5 Brackish-water Shrimp Cultivation Threatens Permanent Damage to Coastal Agriculture in Bangladesh

Md. Rezaul Karim
Urban and Rural Planning Discipline, Khulna University, Khulna, Bangladesh,
e-mail: rk@bttb.net.bd

Abstract

Over the past 20 years, brackish-water shrimp cultivation in the coastal zone of Bangladesh has contributed increasingly to the national economy, but there is a lack of quantitative data on the effects of shrimp farming at the household and community levels. This chapter investigates the impact of shrimp cultivation on the environment and farmers' livelihood in a typical subdistrict of the coastal zone in Bangladesh. The variables involved with shrimp cultivation and their impact on the land are also taken into consideration and an attempt is made to analyse the patterns of land-use change that occurred between 1975 and 1999. The extensive pattern of shrimp cultivation is achieved by expansion of area rather than by intensification. The expansion of shrimp farming has resulted in decreases in crop production and many environmental problems in the form of a shortage of livestock fodder, fuel scarcity and decreases in traditional labour forces. Under the present circumstances, shrimp cultivation is no doubt beneficial for a selected group of people, but it has negatively affected the livelihoods of landless and marginal farmers, making it difficult for them to survive in the area.

Introduction

The Bangladesh coastal zone (Fig. 5.1) is a significant maritime habitat of ecologically rich and economically important natural resources. The area is situated along the largest river system running below the Himalayan Mountains. In this zone, the rivers discharge an enormous quantity of fresh water and maintain a level of salinity both on land and in sea that favours the rapid growth of a wide variety of vegetation and aquatic life.

The coastal region, especially the south-western portion (Satkhira, Khulna and Bagerhat), is one of the most promising areas for shrimp cultivation for two major reasons (MOFL, 1997; Karim and Shah, 2001): first, its fresh- and saltwater resources are abundant in almost all seasons; second, the world's largest continuous mangrove forest, the Sundarbans, provides a food source and nursery for the offshore fishery. The mangrove forests provide a critical habitat for shrimp and other fish. Most of the shrimp culture being practised is by the extensive and improved extensive methods, known as *gher* culture. *Gher* means an enclosed area characterized by an encirclement of land

 Environment and Livelihoods in Tropical Coastal Zones (eds C.T. Hoanh, T.P. Tuong, J.W. Gowing and B. Hardy)

along the banks of tidal rivers. Dwarf earthen dykes and small wooden sluice boxes control the free entrance of saline water into the enclosed areas. In the *gher*, the sluice gates are opened from February to April to allow the entry of saline water, containing a wide variety of fish fry and shrimp postlarvae that have grown naturally to the juvenile stage in the adjacent sea and estuarine waters. This practice of natural stocking is being progressively replaced by artificial stocking of the *ghers* with only the young of specific, desired species of shrimp.

It is estimated that about 250,000 ha of land has good potential for coastal aquaculture (Ahmed, 1995). Of that, about 180,000 ha is suitable for shrimp culture (Khan and Hossain, 1996). Coastal aquaculture increased from 20,000 ha in 1994/1995 to 135,000 ha in 1996/1997, and production from 4000 to 35,000 metric tons in the same period (MOFL, 1997). The rapid expansion of shrimp farm development during the last decade, along with the adoption of extensive and improved extensive culture techniques, has caused growing concern as to its adverse effect on the coastal environment and damage to the traditional agricultural systems. The socio-economic scenarios have changed rapidly.

This chapter aims to assess the effects of the past and current situation as regards shrimp cultivation methods in relation to the coastal environment. In particular, the research aims to identify the inherent potentials and problems, as well as the emerging trends in the causes and extent of land-use changes over a period of time, with a view to understanding the implications for land-use planning and the development of more environmentally acceptable shrimp cultivation methods.

Methods

The study was conducted in 43 selected villages of Rampal Upazila (subdistrict), Bagerhat District, Khulna Division (Fig. 5.1), in 1999. Rampal Upazila covers 33,546 ha of land and is located in the centre of the western region of the coastal zone. It is situated on the Mongla River and is well connected to the Passur River. The area is close to the Sundarbans mangrove forest. The study area was selected on the basis of the following criteria: (i) the area should have extensive shrimp culture; (ii) shrimp farming should have been going on for at least 10 years in the area; (iii) the change in the physical environment should be homogeneous and representative of the situation in the coastal areas; and (iv) shrimp should be the main crop and provide the major share of income of the farmers of the area.

Information was collected from 373 respondents belonging to five landowner categories using land-use survey and questionnaire survey techniques. Field observation based on the perception of local people was carried out and recorded documents of relevant studies were examined. Changes in the land-use pattern, socio-economic conditions and the environmental situation of the area were recorded for three time periods: 1975, 1985 and 1999. Information relating to the landscape ecology in the past was collected with Retrospective Inquiry System (RIS) techniques and ground truthing was performed with the help of aerial photography and satellite images.

Results and Discussion

The percentages of major land-use categories for 1975, 1985 and 1999 are presented in Fig. 5.2. This shows that more than 80% of the land in Rampal Upazila was under rice cultivation in 1975, whereas in 1999 it decreased to less than 20%. Over this period, most of the rice land was replaced by rice–shrimp farming (rice in the rainy season and shrimp in the dry season), indicating a sharp increase in shrimp cultivation. Land occupied by other uses has not changed significantly during the study period.

Shrimp farms

Table 5.1 describes the size of shrimp *ghers* according to the household respondents. Before 1970, there was no shrimp cultivation in the study area. Most shrimp *ghers* in 1975

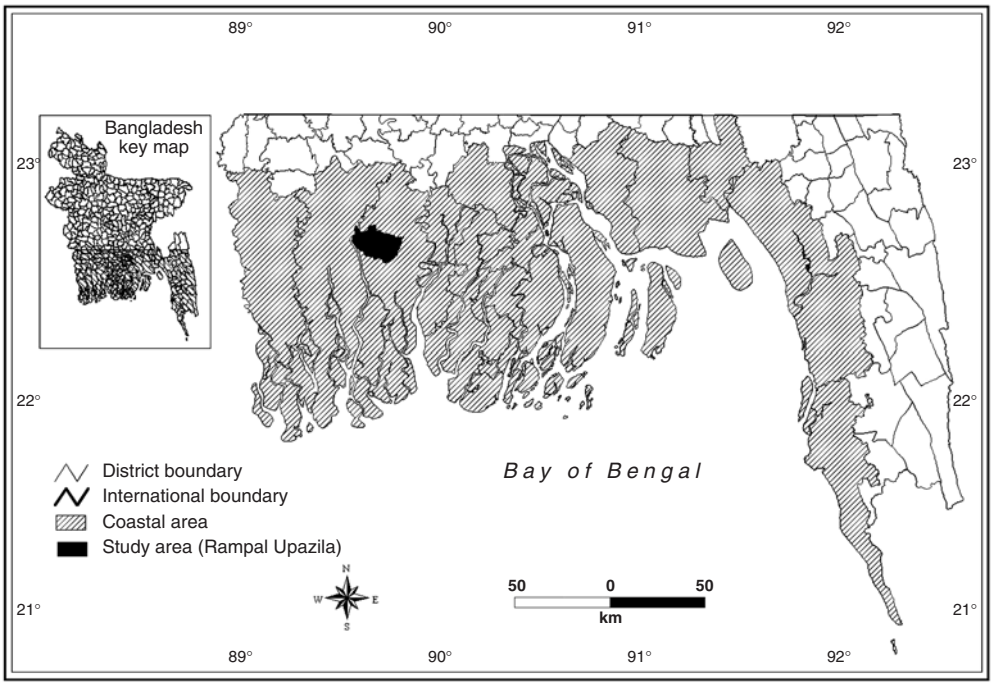

Fig. 5.1. The coastal area of Bangladesh.

were from 0.2 to 1 ha. A large number of pocket *ghers* (less than 0.2 ha) were introduced during 1975–1985 and 1985–1999 (accounting for 66.2% and 70% of the total shrimp *ghers* area, respectively). Farm areas of more than 6.47 ha represented 2.9% in 1985 and increased to 4% of the total shrimp *ghers* in 1999. Table 5.2 shows the size of shrimp *ghers* followed by paddy cultivation. The concentration of shrimp–rice farms was within the group of 0.2–1.0- and 1.0–3.0-ha categories. The percentage of farms greater than 3 ha increased during 1975–1999.

Field crops

Transplanted aman rice (rainy season) is the dominant crop in the study area. Mostly, traditional tall varieties with low yields (ranging from 1 to 3 t/ha) are cultivated. The cropping intensity of the study area was 113% in 1975 and decreased to 105% in 1985, which is much lower than the country's average (151%) (BBS, 1986a). In 1999, however, the cropping intensity in the study area was 100%. Shrimp cultivation was the only reason for the decrease in cropping intensity reported by respondents in the study area.

Yields of most of the field crops in the study area have also declined (Fig. 5.3) following the start of shrimp cultivation. Production of wheat, jute and sugarcane has been affected seriously, and now it is not possible to grow these crops because of soil salinization. The yield of the aman rice crop also declined quickly and, during the field survey in 1999, it appeared that farmers were not interested in harvesting transplanted rice crops from fields because of the very poor yield. Farmers in the study area attributed the decrease in rice yield to salinization. Though we did not have any quantitative data to support the farmers' claims, other studies mention that brackish-water shrimp farming (Rahman *et al.*, 1992) and salinity present in the soil are the major factors restricting crop production (BARC, 1990; Flowers, 1999). The soil characteristics surrounding the study area have deteriorated

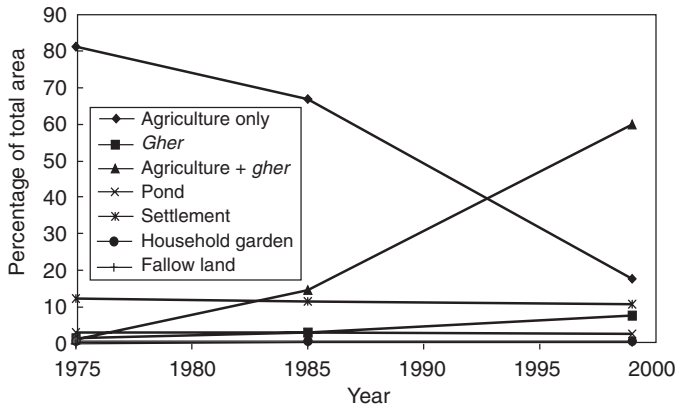

Fig. 5.2. Land uses over different years in Rampal Upazila.

Table 5.1. Size of shrimp *ghers* according to the household respondents in Rampal Upazila from 1975 to 1999 (from field survey, 1999).

Land area (ha)	Percentage of *gher* households		
	1975	1985	1999
<0.2	0	66.2	70.0
0.21–1.0	66.7	16.2	11.6
1.1–3.0	16.7	10.3	8.6
3.1–6.47	16.7	4.4	5.9
>6.47	0	2.9	4.0
Total	100	100	100

Table 5.2. Size of shrimp *ghers* followed by paddy cultivation (shrimp–rice system, SR) in Rampal Upazila from 1975 to 1999 (from field survey, 1999).

Land area (ha)	Percentage of SR households		
	1975	1985	1999
<0.2	0	36.1	41.2
0.21–1.0	75.0	28.9	25.3
1.1–3.0	25.0	27.8	22.0
3.1–6.47	0	5.2	7.9
>6.47	0	2.1	3.7
Total	100	100	100

substantially because of the gradual accumulation of salt over the years (Rahman *et al.*, 1992). Findings of these studies indicate that, once the soil becomes saline, subsequent floods and monsoon rainfalls may not leach out the salt completely and residual soil salinity is likely to increase over time.

In the study area, farmers grow some kharif vegetables such as pumpkin, brinjal (aubergine), spinach, etc, on their homestead lands. In the kharif season, which starts with the summer rains, salinity does not pose serious problems for the growth of vegetables as there is enough rain to leach out the salt, but

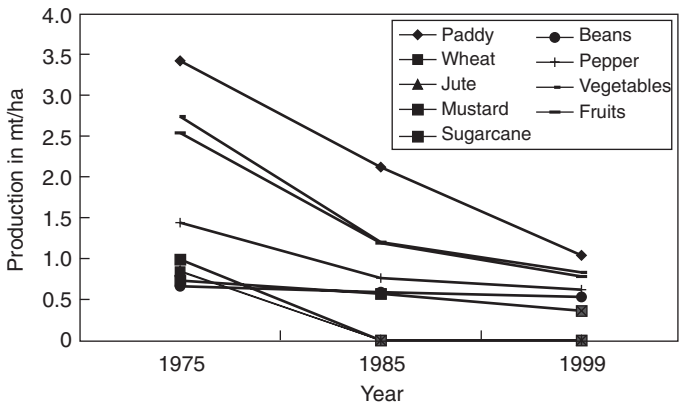

Fig. 5.3. Change in major crop yields (metric tons) in Rampal Upazila.

still production has not been satisfactory. In the rabi season from November to April, however, the intensity of soil salinity increases, which restricts most of the rabi vegetables. Small portions of land in the study area, consisting of 7% of the sampled villages (three villages), have shown that rabi crop production is affected in this way.

Table 5.3 shows that most respondents grew a large variety of vegetables in 1975. From 1975 to 1985, vegetable cultivation was seriously affected, and in 1999 the cultivation of major vegetables declined drastically. More than 80% of the sample villagers reported that vegetable cultivation was not possible because of the high soil salinity in the study area.

Vegetation

Shrimp cultivation can be considered as a land development process in which swampy forest or agricultural lands of low elevation are normally converted into shrimp ponds by embankment construction. Trees and bushes in the swampy forest or bushy land were totally cleared in preparation for shrimp farming. About 3.5% of forest and 2.4% of pasture land in the study area have been converted into shrimp ponds. Once shrimp cultivation starts, the remaining trees and vegetation also disappear fast because of high salinity and inundation. Sometimes, trees remained longer on the dykes and embankments, but they also disappeared over time because of seepage of saline water. Reeds and grasses that are used for fuel or for making mats are gradually lost because of the rise in saline levels in the waterlogged areas. The interviewees named several aquatic plants and weeds that had completely disappeared because of shrimp farming in the coastal area: durba (*Cynodon dactylon*), baju (*Tamarix troupii*), chehur (*Bauhnia vahlii*), thankuni (*Centella asiatica*), ambalisak (*Oxalis corniculata*) and kachuripana (*Eichhorina crassipes*). However, these species are still found in the non-shrimp area (Rahman *et al*., 1992).

Table 5.4 shows the gradual encroachment of shrimp farms into the homestead areas. Before 1975, most shrimp farms (81.4%) were located farther than 500 m away from and only 1% were closer than 100 m to homestead areas. In 1999, 46% of the shrimp *ghers* were less than 10 m from homestead land, and only 2.1% were farther away than 500 m. This encroachment caused serious problems for the survival of trees in and around homesteads. A wide range of fruit trees and plant species grew abundantly before shrimp cultivation in the study area (Table 5.5). By 1985, about 60% of these trees had died. In 1999, some species (e.g. *Litchi chinensis*) almost disappeared. The interviewees reported that only some tree species, such as raintree and *sobeda*, survived to a limited extent. In some homesteads, betelnut, coconut, palmyra palm and date palms were present but did not bear fruits.

Table 5.3. Percentage of vegetable cultivation in Rampal Upazila from 1975 to 1999 (from field survey, 1999).

Scientific name	Local name	English name	Percentage				
			1975	1985	1999	1985–1999	1975–1985
Lagenaria vulgaris	Lau	Bottle gourd	98.1	83.7	50.5	–33.2	–47.6
Cucurbita maxima	Kumra	Sweet gourd	85.3	54.3	24.3	–29.9	–61.0
Amaranthes gangeticus	Lal Shak	Celery	94.4	45.2	12.3	–32.9	–82.1
Aloe indica	Sabuz Shak	Greens	95.7	46.5	19.0	–27.5	–76.7
Brassica oleracea var. *botrytis* Linn.	Ful Kopi	Cauliflower	77.5	9.4	2.9	–6.4	–74.6
B. oleracea var. *capitata* Linn.	Badha Kopi	Cabbage	79.1	7.0	1.1	–5.9	–78.1
B. oleracea	Oal Kopi	Turnip	83.7	10.2	3.5	–6.7	–80.2
Solanum melongena	Begun	Aubergine	90.1	43.6	20.1	–23.5	–70.1
S. tuberosum	Alu	Potato	86.6	27.0	10.4	–16.6	–76.2
Lycopersicon esculentum	Tomato	Tomato	91.2	24.1	6.4	–17.6	–84.8
Trichosanthes dioica	Patol	Pointed gourd	35.3	8.0	2.4	–5.6	–32.9
Luffa acutangula	Zhinga	Luffa	78.9	11.8	2.1	–9.6	–76.7
Dolichos lablab	Shim	Country bean	81.3	17.6	4.3	–13.4	–77.0
Momordica cochinchinensis	Kushi	Snake gourd	80.5	8.8	5.6	–3.2	–74.9
Abelmoschus esculentus	Dherosh	Lady's finger	79.4	14.2	9.4	–4.8	–70.1
Cucumis sativus	Sosha	Cucumber	73.3	6.1	0.8	–5.3	–72.5
Capsicum frutescens	Kathcha Morich	Green pepper	91.7	31.0	9.9	–21.1	–81.8
Vigna catiog	Borboti	Yard-long bean	75.7	3.7	2.1	–1.6	–73.5
Batatas edulischoisy	Misti Alu	Sweet potato	77.3	3.5	1.1	–2.4	–76.2
Amorphophallus campanulatus	Oal Kochu	Elephant food	79.4	5.3	0.8	–4.5	–78.6

Table 5.4. Encroachment of homestead land by shrimp farms in Rampal Upazila from 1975 to 1999 (from field survey, 1999).

Distance from homestead (m)	Percentage		
	1975	1985	1999
<10	0	0.9	46.0
10–24	0	3.4	24.1
25–50	0.3	7.8	15.8
51–100	0	4.0	5.3
101–300	0.7	5.6	3.5
301–500	17.6	19.3	3.2
>500	81.4	59.0	2.1
Total	100	100	100

In addition to its effects on vegetation clearance, decrease in pasture land and disappearance of trees, shrimp culture has had some indirect effects on vegetation. Farmers use the residues from agricultural land as fuel for cooking food, and cow dung for fuel and manure. After the introduction of shrimp cultivation, households became totally dependent on trees and forest vegetation as a fuel resource. The decrease in vegetation led to increasing soil erosion and sedimentation in the rivers and agricultural fields, which created problems within local ecosystems. The non-availability of cow dung may decrease the organic matter and fertility of the soil on the remaining agricultural land and gardens.

Livestock and poultry

Livestock and poultry play a crucial role in the traditional agricultural economy of Bangladesh. Livestock and poultry accounted for 5% of the gross domestic product (BBS, 1986b) of the country. The 1983/1984 statistics for cattle per household in the study area were 7.56, compared with 14.9 for the Greater Khulna District and 3.89 nationally. The survey result shows a sharp decline in the production of livestock and poultry in the study area (Fig. 5.4 and Table 5.6). The rate of decrease from 1985 to 1999 was nearly double that of 1975 to 1985.

It is, of course, very difficult to isolate the effects of shrimp culture from the general trends of livestock and poultry all over the country. But it was also reported that ducks

Table 5.5. Changes in numbers of trees in homestead gardens in Rampal Upazila (from field survey, 1999).

Scientific name	Local name	English name	Number of trees		
			1975	1985	1999
Mangifera indica L.	Aam	Mango	3,302	1,833	928
Artocarpus heterophyllus Lamk.	Kanthal	Jackfruit	1,369	629	197
Psidium guajava (L.) Bat	Pyara	Guava	1,752	771	603
Syzygium spp. (Wt.) Wall.	Jam	Berry	627	272	121
Bombax ceiba L.	Shimul	Silk cotton	440	160	321
Melia azadirachta L.	Nim	Neem	649	283	253
Albizzia lebbeck	Shirish	Rain tree	2,087	1,159	1,224
Borassus flabellifer L.	Tal	Palm	2,178	1,090	792
Phoenix sylvestris (L.) Roxb.	Khejur	Date	11,079	6,607	3,859
Cocos nucifera L.	Narikel	Coconut	10,525	6,115	3,953
Bambusa vulgaris Schrad	Bash	Bamboo	7,682	2,725	1,598
Areca catechu L.	Supari	Areca nut	41,960	15,625	8,603
Zizyphus jujuba Lamk.	Boroi	Plum	1,025	478	364
Eugenia malaccens	Jamrul	Star-apple	422	164	94
Citrus aurantifolia (Christ)	Lebu	Lemon	827	249	168
Litchi chinensis	Lichu	Litchi	310	75	20
Tamarindus indicus L.	Tentul	Tamarind	1,272	444	510
Musa sapientum	Kola	Banana	19,733	7,617	3,687
Achras sapota	Safeda	Sapota	342	250	193

were not allowed to move on to the shrimp farms and that poultry birds had lost their scavenging fields. This indicates that there was definitely some pressure against raising poultry and ducks in the shrimp-producing areas. The decrease in cattle population could be related to the decrease in grazing areas and the availability of food and fodder (e.g. rice straw) brought about by shrimp farming.

Table 5.6. Changes in numbers of livestock and poultry in Rampal Upazila from 1975 to 1999 (from field survey, 1999).

Type	Number of animals		
	1975	1985	1999
Cattle	2,574	1,453	585
Buffalo	691	300	92
Goats	1,289	698	257
Ducks	13,305	5,470	3,545
Chickens	8,597	5,014	3,933

Occupation and income

Table 5.7 suggests that total unemployment increased from 0% to 19% among males and from 46% to 55% among females because of the introduction of shrimp farming. These changes were highly related to the decline in agricultural employment (1975–1999) from 75% to 38% for men and from 37% to 0% for women. As shrimp farming is less labour-intensive than agriculture, with the decrease in crop cultivation, the local job market declined substantially. Before shrimp cultivation, most of the women were engaged in activities related to crop production such as harvesting crops, husking paddy, rearing livestock and poultry, cultivating vegetables, etc. Rearing of livestock became difficult because of the lack of grazing land after extensive year-round shrimp cultivation. However, a small proportion of women and children were found to be working in shrimp-processing factories, as well as in the collection of shrimp fry, because of new developments.

Table 5.8 summarizes the cost–benefit analysis of shrimp in the study area. The net annual income of the households in their own *ghers* was Tk 49,967/ha, whereas annual income from rented *ghers* was Tk 43,944/ha. Shrimp farmers who could invest around Tk 34,000/ha in their land had an opportunity to earn a net income of Tk 50,000/ha, whereas those who could not afford to lease out their land could get only Tk 6000/ha of land as lease money. As such, it can be concluded that shrimp culture is responsible for creating inequity in the society, although it had provided an opportunity for more economic use of land. On the other hand, paddy farmers had earned a net income of Tk 2700/ha with an

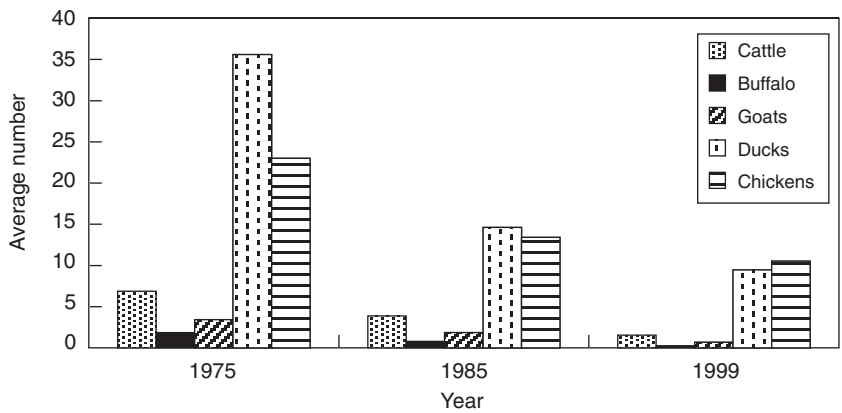

Fig. 5.4. Livestock and poultry per household in Rampal Upazila.

Table 5.7. Occupational changes in Ramzila Upazila (from field survey, 1999).

	Before shrimp culture (1975)		After shrimp culture (1999)	
Occupation	Males (%)	Females (%)	Males (%)	Females (%)
Agriculture (crop culture)	75	37	38	0
Shrimp farming/fry collection	6	0	12	23
Service	1	0	7	8
Business	6	0	10	3
Day labour	4	0	12	8
Others	8	17	2	3
Unemployed	0	46	19	55
Total	100	100	100	100

investment of around Tk 7000/ha. As a result, people are no longer interested in cultivating paddy because of its low return.

Environmental impact of shrimp farming

Brackish-water shrimp farming has altered the physical, ecological (aquatic and terrestrial) and socio-economic environment. A schematic flow diagram (Fig. 5.5) describes the various functions and interrelationships among the processes, effects and changes of each subcomponent. The practice of shrimp culture needs saline water as an input to the shrimp pond. Sluice gates are normally allowed to open two or three times when the salinity in the shrimp pond decreases and saltwater exchange from the river is necessary. As a result, heavy sedimentation from upstream water settles in the riverbed and canal bed, causing waterlogging in the shrimp ponds and on agricultural land. The shrimp-processing depot and industry drain their pollutants into the river, causing water pollution. Water in the shrimp ponds is also polluted because of the application of feed and fertilizer for the development of the shrimp. Thus, the by-products of the shrimp ponds and shrimp industry pollute water and soil and degrade the quality of the overall environment. Vegetation, crops, fish and livestock are seriously damaged by the process of shrimp cultivation, as has been discussed.

Figure 5.6 shows the interrelationship of the direct and indirect effects of shrimp farming on physical, ecological, socio-economic and environmental conditions in the study area. The problems created by shrimp cultivation are interdependent, as discussed in previous sections. The conversion of agriculture to shrimp farming created a physical and ecological imbalance, which has largely destroyed the natural ecosystem of the study area.

Conclusions

Brackish-water shrimp production in Rampal Upazila gave higher income than rice cultivation, but its expansion has had negative effects on the physical, social and natural environment. There is a need for effective planning, site selection and management of

Table 5.8. Cost–benefit analysis (in Tk) of shrimp culture in Rampal Upazila in 1999 (from field survey, 1999).

Crop	Operational cost/ha	Gross income/ha	Net income/ha
Shrimp (own *gher*)	34,033	84,000	49,967
Shrimp (rented *gher*)	40,056	84,000	43,944
Paddy	7,176	9,880	2,704

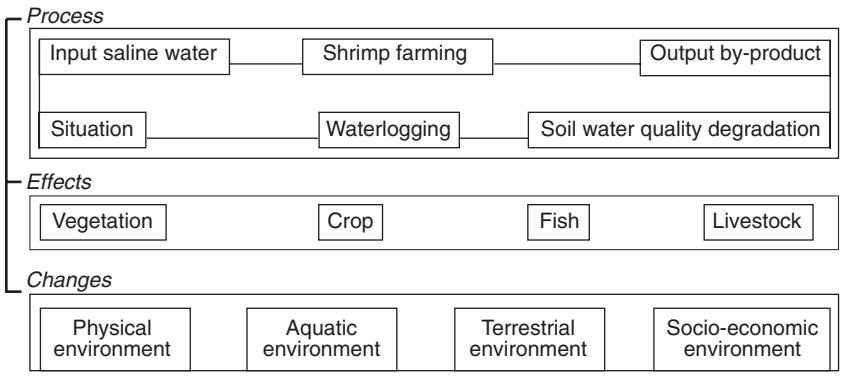

Fig. 5.5. A diagrammatic model of overall function and implications of shrimp farming.

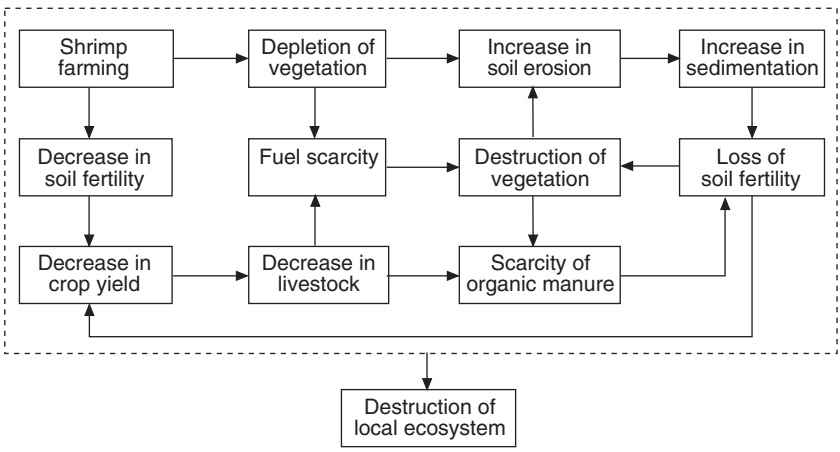

Fig. 5.6. A diagrammatic model of direct and indirect effects of shrimp farming.

shrimp farms, with due consideration given to the capacity of the environment and a comprehensive approach to sustainable development. In the economic analysis, it is important to take into account the cost of environmental degradation. Reducing the area under shrimp cultivation and raising the yield may be one way to help minimize these costs, but there may be other alternatives that require further investigation. One of the reasons for the decline in vegetation cover and biodiversity affecting livelihoods of farmers is the encroachment of shrimp ponds towards the homestead. A case can therefore be made for demarcating a buffer zone around homestead areas within which shrimp ponds should not be developed.

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