MONITORING AND IMPACT ASSESSMENT OF SHRIMP FARMING IN THE EAST COAST OF THAILAND USING REMOTE SENSING AND GIS

M. K. HAZARIKA*, L. SAMARAKOON*, K. HONDA*, J. THANWA, T. PONGTHANAPANICH**, K. BOONSONG*****

*ACRoRS, Asian Institute of Technology, Klong Luang, Pathumthani, Thailand
manzul@ait.ac.th
**Faculty of Economics, Kasetsart University, Bangkok, Thailand
***Faculty of Science, Chulalongkorn University, Bangkok, Thailand

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ABSTRACT

A phenomenal growth of Intensive shrimp faring has been seen in the Chanthaburi province in the East Coast of Thailand since its inception in late 1988. The province got more attention after failure of shrimp farms in the upper Gulf of Thailand. Using Landsat TM data of 1987, status of shrimp farming before the beginning of full scale intensive shrimp farming in Chanthaburi province has been examined and it is found that only 299 hectare of land was under farming during that period of time. ADEOS-AVNIR image of 1997 provides a very clear picture of recent status and it found that 11,277 ha of land is under shrimp farming.

Environmental impacts and its costs vary with the locations of the shrimp farms and it is dependent on specific environmental conditions of farm location. Shrimp farms located in the mangrove area, having impacts on nearby farmlands bear maximum environmental cost. Since such kinds of land provide a number of goods and services, therefore, environmental cost is very high. Environmental cost is quite low for those located in the vacant land without having impacts on nearby lands. It is found that from private point of view, economic incentive or excess profit (64,338 Baht/rai/year, 1 US$ = 37 Baht) still exists and this will bound to attract further investment in future. This kind of profit may possibly be the highest among many other farming alternatives. However, on considering the environmental cost, Net Social Profit (21,309Baht/rai/year) of the shrimp farming becomes significantly low.

1 INTRODUCTION

Traditional extensive aquaculture has been practised for many years in Thailand. Conditions are ideal for shrimp farming in Thailand with 2,700 km of coastline with warm and calm sea as well as abundant natural seed. Originally dykes were built around rice fields to retain wild shrimp seed entering in to the fields. The high demand for shrimps in overseas markets had changed the traditional farming practices along the coastal areas. Thai farmers converted the coastal rice fields and mangrove forestlands to shrimp ponds. Before 1984, Thailand harvested as much as 90% of its shrimp from natural resources, mainly from the gulf of Thailand. In mid 1980s a combination of technological and economic factors allowed the development of increasingly intensive farming system, using hatchery-reared seed and formula feeds. By late 1980s, focusing on black tiger prawns, shrimp culture took off in Thailand. As a result, structure of shrimp production gradually changed from captured shrimp to cultured shrimp, roughly half of the total production. This trend has steadily increased since then and cultured shrimp now comprise of 70% of the total production.

Chanthaburi is the second largest shrimp-producing province in Thailand after Nakon Srithammarat. Like other areas in Thailand, Chanthaburi province also experienced a quantum growth in Shrimp cultivation since its initiation at late 1980s. There was a mushroom growth of shrimp farms from 315 in 1987 to 1,516 in 1988, increasing the production by nearly ten times. Having certain environmental advantages from the upper Gulf of Thailand, shrimp production in the province continued to grow in faster rate than ever, resulting in rapid destruction of mangrove forest and coastal environment. Table 1 provides a picture of the destruction of mangrove forest area and increase of shrimp farm area in the province. From 1986 to 1991, an area of 12,100 ha (Charuppat, 1993) of mangrove forest was destroyed and during the same period of time, shrimp farm area was increased by 11,675 ha. There is a significant relation between the decrease of mangrove forest and the corresponding increase of shrimp farming area in Chanthaburi Province.

Year	Mangrove Forest (ha)	Shrimp Farm Area (ha)
1975	26,100	921.12
1979	24,100	871.52
1986	14,500	1,924.64
1989	8,700	10,454.88
1991	2,400	13,600.00

Table 1 Comparison of mangrove and shrimp farm area in Chanthaburi Province

2 IMPACTS OF SHRIMP FARMING

Use of coastal resources together with farm inputs and technology will not only produce shrimp, but also give birth of environmental problems. Environmental impacts on following four major resources are considered in this study for valuation environmental cost arising from shrimp farming. Figure 1 shows possible impacts emerging out of shrimp farming. Impacts of shrimp farming are mainly in four areas, namely, land resource, water resource, forest resource and fishery resource.

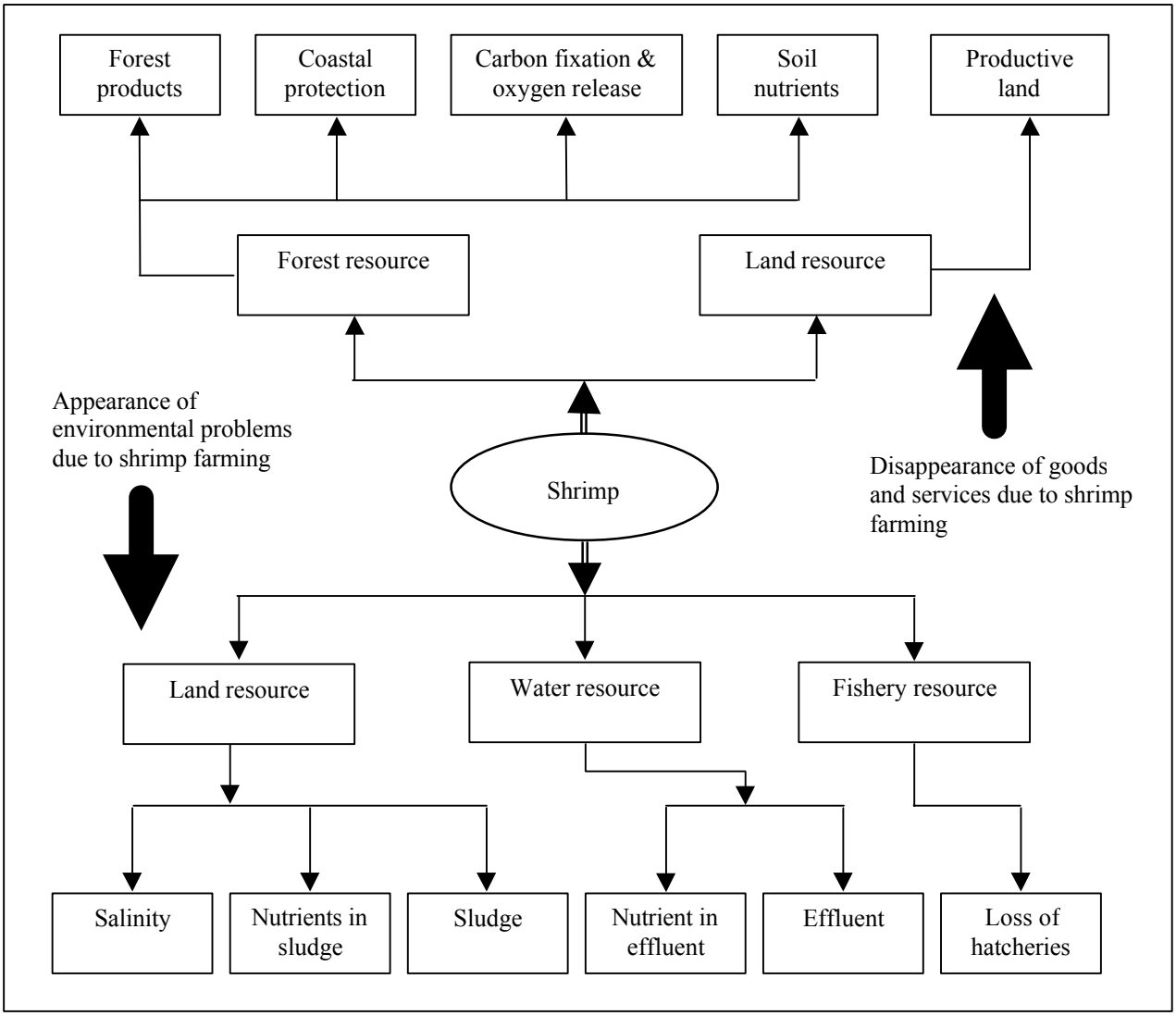

Figure 1 Impacts emerging from shrimp farming

2.1 Impact on land resource

The most serious and major environmental issue of concern is the draining of effluent and sludge from intensive shrimp farms. Sludge produced by the ponds must be disposed somehow before it can be used for a new crop. Sludge are often

disposed in to canals, wetlands and lands in between farms which contains un-consumed feed, organic wastes, chemicals, nutrients, drugs and antibiotics, solid wastes, and pathogenic micro-organisms. Salinisation of soil due to shrimp farming has also been reported in Chanthaburi province. Saline soil contains enough soluble salts to interfere with the growth of most crop plants and thereby farm productivity is adversely affected.

2.2 Impact on water resource

The load of effluent exiting from the shrimp farms normally exceeds the carrying capacity of the receiving water bodies. Nutrients in effluent promote the eutrophication to produce plankton in adjacent estuary or near-shore ecosystems along with sedimentation. However, nutrients from the effluent and plankton serve as the potential food source for many species of coastal fish and invertebrates.

2.3 Impact on forest resource

Indiscriminate and extensive clearance of mangrove forest may cause significant environmental, economic and social impacts. Naturally, mangroves and mud play an important role in regulation of the nutrient balance in the coastal environment. Mangrove absorbs excess nutrients and other pollutants from entering in to the seawater while facilitating the export of the large amounts of organic matter in the form of detritus by tidal current to support the productivity of the adjacent coastal ecosystem. Thus, if there are any remaining mangroves in the vicinity of the shrimp farm, it will act as a "natural sewage treatment plant" by absorbing excess nutrients originating from effluent. Destruction of mangrove forest impedes the natural process of nutrient supply, carbon fixation and oxygen release. Through the process of decomposition of its bio-mass, mangrove forest improves the soil quality by supplying adequate soil organic matter, nutrients and aeration.

Carbon fixation is a process that transforms the low-energy carbon dioxide in to high-energy compounds. Mangrove forest also release oxygen in the process of carbon fixation. The ratio of oxygen and carbon fixation release is reported to be 1:1.3.

Mangroves also play an important role in protection of coastlines from storms and tides. Destruction of mangroves may cause coastal erosion, changing the patterns of sedimentation and shoreline configuration. As a part of natural resources, mangrove also provides livelihood of coastal communities with fishery products, timber, fuel and thatching material. Coastal communities might be very adversely affected, if these good and services are no more available due to destruction of mangrove forest.

2.4 Impact on fishery resource

Destruction of mangrove forest due to shrimp farming causes adverse impact in fishery production. Mangrove forest provides a habitat for breeding and nursing of some marine fishes, oysters and crabs which eventually gives the livelihood for fisherman. The detritus in these mangrove forest areas also supplies valuable organic nutrients to the waters, which serve as a rich food source for many coastal and offshore species. However, mangrove ecosystem varies from submerged inter-tidal zone to semi-terresrial wetland with considerable variations in salinity, tidal regime, and subsurface conditions and water quality. Thus, the role of mangrove forest in fishery production is limited to sub-tidal and inter-tidal zones where good quality water and abundant food staff exists.

3 LOCATION OF STUDY AREA AND DATA USED

The study is the Chanthaburi province in Thailand, located in the eastern coast of the Gulf of Thailand. Chanthaburi province is extended from 100?32?to 100?42?in the east and 12?18?to 13?20?in the north. The total area covered in the study is 6338 km^2. The total length of the coast in the province is 80.2 km. following data sets were used in the study.

a) Landsat TM data of 02-12-87 and 01-02-93; ADEOS AVNIR data of 14-01-97
b) Topographic Maps at a scale of 1:50,000
c) Primary data on water quality and socio-economic status
d) Secondary data from survey, Department of Fisheries (DOF) and Royal Forest Department (RFD)

4 METHODOLOGY

In this study, significant environmental impacts of intensive shrimp farming in the coastal districts of Chanthaburi province have been examined. These significant environmental impacts are selected from the criteria of availability and reliability of supporting data. Data on sludge discharge, nutrient loading, salinity, land reclamation, water quality and

forest Products are collected from the field. Data on soil nutrient from forest, carbon fixation, oxygen release, loss of hatchery or fishery and coastal protection are gathered from various sources like Department of Fisheries, Royal Forest Department etc. Figure 2 shows the methodology for estimating the environmental impacts and costs.

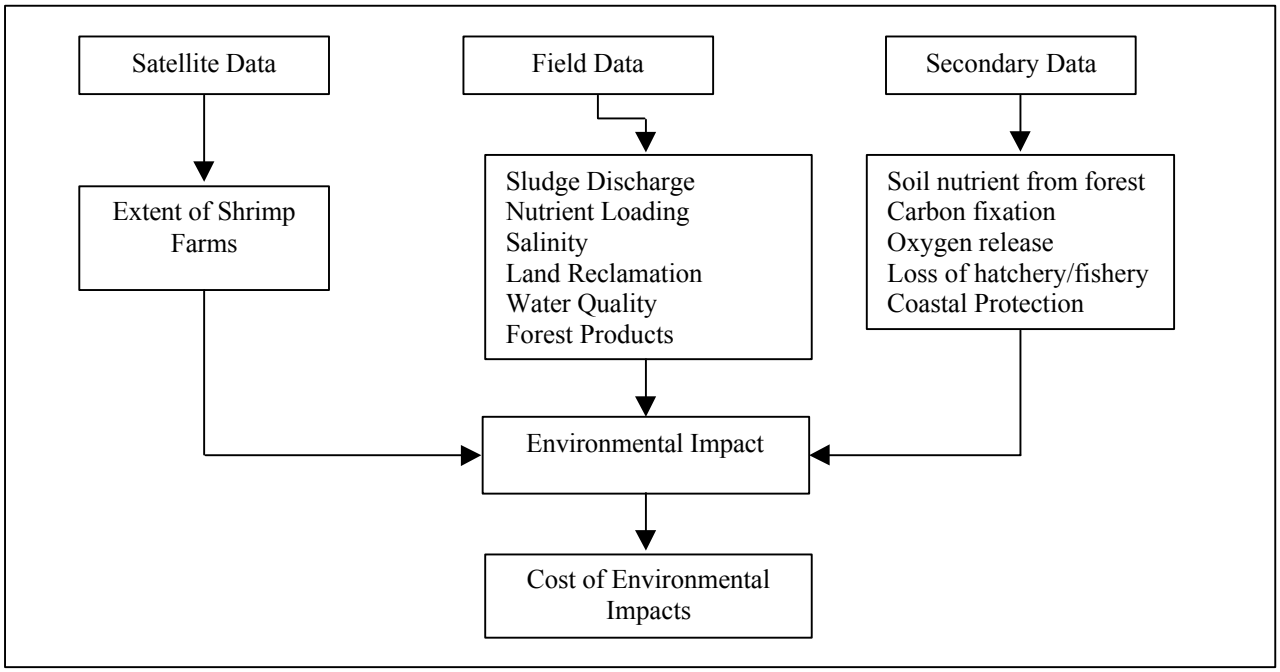

Figure 2 Methodology for estimating environmental cost

4.1 Estimation of shrimp farm growth

Multi-temporal satellite images of 1987 (Landsat TM), 1993 (Landsat TM) and 1997 (ADEOS AVNIR) are used to examine the growth of shrimp farms. Satellite images are corrected geometrically using Ground Control Points (GCP) taken form topographic maps of 1:50,000 scale. A second order polynomial transformation equation has been used to rectify the images. Unsupervised classification is first carried out for each of the images with thirty classes. Class aggregation has been done with extensive field visit. Finally, classes are carefully interpreted using visual interpretation and total shrimp farm area in the province has been estimated.

4.2 Valuation of various environmental impacts

Environmental impacts of shrimp farming are estimated using non-market economic techniques. Selection of non-market economic techniques is quite subjective, therefore, criteria for selection of a specific techniques depends on theoretical validity, market validity, data availability and skill. Table 2 summarises the valuation approaches used for estimation of environmental cost of shrimp farming.

Resources	Environmental Impacts	Valuation Technique
Land	Sludge	Preventive expenditure approach
	Nutrient in sludge	Opportunity cost approach
	Saline water intrusion	Change in productivity approach
	Abandoned land reclamation	Replacement cost approach
Water	Effluent discharge	Preventive expenditure approach
	Nutrient loading in effluent	Opportunity cost approach
Forest	Loss of forest products	Opportunity cost approach
	Coastal protection	Replacement cost approach
	Soil nutrient from forest	Opportunity cost approach
	Carbon fixation	Opportunity cost approach
	Oxygen release	Opportunity cost approach
Fishery	Loss of natural hatcheries	Change in productivity approach

Table 2 Valuation approach for possible impacts

4.3 Economic analysis of environmental impacts

The following economic indicators are used in this study for economic analysis of impacts.

a) Total Revenue
b) Net Private Return (Total Revenue - Total Variable Cost)
c) Net Private Profit (Total Revenue - Total Fixed Cost - Total Variable Cost)
d) Net Social Return (Total Revenue - Total Variable Cost- Total Environmental Cost)
e) Net Social Profit (Total Revenue - Total Cost- Total Environmental Cost)

5 RESULTS AND DISCUSSIONS

5.1 Estimated area of shrimp farming from satellite images

There has been an exponential growth of intensive shrimp farms in Chanthaburi province since its inception in 1988. Using Landsat TM data, it is estimated that shrimp farm covered an area of 299 ha in Chanthaburi province in 1987 whereas Department of Fisheries (DOF), Thailand reported it as 315 ha. In 1993, using Lansat TM data, it is found that shrimp farm area is 10,976 ha, but DOF reported it as 13,862 ha. Shrimp farm area in 1997 is estimated as 11,277 ha using ADEOS AVNIR data (Figure 3) and DOF figure in this year was 8,538 ha. Thus, there are some discrepancies in estimated of shrimp farms area using remote sensing data and those reported by the DOF. This is, probably, due to 1) DOF reports the active shrimp farms in a particular year, whereas using remote sensing data, both active and non-active shrimp farms are estimated and 2) possibility of misclassification of remote sensing data.

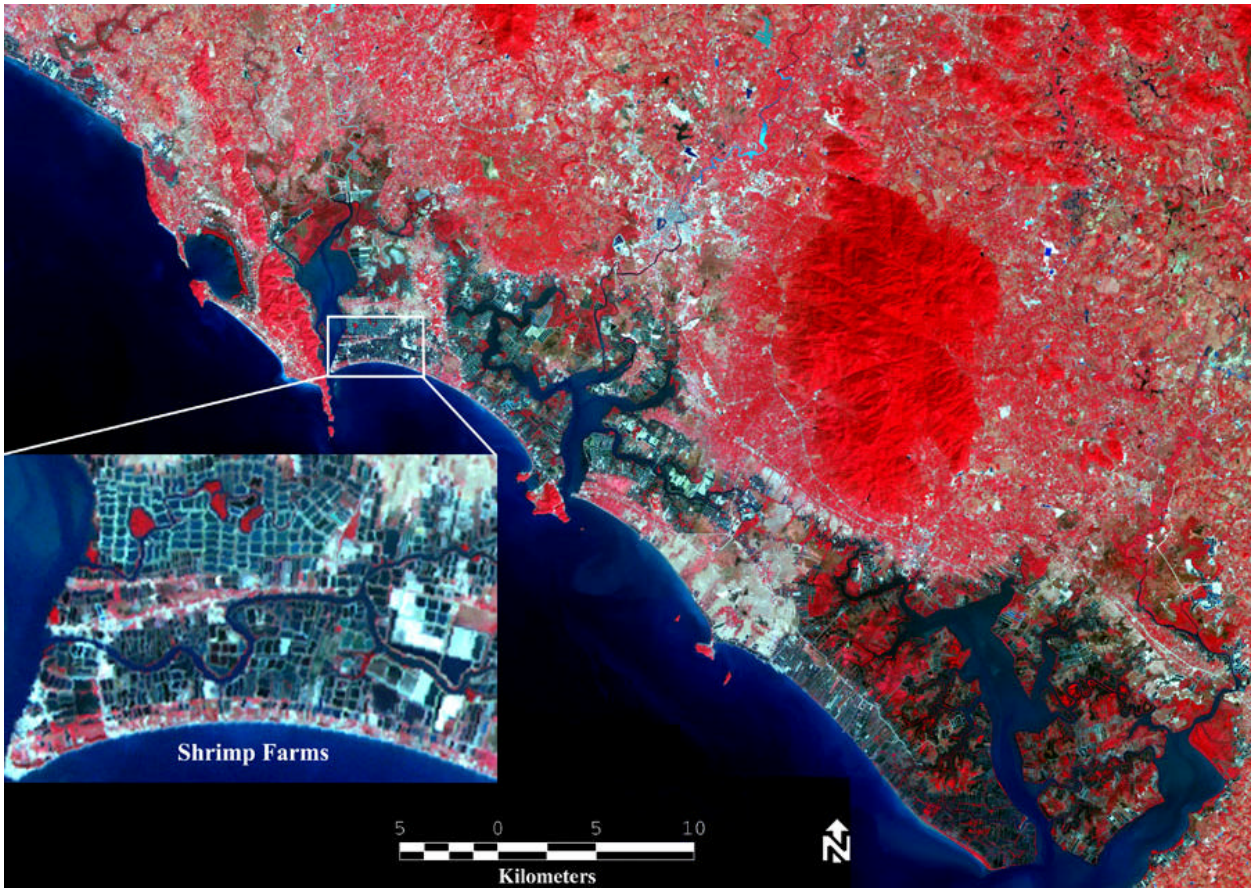

Figure 3 False colour composite of ADEOS-AVNIR image (1997) of Chanthaburi province

5.2 Cost estimation of variousenvironmentalimpacts

Shrimp farms are not homogeneous in terms of location and surrounding environment. Thus, it is not fair to consider all the shrimp farms in one category for estimating the environmental impacts and costs. Accordingly, shrimp farms in Chanthaburi province have been categorised in four types as follows:

a) Type-I : Shrimp farms located in vacant land
b) Type-II : Shrimp farms located in vacant land, having impacts in nearby farm lands
c) Type-III : Shrimp farms located in mangrove forest
d) Type-IV : Shrimp farms located in mangrove forest, having impacts in nearby farm lands

Environmental Impacts	Externalities	Type-I	Type-II	Type-III	Type-IV	Average
Sludge	- (ve)	2,658	2,658	2,658	2,658	2,658
Nutrient in sludge	+ (ve)	-1,306	-1,306	-1,306	-1,306	-1,306
Salinity	- (ve)		620		620	310
Abandoned land	- (ve)	12,195	12,195	13,344	13,344	12,770
Effluent	- (ve)	9,542	9,542	9,542	9,542	9,542
Nutrient in effluent	+ (ve)	-140	-140	-140	-140	-140
Coastal forest products	- (ve)			12,299	12,299	6,150
Coastal protection	- (ve)			7,414	7,414	3,707
Soil nutrients	- (ve)			731	731	366
Carbon fixation	- (ve)			1,907	1,907	954
Oxygen release	- (ve)			5,105	5,105	2,553
Fishery loss	- (ve)			10,934	10,934	5,467
Total Environmental cost		22,949	23,569	62,488	63,108	43,029

Unit: Baht/rai (1 US$ = 37 Baht , 1 hectare = 6.25 rai)

Table 4 Environmental costs and external benefits of intensive shrimp farming in a year

Table 4 shows the costs of each of the environmental impacts of shrimp farming considered in this study. The average cost of environmental impacts of shrimp farming is estmated as 43,029Baht/rai/year in the Chanthaburi province. Shrimp farms located in the mangrove forest area have relativley high environmental cost whereas environmental cost of the farms located in the vacant land is nearly one-third of those located in the mangrove forest land. Abandoned land attributes highest towards environmental cost as a high amount of capital is required to reclaim such lands. Environmrntal cost for salinity is low inspite of the fact that it creates conflicts among agricultural farmers and shrimp farmers. Low environmental cost of salinity is due to low farm productivity and low price of proxy goods considered, for example rice. It should be noted that values of the nutrients in sludge and nutrients in effluent are assumed to have positive environmental impacts, like supplying of soil nutrients and feed to the marine lives. Thus value from these two impacts, though small in amount, are deducted to estimate the net environmental cost of shrimp farming.

5.3 Analysis of cost and return

Table 5 shows that Net Social Return (NSR) and Net Social Profit (NSP) from shrimp farming are 64,338 and 21,309 Baht/rai/year. Thus, there is a very high amount of profit from shrimp farming if environmental cost is not taken in

Indicators	Baht/rai/crop	Baht/rai/year	Remarks
Total Revenue (TR)	183,456	366,912	-
Total Environmental Cost (TEC)	-	43,029	-
Total Fixed Cost (TFC)	20,081	40,161	-
Total Variable Cost (TVC)	131,206	262,412	-
Total Cost (TC)	151,287	302,574	TFC+ TVC
Total Social Cost (TSC)	-	345,603	TC + TEC
Net Private Return (NPR)	32,169	104,500	TR - TVC
Net Private Profit (NPP)	52,250	64,338	TR – TC
Net Social Return (NSR)	-	61,471	TR – TVC- TEC
Net Social Profit (NSP)	-	21,309	TR – TC- TEC

Table 5 Analysis of cost and return of shrimp farming in Chanthaburi province

account. Thus, there is no doubt that from private point of view such an economic incentive or excess profit will attract more investment in future.

6 CONCLUSIONS

A phenomenal growth of Intensive shrimp faring has been seen in Chanthaburi province since its inception in late ?1980s. Chanthaburi got more attention after the failure of shrimp farming in the upper Gulf of Thailand. It was estimated that during 1986 to 1991, in a span of 5 years, shrimp farms area was increased by 11,675 ha whereas the mangrove area was decreased by 12,100 ha. Thus, expansion of shrimp farms took place at the cost of mangrove forest in the Chanthaburi province.

Environmental impacts and its costs vary with the locations of the shrimp farms. E nvironmental costs are very high for shrimp farms located in the mangrove area, having impacts on nearby farmlands (Table 4). Such kinds of land provide a number of goods and services and, therefore, environmental costs of destroying these lands are very high. Environmental cost is significantly low for those located in the vacant land without having impacts on nearby lands.

From private point of view, economic incentive or excess profit (64,338 Baht/rai/year) still exists and such kind of profit may possibly be the higest among many other agricultural alternatives. Thus, shrimp farming is bound to attract more farmers for further investment in coming years. However, on considering the environmental cost, Net Social Profit (21,309 Baht/rai/year) of the shrimp farming becomes significantly low. Again, Net Social Profit will depend on the location of shrimp farms.

Intensive shrimp farming is a classic example of resource based production in developing economy. It creates significant environmental impact affecting the whole coastal eco-system. But, the above mentioned environmental cost is often ignored and it results in underestimated cost of production. This phenomenon is considered as an economic illusion from failure of the market system, because resource based commodity does not reflect the true cost of production and environmental impact on the society. Therefore, environmental cost of shrimp farming must be accounted while estimating the costs and benefits of shrimp farming. Else, permanent farming is likely to become infeasible, leaving shrimp farming as a non-returning enterprise.

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