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ECONOMIC ANALYSIS OF RICE-PRAWN-FISH FARMING PRACTICES IN SOUTH-WEST COASTAL BANGLADESH

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Abstract: A field survey through questionnaire was conducted in rice-prawn (*Macrobrachium rosenbergii*)-fish culture *gher*s in six villages of Khulna, Satkhira and Bagerhat districts of south-west Bangladesh during March to December, 2008 to assess present culture practices. About 10-25% of the total area of land was converted for building canals and dikes and the remaining area were used for rice cultivation. *Boro* with prawn and fish appeared to have positive impact on the economic return as well as on the livelihood of the farmers. After harvesting rice, total area were used for prawn and fish culture. Cost benefit analysis revealed that the seed cost of prawn was the highest variable cost. Higher seed cost of prawn and fish can be reduced by ensuring the available supply of seed in proper time. The average Net Return (NR) was BDT 72,395±4,6943 $ha^{-1}yr^{-1}$ and the Rate of Return (RR) of the rice-prawn-fish farming was 14.64%. Compared with mono crop culture system, the rice-prawn-fish integrated farming in *ghers* appeared to be economically viable, socially acceptable and environmentally sustainable.

Keywords: Prawn, rice, farming, *gher*, economic return

Introduction

Shrimp culture is practiced in coastal region of Bangladesh. Currently farmers are practicing prawn (*Macrobrachium rosenbergii*) culture with High Yielding Varieties (HYV) of rice where salinity is very low. This freshwater prawn (*Macrobrachium rosenbergii*) farming is currently one of the most important sectors of the national economy, and during the past two decades, its development has attracted considerable attention because of its export potential. The freshwater prawn (locally known as *Golda*) is a highly valued product in international markets, most of which are exported to USA, Europe, and Japan (Ahmed, 2004). The quantity of prawn exported remains rather obscure because export statistics often do not distinguish between prawn and shrimp. The contribution of fisheries sub-sector to the total export earnings during 2013-2014 was 2.09%. The quantity of shrimp/prawn in frozen food export was 47,635 Metric Tons. Currently golda are farming in *gher*, pond, and paddy field covering an area of about 0.63 lakh ha. About additional 0.60 lakh MT fish are produced along with prawn (DoF, 2014).

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Freshwater prawn farming has been mostly concentrated in south-west Bangladesh, mainly in Khulna, Bagerhat, and Satkhira districts. The increase in demand for prawn in the international markets attracted many farmers to switch to prawn cultivation by converting their paddy lands. However, such monoculture of prawn has resulted in serious socio-economic and environmental consequences. Therefore searching for a sustainable, environment-friendly alternative has always been high on the agenda. The most promising alternative appeared to be a form of integrating farming which involves culturing prawn and other fin fish with paddy. Rice-fish farming is practiced in many countries in the world, particularly in Asia. While each country has evolved its own unique approach and procedures, there are also similarities, common practices and common problems (Halwart and Gupta, 2004). In Bangladesh, fish are reared in November/December followed by cultivation of paddy from December/January to March/April in the same land (Gupta and Mazid, 1993).

The region is one of the most promising areas for aquaculture due to two major factors. Firstly, it's fresh and coastal water resources which are the most abundant in the country. Secondly, the world's largest continuous mangrove forest is situated in the region which supports a great diversity of fresh and marine water fish, crustaceans and others aquatic organisms. Culture of these fresh and marine water fish, shrimp and other crustacean species are highly important as it can be integrated with other activities such as agriculture and livestock rearing.

Rice-prawn-fish farming is one of the suitable techniques to meet the demand of this age where population is increasing but land is not. By adopting rice-prawn-fish farming farmers can better utilize their land and improve their livelihood and lift-up their social status. This study was undertaken to identify the present status and to assess the return of rice-prawn-fish farming in south-west region of Bangladesh.

Materials and Methods

Selection of the study area: The study area was located in the south-western part of Bangladesh in three administrative districts-Khulna, Satkhira and Bagherhat. The farms which are traditionally called *ghers* were selected randomly from six villages namely *Baghdanga*, *Chandkathi* of Tala, Satkhira; *Shahapur*, *Hasanpur* of Dumuria, Khulna and *Failarhat*, *Digraj* of Bagerhat.

Culture season: The peak season of rice is from January to April and prawn and fish farming is from February to December. Normally High Yielding Varieties (HYV) of rice like IRRI, BIRI, and other hybrid species of rice are cultivated in these areas. Postlarvae of prawn and finfish are stocked in May to June and are harvested from November to January. The culture period of around 10 months is limited to one crop annually (both fish and rice). Feeding practice for fish generally includes use of supplementary diets consisting of a mixture of locally available feed ingredients such as rice bran, wheat bran, oil cake, and fish meal.

Data collection: Data were collected for 10 months from March to December 2008. Primary data collection involved the inspection of the study area in terms of rice, prawn and finfish production, cost structure and profitability. To collect financial information a combination of participatory, qualitative and quantitative methods was used for data collection.

Questionnaire interviews: Visits to rice-prawn-fish farms and primary interviews with 30 farmers were conducted. Rice-prawn-fish farmers were selected through random sampling (*Ghers*/group of *Ghers* were selected from six villages). The interviews focused on rice-prawn-fish farming systems, productivity, constraints of farming, production costs, returns, and profitability.

Results

Rice-prawn-fish farming: In the last decade (1990-2000 AD) normally two or three crops of rice were cultivated but during field survey it was found that only one crop (Boro rice) was cultivated. Usually, a small area of land is excavated to build a canal along the periphery of the farm that is used as a reservoir area for the prawn and also white fish during culture of rice. After harvesting the rice, the total field is used for prawn and white fish culture.

Paddy field renovation: Most paddy fields used for rice-fish culture were found to be renovated to varying degrees in favor of fish growth. The renovation usually includes the excavation of ditches and swamps as shelter for fish and building of higher and wider dikes. About 10- 25% of the total area was converted for these purposes. The *Gher* size varied between 0.25 ha and 5.06 ha with an average size of 1.16±0.94 ha in the study area.

Plantation of paddy: After harvesting of fishes, the *Gher* area was prepared for paddy plantation by ploughing followed by application of fertilizers. At the time of preparation, inorganic fertilizers such as urea, TSP, Potash and Gypsum were applied at the rate of 91±52, 55±26, 23±7 and 10±8 kg ha^{-1}, respectively. Different High Yielding Varieties of rice including BR-28, IRRI, Hybrid-Sonar Bangla, Hira, Alok were transplanted in rows in January, which were seeded in November. In some *Gher*s, urea at the rate mentioned above was applied after 2-6 weeks of transplantation. The paddy field was irrigated for two times and weeding was done after 30 and 60 days of transplantation.

Rice production: The average productions of rice of IRRI-28, Hybrid-Sonar Bangla, Allok, Hira and BR-28 in the harvesting month of March at different *Gher*s were 4,746±882, 5,780±937, 6,241±1,149, 5,994±858, and 4,917±721 kg ha^{-1}, respectively.

Fish species used in rice-fish-prawn farm: During the survey it was found that all fish farmer respondents cultured prawn (*Macrobrachium rosenbergii)* with fish. A range of Indian major carps such as catla (*Catla catla)*; rohu (*Labeo rohita)*; mrigal (*Cirrhinus cirrhosus)*; exotic carps mainly silver carp (*Hypophthalmichthys molitrix)*; and grass carp (*Ctenopharyngodon idella)* were cultured with the prawns. Regardless of farming systems, farmers did not follow any specific ratio of different carp species.

Stocking: Stocking rate of fingerlings varied from farmers to farmers and area to area. The stocking rates of prawn, rohu, catla, mrigal, silver carp, grass carp and common carp were 28,158±7,298, 280±60, 274±56, 293±66, 265±43, 223±67 and 293±62 nos ha^{-1}, respectively.

Fertilizing (for prawn and fish culture): Farmers generally used both organic and inorganic-urea fertilizers. Most of the farmers collected fertilizer from local market and the price of fertilizer is retailer price. Application rate of urea, TSP, cow dung, mustard oil cake and lime were 79±25, 43±11, 288±94, 288±94 and 229±66 kg ha^{-1}, respectively.

Feed and feeding rates: A variety of feed materials such as mixture of rice bran, oil cake, wheat flour, and fish meal were used for prawn production. Snail meats were also used by the farmers in prawn farm. In general, feeding of fish was done twice a day in the morning and evening although some farmers applied feed only in the evening.

Survival rate: The survival rate of prawn, rohu, catla, mrigal, silver carp and grass carp were 67±14, 82±7, 79±9, 82±6, 80±5 and 73±6 % respectively.

Harvesting and marketing of prawns: Farmers harvested their prawns using cast nets and seine nets, usually netting several times at few weeks intervals. Cast nets were generally used for small *Gher*s and seine nets for big one. Harvested prawns were kept in aluminum containers, plastic containers, or bamboo baskets. After harvesting, farmers grade all head-on prawns by size and weight and sell them to the agents.

Financial analysis

Operating cost: Operating costs involved variable costs and fixed costs. Variable costs are shown in Table 1 and fixed costs are shown in Table 2.

Table 1: Annual operating cost $ha^{-1}year^{-1}$ of rice-prawn-fish farming (variable cost)

Items	*Quantity*	*Rate*	*Cost (BDT)*	*% of total cost*
Variable cost				
Ploughing (Rice)	1	4,493.33±445.424	4,493.33±445.424	1.06
Ploughing (Prawn)	1	5,164.87±448.041	5,164.87±448.041	1.22
Lime (kg)	249.47±45.57	13.12±0.87	3,264.11±602.18	0.77
Urea (Paddy) (kg)	90.45±52.38	7.80±1.92	762.16±672.46	0.18
TSP (kg)	54.75±26.68	44.40±13.33	2,720.29±2,470.44	0.18
Potash (kg)	21.99±5.89212	41.29±16.49	620.71±523.79	0.15
Gypsum (kg)	13.45±1.41	7.13±1.36	82.13±74.58	0.02
Cow Dung (kg)	389.26±105.77	1.24±.254	483.53±169.406	0.11
Mustard Oil Cake (kg)	279.30±97.75	25.19±0.80	7039.50±2483.06	1.67
Chemicals and Pesticides	LS	1,584.98±772.17	1,584.98±772.17	0.37
Chemicals (Fish)	LS	1,541.58±701.54	1,541.58±701.54	0.36
Seed (Prawn)	28158.00±7298.44	4.5±0.79	1,26,422.83±32,604.50	29.95
Seed (Paddy)		3,110.34±1552.95	3,110.34±1,552.957	0.74
Seed (Rui)	276.82±60.747	8.92±3.52	2,470.00±113.41	0.58
Seed (Catla)	278.82±61.465	8.92±3.52	2,470.00±113.41	0.58
Seed (Others FF)	297.65±61.465	8.24±2.98	2,453.33±120.29	0.58
Feed (kg)	3,200.77±55.78	25.67±5.25	80,666.67±18,620.22	19.11
Labor (Paddy)	39±0.77	100±9.88	3,970.00±280.58	0.94
Watering	1	2,233.88±736.77	2,233.88±736.77	0.53
Transportation	1	637.70±368.22	637.70±368.22	0.15
Fuel (LS)	50.57±5.86	63.87±2.89	3,229.46±125.73	0.76
Miscellaneous			3,156.86±124.83	0.75
Total			2,58,578.30±64,124.01	61*

LS=Lump Sum

Table 2: Annual operating cost $ha^{-1}year^{-1}$ of rice-prawn-fish farming (fixed cost)

Items	*Quantity*	*Rate*	*Cost (BDT)*	*% of total cost*
Fixed Cost				
Land use (ha)	1	28,176.36±6,668.79	28,176.36±6,668.79	6.67
Depreciation (%)	40,100.00±4,992.06	30	12,030.00±1,497.62	2.85
Staff salary (Month)	10	3,320.00±4,44.429	3,3200.00±4,440.29	7.87
Gher reconstruction	1	16,803.41±7041.14	16,803.41±7041.14	3.98
Gate (Sluice gate)	LS	1,635.94±899.298	1,635.94±899.29	0.39
Net (Netting)	LS	4,099.98±4,453.65	4,099.98±4,453.65	0.97
Dyke repair	1	6,900.00±1,577.864	6,900.00±1,577.864	1.63
Sluice gate repair	LS	416.67±87.428	416.67±87.428	0.10
Pump repair	LS	1,583.33±323.86	1,583.33±323.86	0.37
Guard shed	LS	1,350.00±119.626	1,350.00±119.626	0.32
Screen repair	LS	365.00±93.91	365.00±93.91	0.09
Net repair	LS	1,866.67±524.13	1,866.67±524.13	0.44
Interest	3,67,005.62±25,296.26	15%	55,050.843±3,794.45	13.04
Total			1,56,061.8±31,522.048	39*

LS=Lump Sum**;** *% of total cost (Table 1+Table 2)= (61+39)=100%

***Return from the rice-prawn-fish farms*:** Return from the rice-prawn-fish farms are shown in Table 3.

Table 3: Return from the rice-prawn-fish farms (BDT $ha^{-1}year^{-1}$)

Items	*Quantity (kg)*	*Rate (BDT)*	*Return (BDT)*	*% of return*
Rice	5,535.436±665.91	19.75±1.04	1,08,836.50±8,649.27	22.01
Prawn	569.86±73.55	568.33±46.85	3,24,093.21±52,013.49	65.55
Rohu	155.12±6.51	102.00±12.42	15,426.17±3587.73	3.12
Catla	154.84±7.26	113.45±19.50	17,517.46±2,747.35	3.54
Mrigal	106.00±18.68	66.33±13.06	6,991.67±1752.04	1.41
Others Finfish	143.18±14.72	75.86±8.56	10,520.21±2686.81	2.13
Straw			11,066.67±1,546.59	2.24
	Gross Return		4,94,451.89±72,983.28	100

Economic returns: Gross economic return from rice-prawn-fish production is shown in Table 4.

Table 4: Gross Economic return from rice-prawn-fish farms $ha^{-1}year^{-1}$

Economic Indicators	
TC=FC+VC	4,22,056.433±26,020.026 (BDT)
NR=(GR-TC)	72,395.457±4,6943.254 (BDT)
Income above VC (GR-VC)	2,35,873.59±8,859.27 (BDT)
Rate of Return (NR/GR) ×100(%)	14.64%
BCR= GR/TC	1.17

TC=Total Cost; FC= Fixed cost; VC= Variable cost; NR=Net Return; GR=Gross Return; BCR=Benefit Cost Ratio

Discussion

Aquaculture is a dynamic and probabilistic biological production system which depends upon the complex interplay between various biological, physical and economic variables. Costs of production vary primarily with the level of management input and types of facilities, and revenue returns are affected by the level of production, farm price and by the size and quality of products in a competitive seasonal market (Shang, 1990).

The average size of farms in this study was 1.16±0.94 ha with the largest and smallest *Gher*s being 5.06 and 0.25 ha, respectively. This compares with an average of 0.35 ha in Bagerhat (Rutherford, 1994).

The larger area of the rice-fish fields (50–70%) is more than compensation for the 10-15% of the total area lost by the construction of canals. The size of the canals is similar as mentioned in earlier studies and within the range (10–20% of total field area) recommended for rice-fish farming (Sinh, 1995; WES, 1997).

Regardless of farming systems, the average stocking density of prawn post larvae was 28,158±7,298.436 ha^{-1}, in the reference year. These figures are comparable with stocking rates of 20,000 PL ha^{-1} suggested by Hoq *et al.* (1996) and 20,680 PL ha^{-1} noted by Ahmed (2003). However, New (1995) noted that higher densities appear to result in a greater size variation at harvest and recommended a stocking rate of 12,500 PL ha^{-1}, which provides better yields.

All respondents cultured prawn with a range of Indian major carps such as catla, mrigal; exotic carps mainly common carpio, silver carp and grass carp. Durairaj and Umamaheswari (1991) noted the growth and yields of prawn in integrated farming systems did not appear to be influenced by fish; therefore, prawn-cum-fish culture was technically and economically viable. According to Shang and Tisdell (1997), polyculture of prawn and fish are usually ecologically sound than monoculture because of more efficient use of waste and energy on the farm.

It was observed that the average annual yield of prawn was 570±74 kg ha^{-1} which was higher than previous reports. Ahmed (2003) reported that the average annual yield of prawn in south-west Bangladesh was 432 kg ha^{-1}. However, more than a decade ago, the average annual yield of prawn was only 168 kg ha^{-1} in south-west Bangladesh (Kendrick, 1994). Hoq *et al.* (1996) stated that prawn production when reared together with fish varied from 162 to 428 kg ha^{-1}. Chand *et al.* (2002) obtained the production rate from poly culture of prawn 1,243 kg ha^{-1} for the fishes and 229 kg ha^{-1} for the prawns.

The average annual fixed costs were 1,56,061.8±31,522.048 BDT (Table 2). Table 4 shows that total costs of this farming system averaged BDT 4,22,056±26,020 ha^{-1} yr^{-1}. Ahmed (2004) reported that the average prawn production cost in south-west Bangladesh was US$ 1,204 ha^{-1} yr^{-1}, which is way below the average total cost estimated in this study. The author didn't mention the source and methodology of data collection and analysis. However, considering the fact that the total costs required to stock prawn seeds alone are higher than the estimated total costs of US$ 1,204 ha^{-1} yr^{-1} this data seems highly unrealistic and thus a direct comparison with that obtained in the present study is not possible.

According to Shang and Tisdell (1997), increased income of a farm depends not only on increased production but also on the existence of a potential market and an efficient marketing system. At the farm level, net income is affected by the level of production, farm price, and operating cost. Increase in farm productivity, reduction in production costs, and increase in average farm revenue are major measures to increase net return.

Ahmed *et al.* (2008) mentioned that once the fixed investments have been made, farmers' production decision should be based on the expected returns or income above variable costs. Fixed investments are considered as sunk costs and may not be recovered in the very short-run period of at least one farming season.

Xiuzhen (2003) mentioned that rice-fish culture is a relatively easy, low-cost and low-risk entry point for rural farming communities to improve their livelihood and household income without jeopardizing the sustainability of rice production. Compared with pond-based aquaculture, rice-fish culture is less restricted by initial capital investment and labor requirement. Rice-fish culture is now used widely as an alternative livelihood improvement and poverty alleviation. Prawn culture in rice fields provides not only an additional income from the yield of fish, but also improves the yield of rice (Arce and dela Cruz, 1979; Li, 1988; Lightfoot *et al.,* 1990; Halwart, 1994).

Conclusion: Rice-prawn-fish farming offers tremendous potential for food security and poverty alleviation in rural areas. It is an efficient way of using the same land resource to produce both carbohydrate and animal protein. The various sub-sectors in agriculture need to recognize rice-prawn-fish farming as a distinct and viable farming system that farmers can choose to adopt wherever the physical conditions are appropriate.

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