Environmental and Social Conflicts of Aquaculture in Tamilnadu and Andhra Pradesh

I. Emerson Kagoo[*] and N. Rajalakshmi[*]

Abstract

The damage wrought by aquaculture to the surrounding ecosystem has led to serious socio-economic and environmental conflicts in coastal Tamilnadu and Andhra Pradesh. If the interdependence between the ecosystem and industry is not recognised, aquaculture will be limited by the impacts of its actions on the environment. This paper focuses on the environmental and social conflicts of aquaculture in Tamilnadu and Andhra Pradesh, which was confirmed by environmental analysis of soil and water samples collected from the problematic areas at varying distances (1–5 kms). The paper discusses the impact on water quality, coastal ecosystem, surface water and groundwater. Further, it discusses the various types of social conflicts arising due to aquaculture, and stresses the need to implement fiscal and market-based instruments to promote an eco-friendly industry for sustainable development.

Introduction

Aquaculture is a highly profitable venture in India. Also, it has increased the availability of nutritive food for the growing population. The advent of aquaculture is mainly due to depletion or standstill of capture fishery since the seventies, and availability of vast stretches of brackish water lands (1.2 million sq. km). The industry has grown enormously, leading to purchase of agricultural and fallow lands by entrepreneurs for setting up small and large-scale aqua farms in Tamilnadu and Andhra Pradesh. However, the rapid expansion of intensive aquaculture in Tamilnadu and Andhra Pradesh has severely damaged the adjoining ecosystems, leading to socio-economic and environmental problems in the coastal areas of Tamilnadu and Andhra Pradesh. The environmental impact of aquaculture includes eutrophication, oxygen depletion and pollution of the surrounding waters and their biota, which have made these waters and the associated ecosystems less suitable for other purposes like further culture and harvesting of natural stocks.

Many aquaculture units have been managed in a sectorial fashion, focussing on the rearing site, yield and growth directed by market demand. However, the capacity of the ecosystem to support the expanding industry with resources and by

* Department of Economics, University of Madras, Chepauk, Chennai- 600 005, Tamilnadu, India.

processing its waste has rarely been taken into account in the optimistic economic projections. It is claimed that the rapidly expanding aquaculture industries may presently repeat the pattern of conventional resource exploitation (as opposed to sustainable resource use) described for several other resources and ecosystems. The success of this type of resource exploitation is judged by immediate economic results. It ignores either its impact on the structure and function of the ecosystem supporting the production of the exploited resources, or the knowledge of the original communal resource users, who are often displaced or marginalised by technically more effective exploiters moving into the area (Berkes 1985).

Although intensive aquaculture practices provide foreign exchange from exports, one may strongly question whether it benefits the country and its indigenous population in terms of sustained socio-economic benefits (Meltzoff and Lipuma, 1986; Goodland and Ledec 1987; Bailey 1988; Primavera 1991). The switching from food to cash deletes the social / cultural experience of sustainable resource use. The progressive exploitation of the ecosystem to expand the economy has made it necessary to redevelop the ecosystem in order to maintain the economy (Regier and Baskerville 1986). Fisheries and aquaculture are facing similar problems, which need to be tackled from an integrated societal-environmental systems perspective, where interrelations between sectors and their dependence on the processes and functions of coastal seas need to be explicitly recognised.

The expansion of aquaculture is limited not only by what is happening in the market or in other parts of the economy, but also by an increasing demand for environmentally produced goods and services, sustained by intricate ecological connections. These are more easily disrupted as the scale of aquaculture grows relative to its supporting ecosystems (Folke and Kautsky 1989). This also means that there are physical limits to aquaculture. It should be emphasised that environmental support is seldom accounted for in aquaculture production and generally not perceived in aquaculture management, although it is basic to the survival of the industry. Hence, if the ecosystem–industry interdependence is not recognised, aquaculture will be limited by the impact of its actions on the environment, as in the case of intensive shrimp farming.

Therefore, objectives such as sustainable utilisation of species and ecosystems, as well as recognition and evaluation of the benefits derived from ecological processes and the life-supporting ecosystems must play a significant role in aquaculture development.

Objectives

- To evaluate the environmental impact of aquaculture in Tamilnadu and Andhra Pradesh.
- To assess the social conflicts associated with aquaculture farms in Tamilnadu

and Andhra Pradesh.

- To analyse the extent of conflicts of common property resources for multiple uses.

Study Areas

The following zones were selected to study the economic and environmental impacts of aquaculture in Tamilnadu and Andhra Pradesh:

Tamilnadu

Zone 1	-	Chennai	-	Ponneri, Minjur, Kancheepuram
Zone 2	-	Pondicherry	-	Cuddalore, Parangipettai, Chidambaram
Zone 3	-	Nagapattinam	-	Sirkazhi, Poompuhar, Thanjavur
Zone 4	-	Ramnad	-	Pattukottai, Thondi, Mimisal,

Andhra Pradesh

Zone 1	-	Nellore	-	Ongole, Gudur
Zone 2	-	Vishakapatnam	-	Thimmapuram, Palmanpet
Zone 3	-	Machilipatnam	-	Bheemavaram, Akivedu,
Zone 4	-	Kakinada	-	Narasapore

Information was collected from agriculturists and aquaculturists through land surveys and questionnaires. Soil and water samples were collected from problematic zones in the areas concerned and analysed for their environmental conflicts.

Status of Aquaculture

Most of the aquafarmers in Tamilnadu and Andhra Pradesh have taken up shrimp culture mainly for export. Shrimps cultured in these farms are sold to agencies and exported. Aquaculture is a financially lucrative venture, yielding profits ranging from 20 to 50 per cent per annum, much beyond the returns that can be expected from any other activity. Unemployed coastal folks and agriculturists are offered jobs in the aqua farms for wages that far exceed those in other farming activities. The increased profits and wages are responsible for the overall improved economic activities and better standard of living of the people in the region. However, the advancement of shrimp farming is reported to have led to pollution of drinking water, imposing additional costs on society. These costs incurred are external costs, which are not included in the cost of shrimp production.

As per NEERI's estimate, environmental costs exceed the value of shrimps produced and exported. For Andhra Pradesh, the report estimated annual earnings at Rs.1,500 crore, against annual value of the damage caused by aquaculture at Rs.6,300 crore. Thus, for each rupee of gain, there would be four rupees of damage.

For Tamilnadu, the estimated annual earnings of Rs.280 crore are outweighed by damage cost estimated at Rs.430 crore.

Environmental Analysis in Problematic Zones

To assess soil and water quality in the agricultural fields near the aquaculture farms, water and soil samples were collected from various locations in problematic zones and analysed for deterioration in quality. The samples were collected from agricultural areas at distances of 1 km, 3 km, and 5 km from the aquaculture farms. The following are the data of their chemical composition obtained from the analysis of the samples collected from prime locations of aquaculture industries in Tamilnadu and Andhra Pradesh. The data are compared with those obtained from the analysis of the sample collected from agricultural areas free from aquaculture. The tables below show averages of all the parameters at varying distances in Nagapattinam, Vishakapatnam and Nellore.

Results

The closer the aqua farm the lesser the content of DS/pH/Co_3 /HCo_3 /Cl/ Ca/Mg/Na. This reveals that the intrusion of saline water has led to a decline in the optimum contents of the fresh water quality. Agricultural fields located at a distance of 3 km and 5 km are less affected by the changes in their content. Slight changes in their contents are noted in the case of paddy fields located away from the aqua farm. This shows that there is little influence on the quality of water in the agricultural fields. However, it could be authenticated by analysis of the water samples collected at distances of 1 km, 3 km and 5 km from the aqua sites that aquaculture does not cause any marked changes in the agricultural fields and in water quality.

Soil samples collected closer to aqua farm sites, ie., (1–3 km), reveal a light brown colour, whereas samples collected at a distance of 5 km reveal the natural grey colour. But changes in soil texture are not definite since the pattern is not the same in all the aquaculture areas. A uniform pattern occurs in the lime status of the soil samples collected 5 km away from the aqua farm. These reveal profuse lime status, whereas other samples collected 1 – 3 km away from the aqua farm show nil lime status.

In short, agricultural farms located in the vicinity of the aqua farms (1–3 kms) are more influenced by the increase in chemical contents than those located far away (5 km) from the aqua farms.

Water Quality Deterioration

Waste water from shrimp farms is high in nitrogen, phosphorous, carbon compounds, organic matter, shrimp excretory products, plankton and some chemical and antibiotic residues. Most of the shrimp farms do not have water treatment systems ;

Table 1: Analysis of Water and Soil in Areas Close to Aquaculture Farms

Composition	Nagapattinam (TN)	Vishakapatnam (AP)	Nellore (AP)
Water			
Dissolved matter	2.7 - 7.6	2.4 - 6.9	2.8 - 6.9
PH	7.6 - 8.2	7.3 - 8.2	8.0 - 8.2
Carbonate (Co_3)	Uniform	0.1 - 0.3	0.1- 0.3
Bicarbonate (HCo_3)	6 - 18.5	7.0 - 16.1	6.0-16.8
Chloride (Cl)	18 - 58	16.2 - 56.0	20.8 - 58.0
Sulphate (So_4)	0.4 - 0.18	0.04 - 0.14	0.04 - 0.14
Calcium (Ca)	6.0 - 13.8	6.1 - 10.1	6.0 - 13.8
Magnesium (Mg)	5.3 - 12.3	6.2 - 57.6	4.5 - 16.2
Sodium (Na)	14.24 - 44.24	7.24 - 46.24	14.24-46.13
Potassium (K)	1.70 - 2.51	1.51 - 2.51	1.41-2.51
Type of water	Sodium Chloride	NaCl (8); MgCl(1)	NaCl (all)
Soil			
Dissolved water	.07 - 1.60	0.07 - 0.71	0.11 - 0.50
PH	6.2 - 9.5	6.6 - 7.9	6.6 - 7.5
Av nutrients			
N	14 - 36	14 - 25	14 - 28
P	2.08 - 4.16	2.08 - 4.42	2.08 - 4.16
K	65 - 115	65 - 95	65 - 95
Colour	Grey (1) and light brown (8)	Light brown (5) Grey (3)	Light Brown (7); Grey (2)
Texture	Sandy loam (4); Sandy clayey (3); Loamy sand (1); Sandy (1)	Loamy sand (7); Sandy loam (2)	Loamy sand (4); Sandy loam (5)
Lime status	Nil lime (8), Profuse lime (1)	Nil (7); Profuse (2)	Nil lime (8); Profuse lime (1)

Table 2: Analysis of Water and Soil in Areas without Aquaculture Farms

Composition	Nagapattinam (TN)	Vishakapatnam (AP)	Nellore (AP)
Water			
Dissolved matter		-	-
pH	7.8	7.2	7.7
Carbonate (Co_3)	-	-	-
Bicarbonate (HCo_3)	1.0	6.0	1.5
Chloride (Cl)	95.4	11.8	11.5
Sulphate (So_4)	0.24	0.14	0.12
Calcium (Ca)	8.9	2.8	4.0
Magnesium (Mg)	47.5	5.7	3.2
Sodium (Na)	49.5	4.0	4.7
Potassium (K)	2.51	0.29	0.48
Type of water	NaCl	MgCl	NaCl
Soil			
Dissolved water	-	-	-
pH	7.8	7.4	7.1
Av nutrients			
N	31	42	39
P	16.1	13	9.1
K	45	125	35
Colour	Light brown	Light brown	Light brown
Texture	Sandy loam	Sandy loam	Sandy loam
Lime status	Non-Calcareous	Non-Calcareous	Non-Calcareous

they discharge the drain water directly into public water courses of the sea. If the waste water is discarded without dilution of treatment, it pollutes the environment. The discharge of pond effluent is found to have led to deterioration of water quality in irrigation canals and coastal areas. The effluent water from shrimp ponds includes what is released during rearing to control the quality of water in the ponds, as well as the discharge during harvesting of pond preparation for a new crop. This effluent comes from the high volumes of low-concentration effluent and concentrated releases during harvest and cleaning of shrimp ponds. The loadings are substantially more in the final stages of harvesting and cleaning of ponds when there is a high concentration of both nutrients and organic matter.

The discharge of dissolved organic matter from metabolites and decomposition of uneaten food and shrimp faeces into the sea from intensive shrimp farming operations have resulted in fish death and foul-smelling water in many wetland

areas. Therefore, it is inferred that water treatment facilities are compulsory for farms.

Water management and quality control in aqua farms can be subdivided into three phases, viz., (i) inlet water management (ii) daily water management (iii) control discharge water management. Frequent exchange of water helps to maintain its quality. It also prevents the accumulation of waste products, trace metals, depletion of organic compounds and accumulation of waste products that increase the Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) levels in the pond. Thus, the characteristics of the discharged water directly reflect the internal process involved in water quality management at all three stages, viz., inlet water, daily pond water, and discharge water. It is therefore sought to be highly essential for maximising prawn production.

The aqua farm discharge needs to be regulated in order to protect both the industry and the environment. Further, regulations governing discharge from aqua farms need to be developed. It is suggested that environmental deterioration could be overcome using a closed water recycle or recirculation system so as to overcome adverse conditions, like pollution, which lead to outbreak of diseases. The real challenge for aquaculture is to find ways to redirect the industry's present behaviour towards a path where development and environment go hand in hand.

Impact on the Coastal Ecosystem

Aquaculture effluents discharged into the marine environment are reported to threaten the survival of coastal resources. The effects on coastal habitats are mainly due to improper saline water released as pond effluents, which have a pronounced effect on both marine and freshwater organisms. However, this appears to be incorrect since the effluents of aquafarms consist of only biological wastes like feed remains made up of soyameal and other fishery products. Further, salinity remains constant since the water is pumped in from the natural source of the same salinity, which is maintained for successful growth of the culture.

Impact on Surface Water and Groundwater

The salinization of surface water is another impact from shrimp farms to the receiving waters. It is reported that shrimp farm construction can potentially alter surface water flow patterns and water quality. Water flows were found to be affected by the temporary blockage of permanent division of canals. Discharge of untreated pond effluents into the natural system were known to hinder the quality of water. Further, seepage of saline water from the ponds into the ambient areas also leads to salinization of groundwater. There are cases of stratification occurring on the surface of fresh water zone as it mixes with the deeper saline water that will affect agricultural land when farmers unknowingly pump salinised water into farm land. The shrimp farmers directly discard untreated waste water into the public canal or coastal area or

river and inshore areas, causing general pollution and public health hazards.

Effective pumping of saline water, in the case of bore water-dependent farms, and fresh water, in the case of coastal farms, lowers the groundwater table. The salinized groundwater also affects the drinking water sources of coastal villages.

Shrimp farming causes dispersion of salt into land around the shrimp farms, thereby affecting paddy fields and other plantations. The soil salinization further devalues marginal agricultural land. Abstraction of fresh water from underground aquifers for intensive shrimp farming has also resulted in salt-water intrusion and salinization of freshwater aquifers. While freshwater aquaculture has little negative impact on groundwater and aquifers, brackish water aquaculture is detrimental to subterranean water resources.

Common Property Resources and Rights

Creeks and coastlines have been used to set up shrimp farms along the east coast as they are common property resources. These resources as well as the sea have been, since time immemorial, the means of livelihood of the local fishermen, who are now being denied access to the sea. This has resulted in conflicts and clashes, leading to protests and threats to destroy the shrimp farms in Tamilnadu.

Types of Conflicts

A number of shrimp farms have been set up in violation of many rules, with no proper systems for their supervision and monitoring. This has resulted in conflicts in the use of common property resources. The shrimp farms fenced their area without prior notice and did not allow the public, especially the fishermen who were using the beaches for years together because of lack of proper rights to use the common property resource. The shrimp farms have been set up without considering the hardships of the local fishermen from open access to the seashore. Open access system has given rights to the fishermen to use the seafront for their livelihood.

Likewise, the owners of shrimp farms purchased the cultivable lands from agriculturists and converted them into aqua ponds. This has resulted in conflicts with the users of land for agricultural activities. Some of the farms have not shown any concern when the groundwater sources turned brackish. Very few farms have made arrangements for supply of potable water to the local people. Such conflicts have triggered severe protests from the local people against the shrimp farms.

Conflicts Between Fishermen and Aqua Farms

A major issue observed by this study was the conflict between the shrimp farmers and the fishermen over accessibility of fishing areas. The shrimp farms do not provide access to the beach for traditional fishermen who have to reach the sea

from their villages. As aqua farms are located on the seafront and entry is restricted, the fishermen have to take a longer route of 4–5 kms to sea. The traditional, local fishermen, who have been fishing for years, are subjected to such hardships because of the newly emerging aqua farms. The accessibility of fishing areas / beaches through larger aqua farms is a major source of conflicts between aqua farmers and the local people. It can be resolved through negotiations among themselves on provision of suitable approach roads. While such large farms do help by providing advanced aquaculture know-how, and supply of aquafeed, hatchery-produced seed, etc., to small farmers, coastal communities in general seldom benefit directly from such aquacultural development.

The conflict described above is restricted to a few farms near Nagapattinam district and in Kandleru creek in Andhra Pradesh. It is not a major issue in many shrimp farm areas since the big farms, of more than 20 ha, especially those in the corporate sector, do not hinder accessibility of the fishing areas. Moreover, the problem can be easily solved through negotiations.

Conflicts in the Land Use Pattern

Indiscriminate conversion of fertile agricultural lands into aqua farms in the initial stages of aquaculture development was found to have led to many conflicts prevailing till today. This practice aggravated the landlessness among farmers. Absentee landlords sold their lands to aqua enterprises for a high price. Those who were working or cultivating under tenancy farming lost their livelihood, and crop production was also affected. In the earlier years, vast areas of mangroves were destroyed for agriculture. Though mangroves have legal protection, they were initially destroyed to make way for aqua farms. The utilisation of mangrove area for shrimp farming was minimal, and restricted to traditional aquaculture practice by only those who take up cost-intensive systems of shrimp farming. However, this activity has been completely curtailed in the mangrove ecosystems of Tamilnadu and Andhra Pradesh since 1996.

Conflicts between Aquaculture and Agriculture

In the early nineties, when aquaculture began, entrepreneurs acquired lands from agriculturists who were incurring tragic losses in agriculture. As this continued, conflicts arose with the support of NGOs against aquaculture. With a view to avoiding such conflicts, the commercial farms that developed subsequently were constructed on fallow wastelands, unsuitable for agriculture. These lands are registered in the revenue records in the agricultural category, and have therefore led to criticism that aqua farms are constructed on agricultural lands. Depending on the soil texture, soil salinization may take place on neighbouring agricultural land where coastal aqua farms are set up. It is a well-established fact that the aqua farms, having higher

percentage of sand particles, are causing salinization of agricultural lands, the major conflict that led the coastal aquaculture to legal disputes. Similarly, where coastal aqua farms exist on clayey soils, soil salinity could not exceed the permissible limits in adjacent agricultural farms.

The salinization of groundwater and agricultural lands depends entirely on soil texture and fabrication. Even where there are no shrimp farms, the lands and groundwater are saline because of the nearness of the sea and regular tidal flushing, seepage, humid climate, and meagre and narrow freshwater tables in the coastal belt. That is why the area not only around shrimp farms but also of the coastal plains in Tamilnadu remains devoid of agricultural activity. However, salinization around shrimp farms is not a problem in Andhra Pradesh because most of these farms have been set up on coastal plains away from the sea (0.6 – 22 km) with relatively less tidal flushing. Moreover, tidal creeks and canals in Andhra Pradesh are regularly flushed with the fresh water of perennial rivers, namely Krishna and Godavari. This is why shrimp farms co-exist with paddy fields, and mango orchards or horticulture crops in coastal Andhra Pradesh. It is interesting to note that good quality drinking water was available from borewells installed in the middle of some of the shrimp farms in Andhra Pradesh.

Use of groundwater for aquaculture activities is a disputed issue. Use of ground freshwater for inland aquaculture can reduce the groundwater table, further limiting the future of aquaculture. Similarly, in the coastal areas, use of ground freshwater (abundant in sandy soils) can reduce the water table and possibly promote salinization due to intrusion of saline water. However, some experts believe that salinization of land and drinking (borewell) water may be attributed to various other factors too like proximity to the sea, frequency of the tides, nature of soil, climatic conditions, groundwater table, and geomorphological characteristics of the area.

Human Health Impact

The social movements against shrimp culture in Sirhazhi, Tamilnadu, have alleged that shrimp culture activities have resulted in various diseases, which pose a threat to the local population. However, only one or two cases have been reported in Tamilnadu, and none in the shrimp culture areas of Andhra Pradesh. Further, the public has maintained that shrimp culture industry is the only viable alternative to agriculture, particularly in the context of the present water scarcity, which has been a disaster to agriculturists. In such circumstances, aquaculture has come to their rescue by providing better employment opportunities to the local labour including womenfolk. The public has also pointed out that they are comfortable with the development of the industry, and that any move to destroy it will make them homeless.

Socio-Cultural Impact

Shrimp culture is essentially a human activity with varying socio-cultural and economic impacts on human communities involved. An appreciable number of rural people have found employment as owner operators or wage earners in shrimp farms, and their economic standard has risen. The State Government is leasing out sites to co-operatives or to the poor, with a view to helping them earn cash benefits. Since shrimp commands a high price in the market, the overall socio-cultural and economic standards of marginal and small-scale farmers will certainly improve.

Shrimp farming suffers from lack of social acceptability. Indiscriminate conversion of agricultural lands into shrimp culture farms has aggravated landlessness among farmers, changing land use patterns in the coastal areas.

The ownership pattern has radically changed for various reasons. About 20 per cent of the coastal landholdings were sold as they were small (less than one ha), 40 per cent were sold due to high price, 30 per cent due to inadequate profit from crop production, and 10 per cent because of shortage of labour. The traditional agriculturists in the coastal areas have profitably utilised the sale proceeds to purchase fertile interior farms for shrimp farming.

The statement of the Sarvodaya leader, Mr. Jagannathan, against unemployment in aquafarms has proved to be false since many employment opportunities are being offered to the local people and the agriculturists. Further, his statements that the land used for prawn farming is unusable after 10 –12 years have also proved to be wrong since many farmers are converting their paddy fields to aquaculture farms in Tamilnadu. Certain areas in Bheemavaram, Andhra Pradesh, that were used for aquaculture were reconverted to agriculture to maintain crop rotation and high yield both in aquaculture and agriculture, and to prevent diseases.

Also to be noted is that only fallow lands and cultivable waste areas have been converted into prawn farms in Tamilnadu. Besides, on account of the persisting Cauvery water issue, farmers harvesting only one crop in Poompuhar area have given up agriculture, and prawn farm companies / investors purchased fallow lands from them. In fact, these companies came to the rescue of the farmers.

Positive Impact of Aquaculture

Aquaculture has a positive impact on the environment, and biodegradable wastes provide nutrition for agricultural production; otherwise it is mineralised by bacteria. The environmental effects of aquaculture include change in resources such as water and land, and competition between users. Aquaculture can contribute positively to the environment in many ways, but this is seldom recognised in environmental forums. Hence, more analysis is called for by social scientists.

Human Impact

Human impact encompasses the social, cultural and economic impact of aquaculture. Though aquaculture, like agriculture, is included in the primary sector, its social impact is significant. Local fishermen as well as agricultural farmers have found jobs in shrimp farms, though most of the owners of big farms have been from the urban areas. It has resulted in a good relationship between management and workers. Employees of aquafarms are of the opinion that they get better wages in the shrimp farms. Though India has a vast area that is well-suited to introduction of aquaculture, only a fraction of it is being used for such activities, which are a promising agent of economic welfare and a good source of foreign exchange.

Aquaculture is making it possible to rear various types of fish, especially shrimps, in India, thereby increasing the availability of food for the ever increasing population, which reached the one-billion mark, on May 11, 2000. It is unwise to depend on agriculture, especially wheat and paddy alone, to meet the food requirements of this huge population. Moreover, we have surplus agricultural production. It is necessary to look into commercial as well as export-oriented products.

The depletion or standstill of capture fishery since the seventies and availability of vast stretches of brackish-water lands (1.2 million sq. km) in India have resulted in the development of shrimp farming in the country. Owing to high profits and financial viability it has rapidly expanded. In Tamilnadu also, the aquaculture industry developed rapidly and is still being practised despite the Supreme Court's ban on aquaculture farms set up within 500 metres from the sea landward. Agricultural lands were purchased for the setting up of aqua farms. In Sirkali taluk, more lands have been purchased at high prices, but most of them are now idle on account of opposition from all walks of life.

Economic Aspects

Shrimp farms are highly profitable ventures, provided no viral diseases attack the prawns. Their unique taste makes them a culinary delight all over the world. They are cultured in many of the Southeast Asian countries, since the captured production remains at a standstill. In India too, shrimp culture is being encouraged, as there is ample space available. Shrimp farms have been set up in Tamilnadu but only in meagre areas, compared with Andhra Pradesh, though the potential is bright. The country earns nearly Rs.5,000 crore of revenue from aquaculture production and export. Thus, it is important to consider expansion of this industry on a still larger scale, waiving the environmental aspects, which are common on either side of the establishment of a flourishing industry.

Since the opportunity cost is favourable to aquaculture producers in place of agricultural producers, the shift is obvious. Any activity is to be considered an

industrial or agricultural activity that will depend on the technology being used and the way the surplus so generated by such technology is distributed within the community dependent on it. Aquaculture, as a commercial activity, should be combined with concern for both the natural and the human environment. Otherwise, the first casualty would be aquaculture itself.

Conclusion

For the shrimp industry to thrive, conflicts between aquaculture and agriculture and between aquaculture and other uses of the coastline should be minimised. If fishermen and landless agricultural labourers were encouraged to practice shrimp culture, clashes and conflicts would be avoided. Though shrimp aquaculture is polluting the surroundings, measures could be introduced to minimise pollution. This is not the only polluting industry; dyeing and leather processing industries also cause pollution, but are allowed to function under the necessary controls. Similarly, the aquaculture industry may be permitted to operate with appropriate safeguards.

If the societal value of the life-supporting environment is not recognised, there is a grave risk that a short period of prosperous growth of the aquaculture industry, based on intensive ecosystem exploitations, will turn into severe ecological, economic and social problems and conflicts. In addition, it will disrupt cultural traditions of significance for sustainable resource use. The management of sectorial aquaculture for short-term profits does not recognise the interrelations between resource use, environmental impacts and the working of ecosystems. There is huge potential for recycling of resources and reduction of waste and pollutants in aquaculture. This means that there is potential for economic growth of aquaculture based on development. Such efficiency-increasing development is very different from the throughput-increasing growth witnessed in the unsustainable shrimp farming in recent decades.

Sustainable food production via aquaculture can be achieved by carefully combining different types of aquatic and terrestrial cultivation systems (Yan and Ma 1991). An integrated culture may help to curtail environmental hazards by using the wastes to increase production further and at the same time reduce the environmental impact.

It is inferred that environmental effects can be considerably reduced by rearing the commercial species, by creating recycling and other feedbacks between the ecosystem and the cultured species.

On the basis of this study it is felt necessary to promote aquaculture development in Tamilnadu and Andhra Pradesh through various policies that will benefit the farmers. But it is important that aquaculture and environmental preservation are achieved as a motto for sustainable development.

References

Bailey, C. (1988). The Social Consequences of Tropical Shrimp Mariculture Development, *Ocean and Shoreline Management*, 11: 31–44.

Berkes, F. (1985). The Common Property Resource Problem and the Creation of Limited Property Rights, *Human Ecology*, 13: 187–208.

Folke, C., and Kautsky, N. (1989). The Role of Ecosystems for a Sustainable Development of Aquaculture, *Ambio*, 18: 234–43.

Goodland, R., and G. Ledec (1987). Neoclassical Economics and Principles of Sustainable Development, *Ecological Modelling*, 38:19–46.

Meltzoff, S. K., and E. Lipuma (1986). The Social and Political Economy of Coastal Zone Management: Shrimp Culture in Equador, *Coastal Zone Management Journal*, 14: 349–80.

Primavera, J.H. (1991). Intensive Prawn Farming in the Philippines: Ecological, Social and Economic Implications, *Ambio*, 20: 28–33.

Regier, H. A., and G. L. Baskerville (1986). Sustainable Redevelopment of Regional Ecosystems Degraded by Exploitative Development. In Clark, W.C., and R.E. Munn (eds.). *Sustainable Development of the Biosphere*, 75–101. Cambridge: Cambridge University Press.

Yan, J., and S. Ma (1991). The Function of Ecological Engineering in Environmental Conservation with Some Case Studies from China. In C. Etnier and B. Guterstam (eds.). *Ecological Engineering for Waste Water Treatment*, 80–94. Gothenberg, Sweden: Bokskogen Publishers.

Received : April 17, 2001 Accepted: February 14, 2002