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Impacts of Shrimp Farming on the Socioeconomic and Environmental Conditions in the Coastal Regions of Bangladesh

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Abstract: The study was carried out to analyze the comparative economic returns of alternate shrimp-crop farming and to assess the socioeconomic and environmental impacts of shrimp farming in coastal areas of Bangladesh. Shrimp farmers as well as other groups of people such as land lessors, shrimp farm labourers and shrimp seed collectors directly benefited and affected were randomly selected for the study. Accordingly, an appropriate number of all these sample households were selected from four different areas of greater Khulna and Cox's Bazar regions. In shrimp growing areas, four different farming practices such as alternate shrimp-rice farming, shrimp-salt farming, year round shrimp farming and year round rice farming were studied. In alternate shrimp-crop farming, shrimp was the main crop, and the rice and salt were secondary crops. It was found that under alternate shrimp-salt farming per hectare production of shrimp was higher compared to the production of shrimp under alternate shrimp-rice farming. Of the different farming practices, the highest gross (Tk. 247,165 ha^{-1}) and net (Tk.155,048 ha^{-1}) income was recorded in alternate shrimp-salt practice, which was successively followed by the year round shrimp farming (Tk. 125,005 ha^{-1} and Tk. 77,226 ha^{-1}), alternate shrimp-rice farming (Tk. 107,235 ha^{-1} and Tk. 62,300 ha^{-1}) and year round rice farming (Tk. 44,760 ha^{-1} and Tk. 29,698 ha^{-1}). But per hectare production of shrimp obtained from year round shrimp farming was relatively higher (275 kg) than those of shrimp-salt (245 kg) and shrimp rice farming (207 kg). It was clearly implied that farm income from year round rice farming within the vicinity of shrimp growing areas was the lowest among the four different farming practices. The results obtained indicated that shrimp farmers and other related people accrued socioeconomic benefits from shrimp culture. By providing income generation, employment opportunities and escalating many activities, coastal communities including women had chances to improve their socioeconomic condition through their direct and indirect involvement in coastal farming. The study revealed that undesigned and unplanned shrimp farming has affected the production of cereal crops and vegetables, trees, poultry and livestock in the coastal region of Bangladesh. Shrimp farming has also negative effects on biodiversity, productivity of estuarine waters, agro-ecosystem, socioeconomic conditions and friendly environment. Appropriate measures should be taken urgently to improve the natural and social environment of the coastal regions of Bangladesh.

Key words: Alternate shrimp farming, *Penaeus monodon* post-larvae, rice, salt, socioeconomic, environment, coastal region

INTRODUCTION

Coastal aquaculture in Bangladesh was initiated in 1970's as an important economic activity, oriented towards shrimp aquaculture with the target species *Penaeus monodon*, locally known as "bagda chingri". Initially shrimp culture restricted to peripheral land between the flood and brackish water inundation, within the flood protection embankments areas and the main river, the success of these early shrimp farming encouraged the pioneering shrimp farmers to expand their activities within the land area inside the flood protection embankments, known as polder areas. The culture system was quite primitive with large and ill-designed ponds without pre-stocking pond preparatory techniques or any additional inputs into the system (Karim and Aftabuzzaman, 1995). Shrimp culture was primarily initiated by the rich outsiders. After two decades, the locals became conscious about the economic inequalities and environmental degradation and finally came forward to cultivate shrimp into their own land collectively and the presence of outsiders has been declining significantly. At present many landowners are coming out from the group enterprise and start shrimp farming singularly under own

and control management. Shrimp farming has now emerged as a main source of employment and income for hundreds of thousands of people.

Bangladesh has a great potential for shrimp farming development. The country is endowed with an extensive coastal area comprising mangrove swamps and a huge river delta area. There are about 2.5 million ha of tidal lands in the coastal areas including low-lying areas, paddy fields and polders. It is estimated that about 120,000 to 150,000 ha of potential area are suitable for shrimp culture (Khan and Hossain, 1996). The Bangladesh coast also supports around 587,400 ha of natural mangroves (Mahmood, 1986) and a further 100,000 ha of planted mangroves (Khan and Latif, 1997). This vast area supports the habitat of several species, particularly the younger stages of shell fish and fin-fish (Mahmood *et al*., 1994) and serve as buffer zones against cyclones and tidal surges (Khan and Latif, 1997).

Shrimp culture has been developed extensively in the coastal areas for more than a decade due to abundant natural fry and brackishwater in the estuaries of Bay of Bengal. At present, there are 15,978 large and small size shrimp farms consisting of 147,000 ha of land in Bangladesh (Karim and Khandaker, 1997). Three different culture systems are being practiced in the coastal regions of Bangladesh. These are known as traditional/extensive, improved traditional and semi-intensive culture systems. More than 90% of the total farms still practice a traditional or extensive system. Per unit production of shrimp in Bangladesh is very low (150-250 kg ha^{-1}/year) and that incurred higher production cost compared to other shrimp growing countries of the world (Braten, 2001).

Shrimp farming activities contribute significant role in the national economy of the country. Shrimp is one of the most important exportable commodities in Bangladesh having a high demand and price in the international market. Besides, its production through aquaculture and trade offers unique opportunity in providing employment and poverty alleviation and it is the third largest hard currency earner for the country. The country earned about Tk. 16,100 million in 1998-99 from the export of shrimp alone (Mazid, 2000). In the national export earning, shrimp and other fishes contributed about 5.7% in value of the total fisheries and shrimp alone contributed about 93%. In 2000-01 the country earned about Tk. 2032.75 crore foreign currencies by exporting shrimp and other fishes (DOF, 2002). Realizing the importance of shrimp culture both for increasing production and also for increasing volume of foreign exchange earning, the Government of Bangladesh has already declared shrimp culture as an industry.

Shrimp farming is a capital intensive enterprise. Credit infrastructures are absolutely insufficient for the majority medium and small farmers of the area. The rich people mainly enjoy the loan from institutional banks. The other people have to depend on informal institution e.g. *mahajans* (traditional money lender), friends and relatives. 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).

Shrimp farming brings many benefits for the country but it gradually changes the nature and social environmental patterns of the coastal areas. Unplanned and uncontrolled shrimp culture development and competition for diminishing coastal resources have resulted conflict. Environmental and social issues associated with shrimp farming development in coastal belts have been addressed by many local, national and international organizations. Very few works have been done on shrimp production and their impacts on socioeconomic and environment in the country. Considering the above views the present study was conducted to ascertain the production of shrimp aquaculture, financial profitability of alternate shrimp-crop farming and to analyze the socioeconomic and environmental impacts of shrimp farming.

MATERIALS AND METHODS

The study was carried out in the coastal regions of Bangladesh. Three experimental sites such as Paikgacha, Shamnagar and Teknaf of Khulna, Satkhira and Cox's Bazar districts, respectively were selected. Ninety shrimp-crop farmers and 30 rice farmers were selected under different management systems to determine and compare the economic returns of alternate shrimp-crop farming. In addition, 120 stakeholders involved in shrimp farming were selected to document their views on impact of shrimp farming in coastal areas.

Data and information on shrimp production under different management practices, cost of using inputs and revenue received from disposal of shrimps and other crops, and impact of shrimp farming were also being collected from shrimp farmers. Cobb-Douglas production function was used to determine the factors that influenced the economic returns of shrimp farming. Information on the nature and magnitude of socioeconomic impacts was collected from cross section of concerned people.

Alternate shrimp-crop farming method: The culture practices and production period of shrimp in the south-

west and south-east region are totally different due to fluctuation of water salinity. In the south-east region, water salinity remains over 20 ppt during the month of November to April and shrimp is cultured in rotation with salt. On the other hand, salinity remains in the range of 0-20 ppt in the south-west region of Bangladesh. At present, there is no semi-intensive shrimp farming in Bangladesh due to out break of shrimp diseases. More than 80% farmers follow the extensive method and few farmers follow improved extensive method.

a) Alternate shrimp-rice farming: Alternate shrimp-rice farming is followed in Khulna region. In this pattern, one crop aman rice (e.g. local varieties and HYV) is grown between August/September to December, which is followed by crop of shrimp in between February to July/August. Under this system, shrimp is completely harvested by August or September before the water salinity drops below the tolerance limit of *Penaeus monodon*. After the transplantation of T. *aman*, rain water is allowed to accumulate inside the *gher* to flood the land, where the fin-fishes are allowed to grow until harvest.

b) Alternate shrimp-salt farming: Both alternate shrimp-rice farming and rice-salt farming are practiced in Teknaf and Chokaria of Cox's Bazar district. Farmers practice alternate shrimp-salt farming specially at the southern part of Teknaf. In Cox's Bazar, seawater is allowed to enter the salt beds surrounded by low earthen dikes and preserved and evaporated during the dry months between December to mid April. Salt can not be produced between May and early November due to rainfall. Under this system shrimp is cultured through May to October.

c) 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. Partial harvest and partial stock is done within this period. For rest of the period farmers use to rear shrimp post-larvae (PL) in the canal or ditch of the shrimp farm and these PL are used for the next production season. Farmers of Shamnagar and Kaligonj upazila of Satkhira district practice year round shrimp farming.

d) Year round rice farming: Within the vicinity of shrimp growing areas, still some areas are kept away from shrimp farming where farmers produce different crops specially rice. In coastal area, agro-ecosystem and salinity vary even within a short distance. Farmers prefer rice cultivation to shrimp farming and they protect their land from intrusion or flooding saline water. 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, but it has other advantages.

Therefore, to have a comparative economic return of alternate shrimp-crop and/or only shrimp or rice production, returns were calculated from the viewpoint of farmers. Financial profitability from different shrimp based farming systems was explored. Returns from shrimp include the value of different grades of shrimps and other fin fishes were computed. Cost of shrimp cultivation includes both fixed and variable costs were calculated.

RESULTS AND DISCUSSION

Economic returns of alternate shrimp-crop farming: Economic returns from alternate shrimp-crop farming in terms of per hectare yield, total cost, gross income and net return are presented in Table 1. The gross income for alternate shrimp-salt farming was the highest (Tk. 247,165 ha^{-1}) followed by the year round shrimp farming (Tk. 125,005 ha^{-1}), and alternate shrimp-rice farming (Tk. 107,235 ha^{-1}). From rice farming it was only Tk. 44,760 ha^{-1}. It was noted that in alternate shrimp-salt farming, shrimp production contributed about 46% of gross income while in case of alternate shrimp-rice farming, shrimp production contributed about 90% of gross income. However, as a supplementary crop, income from salt shared the major portion in alternate shrimp-salt farming.

Per hectare production of shrimp in alternate shrimp-rice farming, alternate shrimp-salt farming and year round shrimp farming was 207, 245 and 275 kg, respectively. With the twice rice production in shrimp producing areas per hectare total production of rice was 6,180 kg. It was mentioned that per unit price of shrimp (Tk. Kg^{-1}) varied depending on the transportation, marketing system, quality of shrimp, size of the shrimp and other enterprises.

Alternate shrimp-rice farming system was practiced in Paikgacha of Khulna region. Per hectare gross income, total cost of production and net income of alternate shrimp-rice farming was Tk. 107,235, 44,935, and 62,300, respectively. The results indicated that return from rice farming constituted only 8% of total net returns. Thus returns from shrimp constituted overwhelmingly higher amount (92%) of return under this system.

Total cost, gross income and net return per hectare of shrimp-salt farming were Tk. 92,117, 247,165 and 155,048, respectively. This production system was more profitable compared to others farming. It was found that the cost of salt production was very small compared to its economic return that made net return higher.

Table 1: Gross income, cost of production and net returns of different types of shrimp farming during the study period

	Types of farming			
Costs and returns	Alternate shrimp-rice farming	Alternate shrimp-salt farming	Year round shrimp farming	Year round rice farming
Gross income:				
I. Shrimp + fin fish	96,775 (90)	114,925 (46)	125,005	-
ii. Rice	10,460 (10)	-	-	44,760
iii. Salt	-	132,240 (54)	-	-
A. Total gross income (TGI)	107,235	247,165	125,005	44,760
Total cost:				
I. Shrimp	39,719	69,091	47,779	-
ii. Rice	5,216	-	-	15,062
iii. Salt	-	23,026	-	-
Total cost (TC)	44,935	92,117	47,779	15,062
Variable cost:				
I. Shrimp	23,254	35,341	32,277	-
ii. Rice	5,216	-	-	15,062
iii. Salt	-	23026	-	-
Total variable cost (TVC)	28,470	58,367	32,277	15,062
Fixed cost				
I. Shrimp	16,465	33,750	15,502	-
ii. Rice	-	-	-	-
iii. Salt	-	-	-	-
Total fixed cost (TFC)	16,465	33,750	15,502	-
B. Net return				
I. Shrimp	57,056	45,834	77,226	-
ii. Rice	5,244	-	-	29,698
iii. Salt	-	109,214	-	-
C. Total net return				
(TNR= TGI-TC)	62,300	155,048	77,226	29,698

Figures within parenthesis indicate percentage of total gross income

Table 2: Comparative annual profitability of different types of farming during the study period

	Types of farming				Rank of economic return			
Particulars	Alternate shrimp-rice farming (Tk ha^{-1})	Alternate shrimp-salt farming (Tk ha^{-1})	Year round shrimp farming (Tk ha^{-1})	Year round rice farming (Tk ha^{-1})	Shrimp-rice	Shrimp-salt	Shrimp	Rice
Gross income (GI)	107,235	247,165	125,005	44,760	3	1	2	4
Total variable cost (TVC)	28,470	58,367	32,277	15,062	3	1	2	4
Total cost (TC)	44,935	92,117	47,779	15,062	3	1	2	4
Gross margin (GM=GI-TVC)	78,765	188,798	92,728	29,698	3	1	2	4
Net return (GI-TC)	62,300	155,048	77,226	29,698	3	1	2	4

Source: Table 1.

Table 3: Estimated values of coefficients and related statistics of Cobb-Douglas production function model for different farming practices during the study period

	Coefficients of alternate farming			
Explanatory variables	Alternate shrimp-rice farming	Alternate shrimp-salt farming	Year round shrimp farming	Year round rice farming
Intercept	7.154	5.721	2.253	14.905
Farm size (X_1)	0.865* (0.132)	0.280 (0.134)	0.642** (0.152)	3.750* (0.586)
Urea (X_2)	0.408*** (0.190)	2.095*** (0.810)	0.305** (0.077)	-0.524* (0.053)
TSP (X_3)	-	0.393** (0.151)	-0.167** (0.965)	-
Feed cost (X_4)	0.219 (0.198)	-	0.061 (0.052)	-
Paddy seed cost (X_5)	-0.668* (0.175)	-	-	0.427*** (0.182)
Human labour (X_6)	-0.0182 (0.152)	-0.483** (0.161)	0.334*** (0.155)	-0.650* (0.063)
Animal labour (X_7)	-	-	-	-4.898* (0.683)
No. of harvesting (X_8)	1.123** (0.512)	-2.557*** (1.181)	-0.160 (0.189)	-
No. of shrimp PL stocked (X_9)	-	1.421 (1.099)	0.757*** (0.362)	-
Manure (X_{10})	-	-	-	2.593* (0.289)
Pesticides (X_{11})	-	-	-	0.106 (0.081)
R^2	0.889	0.885	0.886	0.933
Return to scale	1.938	1.149	1.772	0.811
F-value	37.411	26.440	192.808	65.022

*Significant at 1% level of confidence. **Significant at 5% level of confidence. ***Significant at 10% level of confidence.
Figures in parentheses indicate standard error.

In year round shrimp farming system per hectare total cost, gross income and net return were Tk. 47,779, 125,005 and 77,226, respectively. Thus year round shrimp farming was more profitable than that of shrimp-rice farming.

Table 4: Positive socioeconomic impacts of shrimp farming during the study period

Positive socioeconomic impacts	% distribution 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
Developed housing and sanitation	63	80	80	65	70	50	50	65
Increased savings	47	50	65	45	65	30	30	47
Developed socioeconomic infrastructure	73	80	90	50	70	65	65	70
Increased investment to other business	50	70	60	30	40	15	-	38
Created employment opportunity	83	90	85	60	70	65	60	73
Developed marketing facilities	57	60	65	55	80	70	70	65
Increased education of children	77	80	80	45	70	30	30	59
Extend electricity facility	50	60	60	50	60	40	30	50
Increased knowledge of technology about shrimp farming	83	70	80	-	-	30	-	38
Improved life style	57	70	75	60	80	50	50	63

Table 5: Socioeconomic consequences and sustainability of shrimp farming during the study period

Socioeconomic factors influence shrimp farming	% distribution of respondents reported: Alternate shrimp-rice farmers (n=30)	Alternate Shrimps-salt farmers (n=30)	Year round shrimp farmers (n=30)	Land lessors, (n=40)	All average
A. Leasing arrangement and managerial constraints					
Leasing arrangement of brakishwater areas and conflict of land use	32	10	20	40	26
Salination of paddy field and forceful occupation of land	15	10	-	35	15
B. Social problems and conflicts					
Multiple ownership of *gher* and its further division	35	25	15	-	19
Stealing and violence in farming areas	33	30	33	50	37
Shrimp farming and its adverse effect on local fishermen	73	50	60	70	63
Scarcity of land for rice cultivation on share cropping basis	43	40	50	55	47

Table 6: Administrative and environmental consequences of shrimp farming during the study period

Administrative and environmental factors influence shrimp farming	% distribution 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)	All average
A. Administrative problems						
Complex procedures in providing institutional credit	67	60	63	-	-	38
Deterioration of low and order	43	50	40	-	30	33
B. Environmental problems						
Scarcity of grazing land	90	70	87	70	81	80
Decreased vegetation	66	50	63	60	61	60
Affected fresh water pond which were used for household works	30	20	25	-	27	20
Extended farming destroyed plants and trees and mangroves	63	60	50	60	58	58
River basin raised	60	-	-	-	-	12
Loss of biodiversity	73	70	70	50	73	67

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

During the production period farmers followed partial harvest and partial stock. Accordingly, shrimp farmers had flow of income from shrimp production over 8–9 months in a year. Usually higher production obtained in the month of November-February when salinity was higher but in the rainy season per unit production declined due to low salinity.

In the study areas, some farmers cultivated rice where shrimp might be produced. As stated earlier that farmers produced rice twice in one year. But due to the effect of

topography and coastal agro-ecosystem per hectare production was relatively low compared to other areas of Bangladesh. Moreover, per hectare gross income, total cost and net return were Tk. 44,760, 15,062 and 29,698, respectively. However, it was found that economic return of shrimp farming was 2-5 times higher than that of year round rice farming in shrimp farming areas.

Comparative statement of economic return of different types of farming in shrimp growing areas: A summary of costs and net returns of different types of farming systems are presented in Table 2. Data revealed that among the alternate shrimp-crop farming, shrimp-salt farming in the Cox's Bazar region offered the highest gross income (Tk. 247,165 ha^{-1}) as well as net return (Tk. 155,048 ha^{-1}) per hectare. However, return from this farming was very sensitive to price of salt. Among different farming practices, the traditional year round shrimp farming in Shamnagar of Satkhira offered the second highest gross income (Tk. 125,005 ha^{-1}) and net return (Tk. 77,226 ha^{-1}) but gross income (Tk. 107,235 ha^{-1}) and net return (Tk. 62,300 ha^{-1}) from alternate shrimp-rice farming were relatively low. The traditional method of alternative shrimp-rice farming has less effect on environment. The gross income (Tk. 44,760 ha^{-1}) and net return (Tk. 29,698 ha^{-1}) of year round rice farming were very low compared to others farming, but it has no effect on environment. It was observed that the alternate shrimp-salt farming incurred the highest cost followed by year round shrimp farming, alternate shrimp-rice and year round rice farming. The results obtained indicated that higher cost yielded higher returns.

Factors affecting yield and economic return of shrimp-crop farming: Estimated values of the coefficients and related statistics of Cobb-Douglas production function for the selected sample farmers producing shrimp and other crops are presented in Table 3. The coefficient of multiple determination, R^2 for different alternate farming varied from 0.885 to 0.933 which indicates that 88 to 93% of the total variation of output of respective farming system is explained by independent variables included in the model.

The relative contribution of specified factors affecting productivity of alternate shrimp-crop farming was seen from the estimates of regression equation for four different farming. There were 26 input coefficients for the production of selected farming systems and of these only 7 coefficients had improper (negative) sign and the remaining coefficients showed positive effect on farm output. Except farm size and number of shrimp PL stocked in alternate shrimp-salt farming, feed cost and human labour in alternate shrimp-rice farming, feed cost and number of harvesting in year round shrimp and using pesticides in rice farming, all other input coefficients were statistically significant at different level (0.01 to 0.10).

The sum of all the production coefficients of alternate shrimp-rice, alternate shrimp-salt and year round shrimp farming (Σb_i) was equal to 1.938, 1.149 and 1.772, respectively, which were greater than one. This means that the function exhibits increasing return to scale that is, if all the inputs specified in the respective function were increased by 1%, farm income would be increased by 1.938, 1.149 and 1.772%, respectively for alternate shrimp-rice, shrimp-salt and year round shrimp farming. The summation of all the production coefficients of sampled rice farming (Σb_i) was equal to 0.811. This means the production function for rice farming exhibits diminishing return to scale. Returns to scale indicated that even with the present technology there were enough scopes to increase the production and income of farm enterprises under alternate shrimp-crop and/or year round shrimp farming. But in case of rice production in the shrimp growing areas, farm income could be increased if more improved technologies are introduced.

Impacts of shrimp farming: Shrimp 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 and in the southeastern region shrimp-salt farming has gained prominence. Financial benefit obtained from shrimp farming and related activities have been enormous. Shrimp culture has created a substantial economic and social transformation in the coastal belt of Bangladesh (Hamid and Alauddin, 1996; Islam, 1999; Rahman *et al*., 1995). A large number of big *gher* owners, urban and semi-urban stakeholders have made quick fortune by producing and trading shrimp. However, the impacts of shrimp culture pattern on income distribution and employment generation may not be negative, as it apparently appears to be. Although shrimp farming itself is less labour intensive than rice cultivation, the overall labour requirement centering shrimp production and processing is likely to be higher. Thus the shrimp industry has the potential for absorbing the surplus labour force of the coastal areas. In fact, the departure from the traditional employment pattern associated with the predominantly rice based farming system to the one with commercial

shrimp culture has created a new employment structure involving movement of rural labour flow within rural areas and between rural and urban areas.

Shrimp culture has also opened up the avenues of new employment pattern for rural women. Before the commencement of commercial shrimp farming, the rural women used to perform various household-based agriculture activities such as threshing, winnowing and drying crops, grading, processing and storing of agriculture produce, feeding and grazing livestock and poultry. These are in addition to the normal household duties such as cooking family meals, cleaning utensils and looking after children. The emergence of shrimp farming and the related backward and forward linkage activities has opened up new dimension for women's involvement in many of the activities. Shrimp depots are the largest source of employment for women. Karim and Aftabuzzaman (1995) reported that women represented 73% of depot workers. They estimated that 65% workers in the shrimp processing plants were women. Shrimp fry collection is also an important source of employment for rural women. Collection of shrimp by women in knee- to shoulder- deep water in the coastal belt is a familiar scene. They also estimated that about 55,000 rural women were engaged in fry collection, constituting 36% 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.

As reported earlier except shrimp farmers other people in coastal areas are also involved and benefited from the overall development of shrimp industry. It is reported that among all other development factors, expansions of shrimp farming play a significant role to develop roads and communication, marketing system, social and economic institutions and to improve overall economic condition in the study areas (Islam and Wahab, 2000).

Benefits may be either directly to a household that is income from shrimp farming or indirectly with the creation of employment opportunity in the shrimp farm or shrimp industry. However, for determining the socioeconomic benefits of shrimp farming, issues raised in discussion with the selected shrimp farmers in the study areas and their views and comments are documented in Table 4. Specific issues of socioeconomic impacts of shrimp farming are provided here to determine the economic benefits (Table 4) and adverse effect of shrimp farming (Tables 5-6).

Positive impacts

- Shrimp farming and related activities helped the concerned people directly or indirectly to increase their household income which led them to more savings and investment resulting in better livelihood and socioeconomic condition. In the study areas, 50-73% shrimp-crop farmers reported this opinion.
- Coastal aquaculture has helped some households to become rich and majority of aqua-households improved their economic condition.
- Average income of shrimp farmers is several times higher compared to those involved in rice farming.
- As a result of shrimp farming, socioeconomic infrastructures have been developed. Overall 70% farmers reported this view.
- Shrimp farming in coastal areas has contributed to poverty alleviation through creating employment opportunity. Seventy three percent farmers reported that employment opportunity has been increased due to shrimp farming.
- Involvement in shrimp farming and shrimp farm activities, 38% sample farmers reported that their investment capacity to other business has increased and 59% farmers viewed that the educational facility for their children has increased due to extra income from shrimp farms.
- Social consequences are related to marketing facility and extension of electricity. Fifty to sixty five percent farmers reported that it has been developed due to shrimp farming.
- 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 towards coastal aquaculture.

Negative impacts: Shrimp farming has made a significant change in the production system from small scale rice production and open water fishing to large scale pond/*gher* based aquaculture in the coastal regions of Bangladesh. This change has created a setback for the small/marginal farmers and the fisherman who used to make their cropping plants independently and was engaged in open water fishing. Thus the gains of the big farmers and traders are alleged to have been achieved at the expense of the small/marginal farmers and the fisherman community. Alauddin and Tisdell (1996) reported an uneven distribution of gains from shrimp culture between big *gher* owners and the small land owners who lease out lands to the *gher* owners for shrimp cultivation.

Actually, it is true that shrimp makes substantial contribution to the national economy by generating income, employment and by earning foreign exchange.

Despite, positive gains there are some adverse effects of shrimp farming on the environment and society at large. Thus the massive and unplanned shrimp culture has come under close scrutiny based on a number of socioeconomic and environmental issues. Some of these are (a) increase salinity of soils within polders leading to serious loss of soil fertility, (b) damage of traditional economic activities such as crop and animal husbandry, © decline of livestock population has resulted in manifold problems for agricultural production (d) damage of household vegetation and social forestry, (e) Loss of common property rights, (f) adverse effects on income distribution, (g) damage to the mangrove forest and loss of biodiversity, (h) raising river beds in shrimp growing areas, (I) increasing social tension resulting from absentee enterpreneurship, having no commitment to conservation of coastal resources and sustainable shrimp culture, (j) insufficient supply of vegetables and small fishes, local people have been suffering from imbalance diet and (k) Administrative corruption has increased in shrimp farming areas. Socioeconomic and environmental consequences of shrimp farming as reported by shrimp farmers and others stakeholders are presented in Tables 5 and 6.

The findings of this study suggest without doubt that the shrimp-salt farming is more profitable compared to the alternate shrimp-rice farming, year round shrimp farming and rice farming. Shrimp does not significantly influence the short term rice production. As a consequence of the introduction of shrimp farming, management practices need to be slightly changed, so that target production can be achieved through proper land use system. In general there are two different ways to increase the shrimp production either by constructing new shrimp farm and/or improving existing farms, or both. Choosing between these alternatives is primarily an economic consideration. Based on the production function analysis it was found that, increasing farm size by 1% would induce an increase in gross income, which is relatively large in comparison to the application of additional unit of fertilizer and feeding. Of course, if other material inputs are added together with fertilizer and feeding, the combined effect will be larger than that of the effect of increasing farm size.

The shrimp farming has both positive and negative impact. The results of the study clearly implied that shrimp farmers and other related people accrued socioeconomic benefits from shrimp farming. By providing income and employment opportunities and escalating many activities, coastal communities including women have 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 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. However, due to social intervention natural and social environments in the coastal areas have been gradually improving

The government of Bangladesh is concerned about the impacts of shrimp farming. The government provided crucial support to the sector through accession of land, leasing of *khas* land to shrimp farmers, and providing financial support in the production and marketing of shrimp. Regarding negative impacts of shrimp culture, the government subsequently introduced some regulatory measures to mitigate some of the negative impacts. However, those measures are alleged to be inadequate and even not-implemented to protect the negative socioeconomic and environmental consequences.

With the mixed implications of the shrimp culture practices in Bangladesh, the policy makers have faced with a number of alternative choices: (a) continuing with the existing phenomena favoring private entrepreneurs at the expense of negative impacts on socioeconomic and natural environment, (b) imposing total ban on shrimp culture to the detriment of export earning, income and employment generation, and © incorporating policy mix of allowing shrimp culture on selective basis and introducing regulatory measures to protect the socioeconomic and natural environment. It seems that the third option is the desirable one and if so, the policy package should contain the contribution of necessary incentive structure and regulatory framework for sustainable shrimp culture conducive to the socioeconomic and natural environment. Such policy formulation should be based on sufficiently quantitative analytical studies pertaining to the interlinkage effects of the shrimp industry of Bangladesh (Talukder, 1999).

Shrimp cultivation will benefit the great majority of the people, depends on government attitudes, proper planning and rational policies. There should be clear-cut legislation, describing the categories of people who would eligible for shrimp cultivation. Based on the above facts lessons and socioeconomic and environmental consequences of shrimp farming, following recommendations can be made about shrimp culture:

- Depending on agro-ecosystem, the coastal areas should be categorized on the basis of salinity level to ensure proper use of valuable land resources and to avoid land use conflict.

- Considering the potentiality and feasibility of shrimp culture in different location of coastal areas, improved traditional and semi-intensive culture system should be introduced to increase the production.
- The land owners should be encouraged and organized to cultivate the shrimp themselves or they should have to lease out their lands to the entrepreneur farmers. There should be legal and organizational efforts in maximizing the access to shrimp culture among landowners.
- The shrimp culturists must harvest all the shrimp by 15 July and all saline water is pumped out of the farms to make them suitable for paddy cultivation. Separate sites should be selected for production of seedling.
- Shrimp cultivation should not be allowed on land where it would pose a great threat to rice crops in adjacent lands.
- In the shrimp farms areas where paddy could be grown alternatively should be scientifically developed into easily manageable small unit, with the provision of a net work of water supply and drainage canals. Construction of farm in a land of a large numbers of lessors should be discouraged.
- The land can be leased out on condition that lessors will get production share of shrimps depending upon the size of their leased out land rather than getting a fixed amount as cash rent. In this case, the main entrepreneur should get the profit share of capital invested.
- Feed and fertilizers should apply at recommended doses to increase the shrimp production.
- Research organization, extension department, universities and NGOs should come forward to provide training to shrimp farmers to improve their knowledge of farm management aspects. The farmers should be instructed to maintain friendly eco-systems.
- Continuous efforts should be extended to organize the implementation of government policies related to shrimp culture especially with a special focus on environmental consequences of shrimp culture.

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