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**SOCIOECONOMIC AND ENVIRONMENTAL IMPACTS OF
ALTERNATE SHRIMP-CROP FARMING IN BANGLADESH**

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ABSTRACT

The study was designed to analyze the comparative profitability of alternate shrimp-crop farming and to determine the socioeconomic and environmental impacts of shrimp farming in coastal areas of Bangladesh. In shrimp growing areas, four different farming systems were studied - alternate shrimp-rice farming, alternate shrimp-salt farming, and year round shrimp or rice production in the shrimp farming areas. It was found that, combined economic returns from producing shrimp and salt was substantially higher than those of combined returns from shrimp and rice production under alternate shrimp-rice farming system. Shrimp and rice were also produced individually as year round crop. In year round shrimp farming per hectare production of shrimp was higher compared to the production of shrimp under alternate shrimp-crop farming but in terms of farm income, farmers producing year round shrimp earned lower income than the combined income earned from shrimp and salt production. Under the present farming system, farm income from year round rice production within the vicinity of shrimp growing areas was the lowest among the four different farming systems in the study areas. The results of the study clearly indicate that shrimp farming and other related activities accrued socioeconomic benefits to the shrimp farmers. The coastal communities including women had chances to improve their socioeconomic condition through their direct and indirect involvement in coastal aquaculture. The study revealed that the existing unplanned shrimp culture has adversely affected the production of cereal crops and vegetables, trees and plantation, poultry and livestock in shrimp growing areas. Shrimp farming has also negative effects on coastal environment and agro-ecosystem, which have moderately changed the bio-diversity in the study areas.

I. INTRODUCTION

Shrimp farming and related activities contribute significantly to the national economy of Bangladesh. The main areas of contribution are export earning and employment generation for on and off-farm activities. At present, shrimp has emerged as the third largest export earner of Bangladesh. The country earned about Tk. 136.60 million in foreign currency during 1997-98 by exporting fish and shrimp, of which shrimp alone contributed more than 80% (DOF 1998).

Shrimp farming offers excellent employment opportunities through a series of backward and forward linkage activities. Shrimp farming itself is less labour intensive than rice production; but the overall labour requirement of the shrimp industry (including labour

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requirements in the ancillary activities) is higher than that of rice production. Thus it seems quite logical to assume that the shrimp industry could play an important role in absorbing surplus rural labour force, particularly in the coastal areas of Bangladesh. The shrimp industry consists of four distinct subsectors viz, shrimp farms (*ghers*), shrimp hatcheries, feed mills and shrimp processing plants (Haque, 1994). All these subsectors are linked together to constitute vertical integration of activities whose goal is to boost export of shrimp products. Shrimp farms (*ghers*) are the mainstay of this industry and the activities of the other subsectors depend largely on the growth and sustainable development of shrimp farms in the country (Talukder 1999).

Bangladesh has about 2.5 million hectares of coastal tidal land under brakish water shrimp farming (FFYP 1998). Shrimp farming area is steadily expanding. But most of the farmers (>90%) still follow the traditional method and so per unit production is very low (150250 kg/ha), causing higher production cost compared to other shrimp growing countries of the world (Braten 2001). Bangladesh appeared to be the seventh largest exporter of shrimp to the combined Japan and US market (ASCC 1995). The increased production and export of shrimp is largely due to the effects of various government policies and high demand for shrimp in other countries. The shrimp industry is influenced by a range of government policies, institutional arrangement including subsidized credit and leasing of government land for shrimp farming (Alauddin and Tisdell 1998). Secondly, some socioeconomic and institutional aspects related to brakishwater aquaculture also affect the production (Islam and Wahab 2000). Accordingly, expanding shrimp cultivation is consistent with ecologically sustainable development of the coastal areas (MOF and FAO 1992, Rahman et al. 1994, Khalekuzzaman 1996). There are not adequate available information about the production practices and financial profitability of alternate shrimp-crop farming and socioeconomic and environmental consequences of shrimp farming in the coastal areas of Bangladesh.

This paper presents a brief description of production practices of shrimp farming and provides the financial profitability analysis of alternate shrimp-crop farming. It also analyses the socioeconomic and environmental impacts of shrimp farming. Conclusions and policy recommendation are made in the last section.

II. METHODOLOGY

Three study areas were purposively selected from Khulna, Satkhira and Cox's Bazar districts on the basis of concentration of shrimp farms in the areas. The study areas included Paikgacha of Khulna, Shamnagar of Satkhira and Teknaf and Chokaria of Cox's Bazar district.

From the three districts, in total 90 shrimp-crop farmers and 30 rice farmers were purposively selected under different management systems to determine and compare the economic returns of alternate shrimp-crop farming. In addition to shrimp-crop farmers, 120 stakeholders or related people involved in shrimp farming, were also selected to document their views on impact of shrimp farming in coastal areas (Table 1).

As the shrimps are still produced seasonally in traditional methods as alternative to rice and salt production, data were collected both for shrimps and other crops, as they were produced in the same farming areas. Other stakeholders who were directly and indirectly involved with shrimp industry and were benefited and also those adversely affected, were also selected for this study. Data and information were collected for the period June to July 2000-2001.

Table. Sampling design for conducting study on shrimp farming

Sample respondents	Sample households No.	Alternative technologies	Selected areas
Shrimp-rice farmers (in rice growing areas)	30	Alternate shrimp-rice farming	Paikgacha, Khulna
Shrimp-salt farmers (in salt producing areas)	30	Alternate shrimp-salt farming	Teknaf and Cox's Bazar
Shrimp farmers	30	Year round shrimp farming	Shamnagar, Satkhira
Rice farmers	30	Year round rice farming in shrimp growing areas	Paikgacha, Khulna
Land lessors	40	-	Teknaf and Paikgacha
Shrimp farm labourers	40	-	Teknaf, Chokaria and Paikgacha
Shrimp seed collectors	40	-	Teknaf, Chokaria and Paikgacha
Total	240	-	-

Data and information on shrimp production under different management, cost of using inputs and revenue received from disposal of shrimps and other crops, and impact of shrimp farming were also collected from shrimp farmers. Information on the nature and magnitude of socioeconomic impacts were collected from cross section of the concerned stakeholders.

III. ALTERNATE SHRIMP-CROP FARMING METHODS

Due to differences in water salinities in the south-west and south-east regions, the culture practices and production period of shrimp in the two areas are different. In the south-east region water salinities tend to be over 20 ppt during the months of November to April and shrimp is cultured in rotation with salt, while in south-west region where salinities tend to be in the range of 8-20 ppt, two crops are produced: shrimp and shrimp with rice. However, in all

the coastal areas, shrimp and to some extent, rice can be produced; but salt is produced only in those areas where salinity is high.

Over the decades different studies (Das 1992, Miah 1993, Uddin 1998, Miah 2001) were conducted to determine the economic returns of shrimp farming under extensive, improved extensive and semi-intensive methods. At present, semi-intensive shrimp farming is almost non-existent in Bangladesh. More than 80% farmers follow extensive method and a few farmers follow improved extensive method. As a matter of reality, farmers in Khulna and Cox's Bazar region practice alternate shrimp-crop (rice/salt) farming. Also, within the vicinity of shrimp growing areas, still some farmers produce rice. Accordingly, all these alternate farming in shrimp growing areas were studied and financial returns were compared.

Shrimp farming in rotation with salt production in Cox's Bazar area does not involve any technical problem, since shrimps are grown during that part of the year when, because of rains, it is not possible to produce salt. Hence, shrimp farming offers the exclusive opportunity to use the land properly, but land use conflict exists in Khulna area, where shrimp farms are concentrated and shrimp is cultivated in rotation with paddy.

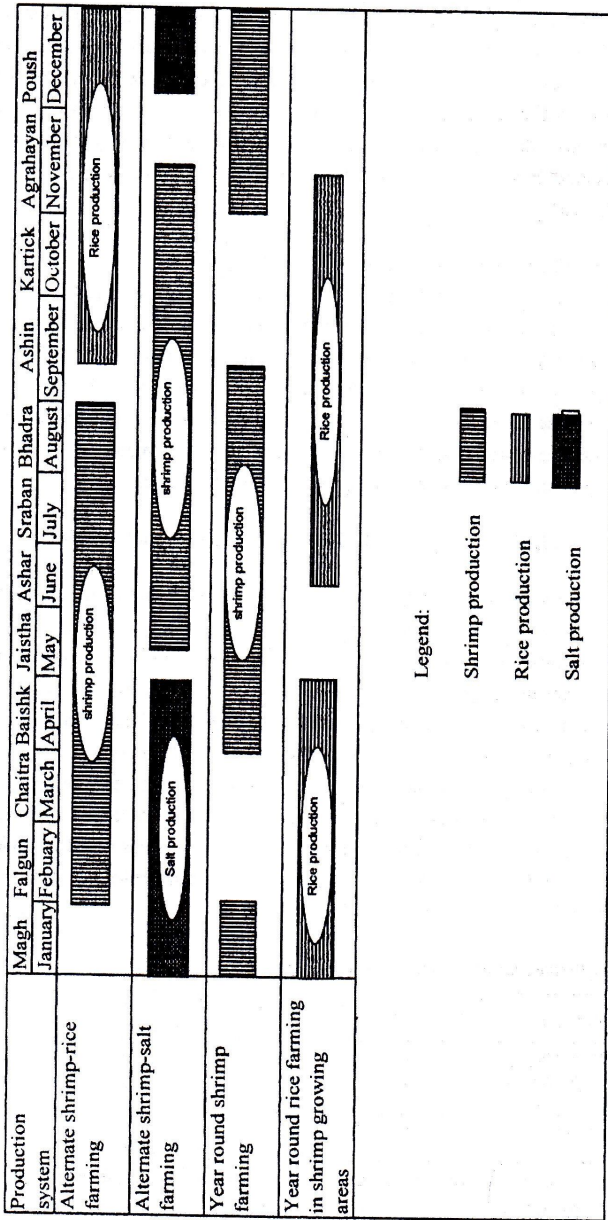
Alternate shrimp-rice farming

Alternate shrimp-rice farming is followed in Khulna region (Fig. 1). In this pattern, one crop of transplanted rice (e.g. local varieties) is grown during September to December following a crop of shrimp during February to August. Under this system, the harvesting of shrimp is completed by August or September before the water salinity falls below the tolerance limit of *P. Monodon*. On the other hand, water in the deeper canals is retained where fin fish such as *Liza Parsia*, *Rhino Mugil Corsula*, *Lates Calcarifer*, *Mystus*, etc., may be stocked during the period of rice production. After the plantation of *T. Aman*, rain water is allowed to accumulate inside the "gher" to flood the land to a depth of 60-100 cm. At this time, fin fishes retained in the canals move back into the inundated lands, and they are allowed to grow until harvest. During the monsoon period, paddy-cum-fish culture may be practiced, if the farmers adopt integrated farming.

Alternate shrimp-salt farming

In Teknaf and Chokoria of Cox's Bazar district, both alternate shrimp-rice farming and rice-salt farming are practiced. Specially in southern part of Teknaf, farmers practice alternate shrimp-salt farming. About 14000 ha of salt beds produce an estimated amount of 46000 rut salt. In Cox's Bazar, salt beds are encircled with low earthen dikes where sea water is brought in, preserved and evaporated during the dry months between December to April (Fig. 1). Between May and early November, salt cannot be produced due to excessive rainfall. About 10000 ha of salt beds are used for alternate shrimp-salt farming in Cox's Bazar area. Under this system production period of shrimp is between May to October (Fig. 1).

Figure 1. Alternate shrimp-crop and year round shrimp and rice production patterns in coastal areas of Bangladesh



Year round shrimp farming

In this method shrimps are cultured in the farm for the period of 8-9 months starting from April or November (Fig. 1). Within this period farmers make several harvesting followed by stocking. For rest of the period farmers generally keep shrimp seed in the canal or ditch of the shrimp farm so that they can stock these larvae or fingerlings for the next production season. It should be noted that, required level of salinity is the precondition for practising year round shrimp culture. Farmers of Shamnagar and Kaligonj of Satkhira district practice year round shrimp farming.

Year round rice farming in shrimp growing areas

In the coastal area, agro-ecosystem and salinity vary even within a short distance. Farmers who prefer rice cultivation to shrimp farming protect their land from intrusion or flooding saline water. If they can have sweet water or moderate sweet water by using STW, they can produce two rice or other crops. But if the sweet water is not available for irrigation, they can produce one rice during the rainy season. Depending on availability of sweet water, farmers produce their year round crop. However, year round crop (rice) production within the shrimp growing areas may not be profitable compared to shrimp production.

IV. RETURNS FROM ALTERNATE SHRIMP-CROP FARMING

Returns from alternate shrimp-crop farming in terms of per hectare yield are presented in Table 2 while gross and net returns are presented in Table 3. To have a picture of comparative return of producing alternate shrimp-crop and/or only shrimp or rice production, returns were calculated from the viewpoint of farmers. In this section, financial profitability from different shrimp based farming systems are examined. Returns from shrimp included the value of different grades of shrimps and other species of fin fish which are harvested as by-products. Cost of shrimp cultivation included both fixed and variable costs. Fixed costs included cost of land use, construction of sluice gate and embankments, other structures including guard shed, fishing equipment and salary of permanent staff. Variable cost items included human labour, shrimp seed, manure, fertilizers, lime, feed, insecticides and miscellaneous items, depending on the method of culture practiced.

Table 2. Alternate shrimp-crop farming and yield/ha

Production system	Shrimp (kg/ha)	Fin fish (kg/ha)	Rice (kg/ha)	Salt (kg/ha)
Alternate shrimp-rice	207	105	1280	-
Alternate shrimp-salt	245	185	-	66120
Year round shrimp	275	91	-	-
Year round rice	-	-	6180 (2 times)	-

It can be seen from Table 3 that the gross income was the highest for alternate shrimp-salt farming (Tk 247165) followed by year round shrimp farming (Tk 125005), and alternate

shrimp-rice farming (Tk 107235). From rice farming it was only Tk 44760. It may be noted here that in alternate shrimp-salt farming, shrimp production contributed about 46 percent of gross income while in the case of alternate shrimp-rice farming, income from shrimp production contributed about 90 percent of gross income. However, as a supplementary crop, income from salt shared the major portion in alternate shrimp-salt farming.

Table 3. Costs and returns of alternate shrimp-crop and rice farming under different management systems

Costs and returns	Farm categories			
	Alternate shrimp-rice farming	Alternate shrimp-salt farming	Year round shrimp farming	Year round rice farming
Taka/ha/year				
Gross income:				
i. Shrimp + Fin fish	96775(90)	114925(46)	125005	-
ii. Rice	10460(10)	-	-	44760
iii. Salt	-	132240(54)	-	-
A. Total gross income (TGI)	107235	247165	125005	44760
Total cost:				
i. Shrimp	39719	69091	47779	-
ii. Rice	5216	-	-	15062
iii. Salt	-	23026	-	-
Total cost (TC)	44935	92117	47779	15062
Variable cost:				
i. Shrimp	23254	35341	32277	-
ii. Rice	5216	-	-	15062
iii. Salt	-	23026	-	-
Total variable cost (TVC)	28470	58367	32277	15062
Fixed cost				
i. Shrimp	16465	33750	15502	-
ii. Rice	-	-	-	-
iii. Salt	-	-	-	-
Total fixed cost (TFC)	16465	33750	15502	-
B. Net return				
i. Shrimp	57056	45834	77226	-
ii. Rice	5244	-	-	29698
iii. Salt	-	109214	-	-
C. Total net return (TNR= TGI-TC)	62300	155048	77226	29698

Figures within parenthesis indicate percentage of total gross income.

Per hectare yield, total cost, gross income and net return of shrimp and other crop production under different management systems are also presented in Tables 2 and 3. To arrive at net return from different types of farming, total costs were deducted from gross returns.

Table 2 shows that, per hectare yield of shrimp in alternate shrimp-rice farming was 207 kg, while in alternate shrimp-salt farming it was 245 kg. In year round shrimp farming it was 275 kg. With 2 times rice production in shrimp farming areas, per hectare total yield of rice was 6180 kg. It may be noted here that per unit price of shrimp (Tk/kg) varied depending on the transportation and marketing system and size of individual grades of shrimp and other enterprises.

It is evident from Table 3 that, among the alternate shrimp-crop farming, shrimp with salt in the Cox's Bazar region offered the highest gross income (Tk 247165) as well as net return (Tk 155048) per hectare. However, return from this farming system was very sensitive to ' price of salt. Among different farming systems, the traditional year round shrimp farming in Shamnagar of Satkhira offered the second highest gross income (Tk 125005) and net return (Tk 77226). But gross income (Tk 107235) and net return (Tk 62300) from alternate shrimp-rice farming were relatively low. The traditional method of alternative shrimp-rice farming had less effect on environment. The gross income (Tk 44760) and net return (Tk 29698) of year round rice farming were very low compared to other types of farming, but it had no adverse effect on environment. From Table 3 it can be observed that the alternate shrimp-salt farming incurred higher cost followed by year round shrimp farming, alternate shrimp-rice and year round rice farming. The result of the study indicated that higher cost yielded higher returns.

V. IMPACTS OF SHRIMP FARMING

Alternate shrimp-crop farming has brought about substantial changes in the physical, economic and social environments in the coastal regions of Bangladesh. The farming system has been transformed from rice-based to shrimp-based one in the southwestern region, but in the southeastern region, shrimp- salt farming system to some extent, has gained prominence. In the northern part of Teknaf, farmers also practice alternate shrimp-rice farming. In practice most of the farmers (>80%) in Bangladesh follow traditional method (extensive type) of shrimp culture and commercial shrimp farm has been developed since last two decades. Coastal aquaculture contributed to diversification of livelihood opportunities for coastal communities. As a result, some positive and negative impacts of aquaculture have also emerged. The present study determined how shrimp farmers and other stakeholders associated with the shrimp industry were benefited and also affected with the extension of shrimp farming.

Positive Impacts and Socioeconomic Implication

From shrimp farming and related activities shrimp farmers and others people involved in shrimp industry gained socioeconomic benefit. The prevailing shrimp farming practices produced substantial impacts on improving the socioeconomic conditions of shrimp farmers and other stakeholders directly and indirectly involved with this industry. (Talukder 1999, Hamid and Alauddin 1996, Islam 1999, Rahman et al.1994). A large number of big *gher* owners, urban and semi-urban stakeholders made quick fortune by producing and trading shrimp. Shrimp farming and related activities helped the concerned people, directly or indirectly, to increase their household income which enabled them to have more savings and investment, resulting in better livelihoods and socioeconomic conditions. In the study areas, 50 - 73 percent of related stakeholders reported that their household incomes increased after involvement in shrimp industry (Table 4). In addition, shrimp farming in coastal areas contributed to poverty alleviation through creating employment opportunity for the rural poor. More than 70 percent stakeholders agreed that employment opportunity increased due to shrimp farming. It is fact that shrimp farming itself is less labour intensive than rice cultivation, but the overall labour requirement for shrimp industry is several times higher than that for rice farming. Thus the shrimp industry has the potential for absorbing the surplus labour force of the coastal areas. Accordingly, the departure from the traditional employment pattern associated with the predominantly rice based farming system to commercial shrimp culture has created a new employment structure involving movement of rural labour force within rural areas and between rural and urban areas (Talukder 1999).

Shrimp culture has created employment opportunity for rural women in coastal areas of Bangladesh. The emergence of commercial shrimp farming and the related backward and forward linkage activities has opened up new dimension for women's involvement in many of the activities. Apart from household works rural women got opportunity to be employed as wage labourer for collecting aquatic weeds and cleaning the shrimp farms. Shrimp processing factories and depots are the largest source of employment for women. Karim and Aftabuzzaman (1995) reported that women represented 73 percent of depot workers. They estimated that 65 percent of workers in the shrimp processing plants were women. Shrimp fry collection is also an important source of employment and income for rural women (Table 4). Collection of shrimp fry by women in knee- to shoulder- deep water in the coastal belt is a familiar scene (Talukder 1999). About 55,000 rural women are engaged in fry collection, constituting 36 percent of the fry collectors. Besides, a large number of women are engaged in collection of shrimp feed (e.g. snail) and artisanal production of fish trapping and packing materials.

Shrimp farmers and other people in coastal areas are also benefited from the overall development of shrimp industry. Different stakeholders involved in shrimp industry reported that among all other development factors, expansions of shrimp farming played significant role in developing roads and communication, marketing system, social and economic institutions and in improving overall economic condition in the study areas (Table 4).

Again, life style and housing condition of related stakeholders have also been improved after expansion of shrimp farming. Thirty eight percent sample respondents reported that their investment capacity to other business increased and 59% viewed that the educational facilities for their children increased due to extra earning from shrimp farms. Moreover, benefits gained from coastal aquaculture operation are higher than any other agricultural activities compared to land productivity. Thus, there is a growing interest of local people in coastal aquaculture.

Negative Impacts

Shrimp farming has made a significant change in production system in coastal areas of Bangladesh and instead of rice production and open water fishing, shrimp farmers have started large scale *pondlgher* based aquaculture. Unplanned development and poor management of shrimp farms has created negative impacts on local people living in coastal areas. The unplanned production and poor management caused some socioeconomic and environmental effect which are shown in Table 5. The table shows how replacement of rice farming by shrimp farming created some problems that affected both production pattern, household management as well as society as a whole.

About 63% farmers reported that extended shrimp farming caused lesser availability of land for rice cultivation, resulting in acute shortage of paddy straw which is the main feed for livestock. Secondly, as a result of shrimp farming and the consequent presence of saline water throughout the year, there was serious decline in grazing land in the shrimp farming areas. Most of the farmers stated that shortage of animal feed was the main reason for declining livestock population in the coastal areas.

Under rice farming practice, landless and small farmers would have rented in land from large farmers for rice cultivation; but with the introduction of shrimp farming that opportunity disappeared. At present, even the small farmers are compelled to lease out their land to shrimp farmers who adopt different tactics to secure land from other to make their farm larger and profitable. In this case, conflict of land use arises between the shrimp farmers and land lessors. The increased incomes from shrimp farming and related activities are not shared rationally among the land lessors.

Before the introduction of shrimp farming in coastal areas, there was open access of local fishermen and other poor people to open water fishing. They could consume fish and earn income from fishing. Now, community fishing is totally restricted in shrimp growing areas. As a result, poor people in these areas suffer from malnutrition.

Considering the environmental impacts and consequences, four aspects may be considered very important as mentioned in Table 5. Continuous standing saline water for several years within polders deteriorated soil health and fertility which adversely affected yield of paddy.

With the extension of shrimp farming, native plants and trees, and mangrove forests have been destroyed. The early phase of the industry's expansion depended upon extensive shrimp farms using large areas located in inter tidal zones. The coastal forest (mangrove) has decreased from 12328 acres in 1993-94 to 6916 acres in 1996-97, a 44% decline during the period (BBS 1999). Shrimp farming also damaged household vegetation and social forestry, particularly in the Khulna and Satkhira areas.

Table 4. Positive socioeconomic impact of shrimp farming

Positive socioeconomic impacts	% of respondents reported							
	Alternate shrimp-rice farmers, n=30	Alternate shrimp-salt farmers, n=30	Year round shrimp farmers, n=30	Year round rice farmers, n=30	Land lessors n=40	Shrimp farm labourers n=40	Shrimp seed collectors n=40	All average
Increased purchasing capacity	67	70	85	60	80	65	70	71
Increased savings	47	50	65	45	65	30	30	47
Developed housing and sanitation infrastructure	63	80	80	65	70	50	50	65
Increased investment to other business	73	80	90	50	70	65	65	70
Increased employment opportunity	50	70	60	30	40	15	-	44
Developed marketing facilities	83	90	85	60	70	65	60	73
Increased education of children	57	60	65	55	80	70	70	65
Extended electricity facility	77	80	80	45	70	30	30	59
Increased knowledge of technology about shrimp farming	50	60	60	50	60	40	30	50
Improved life style	83	70	80	-	-	30	-	66
	57	70	75	60	80	50	50	63

Note: One respondent reported more than one consequences. So, addition of percentages are not likely to be equal to 100.

Table 5. Adverse effect of shrimp farming in coastal areas

Negative impacts of shrimp farming	% distribution of respondents reported					All average
	Alternate shrimp-rice farmers, n=30	Alternate Shrimps-salt farmers, n=30	Year round shrimp farmers, n=30	Land lessors, n=40		
A. Socioeconomic impacts						
Decreased land for rice cultivation	65	55	60	70	63	
Scarcity of grazing land and declined livestock production	90	70	87	70	81	
Leasing arrangement and conflict of land use	32	10	20	40	26	
Unequal distribution of income	73	50	60	70	63	
Loss of common property rights in shrimp growing areas	48	35	30	56	42	
B. Environmental impacts						
Increased salinity of soils within polders	70	80	60	70	70	
Destroyed plants and trees and mangroves	63	60	50	60	58	
Damage of household vegetation and social forest	66	50	63	60	61	
Rise river basin	60	30	65	-	52	

Note: One respondent reported more than one consequences. So, addition of percentages will not necessarily be equal to 100.

Shrimp farmers (52%) reported that, due to unplanned construction of polders and poor drainage system, river beds in coastal areas got elevated, causing heavy siltation and sedimentation. This has been caused over last two decades, and such a differential elevation created problems in natural drainage of both shrimp field and adjacent areas.

Thus the gains of shrimp farmers and traders are alleged to have been achieved at the expense of loss of small/marginal farmers and the fisherman community. Commercial shrimp farming caused an uneven distribution of income from shrimp culture between shrimp farm owners and the small land owners who lease out lands to the farm owners for shrimp cultivation. In an overall sense, all the positive gains of shrimp farming and the related activities are at the expense of adverse effects on the environment and the society at large.

VI. CONCLUSION AND POLICY RECOMMENDATIONS

Depending on agroecosystem and salinity, specific farming system is practiced in certain region. Profitability analyses of the alternative shrimp-crop farming system revealed that the shrimp-salt farming was more profitable compared to the alternate shrimp-rice farming, year round shrimp farming and rice farming. The findings also suggested that management practices were to be improved, so that optimum production can be achieved through proper land use system.

The shrimp farming had both positive and negative impacts. The results of the study clearly indicated that shrimp farmers and other related people derived socioeconomic benefits from shrimp farming. The coastal communities including women got increased opportunities to improve their socioeconomic condition through their direct and indirect involvement with the coastal aquaculture. The study revealed that the unplanned expansion of shrimp culture adversely affected the production of cereal crops and vegetables, trees and plantation, poultry and livestock in the shrimp growing areas. Shrimp farming also had negative effects on coastal environment and agro-ecosystem, which significantly changed the bio-diversity in the study areas. However, due to social intervention, natural and social environments in the coastal areas have been gradually improving. It is suggested that the coastal areas should be categorized into several zones on the basis of salinity and agro-ecosystem to ensure proper use of valuable land resources and accordingly, eco-friendly shrimp culture and improved management should be introduced to increase both private and social benefits.

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