary basis, each group had 10 - 15 members including the head. Each group organized monthly meetings to inform members about the aquaculture situation and so that they could help each other with capital and techniques. However, by 2005 only two communes had maintained this activity, Ho Hai and Phuon Hai, due to lack of activity expenditure, manpower, mechanism and experiences. In fact, management mechanisms were only applied for shrimp and seaweed culture but most farmers did not believe in this type of management due to ineffective activity of the self-management groups. When farmers had problems such as disease they tried to solve themselves. For that reason, authorities should improve activity of self-management groups.

Orientation of aquaculture at Nai Lagoon in future

According to the aquaculture planning project of Ninh Thuan Province, the aquaculture area around Nai Lagoon will be decreased by 200 ha. Khanh Hai and Tri Thuy communes will not continue aquaculture but will develop eco-tourism instead. Aquaculture area for the whole region of Nai Lagoon will be 750 ha including 650 ha (500 ha water surface equivalently) of Phuon Hai, Ho Hai and Tan Hai communes conducting semi-intensive culture and 100 ha of Khanh Hai commune conducting eco-tourism aquaculture.

One crop per year of black tiger shrimp will be conducted and the remaining crop will be other species. In recent times, there have been two types of rotation culture: shrimp – fish (often tilapia) and shrimp – seaweed. However, the rotation culture of shrimp – seaweed has been ineffective in the lagoon region due to poor development of seaweed in ponds. It may be useful for the Fishery Extension Center to carry out more research to improve this model. In addition, shrimp and milkfish co-culture models have been experimented with. The success of this model would enhance income and improve pond environments. However, methods and ratio of co-cultured species should be researched in order not to affect

shrimp as the main culture species (due to competition of milkfish with shrimp about feed). Babylon snail, tilapia, snapper, grouper may provide alternatives to black tiger shrimp. It is clear that the culture model of these species should be further researched to develop sustainable aquaculture. Depending on location and condition of each locality, farmers should be encouraged to culture suitable species.

In order to realize the above mentioned orientations, it is necessary to develop infrastructure and integrated management policy among production branches as well as levels. Additionally, the support and participation of local people should be encouraged.

Conclusion and recommendations

Based on survey results, the following conclusions can be made:

- In recent times, the main cultured species in region of Nai Lagoon was black tiger shrimp.
- Aquaculture is the main livelihood activity of many local households. However, most of them have low technical qualification so culture activity is based on their experience.
- In general, aquaculture activities have not been planned and wastes have not been adequately controlled. Together with low awareness of farmers, these have resulted in degradation of the natural environment, leading to losses for farmers.
- Management activities have generally been ineffective. Aquaculture training has not been considered as good by all farmers. Management mechanisms at different levels have been limited. The activity of self-management groups has not been effective.

In order to sustain aquaculture in the region of Nai Lagoon, some recommendations are proposed:

- Applying waste water treatment systems for aquaculture and restoring mangrove forest in the vicinity of the lagoon to assist with assimilation of nutrients.

- Planning of culture area, conducting rotation aquaculture and co-culture, and carrying out culture activities in suitable season-crops could facilitate sustainable production.
- Further research on culture species to find suitable species for this locality.
- Organisation of frequent aquaculture workshops in order to improve technical skills and environmental awareness of farmers.
- Application of environmental tax/fees on aquaculture activity to assist with prevention, remediation and fund response to emergencies such as disease outbreaks.

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Climate change impacts on fisheries and aquaculture

Sena De Silva, NACA Director General

Climate change is perhaps one of the most important issues confronting the global community and associated debates have intensified over the last decade, most recently with the submission of the final findings of the Inter Governmental Panel on Climate Change (IPCC, 2007). The time has come for development and food production sectors to take note of the above findings, based on a thorough scrutiny and synthesis of the scientific evidence on climate change, and to initiate adaptive and/or mitigating measures.

FAO has initiated many expert consultations on the impacts of climate change on different food production sectors, one of which was held on fisheries and aquaculture. Needless to say that the urgency of the problem has been further exacerbated by the emerging “food crisis” as well as by the potential channeling of food to produce biofuel.

The Expert Consultation on Climate Change Impacts on Fisheries and Aquaculture was held in Rome, 7-9 April, 2008. The consultation was based on three reviews that formed the background for the discussions and the preparation of an all encompassing document to be submitted to the Heads of Government Meetings on Climate change in Rome, July 2008. The three reviews that were provided the background for the consultation were:

- Physical and ecological impacts of climate change relevant to marine and inland capture fisheries and aquaculture (by Manuel Barange and Ian Perry).
- Climate change and capture fisheries – impacts, adaptation, mitigation, and the way forward (by Tim Daw, Neil Adger, Katrina Brown and Marie-Caroline Badjeck).
- Climate change and aquaculture (by Sena S De Silva and Doris Soto).

These reviews will be published as a FAO Fisheries Technical Paper in due course and are expected to provide a useful documentation regarding the potential impact of climate change

on fisheries and aquaculture, and recommendations regarding adaptive measures.

The “policy paper” on climate change on fisheries and aquaculture developed at the consultation is reproduced below. More information from the FAO High Level Conference on Climate Change and Fisheries and Aquaculture is available from the FAO website at: <http://www.fao.org/foodclimate/expert/em7.html>.

Workshop on Climate Change and Fisheries and Aquaculture: “Options for decision makers”

FAO Headquarters, Rome, 7-9 April 2008

Introduction

From local to global levels, fisheries and aquaculture have very important roles for food supply, food security and income generation. Some 42 million people work directly in the sector, with the great majority in developing countries. Adding those who work in associated processing, marketing, distribution and supply industries, and the sector supports several hundred million livelihoods. Aquatic foods have high nutritional quality, contributing 20 percent or more of average per capita animal protein intake for more than 2.8 billion people, mostly from developing countries. They are also the most widely traded foodstuffs and are essential components of export earnings for many poorer countries. The sector has particular significance for small island states. Climate change is projected to impact broadly across ecosystems, societies and economies, increasing pressure on all livelihoods and food supplies, including those in the fisheries and aquaculture sector. Food quality will have a more pivotal role as food resources come under greater pressure,