ARTICLE

Shrimp Farming in Coastal Areas in Thailand and the Proposed Economic Instruments for Sustainable Shrimp Farming

Dararatt Anantanasuwong*

1. Introduction

Coastal areas which used to be mainly covered with dense mangrove forest and rice fields have been converted by local fishermen and outside investors into ponds for shrimp farming. With a short-run profit incentive, many rice farmers have modified their field into shrimp farms causing environmental impacts on the remaining rice fields and other adjacent agricultural areas. The problems of water pollution and deteriorated environment have become so serious that many shrimp ponds can no longer be used. Shifting cultivation to new areas is commonly practiced, and presently, large tracts of coastal land that used to be ponds have been abandoned and remain unused.

The contribution of shrimp farming sector in Thailand has been very impressive. The sector has grown rapidly during the last decade to become a major export revenue generator for the Thai economy. Exports from the sector account for approximately 1% of GDP in 1992 (FAO/NACA, 1995) and generate 3.5% of total export revenue in 1996. At present, the Thai shrimp sector accounts for 20% of the world trade in shrimps and is the world's leading exporter of the Black Tiger prawn. The sector is also favorably supported by the World Bank and the Asian Development Bank for its social welfare profile. Despite its significant contribution to the national income, the Thai shrimp farming sector is characterized by a large number of small owner operated farms with an average area of less than 1.5 hectares (Patmasiriwat et al., 1998).

However, in spite of the impressive growth record of the industry, there have been many economic, socio-economic and environmental repercussions (Duraiappah and Israngkura, 1999). The economic problems of the sector are related to the production sustainability. The shrimp farming sector has over the last 15 years witnessed a series of booms and busts. The first production crash came in 1990 when disease outbreaks wiped out approximately 90% of farms along the Inner Gulf of Thailand where the majority of farms were located. The farmers were able to migrate and expand from the Gulf to the southern coasts (i.e., Prachuab Khiri Khan, Surat Thani, Nakhorn Sri Thammarat) and then across to the Andaman coast. However, production crashes caused by disease outbreaks along the south coasts in 1996 has led to a sharp decline in production while the production crash in 1990 had hardly any effect on production. The continuing decline of production if not addressed can only cause a loss of valuable export revenue and a loss of livelihood for a large

* Proffessor, School of Development Economics, National Institute of Development Administration, Bangkok, Thailand

number of people involved in the shrimp farming sector. Several environmental repercussions are mostly related to mangrove destruction, coastal pollution and salinization of land, which will be discussed in more details later.

Policy makers in Thailand have acknowledged both the importance of the sector as a revenue source on one hand and an environmental and socioeconomic problem source on the other hand. Many policies have been drawn up to address the issues mentioned above but to date have had limited success (Dierberg and Kiattisimkul, 1996; Flaherty and Karnjanakesorn, 1994; Thonrak et al., 1997). Majority of the policy responses have been regulatory in nature with very little attempt to use economic incentives. The monitoring and enforcement of the policies; institutional and financial constraints have been cited as the primary reasons for failure of present regulatory policies (Flaherty and Karnjanakesorn, 1994). It is argued that what is needed are self-regulating mechanisms in which farmers have a personal interest to pursue activities which will help the shrimp sector become sustainable (Thongrak et al., 1997).

In 1995, the Ministry of Finance to find appropriate tax measures to solve environmental problems has established a working group. The working group is composed of representatives from various ministries. At present, the working group is considering the proposal by the Ministry of Science Technology and Environment to collect tax or fee for rehabilitation of abandoned shrimp farms and the suggestion by the Ministry of Finance to charge user fees from coastal aquacultural farmers under the government's wastewater treatment project.

As it is an important source of income and the cause of a rapid increase in the welfare of the local population, shrimp farming certainly cannot and should not be stopped. However, what should be introduced to make shrimp farming sustainable is the main policy concern. Therefore, it is the purpose of this study to review the shrimp farming's impact on coastal environment, stake holders involved in shrimp farming operation, policy approach, and economic instruments proposed to supplement the command and control measures for the sustainability of shrimp farming and, hence, for the coastal area management.

2. Problems of Shrimp Farming Related to Coastal Zone Management

Shrimp farming have created several problems that can be related to the coastal zone management (Boromthanarat, 1995: 431-433) as follows:

1) **Water-related problems:** The water resources management problem in the tropical monsoon countries is basically a matter of "too little" (water shortage in the part of dry season), “too much” (flooding in another season) and “too dirty” (salinity and/or pollution problems throughout the year). Shortages of freshwater leads to a lack of drinking water, mainly in the coastal areas. In addition, the pollution of the surface water by shrimp farming poses a threat to the drinking water sources. Apart from water shortages, flooding of lowland areas in river basins also poses regular problems. Storms of lower strength occur every 2 or 3 years causing inundation of the area. In addition, high water levels in the sea often leads to drainage impediment in the rainy season.

With regard to water quality, salinity intrusion is only one of the many factors. The rapid and uncontrolled extension of shrimp farming may increase the problem of freshwater shortages in the future. There is a large demand for fresh water by shrimp farmers for optional water levels and

salinity control in the shrimp ponds, and the economic strength of the companies may further increase pressures on the water supply. The real water quality problems seem, however, to be caused by shrimp farm wastewater discharges. The drainage water of the shrimp farms generally has high BOD, nitrate, phosphate, chlorophyll-a and bacterial concentrations. Other substances like antibiotics and fungicides are used for disease control and pond cleaning and are also present in the wastewater. Most of the shrimp farms discharge wastewater directly into the surface water system furthers threatening fresh water sources.

2) **Land-related problems:** Initially, the low productivity of the soils, particularly in the lowland swamp areas, pushed down land values. However, land suitability has hardly been a criterion for site selection of shrimp farms; the availability of saline or brackish water was the major factor. Consequently, the boom in the shrimp farming industry has created an enormous shift in land use, which has caused a dramatic increase in the demand for land in the coastal area. For instance, in the area around Pak Phanang in Nakorn Sri Thammarat, the prices of land went up from 200-300 baht per rai (US$50-75 per ha) in 1985, to about 200,000-300,000 baht per rai in 1991 (US$ 50,000-75,000 per ha), but they have since stabilized. Many farmers were inclined to sell their land to shrimp farmers. There has also been an increase in the large-scale illegal clearing of forest and mangrove areas for shrimp farming. In this respect, the chronicle problems of land tenure, land ownership and land registration play a less important role.

3) **Aquaculture-related problems:** Optimal growth of shrimp occurs in a salinity range about one third lower than sea water salinity and, consequently, shrimp culture companies tend to mix sea water with fresh water whenever available. As a result, there is pressure on freshwater resources. In spite of mechanical aeration devices installed in most of the ponds, overstocking of shrimp ponds and inefficient feeding practices may lead to low dissolved oxygen levels. And oversupply of feed and fertilizer will also lead to eutrophication and high chlorophyll levels. These problems, plus disease, raise the mortality rate and diminish yields.

After each 4-month crop cycle, shrimp ponds have to be cleaned and disinfected and the polluted sludge has to be removed. After a period of about 5 to 10 years, the ponds have been polluted and toxified to such a degree that they have to be abandoned completely. This land cannot be used for agricultural production anymore, and other appropriate land uses have not yet been identified.

The shrimp farming industry has learned that highly intensive production methods are quite sensitive to internal operational problems such as pond water quality and disease, and to external factors such as climate and water availability. Therefore, they involve large capital risks. In various places in Thailand, there has been tendency to shift from very highly intensive pond systems to semi-intensive systems. This may also be caused by lower prices on the international market. As previously mentioned, shrimp farming creates several problems to the environment regarding wastewater discharge, sludge removal and storage, as well as land degradation. Fortunately, some of the major international markets have enforce strict quality control on shrimp, particularly with respect to maximum concentration of applied disinfectants and disease control compounds. Hopefully, this will lead to the reduction of inputs of potentially toxic compounds such as antibiotics, herbicides and fungicides, which may slightly reduce the problems.

4) **Coastal zone problems:** Shrimp farming along the coast is quite vulnerable as, in general, it is only slightly higher than the normal high water line. Sand ridges, dikes and other coastal protection constructions are absent, and villages and a major road are still located directly behind the coast. The vulnerability to seasonal storms and typhoons is evidenced by the regular flooding and damage that this area experiences.

Coastal zone management problems refer to an imbalance in the use of the coastal land and water resources, i.e. rapid changes from agriculture to shrimp farming with associated land degradation and water pollution. In addition, in some places along the coast, huge seawater intake installations have been constructed, consisting of large pumping stations and supply canals built on sizeable jetties. These structures cause substantial local sedimentation and erosion, as they disturb the coastal equilibrium of the northwards current that is directed along shore and acts to transport sediment.

The mangrove areas in the region have been cleared for shrimp farming with unknown consequences on coastal and bay dynamics. What is not yet known is the extent to which the growth of mud flats or sand beaches and the silting of bays, both by sand deposition, are affected by this mangrove destruction.

5) **Environmental management problems:** The environmental problems related to the present development within the coastal basin include land degradation, water pollution, the destruction of wetlands and mangrove forest and disturbance of the present coastal equilibrium.

Coastal zones are often the dumping bin of wastes from land and sea-based human activities. The most dangerous is the presence of toxic substances, which might return to the food chain through physical, chemical and biological processes which are difficult to control. Shrimp farm pollutants pose a threat for coastal areas.

The above overview indicates the interdependence between the shrimp farming sector and coastal zone management (i.e. the environmental impacts on shrimp farming and that of shrimp farming) as well as that among shrimp farms themselves (i.e. the shrimp farms on other shrimp farms). More specific details on the interdependence aspects of shrimp farming can be stated as follows:

(1) Environmental repercussions of shrimp farming on mangrove deforestation

One of the most cited environmental problem attributed to the shrimp farming sector in the coastal areas is mangrove destruction. Although there is a certain amount of truth to the sector's role in destroying mangrove forests, the degree of its role may be questionable. A 1995 FAO/NACA (1995) report states that a large portion of mangrove land that has and is being used by shrimp farms were actually degraded mangrove lands. Moreover, Potaros (1995) and Paw (1991) find that only about 30 to 38% of mangroves destroyed can be attributed to shrimp farming. In 1996, a joint government study, comprising of the Department of Fisheries, Royal Forest Department, Land Development Department and the National Research Council of Thailand used remote sensing images to show clearly that 30% of the country's mangrove forest has been lost to date and of that amount approximately 31% was attributed to shrimp farming (Piamsak, 1996).

(2) Shrimp aquaculture, coastal pollution and disease epidemics

Another environmental problem caused by the sector over which there is less controversy is coastal pollution (Thongrak et al., 1997; Tookwinas, 1995, 1998, 1999; Dierberg and Kiattisimkul, 1996; Midas Agronomics, 1995). In a majority of cases, farms dispose their untreated water both during and especially after a harvest directly into the common water canals which eventually flow into the coastal waters. The open access characteristic of the water use and exchange system leads to massive pollution of the coastal waters and at rates that far exceed the natural systems regenerative capacity. Both the shrimp farming sector as well as other sectors dependent on coastal resources have suffered from this pollution. Ironically, the pollution caused by shrimp farms have been cited as one of the principal causes for the frequent disease epidemics. If sustainability of the sector is to be achieved, this pressing issue of water quality must be addressed and resolved immediately.

(3) Shrimp farming and salinization of land

The third and final environmental problem caused by the sector deals with salinization of land. Abandoned shrimp farms have very little alternative agricultural uses due to the high salinity levels in the soils. It normally takes about five to seven years before the land can be used again for other agricultural purposes. To make matters worse, the salinization process from the farm is not localized. Intrusion by surface and sub-surface saltwater from the shrimp farms to adjourning lands force many of the farmers working on these lands to also abandon their farms.

The environmental externalities mentioned above have had serious socioeconomic repercussions for both the shrimp farmers as well as other communities living in the vicinity. The shrimp farmers are usually left with heavy financial debts leading to destitution when they are forced to abandon their farms after a series of disease outbreaks. The degradation of the coastal resources by the effluent discharge from the shrimp farms has caused many of the fishing communities to lose their source of livelihood. This in turn has caused many of these communities to migrate to the cities in search for employment. A similar turn of events face the rice and fruit farmers who have seen productivity of their land drop because of salt water intrusion into their farms.

3. Shrimp Farming Industry

As mentioned above that shrimp farming industry has contributed significantly to the Thai economy. The rapid expansion of the sector has been attributed by the gradual development in production process to increase farm productivity, i.e., from wild shrimp production to cultured one. However, the development in terms of environmental protection ad pollution control has not been advanced.

1) The stakeholders and production process of the industry

The production in shrimp farming involves many stakeholders as shown in Figure 1. On the input side, it involves fisheries catching shrimp fry, shrimp hatcheries, farm equipment, feed stock and chemical industries, and labor. Shrimp farms also depend on technological development from the government agencies, universities, private companies and local wisdom to improve their farm productivity. Traders and shrimp processing industries are important as outlets for their product to be consumed in the domestic and foreign markets. Environment is another important

stakeholder in shrimp farming as waste receptor from farms. The condition of environment, in turn, will effect fisheries that provide shrimp fry to the farms.

Production process of shrimp farming, which has impacts on environment and other shrimp farms, involves 2 main management functions: water management and pond management (Figure 2).

Water management concerns with water exchange system in order to minimize water quality deterioration. Although experts are not sure of the degree of causality between water quality and disease and between water quality and farm productivity, they are unanimous in agreement on the high causality relationship between declining water quality, disease outbreaks and declining farm productivity.

Farm level water quality can be either determined solely by the individual farmer through his/her choice of farm management or it can be influenced by the activities of the other farms - it all depends on the water exchange system the farm decides to adopt. In a case of closed system, the water quality during the grow-out period is completely under the control of the farm. No exchange occurs with the common water channels and therefore no contact is made with the pollutants produced by other farms. However, under the closed system, the water is moved into another pond at the end of the crop cycle, where it is again treated with chemical before it is reused or discharged into the ocean, depending on the number of times it has been recycled.

In the case of a semi-closed or open water exchange system, there is continuous contact with the common water system and the probability of using disease-contaminated water is high. The choice of which particular water exchange system to use comes with cost. A closed system requires more land, as more ponds are needed for water storage and cleansing ponds. For the water quality of the common water system, the deterioration of this water source has significant repercussions not only to the shrimp sector but also to other sectors, which rely on this water stream as input for their production activities. These sectors would be the coastal fishing and tourism sectors, which are important in Thailand - tourism is a major foreign exchange source while the coastal fishing sector provides a source of income for a large proportion of population. For the shrimp sector, irrespective of the water exchange system used, prevention of deterioration of water quality of this source is vital for the long run sustainability of the sector. It is obvious for the semi-open and open water exchange systems but also holds for the closed system because at some point in time, some form of water exchange needs to take place.

Pond management involves decisions on stocking density, seed quality, feed management, water quality management and sludge management.

Stock density and seed quality: Stocking density relates to the number of juvenile post larvae (PL) shrimps per unit area. In the past, the average stocking density was approximately 10-20 PL per sq. m. But over the last two decades, this has increased to about 50-100 PL per sq. m. However, higher stocking densities lead to higher mortality rates. Several reasons can be explained for the high mortality rates. First, it is a “crowding” effect, which results in high stress levels for the shrimps. The high stress levels reduce the resilience of the shrimps toward viruses and are thus more susceptible to diseases. Second, the higher stocking density means a higher discharge rate of waste per unit area. The waste which gets into the water becomes toxic if not cleaned properly and the shrimp living in a deteriorating environment come under stress which results in a loss of resilience and inadvertently forcing them to be susceptible to diseases. The

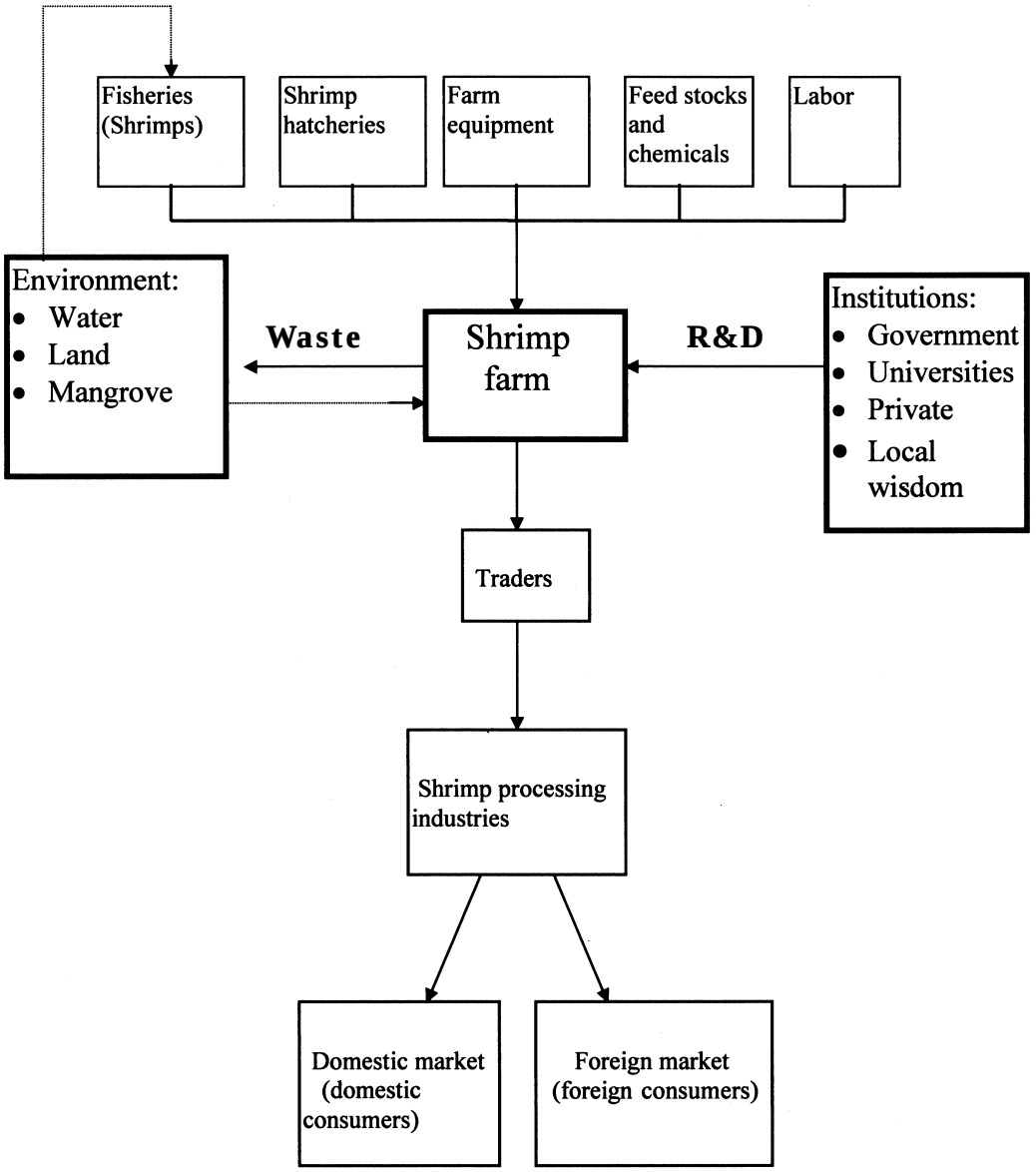

Figure 1: Stakeholders in Shrimp Farming

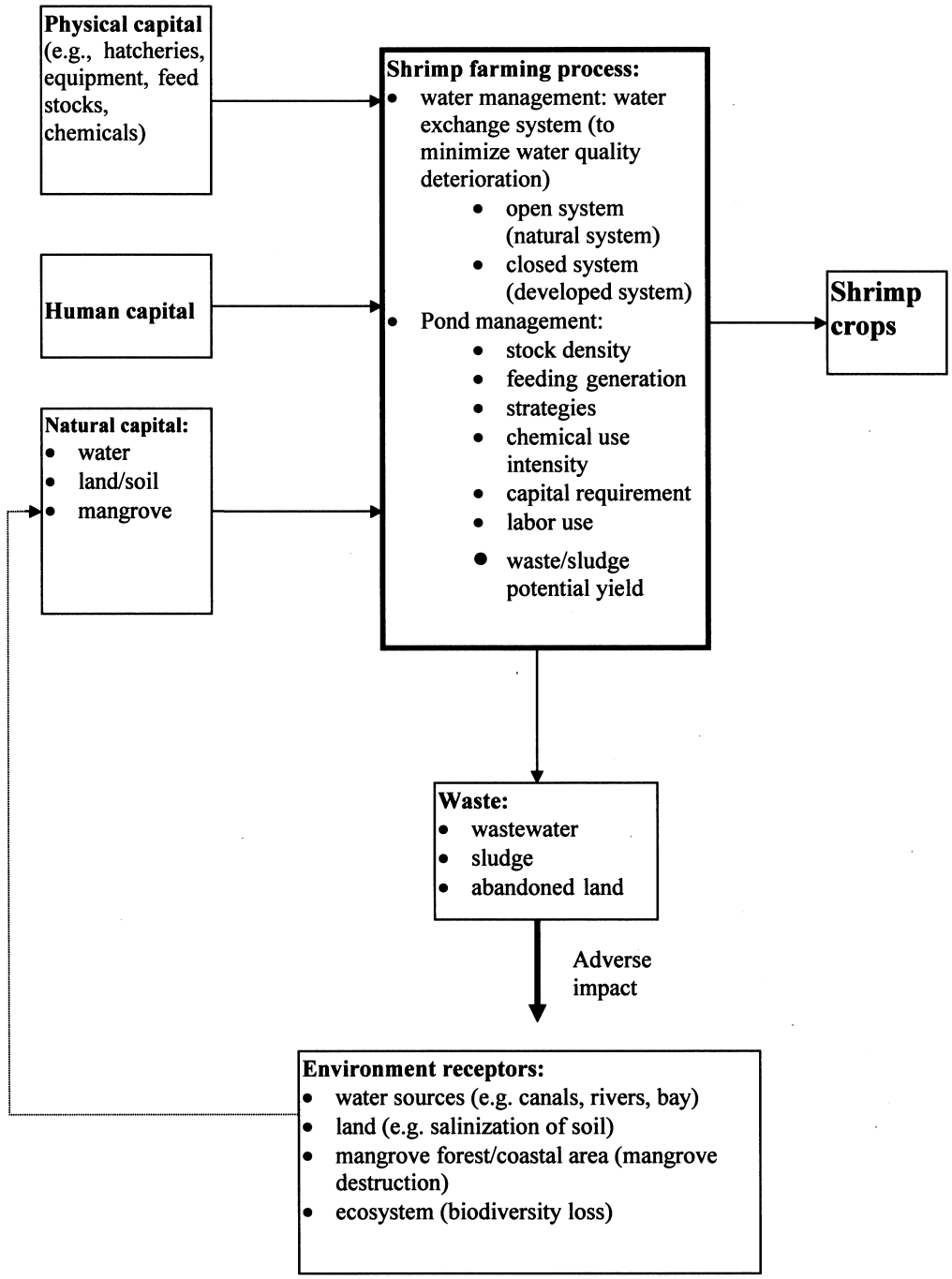

Figure 2: Production Process and Environmental Impacts of Shrimp Farming

third relates to the quality of the cultured seed. Unlike their wild cousins, cultured seed have a lower tolerance to diseases (Olin and Fast 1992; Briggs, 1992; Fegan, 1992). This is because the production of cultured seed comes from a limited gene pool and using a cultured seed to produce more seed produces juveniles, which are inferior in quality to the wild seed.

Feed management: With the adoption of intensive farming techniques, farmers began supplementing natural feed with artificial food options in order to promote faster growth as well as build higher mass in each shrimp. The higher stocking density itself implied a higher feed use per unit area. Coupled with the strategy to increase body mass and rate of growth of this body mass, the amount of feed use increased exponentially from the techniques used prior to intensive farming.

But all food does not get converted to body mass. Based on the food conversion ratio, a certain proportion of the feed provided gets converted to waste of which some becomes dissolved in the water while the rest gets deposited at the bottom of the pond (Brigg and Funge-Smith, 1994; Boyd, 1992). The main nutrients from the feed are nitrate and phosphorus, which at high levels becomes toxic for the shrimps. A high loading of these nutrients causes stress for the shrimps and as in the case of stocking density, increases the susceptibility of the shrimps to diseases (Lightner, 1985; Chien, 1992).

Water management: Water is a crucial input for the production of shrimp. Clean water with the right degree of salinity produces the best crop and reduces the probability of disease outbreaks. Water quality, unlike seed and feed management, is to a certain extent beyond the control of the farms themselves. Until recently, farms used an open system for water management. In an open system farms continuously flushed out wastewater from the ponds into the ocean via canals and pumped in clean water from the ocean. However, as the number of farms increased within the region, the amount of water flushed out with excess nutrients increased and at a certain point went beyond the coastal systems regenerative capacity to cleanse the polluted water (Tookwinas, 1995). Moreover, accessing water from a common pool meant also a bigger exposure to diseases transmitted from other farms in the area.

Sludge management: In intensive farms, where stocking density and feed intensity is high, there is a significant amount of sediment formation at the bottom of the ponds (Boyd, 1992). At the end of each crop cycle, the sludge covered at the bottom of the pond has to be scrapped and removed from the ponds. The removal of the sludge is now considered as one of the more important environmental impacts of shrimp farming. The sludge is highly toxic and saline and if improperly disposed can cause serious problems to the shrimp sector itself and/or other land uses in the vicinity (Brigg and Funge-Smith, 1994).

2) Technology in shrimp farming

Shrimp farming practices in Thailand have developed gradually. The pattern of practice and management (FAO/NACA, 1995:381-383) can be explained as follows:

(1) Extensive farming: This is the original shrimp culture system used at the start of shrimp farming in the Inner Gulf area of Thailand. Farm practices were based on natural seed supply, the conversion of rice fields with the construction of high dikes around it and the installation of a sluice gate to receive seawater containing shrimp seed and nutrients and retain them in the field. Most of the incoming shrimp seed were banana shrimp (Penaeus merguiensis).

Water levels in the field were maintained at depths of 50-60 cm, so the shrimp farms had to be close to the sea, which is also mangrove area. During high tides, seawater would be drained into the field every day to maintain water levels in the ponds. After 3-4 months, when the shrimp had grown to market size (40-50 shrimps/kg), the water was drained out through the sluice gate during low tide and the shrimp were trapped using a bag net set at the sluice gate. Before a new crop of shrimp was started, the dike was repaired and the ditch scoured. These systems produced two crops of shrimp per year: the first during the northeast monsoon season (November-February) as this is a period of high salinity seawater. The main product at this time is banana shrimp, which can live and grow well in high salinity and high yields of 25-30 kg/rai can be attained. The second crop of shrimp is during the rainy season (during the southwest monsoon) with low salinity seawater. The main product will be Metapeneaus sp. shrimp, which grow well in low salinity. Yields of this crop will be less than the first crop. Extensive shrimp farmers usually have large farms (50-300 rais) in order to get enough economic return to keep a family. Farmers try to increase shrimp production by draining more seawater into the field with the aim of increasing shrimp seed and nutrient intake. The pumping of seawater is by water wheel run by windmill or diesel engine.

(2) Semi-intensive farming: In this system, farm management is improved and hatchery seed are used. The Department of Fisheries (DOF) successfully produced shrimp seed of both banana shrimp and black tiger shrimp in 1983. This was necessary as the natural supply of shrimp seed were becoming depleted. The stocking of hatchery seed allows natural populations to recover. The eradication of wild fish is achieved using tea-seed cake, which maintains a high survival rate of the shrimp. The dimensions of shrimp farms change with semi-intensive systems; the area is reduced to 20-30 rai, often equipped with water storage. The stocked species are banana shrimp and black tiger shrimp with stocking densities of 5-10 pieces/sq. m. The seawater is drained into the ponds by a pushing pump, which handles the higher quantity of seawater more easily. Additional feed is applied so that the yield of shrimp increases to 60-100 kg/rai in a 4-month period.

(3) Intensive farming: The development of intensive culture was made possible by the large scale production of seed by the Department of Fisheries and the private sector, with 3-4,000 million produced annually. The large, shallow semi-intensive ponds were converted to 1-5 rais in area and water depths increased to 2-2.5 m. Stocking rates were up to 50-100-pieces/sq. m. Due to the poor tolerance of banana shrimp in poor water quality, the more tolerant black tiger shrimp is stocked. Also black tiger shrimp can grow up to a size of 30-40 pieces/kg in a 4-month culture period, which is better economically as large shrimp fetch a higher price than small shrimp. In intensive farms, heavy feeding rates are applied and after 100 days of culture the pond bottom will form anaerobic conditions, with low dissolved oxygen levels and high concentrations of toxic gases, such as hydrogen sulphide, ammonia, nitrite and carbon dioxide. These conditions will kill banana shrimp but are not as harmful to the black tiger shrimp. In intensive systems, the chemical condition of the water and dissolved gases may be a serious threat to shrimp health. Dissolved oxygen levels in the water column have to be kept at over 5 ppm and additional dissolved oxygen is supplied by paddle wheel or air jet machine. Water is also exchanged at a rate of 10% fresh seawater per day. In intensive systems, a pipe-pumping engine is used instead of a pushing pump because of the distance of the high dike from the sea,

the smaller volumes of seawater, smaller size of pond and shorter pumping times during high tide.

The stocked shrimp are fed with high quality complete feeds, with a protein content of over 45 %, supplemented with vitamins and minerals. The feeding schedule must be at least 4-5 times/day and the quantity of feed fed should be adjusted every 15 days. In converting extensive or semi-intensive ponds to intensive ponds, the farmers need to remove topsoil of the shrimp pond. In general, the sub-soil in mangrove areas has a very high acidity (with pH of around 3-4) caused by the pyrite soils and sub soils. The soil acidity problem can only be solved through time, entails high costs and will be very difficult to mange. Intensive culture requires a 4-5 month culture period with the yields of 0.8-0.9 tons/rai to 2 tons/rai, depending on the farm environment, experience of the management and capital support. On average over the country, yields are 0.6-0.7 tons/rai and 2-2.5 crops can be produced annually.

3) Cost structure

Potaros (FAO/NACA, 1995: 379-381) indicated the cost structure of shrimp farming by using data from the Department of Fisheries in 1992 which conducted a case study of intensive farming of black tiger shrimp (sample size of 20 farms). The cost structure and income of shrimp farms are presented in Table 1 and 2.

Table 1 Production Cost of Shrimp Farming from Intensive Pond Culture, 1992

Unit: baht/rai

Cost Item	Cash Costs	Non-cash Costs	Total	% of total
Fixed Costs				
Depreciation of pond and sluice gate	-	5993	5993	7.2
Depreciation of equipment	-	8,915	8,915	10.8
Depreciation of housing	-	561	561	0.7
Land-use cost	2,000	8,000	10,000	12.1
Interest	2,381	-	2,381	2.9
Opportunity Cost	-	1,184	1,184	1.4
Total	4,381	24,653	29,034	35.1
Variable Costs				
Seed	9,445	-	9,445	11.4
Feed	27,890	-	27,890	33.7
Teaseed cake and lime	1,170	-	1,170	1.4
Drugs and other chemicals	2,147	-	2,147	2.6
Gasoline and lubrication	4,684	-	4,684	5.7
Pond bottom clearing	3,220	-	3,220	3.9
Labor	1,403	1,143	2,546	3.1
Others	128	-	128	0.15
Opportunity costs	-	1,308	1,308	1.56
Total	51,247	2,451	53,698	64.9
Grand total	55,628	27,104	82,732	100.0

Source: Department of Fisheries

Note: 25.5 baht = US$ 1; 1 rai = 1,600 sq. m; 1 ha = 6.25 rai

Table 2 Income and Production Cost from Intensive Pond Culture of Black Tiger Shrimp

Item	Per rai	Per kg
Income		
Production of black tiger shrimp (kg)	659	-
Price (baht/kg)	142	-
Income (baht)	93,931	142.4
Costs		
Variable costs	53,697	81.5
Cash costs	55,627	84.4
Total	82,730	125.5
Net profit over variable costs	40,234	60.9
Net profit over cash costs	38,304	58.0
Net profit	11,201	16.85

Source: Department of Fisheries

Note: 25.5 baht = US$ 1; 1 rai = 1,600 sq. m; 1 ha = 6.25 rai

The cost of rice farming using data from poor-grade paddy production costs in 1992 is present in Table 3 which can be used to compare with that of the intensive shrimp farming. The country average for poor-grade paddy production costs in 1992 was 2,573.5 baht/ton. One rai of paddy field yielded 641 kg/crop and the farm price of poor-grade paddy was 3,060 baht/ton. The income from one crop of poor-grade paddy plantation from one rai was 1,961.5 baht, with a net profit of 314 baht/rai.

Table 3 Cost of Poor-Grade Rice Production from a One-Rai Rice Field in 1992

Unit: baht

Item	Cash costs	Non-cash costs	Total
Variable costs			
Land preparation	90.3	139.7	230.0
Seed preparation and seeding	30.0	56.5	86.5
Weeding and other cares	17.6	190.1	207.7
Harvesting	115.9	119.8	235.7
Expense after harvesting	125.8	99.7	225.5
Seed	22.9	62.6	85.5
Fertilizer	250.1	-	250.1
Insecticide and herbicide	70.0	-	70.0
Gasoline and lubricant	30.7	-	30.7
Equipment and other supplies	7.2	-	7.2
Repair of tools	2.7	-	2.7
Interest and opportunity costs	31.8	20.0	51.8
Total variable costs	795.0	688.4	1,483.4
Fixed costs			
Tax and land-use	20.2	133.5	153.7
Depreciation of tools	-	12.2	12.2
Total fixed costs	20.2	145.7	165.9
Total cost per rai	815.3	834.3	1,649.6
Variable costs per kg paddy	**2.3**		
Total cost per kg paddy	**2.6**		
Total cost per ton of paddy	**2,573.5**		
Paddy production per rai (kg)	**641**		

In 1995 the Department of Fisheries (Fishery Economic Division) surveyed 79 shrimp farms and estimated the production cost as presented in Table 4

Table 4 Production Cost of Shrimp Farming in Thailand, 1995

Cost Item	Fresh water farming with develop system			
	Mixing with sea water	Adding salt	Saline soil	The eastern coastal area of the southern region
1. **Fixed cost (per rai)**	**4,857.04**	**3,683.71**	**5,253.63**	**11,623.18**
- Land use cost	1,244.62	396.35	976.47	5,000.00
- Depreciation cost of ponds and equipment	3,425.61	3,145.68	4,075.10	6,065.09
- Opportunity cost	186.81	141.68	202.06	567.09
2. **Variable cost**	**86,946.05**	**58,470.29**	**69,693.86**	**147,843.82**
- Sludge scrapping cost	1,838.78	2,417,58	2,529.41	3,925.10
- Pond & water gate maintenance cost	692.86	-	-	936.74
- Lime + tea leaves	2,605.60	910.99	689.70	3,076.41
- Shrimp fry (baby shrimps?)	10,565.60	11,714.29	9,129.41	16,607.86
- Seawater (salt)	6,357.73	1,264.00	-	-
- Gasoline + lubricant oil	4,477.33	3,437.3	2,891.24	14,555.11
- Electricity	369.30	395.69	254.55	1,390.18
- Shrimp food(% of total cost) (% of total variable cost)	43,398.97	28,844.69	31,845.05	67,925.29 (42.6) (45.9)
- Medicines + chemicals (% of total cost) (% of total variable cost)	2,201.39	1,423.19	6,710.4	5,170.17 (3.2) (3.5)
- Labor	3,344.59	1,538.46	1,616.67	10,591.02
- Equipment maintenance	1,151.81	1,538.46	2,941.18	2,061.42
- Interests	3,151.52	2,409.03	2,695.89	6,571.17
- Sales cost	896.92	1,493.98	1,117.65	2,789.51
- Others	1,637.25	-	-	1,444.56
- Opportunity cost of family labor	3,438.60	230.70	6,515.47	4,471.70
- Opportunity cost of variable cost	-	-	-	-
3. **Total Cost/rai**	**91,803.09**	**62,154.00**	**74,974.49**	**159,476.00**
Total Cost/kg	**110.06**	**105.95**	**148.49**	**130.92**
4. **Harvest/rai/crop**	**834**	**586.81**	**505.88**	**1,217.95**
5. **Price (baht/shrimp size/kg)**	**147.19/56**	**148/61**	**169.33/47**	**165.69/48**
6. **Profit (baht/kg)**	**37.13**	**42.05**	**20.84**	**34.77**
Profit (baht/rai)	**30,953.37**	**24,693.88**	**10,713.17**	**42,326.13**

Source: Fishery Economic Division, Department of Fisheries
Note: 1. US$ 1 = 35 baht
2. Base on the survey from 79 shrimp farms.
3. Shrimp farming cost is divided into:
* Fixed cost: cash fixed costs of land tax - land rent (land use cost) and interests; non-cash fixed cost of depreciation costs of ponds, water gates and equipment of more than 1 year, opportunity cost of fixed cost in terms of rent rate or investment rate (8% of interest rate)
* Variable cost: cash variable costs of shrimp stocks, feed stocks, lime and tea leaves, electricity, etc.; and non-cash variable costs of opportunity cost of variable cost at 8% of interest rate
* Total cost: the sum of fixed cost and variable cost

4. Policy on Shrimp Farming Industry

The shrimp farming industry has its dual conflicting roles in the Thai economy. It is a main contributor to the national income and a main polluter. Thus, the government policy seems to be indecisive. The Department of Fisheries (DOF) under Ministry of Agriculture and Cooperatives (MOAC) seems to be on the supportive side as a promoter of shrimp production and income, while Pollution Control Department (PCD) under Ministry of Science Technology and Environment (MOSTE) is on the restrictive side of the farms' externalities.

However, the coastal environmental problems, the externalities, related to shrimp farming have been deteriorating to the extent that some public interventions are necessary. Besides the prohibition on shrimp farming operation in freshwater areas in every provinces in 1997 by the National Environmental Board*, the existing policy involving the regulation of shrimp farming is the following:

1) The registration, permit and required conducts of shrimp farms by the Notification of MOAC dated December 21, 1998.
2) Measures to promote and develop shrimp farming by the Cabinet Committee on Economic Policy on May 18,1999.
3) Tax measures for pollution control by the Working Group on Solving Environmental Problems through Tax Measures under the Ministry of Finance (MOF) on October 15, 1999.

1) The Regulation on shrimp farming: registration, permit and conducts

Not until 1991 has shrimp farming sector been regulated. The Notification on November 18, 1991 by MOAC required the shrimp farmers whose farm area was larger than 50 rai to register. However, the significant increase of shrimp farming both along the coastal area and in other areas has led to the public concern of the environmental impact on the natural water sources and other agricultural areas as mention above. Thus, the Notification on November 18, 1991 was replaced by

* The National Environmental Board is empowered by Section 9 of the Enhancement and Conservation of National Environmental Quality Act B.E. 2535 (1992) to enjoin polluters from any acts which may aggravate the adverse effects of pollution

the Notification on December 21, 1998, which has been effective since January 1, 1999. Under the new Notification, shrimp farmers are required to register and obtain permits to operate their farms with required conducts from the Department of Fisheries.

The contents of the Notification on December 21, 1998 are as followed:

Registration:

(1) Place of Registration and Permission: at the District Office of the Department

(2) Documents attached:

i. Registration form

ii. Letter of consent from the district level committee which consists of Tambon Administrative Organization (TAO) representatives from the area where the shrimp farm locates

iii. Identification document of the farmer or the farm company

iv. Land ownership title

v. A one time registration (and the farms that registered under the previous Notification (November 18, 1991) will be considered as registered farm under this Notification)

vi. No registration fee required

Permission and extension:

Salt-water shrimp farmers with more than 50-rai area are required to apply for a permit to conduct farming. The permit has to be extended annually with a letter of consent by the District Committee from the TAO representatives in the area. There is no fee required for permission or extension.

Required conducts:

(1) Shrimp farmers in the coastal area must have water reservoir ponds or sludge ponds of area of no less than 30 % of the feeding pond area before operation. This 30 % area includes canals, distribution canals and drainage.

(2) Shrimp farmers in other areas and not in the prohibited zones by the Section 9 of the National Environmental Act of 1992, before operation, are required to conduct the following:

* Shrimp farmers with less than 10-rai area must have water reservoir ponds or sludge ponds of the area of no less than 50 % of the feeding pond area.

* Shrimp farmers with more than 10-rai area must have water reservoir ponds or sludge ponds of the area of no less than 30 % of the feeding pond area (canals, distribution canals, and drainage are included). In case that the required calculated area makes the water reservoir pond size less than 5 rai, the farmers have to build the reservoir pond area of no less than 5 rai. This is to ensure adequate area of water reservoir when the harvest is conducted.

(3) Shrimp farmers in the coastal area have to submit the pond construction plan for permit approval. The plan has to indicate the construction of feeding ponds, water discharge ponds or sludge ponds of the area of 30 % of the feeding pond area, including canals, distribution canals, and drainage.

(4) Shrimp farmers in other areas and not in the prohibition zone have to submit the plan according to the model determined by the Department of Fisheries for approval as well.

(5) Shrimp farmers whose registration or permit is approved, have to operate under the following conditions:

* The BOD level in the discharged water from the shrimp pond has to be under 10 mg/l.
* No direct discharge of mud sludge from the ponds into natural water sources or public land.
* No discharge of saline water or any act that causes the leakage of saline water from the shrimp ponds to fresh water sources or other agricultural land.

In case of noncompliance to the conditions above, the officials can revoke the registration or permit, but no financial penalty is imposed.

2) Measures to promote and develop shrimp farming

The Committee on Economic Policy has suggested to the Cabinet measures to promote and develop shrimp farming. The measures approved by the Cabinet on May 18, 1999 are as follows:

(1) The establishment of a research and development fund for shrimps and shrimp products by MOAC. The draft of the fund is under consideration of Ministry of Finance.
(2) The relaxation of minimum charge rate of electricity to businesses and industries by the National Energy Policy Committee, temporarily, from 70% of the electricity cost from the peak demand during the past 12 months to 0%. This measure is effective from February, 1999.
(3) Financial credits to shrimp farmers who are operating an environmental friendly farms by the Bank of Agriculture and Cooperative (BOAC).
(4) Improvement of irrigation system by the Irrigation Department and the Department of Fisheries. The Department of Fisheries has conducted a detail study project of fresh water irrigation system to rehabilitate the abandoned shrimp farms along the coastal area in Petchaburi with the 30 mmillion baht budget. The project is in the process of ccirculation among relevant agencies for comment before submit to the Cabinet.
(5) Public relations on Thai shrimps and expansion of transportation spaces of fresh shrimps by the Thai Airways Co.:
   * The Thai has arranged 70 % of the total transportation spaces for agricultural products and 44.2 % are usually for shrimp export during the winter season.
   * The Thai has used shrimps for its domestic food catering in the portion of about 15 % of total meats and it plans to expand the shrimp portion in the near future.
(6) The establishment of central market for shrimps: Ministry of Commerce will set up a central market for shrimps at Pak Panang District in Nakorn Sri Thammarat. The market will be operated by private sector. If the private sector is not ready, Fish Market Organization (a public enterprise) will take responsibility.
(7) Serious inspection of the mud sludge injection and determination of proper zoning for shrimp farming:
   * Ministry of Interior orders its agencies in Bangkok, in coastal provinces and in the provinces with brackish areas where shrimp farms operate, to seriously inspect the mud sludge injection and discharged water from the feeding ponds, and to coordinate with the relevant agencies under other ministries that involve in determining proper zoning for shrimp farming.
   * Ministry of Agriculture and Cooperatives has set up a notification on Dec. 21, 1998 requiring the registration and permission of shrimp farming and the proper conducts. Department of Fisheries has conducting a project on shrimp farming promotion zone as a model for sustainable shrimp farming and a project on shrimp farming estate.
   * Ministry of Science Technology and Environment (MOSTE) has drawn a management plan and

an environmental action plan for coastal aquaculture with the main contents on zoning and solving sludge problems from shrimp farming as followed:

* Determining shrimp farming zone behind the mangrove area which shares no boarder to agricultural lands, communities, industries and no impact on conservation areas, and the zone should be in the area with high and low tides to help circulate wastes discharged from shrimp farms.
* Developing shrimp culture techniques that are environmental friendly. They should be closed system (no discharges of waste and water outside the farm). There should be researches on how to utilize sludge from shrimp farming.

3) Tax measures for pollution control by the Working Group on Solving Environmental Problems through Tax Measures under the Ministry of Finance

(1) Brief background on the Working Group:

The Working Group was established by the Ministry of Finance in 1995 to consider suitable tax measures for environmental management for Thailand. The composition of the working group was the representatives from MOF, MOSTE, and experts. The Working Group held 2 meetings in 1996 to setup its working approaches and principles. It was amended by the MOF Order No. 27/2540 (1997) to include additional representatives from The Ministry of Industry (MOI) and the National Economic and Social Development Board (NESDB). The Working Group met 2 times in 1997 and proposed environmental excise taxes to be collected from batteries, packages, and ozone depletion substances (ODS).

On August 20, 1999, MOF amended the composition of the working group again (Order No. 168/2542 (1999)). The current working group is composed of representatives from MOF, MOSTE, MOI, NESDB, MOAC, and consultants to the Working Group. The Working Group is responsible for providing studies and recommendation on tax measures for solving problems concerning environmental damages and pollution as well as environmental rehabilitation.

(2) Approaches and ways of work of the current Working Group:

The Working Group has agreed upon the approaches in solving environmental problems to be based on:

* The 8th National Economic and Development Plan (of NESDB)
* National Policy and Plan for Promotion and Enhancement of Environmental Quality, B.E. 2540-2559 (of MOSTE)
* Monetary and Fiscal Master Plan for Society, 2539 (1996) (of MOF), i.e., to conserve and rehabilitate environment by using monetary and fiscal measures. Fiscal measures will focus on tax measures collected from polluters and tax measures to support communities to protect environment.

In brief, the policy approach for solving environmental problems will address 3 main issues: pollution, natural resources rehabilitation and management, and promotion of people and community participation.

Ways of working of the Working Group:

* To consider tax measures to solve environmental problems directly via polluters or indirectly via product prices or producers, and via recommendation from other government agencies.

(3) Proposal from MOSTE concerning 3 issues to be considered by the Working Group:
* Tax measures for waste management concerning packages and residual wastes.
* Tax measures to control the import of old engines/parts of automobiles.
* Tax measures for coastal aquacultural management.

(4) Tax measures for coastal aquacultural management by MOSTE:
Policy background:
* MOSTE proposed Environmental Management and Action Plan for Coastal Aquaculture (Letter on June 17, 1999 to the Cabinet's Secretariat). In the Plan, it is proposed that MOF cooperate with the Department of Fisheries (DOF) and the Pollution Control Department (PCD) to study tax measures for more effective environmental management of coastal aquaculture.
* The Cabinet's Secretariat asked MOF on June 23, 1999 to consider the action plan of MOSTE.
* MOF replied to the Cabinet on August 16, 1999 agreeing with the action plan with the following comment:

MOF agreed with the plan that required the DOF to study the collection of tax or fee to rehabilitate the abandoned shrimp farms, and with the proposal for the cooperation among DOF, PCD and MOF to study tax measures for more effective environmental quality management. However, MOF suggested that the scope of study cover more types of fees, for example, user fees to be collected from polluters or coastal aquacultural farmers for the service from the central wastewater treatment project operated by the government.

The role of PCD concerning coastal aquacultural regulation:
* PCD has drafted the effluent standards of discharged water from shrimp farms and presented them to the Pollution Control Board on August 4, 1998. The Board has asked the PCD to reconsider and revise the effluent standards of discharged water from shrimp farms in the coastal area. At present, PCD is revising the standards.
* PCD has established the FY 2000-2001 budget for the development of economic measures to control pollution from agricultural activities and of case studies in applying economic measures, especially the case of the livestock sector. The studied case will be used as a guideline for the application of tax measures to improve the efficiency of coastal aquacultural management.

5. The Proposed Economic Instruments for Sustainable Shrimp Farming

As review in the previous section, the existing policy concerning shrimp farming in Thailand has largely been a command and control approach, i.e., the prohibition of shrimp farm operation in freshwater areas, registration and permit requirement, and technological requirement on farm operation. However, the policy on shrimp farming has nothing to do with the regulation of wastewater discharges (the BOD effluent standard of 10 mg/l is not enforced). There is no measurement of quality or quantity of effluent from shrimp farms. The inflow of water into the

shrimp ponds is not priced. Registration and permit approval of the shrimp farmers whose farm areas are larger than 50 rai require no fee payment. Thus, it can be considered that the policy on shrimp farming in Thailand is only vaguely related to the features of the ambient environment and has no element of environment-impact-related pricing.

Economic incentive approach with economic instruments, such as taxes (tax measures for pollution control by the Working Group mentioned above), charges, and fees, has recently been considered as a supplementary approach to the weak command and control approach. There have been several studies on the environmental impact of shrimp farming and economic instruments have been proposed. Patmasiriwat (1997) suggested a set of economic instruments as water-discharged fee and earmarked fund, shrimp export charge, and land use charge outside the designated zone. A study by Kasetsart University (1999) suggested environmental management fee for sludge and water treatment ponds and emission charge of wastewater from feeding ponds.

In a study to find the optimum size and location for sustainable shrimp farming, Duraiappah and Israngkura (1999) proposed differentiated price permits based on stock density and water system. The differentiated price permit will provide 2 objectives:

(1) By specifying the total number of permits, authorities can control the actual number of farms within specified geographical boundaries.
(2) The price of the permit can be set based on farm management practices as well as on soil characteristics, i.e., a differentiated permit price system based on site and technical properties.

The proposed permit system has advantages over tax measure since tax instrument leaves open 2 critical issues:

(1) Environmental costs caused by soil salinization on both abandoned and adjourning lands.
(2) The number of farms within specified geographical boundaries.

The advantages of the proposed differentiated price permits are

(1) Solving the land use problem: confining shrimp farms in a proper zone or location.
(2) Proper farm management: species cultured, the use of potentially polluting substances, production feed consumption.
(3) Controlling pollution from farms.

The most recent study on economic instruments for shrimp farming has been the report by a group of experts from AEA Technology, Harvard Institute of International Development (HIID) and Thailand Environment Institute (TEI) (2000) (in the process of finalizing the report). The study has proposed a set of economic instruments to restrain the harmful activity and to re-allocate the proceeds to related environmentally desirable activity. The set of economic instruments is as follows:

(1) A permit fee with the revenue earmarked for increasing the flow of information and improved environmental reporting
(2) Differentiated access charge to reduce damage to mangroves through more appropriate siting decisions
(3) An environmental performance bond to reduce the extent of abandonment of shrimp farms on public and private lands

(4) Pollution charge on BOD discharged to reduce discharge of effluents into waterways
(5) Fines for below-prescribed area of settling ponds and reservoirs, for failure to submit a third-party during harvest-effluent-monitoring report, for non-compliance on sludge disposal, and for discharge wastewater onto land
(6) An aquaculture sub-fund in the National Environmental Fund which the proceeds from the economic instruments will be put into and be reallocated for the improvement of shrimp farming operation and rehabilitation of environmental damages caused by the shrimp farming.

6. Conclusion

Shrimp farming in Thailand has played a significant economic role as a main income generation sector. However, its negative externalities on environment, especially, on the coastal mangrove areas can not be ignored. The significance of its economic role has lead to the policy that bias against the environmental conservation. The government failure in dealing with the externalities of shrimp farming with command and control approach has led to a new policy approach toward market-based incentive or economic incentive in Thailand. Since 1998, research efforts have highlighted the shrimp farming activities and various economic instruments have been suggested. But the implementation of economic instruments is still in the early stage and has so many institutional obstructions to overcome.

Reference:

AEA Technology, Harvard Institute of International Development (HIID) and
Thailand Environment Institute (TEI). 2000. *Promotion of Market-Based Instruments for Environmental Management in Thailand*. TA 3013-TH. Draft Final Report to Asian Development Bank. April.

Boromthanarat, Somsak. 1995. " Coastal Zone Management," in *Report on a Regional Study and Workshop on the Environmental Assessment and Management of Aquaculture Development (TCP/RAS/2253)*. Food and Agriculture Organization (of the United Nations), Network of Aquaculture Centres in Asia-Pacific. Bangkok, Thailand. April.

Boyd, C.D. and Y. Musig. 1992. "Shrimp Pond Effluent: Observations of the Nature of the Problem on Commercial Farms," in *Proceedings of the Special Session on Shrimp Farming*. World Aquaculture Society Annual Meeting. Baton Rouge, Louisiana. Pp. 195-197.

Briggs, M. R. P. 1992. "A Stress Test for Determining Vigor Post-Larval Penaeus Monodon Fabricius," *Aquaculture and Fisheries Management*, 23: 633-637.

Briggs, M.R.P. and S.J. Funge-Smith. 1994, "Unsustainable Shrimp Culture. A
Review of Causes and Potential Solutions from Experience in Thailand," in M.R.P. Briggs (ed.), *Development of Strategies for Sustainable Shrimp Farming, Final Report to the Overseas Development Administration*, Research Project R4751. Institute of Aquaculture, University of Stirling.

Chien, Y.H. 1992. "Water Quality Requirement and Management for Marine Shrimp," in *Water Quality Review* (ed. J.Wyban). World Aquaculture Society, Baton Rouge, Louisiana. Pp. 144-156

FAO/NACA. 1995. *Regional Study and Workshop on the Environmental Assessment and Management of Aquaculture Development (TCP/RAS/2253)*. NACA Environment and Aquaculture Series No. 1. Network of Aquaculture Centres in Asia-Pacific, Bangkok, Thailand.

Fegan, D. F. 1992. "Recent Development and Issues in the Penaeid Shrimp Hatchery Industry," in Proceedings of the Special Session on Shrimp Farming, (ed. J.Wyban) World Aquaculture Society, Baton Rouge, Louisiana.

Flaherty, M. and C, Karnjanakesorn. 1994. "Marine Shrimp Aquaculture and Natural Resource Degradation in Thailand," *Environmental Management*, 19: 27-37.

Duraiappah, Anantha K. and Adis Israngkura, 1999. "Farm Permits and Optimal Shrimp Management in Thailand: An Integrated Inter-Temporal and Spatial Planning Model," a paper for Institute for Environmental Studies, Free University, Amsterdam, The Netherlands and Thailand Development Research Institute, Bangkok, Thailand

Dierberg, F.E. and W. Kiattisimkul. 1996. "Issues, Impacts, and Implications of Shrimp Aquaculture in Thailand," *Environmental Management*, 20, 5.

Kasetsart University, 1999. *The Evaluation of Environmental Cost of Shrimp Farming*. Main report submitted to Office of Environmental Policy and Plan, Ministry of Science Technology and Environment. Department of Agricultural and Resource Economics. August. (in Thai)

Lightner, D.V. 1985. "A Review of the Diseases of Cultured Penaeid Shrimps and Prawns with Emphasis on Recent Discoveries and Developments," in *Proceedings of the First International Conference on the Culture of Panaeid Prawns/Shrimps*, (ed. Taki, Y. J.H. Primavera and J.A. Llobrera) Aquaculture Department, SEAFDEC, Iioilo City, Philippines.

Midas Agronomics. 1995. *Pre-Investment Study for a Coastal Resources Management Program in Thailand*. Interim report submitted to the World Bank, Washington D.C.

Olin, P.G. and A. W. Fast. 1992. "Paenaeid pl Harvest, Transport, Acclimation and Stocking," in *Marine Shrimp Culture*: Principles and Practices, (eds. Fast, A.W. and L.J. Lester), Elsevier, Amsterdam.

Patmasiriwat, D. 1997. "Environmentally Sensitive Sector: A Case Study of Shrimp Aquaculture in Thailand Based on Farm Survey," Draft paper. Thailand Development Research Institute. May.

Patmasiriwat, D., O. Kuik, and S. Pednekar. 1998. *The Shrimp Aquaculture Sector in Thailand: A Review of Economic Development and Trade Issues*. CREED Working Paper. No IIED, London.

Paw, J.N. and C. Thia-Eng. 1991. "An Assessment of the Ecological and Economic Impact of Mangrove Conversion in Southeast Asia," in *Towards an Integrated Management of Tropical Coastal Resources* by L.M. Chou, H.W. Khoo, P.E. Lim, J.N. Paw, G.T. Silvestre, M.J. Valencia, A.T. White, and P.K. Wong (eds). ICLAM Conference Proceedings 22. International Center for Living Aquatic Resources Management, Philippines.

Piamsak, M.. 1996. "Mangrove Destruction and Shrimp Culture Systems," *Asian Shrimp News*, No. 27, 3rd Quarter. Bangkok.

Potaros, Manu, 1995. "Thailand," in *Report on a Regional Study and Workshop on the Environmental Assessment and Management of Aquaculture Development*. Food and Agriculture Organization (of the United Nations) Network of Aquaculture Centres in Asia-Pacific (FAO/NACA), Bangkok, Thailand. April. Annex II-16

Thonrak, S., T. Prato, S. Chiayvareesajja, and W. Kurtz. 1997. "Economic and Water Quality Evaluation of Intensive Shrimp Production Systems in Thailand," *Agricultural Systems*, 53: 121-141.

Tookwinas, S.. 1995. "Quality and Quantity of Discharge Water from Intensive Marine Farms at Khung Krabaen Bay, Chanthaburi Province, Eastern Thailand," in *Proceedings of the NCRT-JSPS Joint Seminar on Marine Science* by A. Sanivongs, W. Utoomprukporn and M. Hunspreugs (eds). Department of Marine Science, Chulalongkorn University.

Tookwinas, S., 1998. "The Environmental Impact of Marine Shrimp Farming Effluents and Carrying Capacity Estimation at Kung Krabaen Bay," *Asian Fisheries Science*. 11 (1998): 303-316. Asian Fisheries Society, Manila, Philippines.

Tookwinas, S. and Putth Songsangjinda, 1999. "Water Quality and Phytoplankton Communities in Intensive Shrimp Culture Ponds in Kung Krabaen Bay, Eastern Thailand," *Journal of The World Aquaculture Society*. 30, 1: 36-45.

立命館国際研究　13-3，March 2001

タイ沿岸地域におけるエビ養殖と その将来のための経済策の提案について

この論文は，タイで主な収入源となっているエビ養殖業の重要性と養殖業が与える対外的な影響について考察したものである。エビ養殖業が環境，特に沿岸海浜に密生する紅樹地帯に与える影響には，水質汚染や土地の沈下，湿地帯や紅樹林の破壊，さらに現在の沿岸の均衡破壊がある。この産業の経済的な役割の重要性から今までは環境保護を軽視する政策がとられてきた。しかし政府がエビの養殖業の外的な影響について十分指揮管理することができなかった経緯をふまえ，新たに，市場中心の刺激策や経済的な奨励策をすすめる方向に政策が転換してきた。1998年以来エビ産業の実態について多くの研究がなされ，またさまざまな経済的手だて，例えば，荷揚げ代金や種類別利用許可代金，あるいは環境使用保証金などを課すことなどが提案されてきた。経済的な策を実行するについてはまだ始まったばかりで，いぜんとして多くの制度上の障害を乗り越える必要がある。