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Cost Analysis of the Shrimp-Based Cropping System in Coastal Bangladesh: A Village Level Study

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Abstract The present study provides an analysis of the comparative costs of cropping systems based on *aman* and *boro* rice varieties and shrimp in coastal Bangladesh. The research was conducted in the Shuktia village under Tala Upazila of Satkhira District. The results revealed that the comparative production cost per hectare of land was higher for both *aman* and *boro* rice (45,737 taka/ha and 54,411 taka/ha, respectively) than for shrimp (43,853 taka/ha), whereas the gross income, net income, and benefit cost ratio (BCR) were higher for shrimp culture. The shrimp-*boro* rice rotating cropping system was about 1.56 times superior to a purely rice-based cropping system. The introduction of shrimp-*boro* rice cropping systems changed the local land tenure, and brought a degree of economic freedom for the local farmers, both landlords and tenants. The paper concludes that a rotating shrimp-*boro* rice cropping system has exerted a positive economic impact on the livelihood of local farmers on the southwestern coast of Bangladesh, the area under study.
Key words: Economic performance, Production cost, Rice, Shrimp

Introduction

The shrimp sector in Bangladesh has assumed a great importance for its potential to improve the national economy (Nuruzzaman, 2006). Coastal aquaculture in Bangladesh as an important economic activity began around 1970, and was oriented towards brackish water shrimp culture with the target species *Penaeus monodon*, locally known as "*Bagda chingri*." Shrimp culture was primarily initiated by rich outsiders (Islam *et al*., 2003), whose typical practice was to lease land from local farmers under contracts of around five years and to culture shrimp commercially, utilizing local labor to gain huge economic profit, thus depriving local farmers of a share in the economic benefits. However, two decades later, local farmers became conscious of the economic inequalities and finally started to culture shrimp on their own land; shrimp farming became localized (Islam *et al*., 2003). Shrimp farming then emerged as a main source of income for hundreds of families in the coastal area of Bangladesh.

Shrimp culture has been developed extensively in the coastal area of Bangladesh since the 1980s. In 1996–97, there were 15,978 large-, medium- and small-scaled shrimp farms, exploiting 147,000 ha of land in Bangladesh (Karim and Khandaker, 1997). The sizes of the large-, medium- and small-scaled shrimp farms are about 1-5 ha, 6-10 ha and >10 ha, respectively (Islam *et al*., 2005). This acreage increased to 246,998 ha in 2009–10 (DoF, 2011a). The total number of fish farmers in the country is about 3.08 million, of whom shrimp farmers comprise about 1.15 million. At present, the total number of shrimp hatcheries in Bangladesh is 60, of which 2 are managed by the government of Bangladesh (DoF, 2011b). Two types of shrimp culture systems, extensive-traditional and improved-traditional, with different stocking densities of post-larvae (PL) and different degrees of management are mainly practiced in Bangladesh (Karim, 2003). Most of the farmers (>90%) still follow the extensive-traditional method, which is characterized by a large-sized farm (up to 100 ha).

Shrimp which is one of the most important exportable commodities in Bangladesh contributes significantly to the national economy of the country and also plays a vital role in generating income and employment opportunities within the coastal population. The increased ratio of total production of cultured shrimp was 495% from about 14,773 tons in 1986–87 to 87,972 tons in 2008–09 (DoF, 2010). In the fiscal year 2009–10, Bangladesh exported frozen shrimp to other countries with a value of 2885.21 crore taka (1 crore taka is equivalent to 145,445 USD) (DoF, 2011c). In the national export earnings, from shrimp and other fisheries species of Bangladesh, shrimp alone contributed about 93% of the total share (Islam *et al*., 2003).

Shrimp culture in Bangladesh is practiced in *Ghers*, a pond/field that is situated by riverside and used to

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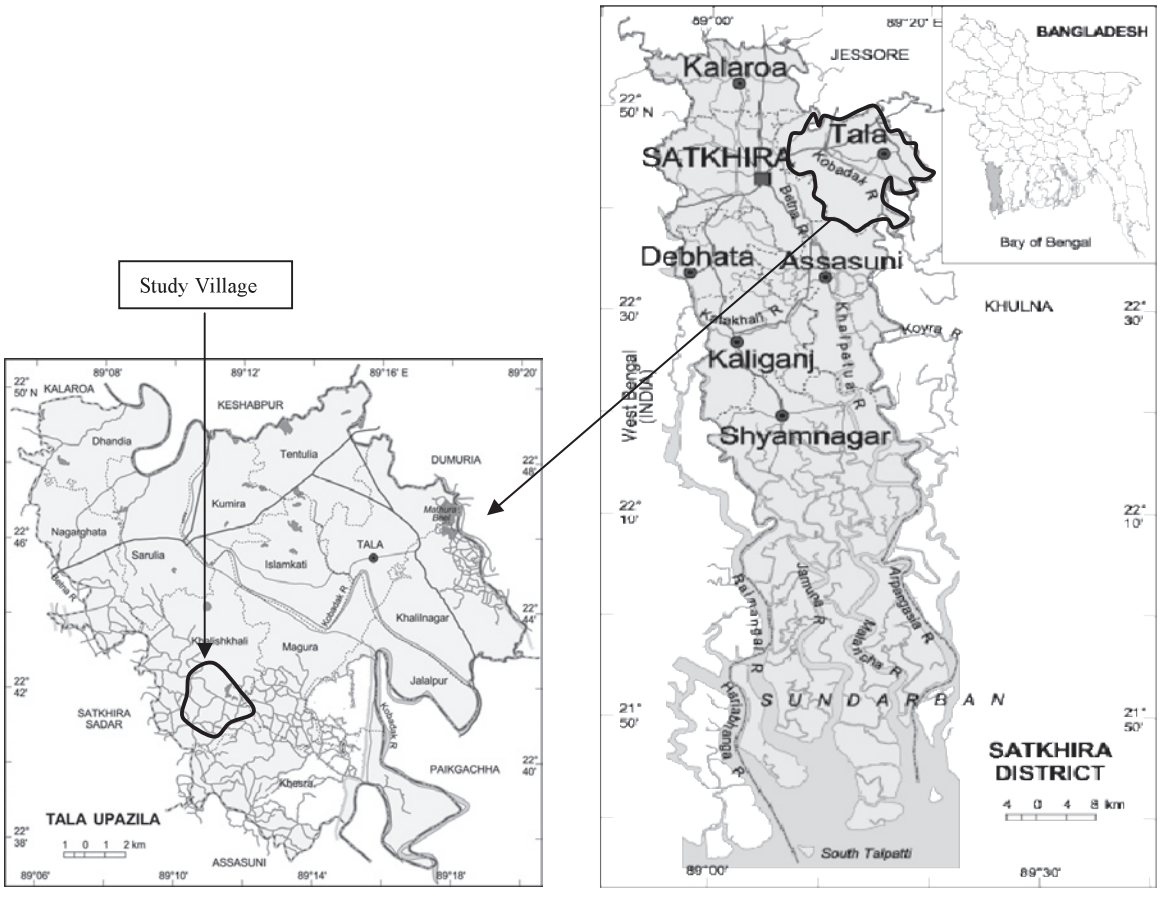
grow rice and shrimp alternately (Ahmed *et al*., 2008). Initially, the cropping system for brackish water shrimp extended from December to July, followed by the cropping of transplanted *aman* rice (monsoon season rice) from July to December. In the course of time, the cropping system has moved from the *aman* rice-shrimp regime to a shrimp-*boro* rice (winter or dry season rice) system. The original or traditional cropping system in the study area was *aman*-based cropping systems without the shrimp culture, but presently, rice cropping has developed two types depending on the hydrological conditions of the rice fields, such as boro rice in the medium lowland and *aman* rice-*boro* rice in the medium highland (Rahman and Ando, 2011). The introduction of shrimp farming in the coastal area of Bangladesh has changed the landholding sizes and the cropping patterns as well as the land tenure systems (Barmon *et al*., 2004). It may be noticed that the large-scale extension of the shrimp culture has changed the economic performance of the traditional rice-based cropping systems. Therefore, the objective of the present study was to identify the comparative economic performance between the *aman* rice-*boro* rice cropping system and shrimp-*boro* rice cropping system under the existing land tenure system. The findings may help policy makers, local farmers, and/or agricultural extension workers in related domains to generate new ideas or policies for the improvement of the livelihood of coastal farming communities.

Materials and Methods

Research site

The study was conducted in a village named Shuktia which belongs to Tala upazila (*upazila* is a local administrative unit under the district) under Satkhira district in southwestern Bangladesh (Fig. 1). Agro-ecologically, the village is located in the Ganges Tidal Floodplain area (Brammer, 1988). The village was selected intentionally on the recommendation of one of the Agricultural Extension Officers of the Satkhira district, because almost all of the area is under rice and shrimp cultivation for the consumption and cash income of the local people. The local farmers cultivate the same field for rice production (using irrigation) in the winter season and for shrimp production in the summer and rainy seasons, using saline water from the nearest *Dolua* river. Another reason for selecting this area as the study site was the ease



Source: www.banglapedia.org

Fig. 1 Location of the study village.

of communication. There is a finely constructed road between the village up to the district Satkhira, and there are good lines of communication with the capital city Dhaka, though travel by bus from the village to Dhaka requires about 12 hours.

Research methodologies

There were 227 households in the study village, of which 174 were engaged in rice and shrimp farming in their fields (Table 1). The survey was performed with two stages. First, all the households in the village were identified and basic information was recorded by personal interview with all the household heads. Second, a detailed survey of 65 randomly selected farmers out of those 174 was conducted. The sample farmers operated with a land area of 0.02-0.2 ha, 0.2-1.0 ha, 1.0-3.0 ha and >3.0 ha hereafter referred to as marginal, small, medium, and large farmers, respectively. Data and information on shrimp production and rice cultivation under different management practices, cost of inputs, and revenue from shrimp and rice farming were also collected from those 65 randomly selected farmers. Focus group discussion and field observation were also carried out. The fieldwork was carried out from September to October 2011 and again from January to February 2012. The benefit cost ratio (BCR) and the cost per unit of product (CPUP) were calculated for both shrimp and rice production, and the following formulae were used:

i) Benefit Cost Ratio (BCR)=

$$\frac{\text{Gross Income}}{\text{Total Cost of Production}}$$

ii) Cost Per Unit of Product (CPUP) =

$$\frac{\text{Total Cost of Production - Value of By product}}{\text{Yield of Product}}$$

Results

Shrimp and rice cropping systems in the study area

Shrimp culture in the study village is not a recent practice. It has been widely adopted since its introduction around 15 years ago. Before the activity of shrimp culture in the village, local farmers used to cultivate only rice in their fields. At that time, rice was grown during two periods in a year. The locally called *boro* rice was cultivated from the month of December/January to April/May, and a second rice variety, *aman* rice, was cultivated from August/September to November/December. The *boro* rice-*aman* rice cropping system was the single dominant regime in the village before the introduction of shrimp culture. This system was maintained in both medium highland and medium lowland. After the introduction of shrimp culture in the village under study, the cropping systems changed in the medium lowland to the shrimp-*boro* rice rotating pattern (where shrimp culture replaced *aman* rice). The medium highland continued to be cultivated under the double rice cropping system. It is considered that the economic return has been one of the major causes of the change to the cropping systems in the medium lowland. The medium highland became highly suitable for the *aman* rice - *boro* rice cropping system and also common cropping system in other regions of Bangladesh after the introduction of irrigated HYV rice cultivation during dry season. However, the local farmers consider that the medium highland of the study area is not suitable for shrimp culture due to the low water holding capacity for shrimp culture. Accordingly, shrimp culture is not practiced by the local farmers, particularly in the medium highland.

Economic return from boro rice and aman rice

The operating cost, material cost, and income from both *boro* rice and *aman* rice are presented in Tables 2, 3 and 4, respectively. It has been found that the differences between *boro* and *aman* rice in terms of operating cost, material cost and income were significant at 5%, 1% and 1% level of significance, respectively. The primary data collected from 65 sample farmers revealed that the total operating cost was higher in case of *boro* rice (average 32,348 taka/ha) cultivation than that of *aman* rice cultivation where the average cost is about 30,165 taka/ha (Table 2). The cultivation of *boro* rice requires some extra-activity, such as seedling uprooting, which

Table 1 Rice and shrimp-based cropping systems according to farm size categories

Cropping systems	No. of Households (N= 174)				
	Marginal	Small	Medium	Large	Total
Boro rice-*Aman* rice-based	18 (0.27)	18 (0.62)	3 (1.31)	1 (3.28)	40
Shrimp-*Boro* rice-based	33 (0.21)	78 (0.68)	21 (1.38)	2 (3.39)	134

The parenthesis indicates the average operating size in hectare by each category of farmers
Source: Field Survey, 2011

Table 2 Operating cost for one ha of *Boro* rice and *Aman* rice cultivation

Activities	Cost (Tk/ha)					
	Boro rice			*Aman* rice		
	Maximum	Minimum	Average	Maximum	Minimum	Average
Ploughing	4,070	1,221	2,882 (±485)	4,440	2,442	3,061 (±517)
Laddering	1,628	1,110	1,475 (±91)	1,628	1,480	1,547 (±77)
Seedling uprooting	1,332	518	896 (±166)	-	-	-
Transplanting	6,512	4,884	6,303 (±449)	7,400	5,920	6,216 (±477)
Weeding	4,736	3,552	4,498 (±402)	5,920	2,960	5,321 (±883)
Harvesting and bundling	9,768	4,440	5,882 (±1238)	7,400	4,440	5,267 (±752)
Carrying	10,360	4,440	8,187 (±1657)	10,064	4,440	6,485 (±2251)
Threshing	4,440	1,776	2,225 (±383)	2,960	1,998	2,267 (±239)
Total operating cost	36,408	24,864	32,348 (±2670)	33,448	26,048	30,165 (±2820)

Note: The parentheses indicate the standard deviation from the mean Source: Field Survey, 2012
Mean comparison was performed by Tukey's-b test with 5% level of significance
1 USD= 82 Tk

involves some extra money over and above the monetary outlay for *aman* rice cultivation. Basically, *aman* rice is cultivated during the monsoon season when ample rainfall prevails throughout the period; the soil remains soft, and the farmers transplant the rice seedlings directly, after uprooting from the seedbed. On the other hand, in case of *boro* rice, as it is cultivated in the dry season or the winter season during which rainfall is very scarce, it is not easy to uproot the seedlings, and thus farmers must hire additional labor to uproot the *boro* rice seedlings. However, the carrying cost (after harvesting of rice, plants are tied in bundles and are carried to the yard of farmers' home for threshing) is also higher in case of *boro* rice because of its higher yield than that of *aman* rice. Accordingly, this carrying cost becomes one of the significant works to increase the total operating cost of *boro* rice. The total material costs are also higher in *boro* rice cultivation than those of *aman* rice (Table 3). The difference in the cost is mainly due to the fuel bill to irrigate the Boro rice field. The water for irrigation is provided from ground water by a low-lift pump (LLP) driven by a diesel engine. The other material costs except for the fuel bill for both the *boro* and *aman* rice are usually the same. Therefore, taking into consideration both operating cost and material cost, the total cost of production was calculated to be higher (average 54,411 taka/ha) for *boro* rice cultivation than for *aman* rice cultivation, where the average cost is 45,737 taka/ha.

The yield and income from both *boro* and *aman* rice are presented in Table 4. The grain yield was higher in *boro* rice (4,950 kg/ha) than in *aman* rice (3,020 kg/ha), whereas the straw yield was almost the same for both *boro* and *aman* rice. The higher yield of *boro* rice is a common phenomenon in the study area; it is similar to that in other rice-growing areas of Bangladesh. However, because of higher yielding in *Boro* rice and the nearly same price of one kilogram rice of *boro* and *aman*, the gross income from *boro* rice is higher than that from *aman* rice. Thus, the benefit cost ratio for one hectare of *boro* rice production is 2.37, whereas it is only 1.90 for *aman* rice production (Table 4). Table 4 also shows that the average CPUP for *boro* rice was 5.01 tk/kg whereas the CPUP for *aman* rice was 6.30 tk/kg. This indicates that one kilogram of *aman* rice is more costly to produce

Table 3 Material cost for one ha of *Boro* rice and *Aman* rice cultivation

Items	Cost (Tk/ha)					
	Boro rice			*Aman* rice		
	Maximum	Minimum	Average	Maximum	Minimum	Average
Seed	5,950	1,480	3,506 (±839)	4,440	1,480	3,391 (±1251)
Fuel for Irrigation	13,542	3,611	5,604 (±1596)	0	0	0
Fertilizer						
-Urea	5,950	2,960	5,359 (±615)	5,950	2,997	4,669 (±746)
-Triple super phosphate	3,034	1,406	2,017 (±300)	2,627	1,887	2,181 (±232)
-Muriate of potash	1,872	740	1,114 (±255)	1,887	947	1,216 (±311)
-Zinc sulfate	2,220	888	1,207 (±365)	1,110	740	1,021 (±148)
Pesticide	3,663	2,294	3,256 (±364)	3,626	2,442	3,095 (±383)
Total material cost	27,839	17,087	22,063 (±2135)	17,952	11,670	15,572 (±2030)
Total Cost of Production	60,103	45,244	54,411 (±3995)	50,520	39,020	45,737 (±3794)

Note: The parentheses indicate the standard deviation from the mean Source: Field Survey, 2012
Mean comparison was performed by Tukey's-b test with 1% level of significance

Table 4 Yield and income from one hectare of *Boro* and *Aman* rice cultivation

Crops	Average yield		Price		Income			BCR	CPUP
	Grain (kg/ha)	Straw (bundle/ha)	Grain (Tk/kg)	Straw (Tk/bundle)	Grain (Tk/ha)	Straw (Taka/ha)	Gross income (Tk/ha)		
Boro rice	4,950	14,800	20	2	99,160	29,600	128,760	2.37	5.01
Aman rice	3,020	14,000	20	1.9	60,411	26,707	87,118	1.90	6.30

Note: Mean comparison was performed by Tukey's-b test with 1% level of significance
BCR: Benefit Cost Ratio
CPUP: Cost of Per Unit of Product
Source: Field Survey, 2012

than one kilogram of *boro* rice.

Economic return from shrimp culture

The cost of production and its corresponding income from one hectare of shrimp culture is shown in Tables 5 and 6, respectively. The primary data from 65 sample farmers' interviews revealed that the average cost for one hectare of shrimp production was about 43,853 taka, of which the maximum investment goes into Post Larvae (PL) stocking, covering more than 50% of the total cost of shrimp production (Table 5). The cost involved for shrimp production consists of dyke preparation, application of $CaCO_3$, fertilizers and medicine, fuel for water change, PL stocking, feeding and harvesting. Among the costs, dyke preparation, fertilizer and medicine application, feeding and harvesting are manual labor work. However, the hired labor is usually only needed once, when the dyke (boundary) for the shrimp farm is prepared at the inception of the shrimp cuture plan. This dyke usually lasts around 15–20 years (Field Survey, 2011). Although some kind of annual repair or maintenance is required for any broken parts of the dyke, this involves very little labor. In that case, the cost falls to a minimum of 23,582 taka/ha.

Table 6 presents the gross and net incomes from one hectare of shrimp culture. The average yield from one hectare of shrimp culture was about 268 kg for six months of growing shrimp in the study area. The price for one kilogram of shrimp varied, depending on the size of the shrimp; usually, the maximum price was about 700 taka/kg, while the minimum was 450 tk/kg, with an average price of 566 tk/kg. It may be estimated that the average gross income and net income were 149,476 taka and 105,623 taka, respectively, and the average benefit cost ratio was 3.67, much higher than that of *boro* and *aman* rice crops. The farmers sell their shrimp at the farm gate, and in most cases shrimp selling does not involve any carrying cost. This also increases the op-

Table 5 Cost of production for one hectare of shrimp culture

Items	Cost (Tk/ha)			Standard deviation
	Maximum	Minimum	Average	
Dyke preparation	3,571	0	1,924	±743
$CaCO_3$ application	1,714	190	687	±370
Fertilizer and medicine	3,482	0	1,351	±761
Fuel for water	9,643	964	2,913	±1605
PL Stocking	54,071	16,071	26,886	±9698
Feeding	28,571	0	9,046	±5838
Harvesting	5,714	0	1,046	±902
Total Cost	91,357	23,582	43,853	±15277

Source: Field Survey, 2012

Table 6 Yield and income from one hectare of shrimp culture

Items	Maximum	Minimum	Average	Standard deviation
Yield (kg/ha)	507	150	268	±64
Price (tk/kg)	700	450	566	±68
Gross Income (Tk/ha)	228,150	97,500	149,476	±29409
Net income (Tk/ha)	155,896	56,299	105,623	±25862
BCR	6.36	1.87	3.67	±1.05
CPUP (Tk/Kg)	321	79	162	±46

Source: Field Survey, 2012

portunity to obtain higher benefits from shrimp culture than from rice cultivation. The CPUP for shrimp culture varies within a range from 79 to 321, with an average value of 162 taka/kg.

Comparative economic return from the cropping systems

The comparative economic returns from the two cropping systems of shrimp-*boro* rice and *aman* rice-*boro* rice cultivation revealed that the total cost of production was almost identical for both cropping systems, but that the total gross income was higher (278,236 taka/ha) in the shrimp-*boro* rice system than in the *aman* rice-*boro* rice system (215,878 taka/ha). Hence the net income also rose (179,972 taka/ha) in the former relative to the latter (115,730 taka/ha). Interviews with the local farmers revealed that for shrimp culture, they do not normally need hired labor except for preparing the dyke, which is hard physical work for several days if the farmer and his family members are only engaged in this work. The other minor works can usually be carried out by the farmer himself. In the shrimp culture, the ordinary farmers can save a substantial amount of the labor cost that is unavoidably incurred in the cultivation of both *boro* rice and *aman* rice cropping systems. The total monetary output per unit acreage is higher in a shrimp-*boro* rice cropping system than in an *aman boro* rice cropping system. The former system is 1.56 times more profitable than the latter. This has increased local farmers' interest in culturing shrimp along with *boro* rice, instead of limiting their system to rice mono-culture in their fields. According to the interview results of sample farmers, it seems that although shrimp culture could be performed all the year round, the farmers do not want it as rice is a staple food for them and the demand for rice could be met up from their own rice production. They also want to avoid the risk of whole year shrimp culture. They think that if there is any viral attack on shrimp during the culture, they could have a total loss of shrimp production, while with a rotation of rice cultivation they could at least get one product from the system (Field Survey, 2011 and 2012).

Relationship between cost and income of rice and shrimp with farm size categories

The relationships between farm size categories and the cost and income of each rice and shrimp production are shown in Fig. 2, 3 and 4. Based on the statistical analysis it was found that the differences among different farm categories in terms of cost and income were not significant, but, shows that there were some numerical differences among the farm size categories. Figure 2 indicates that small farmers were spending more money than the farmers in the other two categories and income also became higher. Figure 3 shows that numerically large farmers were spending more money for *boro* rice production but that the medium farmers were getting maximum output, though statistically, this difference was not significant. However, in case of cost and income from shrimp and its relation with household categories (presented in Fig. 4), we found that the marginal farmers invested more money for the production of shrimp,

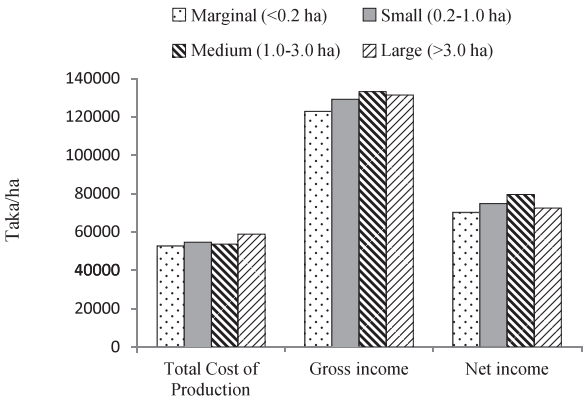


Fig. 3 Relationship between cost and income of *Boro* rice with household categories.

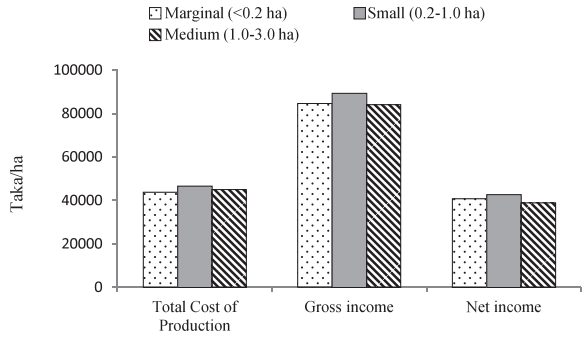


Fig. 2 Relationship between cost and income of *Aman* rice with household categories.

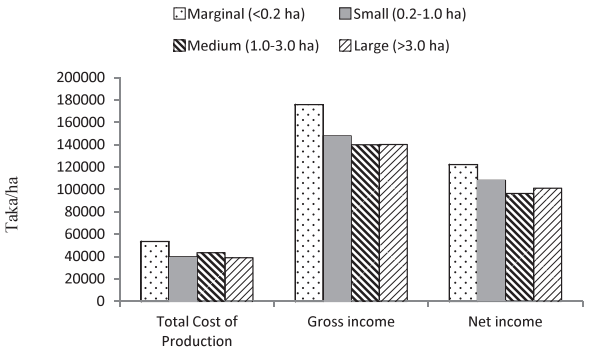


Fig. 4 Relationship between cost and income of Shrimp with household categories.

and they also received a higher gross income and net income than the other categories of farmers. Similarly, in this case, numerically the marginal farmers spent more money and got more profit from shrimp production but statistically, the relationship between farm size and the cost and income from shrimp production were almost identical for all the farm categories. Here the findings indicate that all the categories of farmers in the study area, though they differed in the amount of land, tried to invest the money per unit of production of rice and shrimp to get maximum output. As the target is maximum output and all the farmers want to get it, therefore, in terms of expenses or cost as well as income, there was no significant difference among the farm size categories.

Based on these results, we concluded that rice and shrimp production does not follow any definite patterns of relationship with farm size categories. All the farmers gave almost the same priority to the production of rice and shrimp from the same field.

Land tenure system and its relationship with shrimp and rice cropping systems

In the present study area, land was the principal source of income. Many of the farmers rely heavily on rented land in their cropping activities. There are three types of land tenure systems in the study village; as follows i) *lease system,* locally called *hari*, where the landowner gives his land (leases out) to the tenant (leases in) for a period of 1–3 years, taking a certain amount of money from the tenant, with signatures of both landowner and tenant on a revenue stamp. The contract can be renewed again upon further signature on a revenue stamp after the previous period has expired; ii) *mortgage system,* locally called *bondhok*, in which the tenant gives a certain amount of money per unit of land (mortgages in) to the landowner (mortgages out) with a condition that the tenant will utilize the land until the landowner repays the money; and iii) *renting/sharecropping system,* locally called *borga*, in which the tenant takes the land from the landowner under the condition that the sharing rate of the yield in kind is 50% between a tenant and a landowner in *aman* rice, while in *boro* rice 50% goes to a tenant and each 25% goes to the landowner and irrigation provider. The cost of seeds, fertilizers, pesticides and hired labors are borne by the tenant. In case of irrigation for *boro* rice cultivation, the cost such as fuel, etc. is borne by an irrigation provider. It was observed, however, that very few cases of sharecropping systems were operated in the study village.

The marginal and small farmers depend on the land tenure system to a large extent to culture shrimp in the study village. The land tenure system and its relationship with different farm categories are presented in Table 7. Prior to the introduction of shrimp culture, the main land tenure system was renting/sharecropping. However, after the establishment of shrimp culture, the land tenure system changed to leasing (in or out). Usually, the large farmers lease out their land to the marginal, small, and medium farmers and among them the number of small farmers is the largest. However, in total, 107 farmers were involved in the leasing-in system, and 84 farmers were involved in the leasing-out system, while 38 farmers were involved in both (Table 7). As an example, some medium farmers got land in leases, usually, when they wanted to increase the area of their shrimp farm adjacent to their own land. However, in the case of the mortgage and renting systems, very few farmers were involved, because it is considered that these systems are not much profitable to them.

Discussion

Shrimp farming has brought about significant changes in the social and economic environment in the

Table 7 Land tenure system and its relationship with farm categories

Land tenure system		Number of farm categories, N=227				
		Marginal	Small	Medium	Large	Total
Lease (*Hari*)	In	37	53	17	0	107
	Out	8	54	20	2	84
	Both	**9**	**26**	**3**	**0**	**38**
Mortgage (*Bondhok*)	In	6	6	1	0	13
	Out	3	6	2	0	11
Rent/Sharecropping (*Borga*)	In	6	1	0	0	7
	Out	0	1	3	1	5
Total		69	147	46	3	265

Note: The parentheses indicate the local terms Source: Field Survey, 2011

Since some farmers were involved in more than one system, the total number increased to >174

coastal area of Bangladesh (Islam *et al*., 2003). Coastal farming has been transformed from a rice-based to a shrimp-based system in southwestern Bangladesh, including the present study area. Before the establishment of shrimp culture, the local farmers cultivated only *aman* rice and *boro* rice in both medium lowland and medium highland farms. Following the introduction of shrimp culture, however, *aman* rice cultivation in medium lowland farming has been replaced by shrimp culture.

In the present study, comparative analysis of production costs for *aman* and *boro* rice cultivation with shrimp farming has revealed that the average cost of production for one hectare of *aman* rice cultivation was lower than that of *boro* rice cultivation, but the cost per kg of rice grain production, i.e., the CPUP, was higher for *aman* rice cultivation than for *boro* rice cultivation (Table 4). Thus, the total gross return became higher for *boro* rice cultivation. However, when the production cost of rice cultivation was compared with the production cost of shrimp culture, it appeared that the average cost of production for one hectare of shrimp culture was even lower than that for either type of rice cultivation. This occurred because less labor was required for shrimp culture, since in small-scale shrimp farming, the farmer himself can maintain the shrimp-culture management activities without the need for additional hired labor.

Comparing to the other shrimp culture areas of Bangladesh, it showed that the average yield of shrimp in the present study area was relatively high (268 kg/ha), whereas in the districts of Khulna, Bagerhat, and Cox's Bazar, the yields were 101.6, 100.8, and 76.4 kg/ha, respectively (Nuruzzaman, 2006). This is probably due to the fact that small-scale shrimp culture can easily be managed by the farmers themselves, whereas in the other low-yielding shrimp culture areas, the farm sizes were usually too large to manage.

Considering both shrimp and rice in a cropping system, it appeared that the shrimp-*boro* rice cropping system was more profitable than the *aman* rice-*boro* rice cropping system in every aspect, i. e., total cost of production, gross income, and net income. Our study indicated that the former system was 1.56 times more profitable than the latter. However, in the other parts of the shrimp-culture area of Bangladesh, the net return from the shrimp-rice system was generally about 62,300 taka/ha (Nuruzzaman, 2006), which is much lower than that of the shrimp-rice system in the study village. This divergence might be due to the intensive care management of the farmers, the presence of congenial natural resources, and the availability of good infrastructure. One of the important factors for higher yield is the availability of suitable saline water from the adjacent Dolua river for shrimp culture. The shrimp grows well in water with an EC (Electrical Conductivity) of 16.7-50.1 dS/m (Chanratchakool *et al*., 1994). The level of salinity of the water sampled from the adjacent river was within this range (Field Survey, 2011). In addition, communication facility with the district market through the local market is well developed for the local farmers and sometimes the local buyers directly come to the farmers' field to purchase shrimp.

The cropping pattern/systems in the study area have undergone various changes over time. The factors influencing these changes might be environmental changes (salinity changes), technological improvements, and the economic profitability of the farming systems. Before 1985, the cropping system for medium lowland was only *aman* rice with local varieties, followed by a long fallow period for grazing cattle. After 1985, following the green revolution of the 1960s in Bangladesh, new high-yielding varieties were introduced along with the establishment of irrigation facilities in the study area. Thus the system has changed to *aman* rice-*boro* rice in medium lowland. However, in the meantime during the period of 1980-85 a barrage was constructed on the far side of the river Dolua. It has created drainage problem for the *aman* rice. The barrage has consequently, stopped the water flow of the river during all the season. The excess rainfed water in the *aman* rice fields could not be diverted to the river through the drainage canal between the rice fields during the rainy season (Field Survey, 2011). Thus, this poor drainage condition and low economic profitability of shrimp culture have encouraged the local farmers to convert the cropping system from *aman* rice-*boro* rice to Shrimp-*boro* rice.

Prior to the introduction of shrimp culture, the land-owners rented out their land to the tenants on a sharecropping basis where the tenant had to bear all the production cost with equally sharing the product. The land-owners, furthermore, influenced the tenant's decision on the selection of crops and varieties. Therefore, the tenants usually could not follow their own decision on sharecropped land. However, after the introduction of shrimp culture, the land tenant system has been on the rental contract (lease in or out). Here the landowners do not influence the tenants as long as they receive rents. Since, the landowners also get profit without any investment, therefore, they are more interested in rental contract (leasing in or out) rather than on the sharecrop-

ping system. In sharecropping, after the harvesting of rice grain (in kind), rice is divided between the landowner and the tenant. In this case if the rice grain yield is lowered due to some unfavorable circumstances (e.g. natural calamities) both the landowner and tenant have to share that lowered yield which is economically not profitable for them. But in the case of rental contract (lease in or out), the landowner is getting the money in cash from the tenant and the landowner does not need to worry about any loss off shrimp farming. On the other hand the tenant gives maximum priority to get a higher profit from this rental land by shrimp culture which generally has been found to be economically more profitable than rice cultivation. Therefore, both landowner and tenant are more interested in shrimp culture and as a result, the change of cropping system has induced the change of the land tenure system in the study area.

Conclusion

Shrimp culture is a profitable enterprise compared to the cultivation of *aman* and *boro* rice. After the introduction of shrimp culture, the cropping system changed from rice-based to shrimp-based, resulting in a change of land tenure system from a sharecropping basis to rental contract. As a result, the landlords get cash from the renting farmers and the renting farmers are also actively involved in shrimp culture for getting a higher profit. The gross-income from the shrimp-based rice cropping system has increased significantly in the study village. Although shrimp is economically more profitable than rice, the need to fulfill self-consumption of rice motivates the farmers to continue the *boro* rice cultivation in the study village. To conclude, it might be mentioned that shrimp culture aims to provide a hard cash money source for the farmers to improve their livelihood.

In the present study, the production cost, income, and benefit from a shrimp-based rice cropping system have only been discussed. It is necessary to conduct further research into the impact of this system on the microenvironment of the rice-cum-shrimp field in order to evaluate future policy implications for the development of shrimp and rice cropping systems in southwestern Bangladesh.

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