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Practice and Economics of Freshwater Prawn Farming in Seasonally Saline Rice Field in Bangladesh

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Abstract - This paper evaluates the production pattern and economics of freshwater prawn (*Macrobrachium rosenbergii*) farming in seasonally saline rice fields in Bangladesh. The reconnaissance survey was conducted on 30 rice-prawn *ghers* (RPG) in south-west region of Bangladesh. The farmers were found to use their rice fields for farming prawn and rice (*aman*) concurrently from April/May to January, and for only rice (*boro*) from January to April. In the RPG farming system, farmers use rain water during wet season, and underground water with salinity of 1-5 ‰ during dry season. The average production of prawn, *aman*, and *boro* was recorded as 439.79±90.46, 3155.48±397.33, 4778.54±389.37 kg/ha/yr, respectively. The economic analysis show potentially good return, and the net return and benefit-cost ratio were US$ 1078.35 and 1.25, respectively. The payback period was determined as 9.37 years. The study implies that the culture of prawn in seasonally saline paddy field is economically viable.

Key words: Rice-prawn gher system, *Macrobrachium rosenbergii*, aman, boro, salinity, economics.

Introduction

Bangladesh with its favorable resources and agro-climatic conditions is widely recognized as one of the most suitable countries in the world for giant freshwater prawn (*Macrobrachium rosenbergii*, De Man, 1879) farming. The farming of freshwater prawn is one of the most emerging economic activities in southwest regions of Bangladesh, and over the last two decades, its development has been significantly tangible because of its export potential. The prawn culture area extended from 6,000 hectare (ha) in 1994 (Chanda and Khondaker, 1994) to an estimated 50,000 ha (Khondaker, 2007). It has been expanding on an average of 10-20% per annum (Williams and Khan, 2001; DoF, 2002; Khondaker, 2007). The average production of 336 $kgha^{-1}$ is reported (Muir, 2003) as increased from the typical yield of 200-250 $kgha^{-1}$ in late 1990s (Rahman, 1999).

In Bangladesh, freshwater prawn farming first started in the southwest region in the early 1970s (Mazid, 1994). Around 1978, a few well-off local farmers in Fakirhat area of Bagerhat district began to stock prawn post larvae (PL) in carp ponds, and experimented with construction, design, feeding, stocking and other technical aspects as well (Kendrick, 1994). Finally by around 1987, a few pioneers adopted successfully the first prawn cultivation in *Ghers* converted from low lying lands and rice fields.

Since then the pace of adoption increased dramatically, and this technology spread to other southwest districts such as Khulna and Satkhira. Since 2000, the increased demand for prawn in the international market has attracted many fish farmers to prawn cultivation in freshwater and low-saline waters in different parts of Bangladesh, mainly Noakhali, Patuakhali, Mymensingh and Bagerhat districts (Asaduzzaman *et al*., 2007; Hasanuzzaman *et al*., 2009).

There are two prawn farming systems in Bangladesh: pond and gher. Approximately 71 % of farmers are involved in *gher* systems and the remainder in pond systems (Muir, 2003). The farmers practice monoculture, poly-culture with fin-fishes, as well as concurrent and crop-rotation with rice in rice fields. Rice-prawn *gher* (RPG) farming system is an indigenous agricultural technology solely developed by farmers during mid 1980s (Barmon *et al*., 2007). In RPG farming system, the mid field (locally known as *chatal*) of *gher* is surrounded by high and wide dikes and canals around the periphery of the *ghers*. The whole land of *gher* is filled up with rain-water during rainy season, and farmers cultivate prawn and fin-fishes together. The entire land remains dried from January to April except canal which is used for prawn and fishes. Farmers grow modern varieties *boro* paddy on dried *chatal* and sometimes grow vegetables and fruits on the dikes throughout the year (Barmon *et al*., 2006).

Recently, a number of fish farmers in Satkhira district have started cultivating freshwater prawn in seasonally saline paddy fields together with rice crops. Historically, fish farmers in Satkhira region practice shrimp (*Penaeus monodon*) mono-culture in their *ghers* fed inter-tidal saline water (moderate to high saline) through sluice-operated feeding canal connected to the adjacent rivers. But in the past few years, shrimp farming faced frequent disease outbreaks, as well as social and environmental conflicts associated with salinization of soil and water. And consequently, local small-scale shrimp farmers have been moving towards the farming of freshwater prawn which has lower susceptibility to diseases, easiest integration with paddy cultivation, and increasing export potentiality.

However, the economic sustainability of this RPG system in seasonal saline paddy field claims an analysis in context of production and economic returns. With considering the above indicated issue, the present study was conducted to understand the pattern of prawn farming, and its economics in the study areas.

Materials and Methods

The present study was conducted at three unions namely Atulia, Munsigong and Buri goalini (Fig. 1) in Shyamnagore Upazilla in Satkhira district of Bangladesh. The water quality of the rivers in this study zone is characterized by noticeable salinity variation throughout the year with the highest salinity of 24 ‰ in May and the lowest of 6 ‰ in October (Alam and Phillips, 2004). Although farmers of the study area are traditionally involved in shrimp farming, they have recently changed their attitude and interested to rice-prawn culture with using underground water which is slightly saline.

The study was developed on the basis of primary data acquired from direct field survey. The investigation had two distinct phases namely, pilot survey and organized survey. A pilot survey was done with draft questionnaire to have base line information in context of prawn culture system, rice production, prawn production, cost structure, and profitability. Attention was paid to incorporate any new information that had not been written in the draft schedule. Based on the experience gained from the pilot survey, draft questionnaire was then modified and updated into structured questionnaire. The set questionnaire was filled up by asking 30 farmers selected through stratified random sampling (10 farmers from each union). Validation of collected information was done by cross-check interview with Upazilla fisheries officers, relevant non-government organization (NGO) workers, local researchers and leaders.

All data collected from questionnaire interviews were compiled, rearranged and presented as descriptive statistics using Microsoft Excel software-2007.

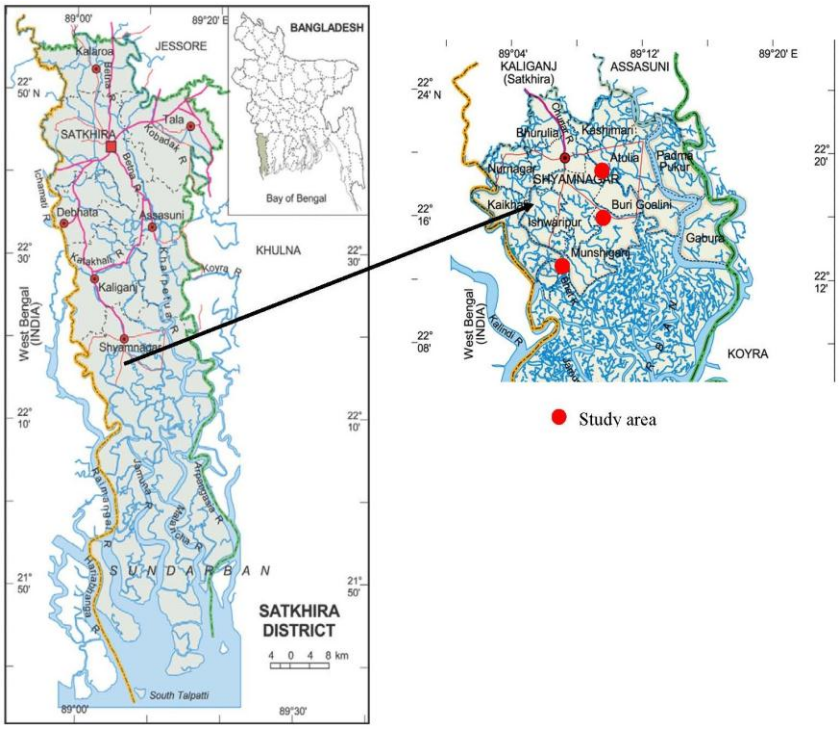

Figure 1. Map of the study area.

Results

Rice-prawn gher production system:

In the study areas, the farmers of 22-62 year aged are found to be mostly involved in rice farming for about 11 years on an average. Over the last 1-6 year, the farmers (i.e. rice cultivators, seasonal fish producers) have

been practicing RPG system. The average gher size was found to be 0.76±0.2 ha, with many small *ghers*. 6 % of the total surveyed *ghers* were of ≤100 decimal, 83 % were of >100-300 decimal, 6 % were of >300-500 decimal and 5 % were of >500 decimal.

The RPG system in the study areas involves concurrently nine-month prawn farming, and six-month *aman*-rice cultivation (Fig. 2). After four-month (January-April) *boro*-rice cultivation, farmers start preparing gher and stocking PL in their *ghers* from May-June when PLs become available locally. Harvesting of prawn generally occurs between November and January but sometimes, farmers start harvesting in late September.

Gher farming Activities		Months											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rice cultivation	*Amon*							■	■	■	■	■	■
	B*oro*	■	■	■	■								
Gher repair					■	■							
Prawn stocking						■	■						
Prawn rearing (feeding, fertilization)							■	■	■	■	■	■	■
Harvesting		■										■	■

Figure 2. Time schedule of prawn farming in seasonally saline paddy field.

Prawn production:

In the RPG system, about 10-30 % of rice field is renovated as ditch and/or sump for shelter prawn throughout the year. The ditch surrounds the periphery of the *gher*. The height of dike varies from 3.5 to 4.5 feet and width or length varies from 1.5 to 2 feet. *Gher* is tilled with tractor i.e. power-tiller after the harvest of *boro*-rice in the month of April. The area of peripheral ditch is not dried wholly; it holds water for prawns stocked in previous year. After tilling and drying of gher, cow dung and different types of fertilizers are applied to the gher.

On an average 23597.72 prawn PLs (ranging from 15,000 to 30,000) are annually stocked in a gher of one hectare. Farmers stock PL continuously throughout the year but primely during May to June when PLs are available. Most farmers (about 70.59 %) were found to stock PL without being reared in nursery systems. 29.41 % farmers were found to use separate small ponds for nursing of post larvae; generally farmers rear PLs for 4-6 weeks but does not maintain any specific stocking density.

In post larval stage, farmers use home made feed prepared by mixing eggs and wheat flour. During grow-out period, they use cooked rice, rice bran, freshwater mussel and/or snail, oil cake and fish meal. Sometimes farmers use commercially manufactured pellet feed purchased from local market. In general, feed is given twice a day in the morning and evening.

The quantity of feed used was reported as about 4306.584 kgha^{-1} in a year. Some farmers also apply feed only in the evening but at irregular.

Two types of fertilizer are used by the prawn farmers: organic, mainly cow dung, and inorganic – urea, TSP and DAP. All farmers apply cow dung, which is relatively cheap and available. Cow dung, urea, TSP and DAP are used at the rate of 410.22 kgha^{-1}, 93.95 kgha^{-1}, 45.88 kgha^{-1} and 40.51 kgha^{-1}, respectively. Sometimes farmers are reported to use 105.68 kgha^{-1} lime in their *ghers* also.

During dry season (October-December) farmers water the peripheral ditch by using shallow pump, and the salinity of this water ranges from 0 to 6 ‰. Farmers harvest their prawns by using cast nets and seine nets (locally known as *berjal*); usually netting several times at a few weeks intervals. Cast nets are generally used for small gher and *berjal* for large gher. A cast net can be operated by a single farmer, while a *berjal* is operated by a group of 3-4 commercial harvesters rather than the producers themselves. Partial harvesting of larger prawn is also practiced for allowing the smaller to grow. Harvested prawns are kept in bamboo made basket or plastic containers. Practically, the prawns are cleaned with water and kept in containers until they are sold to traders. Farmers grade all head-on prawns by size and weight and sell them to the prawn traders. The average production of prawn was found to be about 439.79±90.46 kgha^{-1}. Survival rate differs from gher to gher, and the average survival rate (%) was estimated as 68.23±12.26.The average price of prawn was recorded as US$ 7.86 per kg.

Rice production:

Two crops of rice are cultivated in the study area. *Aman* is cultivated from July to December, and *boro* from January to April. In August, different types of paddy seeds e.g. BR-10, BR-11, BR-23, BR-30 are transplanted in the rice fields which are seeded in July. *Boro* rice such as BR-28, BR-47, and Hybrid-Sonar Bangla are transplanted in the *ghers* in January, which are seeded in December. Specially, either BR-28 or BR-47 is preferable to farmers because these seeds tolerate low salinity and the production of them is high.

After 15 and 45 days of transplantation, urea is applied at the rate of 170 kgha^{-1}. During paddy production different pesticides such as ripcord, nitor, and furadan are also used. During *boro* season, field is watered for two times by using shallow machine and weeding is done after 30 days and 60 days of transplantation. In December, *aman* is harvested and *boro* is harvested in April. The yield of rice in the study area was found as 3155.48±397.33 kgha^{-1}year^{-1} *and* 4778.54±389.37 kgha^{-1}year^{-1} for *aman* and *boro*, respectively.

Economics of rice-prawn gher production system:

The economic analysis of the RPG production system shows that the total annual cost, on an average, was US$ 4262.49±1840.62 per ha of which 38.93 % was entailed by fixed cost and 61.07 % by variable cost (Table 1). The gross revenue came from the RPG system was estimated at US$ 5340.84 to which *aman*, *boro*, paddy straw, and prawn contributes 16.36 %, 16.71 %, 2.21 %, and 64.72 %, respectively (Table 2). The analysis determines the net return as US$ 1078.35.

Table 1. Total cost (US$/ha/yr) of seasonally saline rice-prawn gher system.

Item		Quantity	Cost (US$±SD)	Useful life (years)	Depreciation
Capital Cost	Land use (ha)	1	18908.15 ± 800.21	20	945.41
	Gher construction	1	464.68 ± 50.34	10	46.47
	Pump installation	1	607.28 ± 192.02	10	60.73
	Guard shed	1	19.99 ± 6.59	5	4.00
	Total capital Cost		20000.1 ± 9275.46		1056.60 ± 454.81
Annual operating cost (US$/ha/yr) of seasonally saline rice-prawn gher system					
					% of TC
Annual Fixed Cost	Plough (Rice)		32.59 ± 1.05		0.76
	Depreciation		1056.60 ± 454.81		24.79
	Staff salary (Month)	12	257.12 ± 166.28		6.03
	Gher repair (ha)	1	64.60 ± 50.38		1.52
	Dyke repair (cycle)	1	13.46 ± 12.92		0.32
	pump repair (ha)	1	20.17 ± 19.95		0.47
	Sluice gate repair (cycle)	1	9.84 ± 3.81		0.23
	Interest (25 %)	1	205.07 ± 164.55		4.81
	Total fixed cost		1659.45 ± 355.82		38.93
Annual Variable Cost	Lime (kg)		10.54 ± 3.60		0.24
	Urea (kg) (Paddy+prawn)		48.94 ± 8.83		1.15
	TSP (kg)		31.45 ± 6.85		0.74
	DAP (kg)		24.43 ± 4.64		0.57
	Cow Dung (kg) (Paddy+prawn)		50.55 ± 7.66		1.19
	Chemicals and Pesticides (1/kg)		67.59 ± 16.55		1.59
	Seed (Prawn) No.		800.37 ± 110.54		18.78
	Seed (Paddy) No.		37.46 ± 11.80		0.88
	Feed (kg)		1103.43 ± 178.35		25.89
	Labor (Paddy) (nos)		210.89 ± 47.54		4.95
	Watering (ha)		151.46 ± 7.02		3.55
	Transportation (ha)		21.93 ± 6.87		0.51
	Miscellaneous (cycle)		44.06 ± 19.34		1.03
	Total VC		2603.04 ± 470.62		61.07
	Total cost (FC+VC)		4262.49 ± 1840.627		100

SD: Standard Deviation; FC: Fixed cost, VC: Variable cost, TC: Total cost

Table 2. Economic revenues and profitability from rice-prawn gher system.

Economic Revenue				
Items	Quantity (kg)	Rate (US$/kg)	Return (US$/ha/yr)	Total revenue (%)
Rice(*aman*)	3155.48 ± 397.33	0.28 ± 0.01	873.64 ± 118.22	16.36
Rice(*boro*)	4778.54 ± 389.37	0.19 ± 0.01	892.55 ± 83.65	16.71
Paddy Straw	3930 ± 889.37	0.03 ± 89.3	117.9 ± 638.62	2.21
Prawn	439.79 ± 90.46	7.86 ± 0.66	3456.75 ± 386.02	64.72
Gross revenue (GR)			5340.84	100.00
Profitability				
Economic Indicators			Unit	Total
FC			(US$/ha/yr)	1659.45
VC			(US$/ha/yr)	2603.04
TC=FC+VC			(US$/ha/yr)	4262.49
GR			(US$/ha/yr)	5340.84
Net Revenue (NR=GR-TC)			(US$/ha/yr)	1078.35
Benefit-Cost Ratio (BCR= GR/TC)				1.25
Pay back period			year	9.37

Discussion

Freshwater giant prawn farming is very common in Bangladesh (Hossain and Chowdhury, 1985; Barmon *et al.,* 2007; Ahmed *et al.,* 2008a; Wahab *et al.,* 2008; Hasanuzzaman *et al.,* 2009) and has become crux in linking to the livelihood of small-scale farmers, especially in the coastal regions of Bangladesh. In the study area, farmers who practice RPG system produce prawns on commercial purpose but both *aman* and *boro* rice for family consumption as well as additional incomes. According to Ahmed *et al.* (2008b) and Barmon *et al.* (2007), most prawn-farmers in the southwest part of Bangladesh integrated prawns with fish, and cultivate *boro* rice only during dry season. Alam *et al.* (2007) reported both year round prawn and alternate prawn-rice farming systems. However, farmers in the study areas believe that twice production of rice in a year increases their profit levels.

In the study areas, the gher size ranged from 0.2 to 2.94 ha, which is almost similarly comparable with the range of 0.06 – 1.01 ha reported by Ahmed *et al.* (2008). Considering the availability of prawn PL, especially wild PL which is more preferable to hatchery PLs; farmers practise continuous stocking, and the stocking density has been found in the range of 15,000-30,000 PLs per ha, which is more or less supported by several publications. Ahmed (1996) recommended a stocking density of 15,000 – 18,000 per ha in rice-prawn farming system. Rosenberry (1990) stated a stocking density of 10,000 -30,0000 PLs in the coastal belt of Bangladesh. According to Ahmed *et al.* (2008), prawn farmers practised a stocking density of 19,830 – 21,155 per ha. Tuyen (1993) reported 10,000 - 20,000

PLs per ha stocked in rice-prawn farming system in Vietnam. It is noted that the stocking density in the study areas was found highly variable, which is also in line with a density of 1,500-15,000 per ha reported by Alam *et al.* (2007), and a density of 7,411-39,520 reported by Barmon *et al.* (2007).

The average feeding rate found in the study areas was 4306.58 kg/ha. This feeding rate is extensively varied with 9750 $kgha^{-1}$ in *gher* farming system of prawn reported by Ahmed *et al.* (2008b). Various types of feed are used in the study area but most farmers are found to use home made feed e.g. cooked rice, rice bran, oil cake; which is different from Barmon *et al.* (2006) and Ahmed *et al.* (2008b) who reported snail-meat used commonly in prawn farming system. Similar to Barmon *et al.* (2006), the farmers in the study area do no maintain any standard feeding system but apply trail-error techniques.

The average annual yield of prawns (head-on) reported by respondents was 439.79 $kgha^{-1}$. It supports the production of 432 $kgha^{-1}yr^{-1}$ in Bagerhat region of Bangladesh (Ahmed *et al.*, 2008b) but is higher compared to that of 336 $kgha^{-1}yr^{-1}$ reported by Muir (2003). Productivity of prawns in gher systems is closely related to the quality and availability of seed input. In the study area, farmers were reported to use mostly wild PL, and they also prefer over-wintering PL as it becomes lager and can be harvest throughout the year. The rice production in this study was found to occur twice (*aman* and *boro*) a year, which is different from Ahmed *et al.* (2008b) who reported only *boro* cultivation in *gher* system. The *boro* rice yield in rice-prawn system was almost similar to the yield reported by Alam *et al.* (2007).

The cost-benefit analysis indicates that the *RPG* system is cost effecting in the study area. The net return as US$ 1078.35 was found to be slightly higher compared with US$ 978.8 reported by Ahmed *et al.* (2008b). The difference is thought to be associated with twice production of rice, and higher price of prawn and rice.

However along with good returns from the *RPG* system, there are some constraints reported by the farmers. Natural disasters (*sidr, aila*), ban on prawn export, theft, poisoning, quality of seed, financing, and some sort of diseases related to feed and poor management are their major concerns. Most of the farmers are marginal and poor and they always seek for capital. Most of them finance farming with capital from either selling their cattle and other household assets or personal loan from relatives and friends. A small number of farmers also receive credit from money lenders, NGOs, and Banks. According to the respondents, they always feel insecure about the damages of their product by frequently occurring natural disasters, and diseases. In addition, the recent ban on exporting prawn (~ nitrofuran contamination) in international market has become significant constraint. Most of the farmers raise questions about the quality of seed, especially hatchery reared PL; they seek for wild PL though there is a government-imposed ban on harvesting PL from wild. It is very wondering that the farmers solely rely on PL traders about the sources of PL whether it is from nursery or wild; sometimes they are cheated. The respondents were found to be very positive about having training and credit facilities.

Conclusion

The prawn farming in seasonally saline paddy field concurrently with rice has been becoming popular as livelihood and additional income generation option in the southwest regions of Bangladesh. Though the farmers use underground low-saline water pumped by shallow-well pump, the farming system was found to be economically profitable. As soil salinization and recent ban on shrimp cultivation in the study areas have been major constraints to the livelihood of the poor marginal farmers, the integration of prawn culture into rice farming is found to be good method of livelihood diversification and ecologically sound as well. However, good farming practice training for farmers, training for seed producers and other relevant stakeholders, formal and well arranged credit system, and agro-fisheries insurance policy are needed to make this RPG system sustainable.

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