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Socio–economic aspects of the integrated gher farming system of Dhopakhali union at Kachua upazila in Bagerhat district, Bangladesh

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Abstract: A study was conducted at Dhopakhali union under Kachua upazila of Bagerhat district in Khulna division from December 2021 to February 2022, with a view to know the current practices of integrated rice–shrimp–prawn–white fish in gher farming system. It was found from this study that 80% farmers acquired experience on gher farming system, and 20% farmers had taken training from GOs, NGOs and other organizations. Among these 80% farmers, 33% farmers acquired their experience by self–study, and the remaining 67% gained experience from friends and neighbors. The average land size in the study area was 0.90 acre or 0.39 ha. The information was collected from 15 farmers with questionnaire interviews, which include the physical condition of the ghers, pre–stocking management, stocking management, post–stocking management, integrated gher farming, social condition of gher farmers, production and cost–benefits. No standard stocking densities were followed by the respondents in the study area and as a result, stocking density was varied from farmer to farmer. During the survey, the average stocking densities of shrimp and prawn were found to be 31,191 PL/ha and 12,686 PL/ha, respectively. The average annual cost of production was 3,47,965.60 BDT/ha in the integrated paddy + shrimp + prawn + white fish + vegetable farming systems. The average annual income was obtained to be 6,60,043.55 BDT/ha from the paddy + shrimp + prawn + white fish + vegetable farming system with a net profit of 3,12,977.94 BDT/ha and the cost–benefit ratio was obtained to be 1.0:1.9. The average annual cost was calculated to be 2,65,436.96 BDT/ha from the only integrated shrimp + prawn + white fish + vegetable without paddy in the

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gher management systems with an average annual income of 5,29,805.77 BDT/ha. Net profit was estimated to be 2,64,368.81 BDT/ha and the cost–benefit ratio was obtained to be 1.0:2.0 from the only shrimp + prawn + white fish + vegetable without paddy in the integrated gher farming systems. The yield of paddy per year was reported to be 8,034 kg/ha. In the study area, it was found that fish farmers did not have enough credit facilities and sufficient scientific knowledge on the integrated gher farming system. Therefore, they need appropriate training on aquaculture management as well as adequate funding opportunities to improve the gher farming system in a significant manner in commensurate with the national demands.

Keywords: Integrated gher farming, Aquaculture Production, Cost-benefit, Socioeconomics, Dhopakhali union, Bangladesh

1 Introduction

The economy of Bangladesh is largely dependent on crop agriculture, although aquaculture is gaining importance in recent years. Bangladesh is considered as one of the most suitable countries in the world for freshwater prawn (*Macrobrachium rosenbergii)* farming, because of its favorable resources and agro–climatic conditions. A sub–tropical climate and a vast area of shallow water bodies provide a unique opportunity for freshwater prawn production (Ahmed et al., 2008).

Integrated gher farming is a combined form of aquaculture and agriculture. Integrated gher farming is an indigenous agricultural system, solely developed by farmers in the southwest Bangladesh during mid 1980s. In Bangladesh, two types of gher farming were practiced: one is brackishwater based shrimp culture and another is freshwater based rice–prawn culture. Shrimp gher farming needs saline water, whereas prawn gher farming needs freshwater. In the southwest Bangladesh, freshwater prawns are cultured in modified rice fields, locally referred to as 'gher' (Kamp and Brand, 1994; Rutherford, 1994; Williams and Khan, 2001). The most spectacular development of prawn farming has taken place in the Bagerhat district, where thousands of farmers have converted their rice fields to prawn farms for the profitable prawn culture (Ahmed et al., 2010).

In Bangladesh, giant freshwater prawn farming was first started in the southwest region in the early 1970s (Mazid, 1994) and at Fakirhat sub–district in Bagerhat district (Abedin et al., 2001). In the late 1980s, prawn farming practice began to be adopted widely in the Fakirhat area, where prawns were grown along with fish including Indian major carps (*Labeo rohita, Catla catla* and *Cirrhina mrigala*) and exotic carps (*Hypophthalmichthys molitrix* and *Cyprinus carpio*) with rice (Kamp and Brand, 1994). According to Mitro et al. (2014), shrimp cultivation was not found to be harmful for soil and water quality in the study area (Mitro et al., 2014). In 2017–2018, the total fisheries production was estimated to be 42,76,641 MT in Bangladesh, whereas only shrimp/prawn farm production was 2,54,367 MT (DoF, 2018). Fish market survey (FAO, 2019) reported that shrimp was the second largest traded seafood in the world after salmon fisheries. Most of the production from the culture farm of black tiger shrimp (*P. monodon*) and freshwater prawn (*M. rogenbergii*), were obtained from two major divisions of Khulna (80.44%) and

Chattagong (17.23%), the coastal region in Bangladesh (DoF, 2018). In 2017–2018, the total fisheries production was estimated to be 42,76,641 MT in Bangladesh, whereas only shrimp/prawn farm production was 2,54,367 MT (DoF, 2018). In 2018–2019, the total fisheries production was estimated to be 43,84,221 MT in Bangladesh, whereas only shrimp/prawn farm production was 2,58,039 MT (DoF, 2019). In species-wise production of shrimp/prawn farms in 2017–2018, the total grand production was estimated to be 2,66,154 MT in Bangladesh, whereas only shrimp/prawn production was 1,22,550 MT (DoF, 2019). Species-wise total grand production of shrimp/prawn in 2018–2019 was estimated to be 2,70,123 MT in Bangladesh, whereas only shrimp/prawn production was 1,25,110 MT (DoF, 2019). In 2018–2019, annual exported frozen shrimp/prawn production was 33,362.52 MT (DoF, 2019).

Bagerhat is surrounded on the north by the Gopalganj district, on the east by the Pirojpur and Barguna districts, on the south by the Bay of Bengal and on the west by Khulna district. The total area of this district is 3959.11 km^2 and lies between 21^{o}49′ and 22^{o}59′ north latitudes, and between 89^{o}32′ and 89^{o}98′ east longitudes, respectively. Bagerhat district is consisted of 9 upazilas. Kachua is one of them, which is composed of 7 unions. In the study area, Dhopakhali union is included, which is situated in the Larar canal of Baleshwari river under Kachua upazila. The Larar canal have some saline waters, which are suitable for shrimp (*M. rogenbergii*) and prawn (*P. monodon*) culture. It is therefore need a link among the local production system, local knowledge and environment, and with considering these issues, the present study has been designed on the prawn farming system involved at Dhopakhali union under Kachua upazila in Bagerhat district, Bangladesh. The major objectives of the study were: i) to know the gher management system in the study area of Dhopakhali union under Kachua upazila, ii) to study the current status and farming practices adopted by farmers and iii) to investigate the cost–benefit of the shrimp/prawn gher farming system.

2 Materials and Methods

The study was conducted, based on fish farm survey and the necessary information were obtained through a sample survey among cultivators (Figure 1).

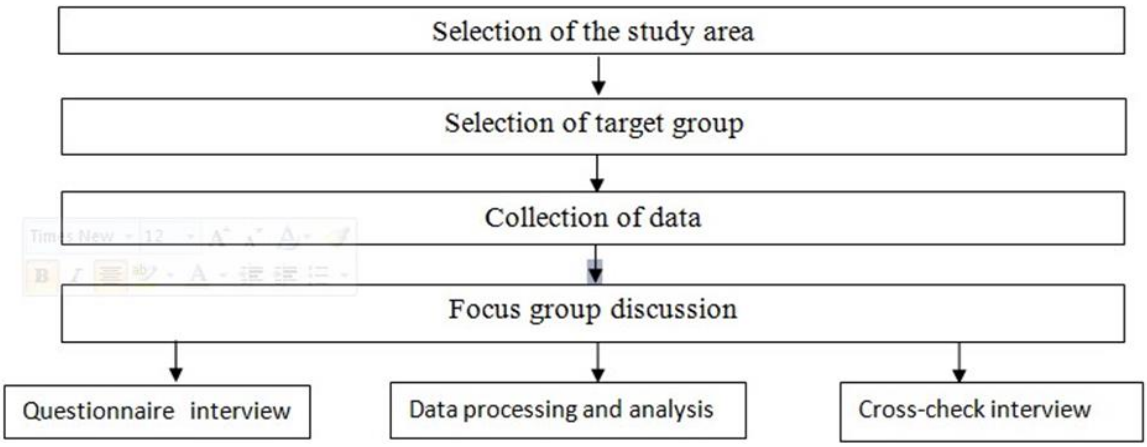

Figure 1. Methodology followed for the study.

2. 1. Selection of the study area

Dhopakhali union of Kachua upazila in Bagerhat district (Figure 2) was selected for the present study. Majority of the people around this study area were involved in shrimp culture. This area was selected because the soil is not suitable for agricultural crops but is appropriate for shrimp/prawn culture due to high salinity percentage. The name of the selected villages, where the survey was conducted and the numbers of interviewed farms are shown in Table 1.

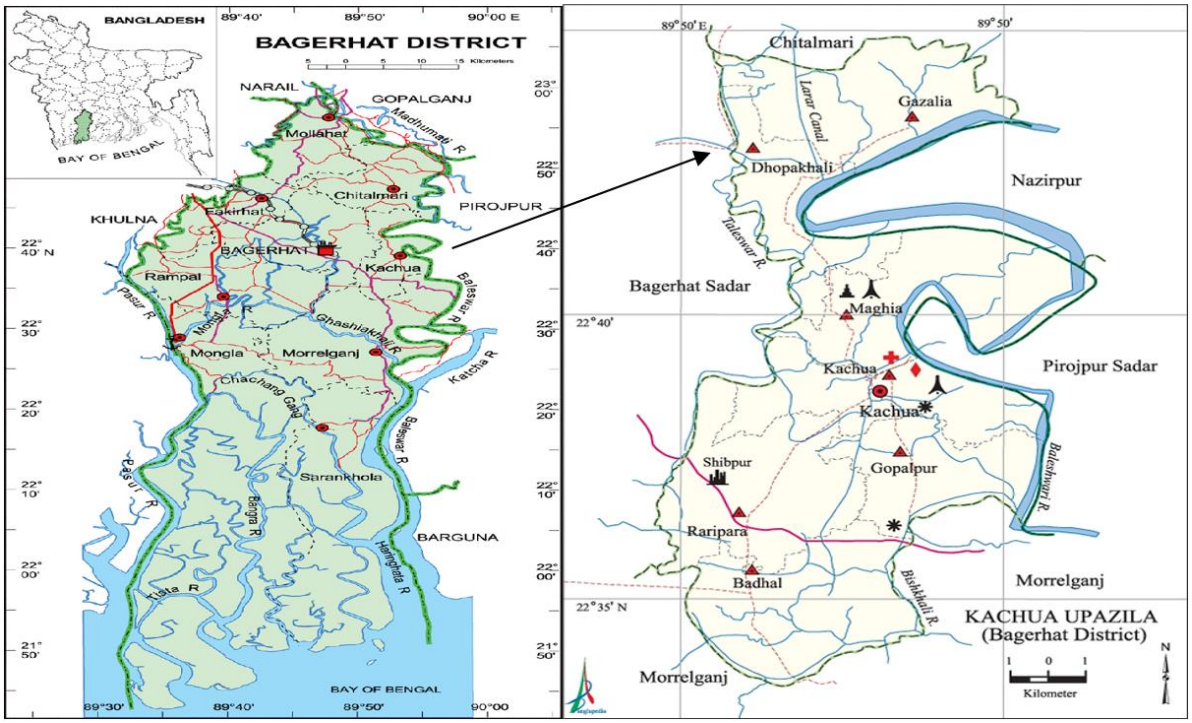

Figure 2. Map of the sampling areas, indicating Dhopakhali union at Kachua upazila in Bagerhat district.

Table 1. Name of the villages under Dhopakhali union at Kachua upazila in Bagerhat district.

SL No.	Name of villages	No. of surveyed farm
1	Uttar Madhobkathi	8
2	Alipur	4
3	Dhokkhin Madhobathi	3
	Total	**15**

2. 2. Selection of target farmers

Most of the farmers live in this area in Kachua upazila and perform prawn farming for family income and nutrition. In the present study, target farmers were selected who dealt with the ghers in Kachua.

2. 3. Data collection

For collecting data on various aspects of livelihood and technological issues, only questionnaire interview method was used. The data were collected from December, 2021 to

February, 2022. For questionnaire interview, simple random sampling method was tracked for fish farmers. Data collection methods were: questionnaire interview with farmers, focus group discussion with owners and cross–check interview with key information.

2. 4. Data processing and analysis

The data were tabulated into a preliminary datasheet in a computer and compared with the spreadsheet to ensure the accuracy of the data entered. After computer entry, the data were analyzed with to computerized Microsoft word 2007 and Microsoft excel 2007, programs.

3 Results and Discussions

3. 1. Present status of shrimp/prawn production

In the recent years, shrimp/prawn cultivation areas has been spread over 8 divisions viz., Dhaka, Mymensingh, Khulna, Barishal, Sylhet, Rajshahi, Rangpur, and Chattogram. Khulna, Chattogram and Barishal are the 3 coastline zones, where the best productions were obtained than other divisions in the year of 2018–2019; total shrimp production in Bagerhat, Satkhira, Khulna, Jashore and Naril districts under Khulna division were 32% (34,038.5 MT), 29% (30,534.6 MT), 27% (28,578.2 MT), 9% (10,062.0 MT) and 3% (2,875.4 MT), respectively (Figure 3) (DoF, 2019). Among the districts evaluated, Bagerhat was found to be the best place for increasing shrimp/prawn production in Bangladesh.

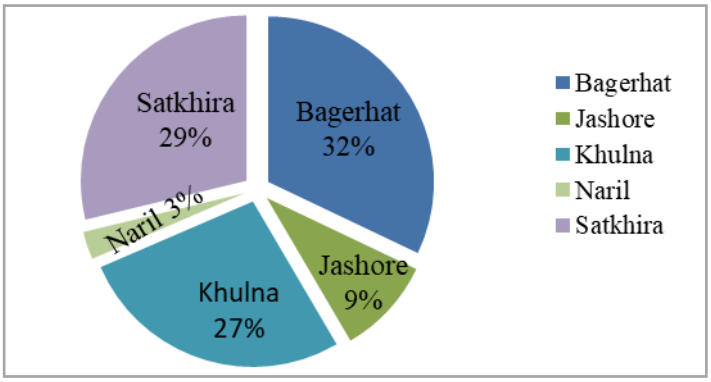

Figure 3. District–wise culture shrimp/prawn production (MT) in different districts under Khulna division of Bangladesh (DoF, 2019).

3. 2. Profile of the farmers

3. 2. 1. Experience and house condition

It was found in the survey area that 47% farmers were experienced with >30 years of gher farming system, 33% with 15-29 years and 20% with <15 years of farming system (Figure 4a). Akter et al. (2014) reported that the maximum, minimum and average farming experience of farmers were 25, 3 and 13 years, respectively in Bagerhat district (Akter et al., 2014).

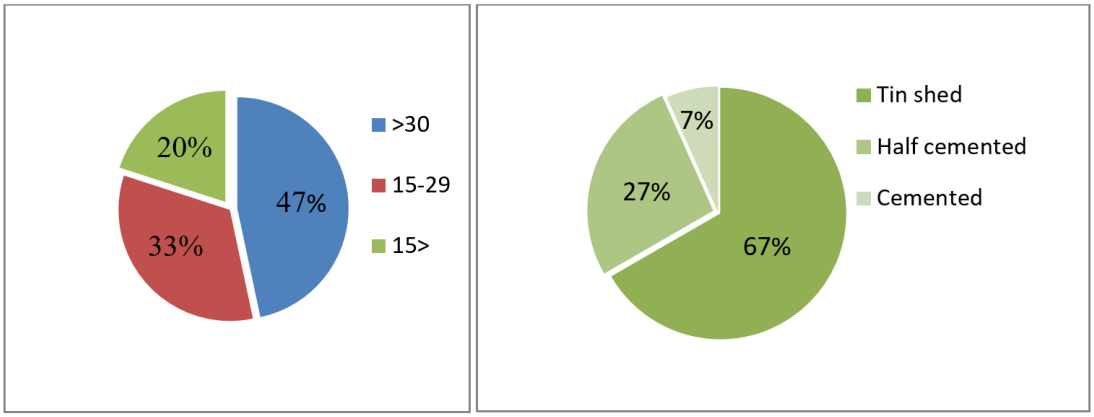

Figure 4. a) Experience on gher farming year by all sample of the fish farmers; b) Percentage of house condition of farmers in the surveyed area.

Throughout the survey, efforts were made of find out the housing condition of the selected pond owners. Most of the houses (67%) of the gher/farm owners were tin shed, while 27% were half cemented and 7% were cemented buildings in this order (Figure 4b).

3. 2. 2. Education

After interviewing with the farmers, it was found that most of the farmers (53%) were illiterate, while 13% had primary education, 27% had secondary education and 7% had higher education (Figure 5). In the present study, 66% of the farmers acquired below SSC level of education due to poor education facilities, which was similar to Akter et al. (2014), who reported that 68% of the farmers acquired below SSC level education in Bagerhat district and also reported that the farmers were educated below SSC level (Akter et al., 2014).

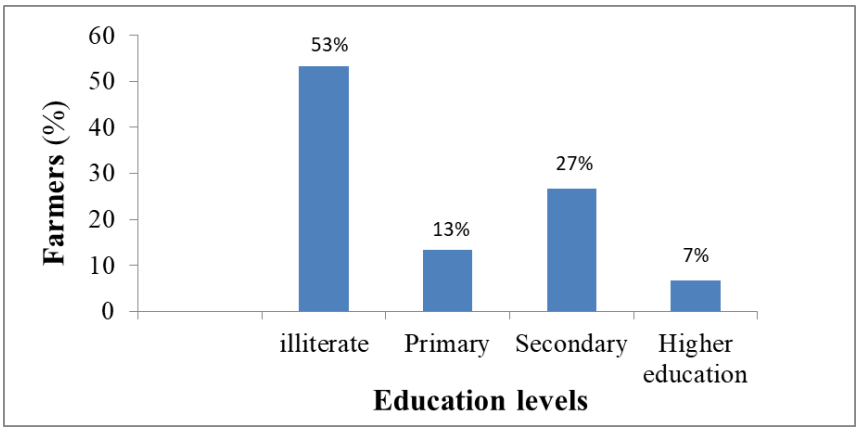

Figure 5. Education level (%) of farmers in the study area.

3. 2. 3. Experience and training on prawn farming

By interviewing with the farmers, it was found that majority of the them in Kachua upazila have not obtained necessary training on improved prawn culture from upazila or district level. They further reported that they gained most of the farming knowledge from ancestors,

neighbors or friends. During the present investigation, it was found that 20% farmers had taken training from GO and NGOs and 80% farmers did not received training (Figure 6a). Among these 80% farmers, 67% farmers gained experience from friends and neighbours, while, 33% farmers gained experience from self–study (Figure 6b). Ahmed (2001) observed that 92% farmers gained experience from friends and neighbors, and 8% farmers received formal training at Kachua upazila in Bagerhat (Ahmed, 2001).

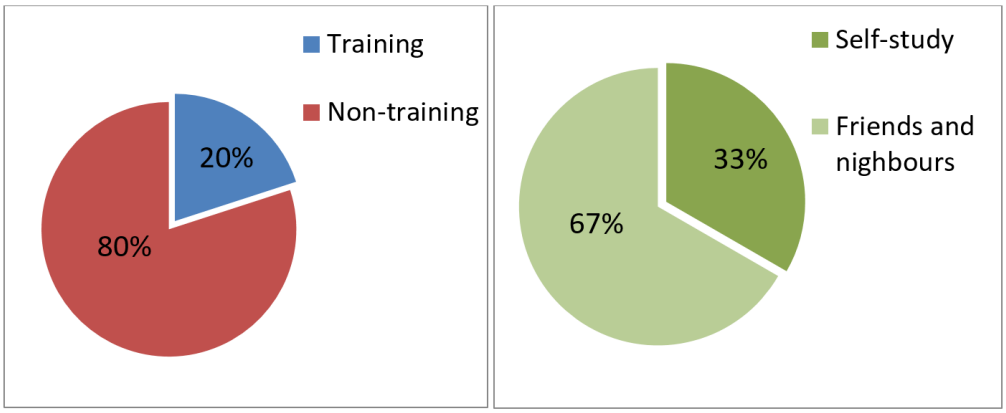

Figure 6. a) Training received by the farmers on prawn farming; b) Experience on prawn farming acquired by the farmers.

3. 3. Culture Seasons

The peak season of prawn farming in rice fields was observed from March to January. Shrimp/prawn post–larvae were stocked when they became available in March to June and were harvested after the culture period of 6 to 9 months, generally from November to December. Shrimp post–larvae were stocked when they became available in March to June but assured that shrimp post–larvae were released in the canal or top in gher, following 3 steps after every 2 months of interval. Shrimps were harvested generally after a culture period of 3 to 4 months. Fish were also stocked with prawn in May to June, but were harvested throughout the year. The prawn culture period was limited to only one crop annually. Boro rice was grown in the dry season from December to April, being transplanted in December–January and harvested in April–May. The details of the gher farming are shown in Figure 7.

Gher farming Activities	**Months**											
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**July**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Crop Cultivation												
Gher repairing												
Prawn/shrimp stocking												
Shrimp/Prawn rearing												
Prawn harvesting												
Seasonal vegetation												

Figure 7. Time schedule of integrated farming in gher systems.

3. 4. Culture methods

3. 4. 1. Rotational culture of crops in gher

There were two ways of integrated prawn/shrimp–paddy farming system like prawn/shrimp culture with paddy at the same time in the same land, and prawn/shrimp culture after paddy cultivation in the same land. In the selected area, prawn/shrimp were cultured after paddy. Prawn/shrimp were also cultured in the paddy fields using polyculture method. Polyculture was done using commercial species such as – prawn, shrimp; and non-commercial species of white fish, which were selected for culture based on farmers choices (Table 2).

Table 2. Polyculture of commercial species (shrimp and prawn) with non–commercial species of white fishes in the integrated gher farming system.

Types of species	common name	Scientific name
Commercial species	Bagda	*Penaeus monodon*
	Golda	*Macrobrachium rosenbergii*
White fishes species	Silver carp	*Hypophthamicthys molitix*
	Catla	*Catla catla*
	Rui	*Labeo rohita*
	Thi sarpunti	*Barbanemous gonionotus*
	Grass carp	*Ctenopharyngodon idella*
	Common carp	*Cyprinus carpio*
Unwanted fish species	Tengra	*Mystus tengara*
	Bele	*Glossogobius Giuris*
	Tilapia	*Orechromis niloticus*
	Punti	*Puntius sophore*
	Shol	*Channa striata*
	Taki	*Channa punctata*

3. 5. Farming technology

3. 5. 1. pre–stocking and post–stocking management

In the study area, the average land size of the integrated farms was 0.96 acre or 0.39 ha and the total sample size was 15 farmers. The detailed characteristics information of the farming technology are summarized in Table 3.

Table 3. Information on the collection of shrimp/prawn PL, its origin and farming system by the farmers of study area.

Characteristics	Category	Sample = 15	%
Origin of PL collection	Natural	0	0.00
	Hatchery	2	13.33
	Both	13	86.67
Places of PL collection	Hatchery	0	0.00
	Aratder	12	80.00
	Depot	3	20.00
Transporting system of PL to the farmer	Aluminium pot	0	0.00
	Cork-sheet box	0	0.00
	Both	15	100.00
Removing of muds	Yes	15	100.00
	No	0	0.00
Drying	Yes	5	33.33
	No	10	66.67
Application of fertilizers	Yes	3	20.00
	No	12	80.00
Application of lime	Yes	15	100.00
	No	0	0.00
Source of water	Canal	15	100.00
	Ground water	0	0.00
PL releasing technique	Direct	6	40.00
	After acclimation	9	60.00
Use of chemical for moulting	Yes	7	46.67
	No	8	53.33
Disease problems	Yes	11	73.33
	No	4	26.67

In the study area, pre–stocking management included the removal of excessive muds, repairing of dikes, drying of farms, removal of aquatic weeds, and application of lime and fertilization before stocking. Almost all farmers (100%) removed excessive muds with the help of water pump from the bottom of the canal and paddy land after harvesting of the stock. However, 66.67% farmers did not dry their gher farms, while 33.33% had sun–dried their gher within 2–3 days. Majority of the farmers (80.00%) did not use fertilizers in the prawn/shrimp ghers before stocking because they used fertilizer for the cultivation of boro–paddy only. Nevertheless, the majority of the farmers in the research area were poor so they could not use fertilizer in their farms. The farmers repaired their farm dikes with the help of labours. About 20.00% farms had good dikes, whereas 53.33% farms had moderate and 26.67% farms had damaged dikes. About 93.33% farmers controlled aquatic weeds manually and around 80.00% peoples removed predatory species using netting method. Pre–stocking management was usually started from January to May, when they cultivated prawn/shrimp with paddy side by side following pre–stocking management. Farmers usually stocked their farm with wild post–larvae (PL) rather than hatchery–produced stock because they thought survival of wild PL was

higher than that of hatchery produced PL. Farmers collected prawn/shrimp PL, which were came from Patelghata, Joykoli, Fakirhat etc. Among the farmers, 13.33% of them collected PL only from hatchery, whereas 86.67% farmers had collected PL from both the natural and hatchery sources. About 80.00% farmers had collected PL from aratder, while 20% farmers collected from depot. Around 60.00% farmers followed the PL releasing technique after acclimatization with gher but 40.00% farmers did not do so. In total, 73.33% farmers found some occurrence of disease problems. Lime and zeolite were used to clean water in the gher where there have been old fish to maintain fish stock and proper aquatic environment. In the study area, 100.00% farmers used lime in their gher farms but 46.67% farmers used chemicals for moulting and 53.33% farmers did not use chemicals for moulting in their gher farms. Organic fertilizer was mainly cow–dung, and inorganic was urea and triple super phosphate (TSP). Majority of the farmers applied cow–dung in their ghers because it is relatively available and cheap. In the study area, 20.00% farmers used fertilizers in their ghers, while 80.00% farmers did not use fertilizers at all. During the survey, it was found that farmers used different types of chemicals such as lime (35%), zeolite (35%), oxy-tablet (12%), murate of potash (7%), urea (5%), salt (5%) and diesel (2%) for eradication of diseases and protection of environment in their gher farms. However, when shrimp/prawn were attacked by virus, all stocks were then destroyed from their ghers.

3. 5. 2. Depth of water level of pond

The details of depth of the canal/top water and their percent values under different depths are summarized in Table 4. The depth of pond in the canal/top water level was found to be 4–6 ft during winter season and 9–12 ft during rainy season. Majority (80%) of the depth of water level in gher farm was 5ft, 13% was 6 ft and 6.67% was 4 ft in winter season and the depth of water level in 40%, 20%, 33% and 7 % in gher farms was 10 ft, 9 ft, 11 ft, and 7 ft in rainy season in this order.

Table 4. Depth of canal/top water level in the pond in integrated gher farm.

Depth of canal/top water level in gher during winter season (ft)	Proportion (%)	Depth of canal/top water level in gher during rainy season (ft)	Proportion (%)
4	7	9	33
5	80	10	40
6	13	11	20
		12	7

3. 5. 3. Stocking density

Stocking density depends on the size of fry. No standard stocking densities of shrimp were followed by the respondents in the study area. As a result stocking density was varied from farmer to farmer. In this study, average stocking density of shrimp was found to be 31,191 PL/ha (Table 5). Thangadurai (1991) also reported the density of 30,000 PL/ha in the same region. On the other hand, McGinty and Alston (1993) advised 25,000 PL/ha of stocking density

for shrimp farming. During the field survey, average stocking density of prawn PL (post larvae) was found to be 12,686 PL/ha with a range from 5,489 to 36,324. Similar stocking densities of prawn from 10,000 to 30,000 PL/ha were also reported by Rosenberry (1992) and Muir (2003). According to Ahmed et al. (2008), prawn farmers practiced a stocking density of 19,830–21,155 PL/ha. Average stocking densities of PL varied in extensive, improved extensive and semi–intensive culture systems at 9,609, 11,502 and 22,847 PL/ha, respectively (Akter et al., 2014). Alam et al. (2007), and Barmon et al. (2007) also reported the average stocking densities of prawn to be 1,500–15,000 PL/ha and 7,411–39,520 PL/ha, respectively. The average stocking densities were found to be 30,000/ha (2.5 PL/m^2) in semi–intensive farming, 20,000/ha (2.0 PL/m^2) in improved extensive and 15,000/ha (1.5 PL/m^2) in extensive systems (Ahmed et al., 2013).

Table 5. Stocking density of shrimp and prawn fry in the study area of gher farms

Types of fry	Average stocking density of PL (number/ha)			
	Minimum	Maximum	Mean	Standard deviation
Shrimp fry	10,978	54,485	31,191	12,569
Prawn fry	5,489	36,324	12,686	7,925

3. 5. 4. Feeding

After stocking the gher farms with PL, the farmers used the supplementary feed, comprising of fish meal (20%), soyabean (15%), dal (13%), rice bran (6%), corn (11%), flour (9%), cooked rice (20%), and sabu (7%). Most of the farmers said that soyabean is good for growth performances of shrimp/prawn. During the nursery phase, PL was fed with the powder of fish meal, flour etc. for about 1 month and then with supplementary feed (Figure 8).

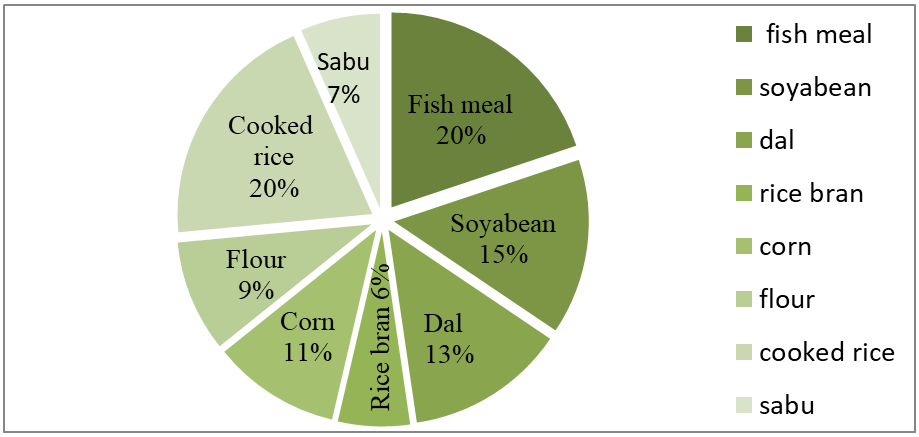

Figure 8. Composition of supplementary feed used by the farmers in the gher system.

3. 5. 5. Average production of prawn, shrimp and white fish

In the study area, the peak season of prawn harvesting and marketing was from November to January and around 90% farmer harvested from November to December. Harvesting of prawn was started after 6–8 months from stocking while shrimp was harvested after 4 months of stocking. During this time, about 80% of the stock of shrimp/prawn was sold and the

remaining 20% was kept for growth in the next season. Harvesting of white fish was started after 4–5 months of stocking. In the present study area, the average annual yields of shrimp, prawn and white fishes were observed to be 130.97, 235.62 and 272.35 kg/ha, respectively (Table 6). Chandra et al. (2010) reported in their study area that the average annual yields of shrimp, prawn and white fishes were 350.37, 428.08 and 172.52 kg/ha in Kachua upazila of Bagerhat.

Table 6. Average production of shrimp, prawn and white fish in the study farm

Types	Average production (kg/ha)			
	Mininmum	Maximum	Mean	Standard deviation
Shrimp production	69.71	224.55	130.97	47.01
Prawn production	112.27	449.09	235.62	116.44
White fish production	74.1	598.79	272.35	163.71

3. 5. 6. Problems faced by the farmers during farming system

Majority of the respondents informed that there were some problems encountered in the study area but some of them claimed to face several problems related to financial (37%), disease (32%), theft (21%) and land (16%), while only 18% farmers did not find in any problems (Figure 9). Nevertheless, among all the problems identified, lack of money was the most important problem in the gher farming system. Mahamud (1998) and Das (1993) however, mentioned about the problems of shrimp farms, which were: the lack of credit, lack of scientific methods and poor quality PL. Al–Mamun et al. (2020) found the problems faced by the shrimp farmers were: high mortality, poor water quality and low market price.

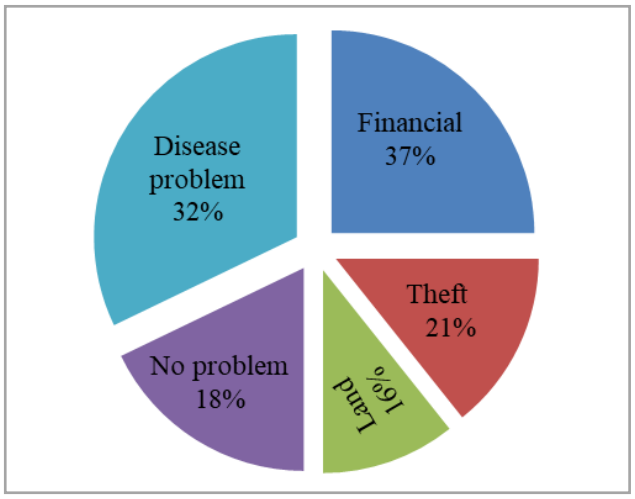

Figure 9. Problems encountered by the farmers during gher farming in the study area.

3. 6. Rice production

The yield of paddy in the study area per year was found to be 8,034 kg/ha, whereas the average annual rice yield was estimated at 2,352 kg/ha under Kachua upazila in Bagerhat district (Ahmed, 2001), which was much lower than the present study. Hasanuzzaman et al. (2011) reported in their study that the yield of Aman and Boro rice was found to be

3,155.48±397.33 kg/ha and 4,778.54±389.37 kg/ha per year, respectively in Shyamnagar upazilla, Satkhira, Bangladesh.

3. 7. Production cost and returns

Cost-benefit analysis in a one cycle production from 1 ha or 247 decimals gher is shown in this section. Although there were broad similarities across the study area, results showed that different zones had different cost structures, depending on the availability and quality of inputs, gher management and other factors. In the present study, culture of shrimp + prawn + white fish + paddy was practiced in gher farming system. During this survey, the total production cost was found to be 3,47,965.60 BDT/ha (Table 7) including all the farm management costs along with crops and the total return was calculated as 6,60,043.55 BDT/ha (Table 8). Accordingly, the net benefit was calculated as 3,12,077.94 BDT/ha and the cost-benefit ratio was figured as 1.0:1.9 (Table 9). Ahmed (2001) reported that the total production cost and total income (Tk./ha) of gher farming at Kachua in Bagerhat zone was 64,049 BDT/ha and 1,37,950 BDT/ha, where the net return and cost–benefit ratio was 73,900 BDT/ha and 1.0:1.2, respectively. In recent years, the growing of vegetables on gher dikes is more popular in this region because vegetables are cultivating for commercial purpose. Culture of vegetables on gher dikes, requires low investment but gets good profits. In the present study, the average cost of vegetables and fruits cultivation was 65,015.67 BDT/ha and the average income was 2,13,053.32 BDT/ha with a cost–benefit ratio of 1.0:3.3, which were similar to the findings of Shah et al. (2008), who reported that the average cost of vegetables was 260 BDT/100 decimal and the average income was 900 BDT/100 decimal, where cost–benefit ratio of vegetables was 1.0:3.5 in the integrated prawn–agriculture gher farming in Bagerhat district.

Table 7. Annual production costs of the integrated gher farming system (shrimp + prawn + white fish + paddy + vegetables and fruits)

Cost items	Average cost (BDT/ha)	Range from minimum to maximum (BDT/ha)	± SD
Fertilizer (paddy)	37,663.36	24,899.19–54,485.29	9,735.27
Water (paddy)	13,234.53	2,987.90–22,454.55	6,282.16
Harvesting (paddy)	31,630.77	14,820.00–97,303.03	21,680.08
Dyke	28,130.55	7,967.74–1,69,000.00	43,111.67
Water (Fish)	11,644.12	3,983.87–22,454.55	5,171.86
Feed	66,055.20	38,422.22–1,08,970.59	22,532.59
Lime and fertilizer (Fish)	14,290.56	7,967.74–24,395.06	4,606.68
Shrimp fry	30,957.80	16,466.67–52,393.94	11,280.65
Prawn fry	36,222.20	9,730.30–90,808.82	25,967.50
White fish fry	13,120.86	5,239.39–33,378.38	9,245.40
Vegetables and fruits	65,015.67	2,744.44–1,72,900.00	55,725.17
Total average cost	**3,47,965.60**		

SD = Standard Deviation; Average = Mean

Table 8. Annual income from the integrated gher farming system (shrimp + prawn + white fish + paddy + vegetables and fruits)

Income items	Average income (BDT/ha)	Range from minimum to maximum (BDT/ha)	± SD
Paddy	1,30,238.78	82,992.00–2,13,582.35	31,143.46
Total vegetable and fruit	2,13,053.32	43,911.11–4,44,600.00	1,40,772.45
Shrimp	83,283.46	53,782.26–1,19,516.13	23,997.61
Prawn	1,70,741.29	44,909.09–3,63,235.29	92,624.88
White fish	62,727.70	14,820.00–1,57,181.82	44,140.79
Total average income	**6,60,043.55**		

Table 9. Total average net–benefit and cost–benefit ratio obtained from the integrated gher farming system (shrimp + prawn + white fish + paddy + vegetables and fruits)

Items	BDT/ha
Total average income (BDT/ha)	6,60,043.55
Total average cost (BDT/ha)	3,47,965.60
Net–benefit	**3,12,077.95**
Cost–benefit ratio	**1.0:1.9**

In present study, the average cost of only integrated gher farming system (shrimp + prawn + white fish + paddy + vegetables and fruits) without paddy was 2,65,436.96 BDT/ha (Table 10) with an average annual income of 5,29,805.77 BDT/ha (Table 11). Net return and cost-benefit ratio from the only integrated gher farming system without paddy (shrimp + prawn + white fish + vegetables and fruits) was 2,64,368.81 BDT/ha and 1.0:2.0 (Table 12) at Kachua upazila in Bagerhat district, which was nearly similar to the findings of Shah et al. (2008), who found that the average cost and income of only integrated gher farming system (prawn + white fish + vegetables and fruits) without paddy was 44,180 BDT/100 decimal and 1,04,850 BDT/100 decimal, respectively where the cost-benefit ratio was obtained to be 1.0:2.4 at Fakirhat upazila in Bagerhat district.

Table 10. Annual production costs of the integrated gher farming system (shrimp + prawn + white fish + vegetables and fruits) without paddy

Cost items	Cost (BDT/ha)	Range from minimum to maximum (BDT/ha)	± SD
Dyke	2,8,130.55	7,967.74–1,69,000.00	43,111.67
Water	1,1,644.12	3,983.87–22,454.55	51,71.86
Feed	6,6,055.20	38,422.22–1,08,970.59	22,532.59
Lime and fertilizer	1,4,290.56	7,967.74–24,395.06	4,606.68
Shrimp fry	3,0,957.80	16,466.67–52,393.94	11,280.65
Prawn fry	3,6,222.20	9,730.30–90,808.82	25,967.50
white fish fry	1,3,120.86	5,239.39–33,378.38	9,245.40
Vegetables and fruits	65,015.67	2,744.44–1,72,900.00	55,725.17
Total average cost	**2,65,436.96**		

SD = Standard Deviation; Average = Mean

Table 11. Annual income from the integrated gher farming system (shrimp + prawn + white fish + vegetables and fruits) without paddy

Income items	Average income (BDT/ha)	Range from minimum to maximum (BDT/ha)	± SD
Shrimp	83,283.46	5,3,782.26–1,19,516.13	23,997.61
Prawn	1,70,741.29	4,4,909.09–3,63,235.00	92,624.88
White fish	62,727.70	1,4,820.00–1,57,181.82	44,140.79
Total vegetable and fruit	2,13,053.32	10,977.78–4,26,913.58	1,40,772.45
Total average income	**5,29,805.77**		

Table 12. Total average net–benefit and cost–benefit ratio obtained from the integrated gher farming system without paddy (shrimp + prawn + white fish + vegetables and fruits)

Iteams	BDT/ha
Total average income (BDT/ha)	5,29,805.77
Total average cost (BDT/ha)	2,65,436.96
Net–benefit	**2,64,368.81**
Cost–benefit ratio	**1.0:2.0**

4 Conclusion

Integrated gher farming has been considered to be highly profitable in the study area of Bagerhat district as this area has favorable resources and good agro–climatic condition. Now–a–days, integrated farming system is a common practice in Bangladesh because it is not only saves space but also leads a high yield and helps to enhance farmers economic conditions in a significant manner. For this, farmers are getting interested to this integrated system for earning high profits. Integrated gher farming plays an important role in the socio–economic condition of the people of Dhoopakhali union at Kachua upazila in Bagerhat district. People of the study area are solely engaged in shrimp/prawn farming due to its higher market value. Farmers are mainly practiced rotational crop and prawn/shrimp culture at their ghers. However, they need enough credit facilities and proper training on good aquaculture practices for understanding the shrimp/prawn culture systems as well as the improvement of the integrated gher farming to a greater extent.

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Conflict of interests

The authors hereby declare that there is no conflict of interests regarding the publication of this manuscript.

References

Ahmed, N. (2001). Socio-economic aspects of freshwater prawn culture development in Bangladesh. PhD Thesis, Institute of Aquaculture, University of Stirling, Scotland, UK. http://hdl.handle.net/1893/1497

Ahmed, N., Demaine, H., & Muir, J. F. (2008). Freshwater prawn farming in Bangladesh: history, present status and future prospects. *Aquaculture Research*, *39*(8), 806-819. https://doi.org/10.1111/j.1365-2109.2008.01931.x

Ahmed, N., Allison, E. H., & Muir, J. F. (2010). Rice fields to prawn farms: a blue revolution in southwest Bangladesh? *Aquaculture International*, *18*(4), 555-574. https://doi.org/10.1007%2Fs10499-009-9276-0

Ahmed, N., Ambrogi, A. O. & Muir, J. F. (2013). The impact of climate change on prawn post larvae fishing in coastal Bangladesh: socioeconomic and ecological perspectives. *Marine Policy*, *39*, 224-233. https://doi.org/10.1016/j.marpol.2012.10.008

Al Mamun, M. A. R., Ara, M. G., Azad, K. N., Fatema, J., Ahmed, Z. F., & Fatema, M. K. (2020). Present status of shrimp farming in Satkhira, a southwestern district of Bangladesh. *Research in Agriculture Livestock and Fisheries*, *7*(2), 311-320. https://doi.org/10.3329/ralf.v7i2.48874

Abedin, J., Islam, S., Chandra, G., & Kabir, Q. (2001). Freshwater Prawn Subsector Study in Bangladesh. *CAREGOLDA project, Bangladesh*.

Akter, S., Hossain, M. M. M., Bappa, S. B., Dey, B. K., & Zaman, M. F. U. (2014). Farming of giant freshwater prawn (*Macrobrachium rosenbergii*) in Bagerhat, Bangladesh, *Journal of Fisheries*, *2*(3), 187-194. https://dx.doi.org/10.17017/jfish.v2i3.2014.38

Alam, M. J., Islam, M. S., Pal, H. K., & Karim, M. (2007). Year-round and rotational freshwater prawn, *Macrobrachium rosenbergii* and paddy farming: size quality, production and economics. *Bangladesh Journal of Fisheries Research*, *11*(1), 75-92.

Barmon, B. K., Kondo, T., & Osanami, F. (2007). *Agricultural technology adoption and land productivity: evidence from the rice-prawn gher farming system in Bangladesh* (No. 689-2016-47254).

Chandra, K. J., Chowdhury, A. R., & Das, D. R. (2010). Shrimp culture practices at farmers level in Bagerhat district. *Progressive Agriculture*, *21*(1–2): 173-185.

Das, L. (1993). *Economics of shrimp culture in some selected areas of Bangladesh* (Doctoral dissertation, MS Thesis. Submitted to the Department of Agricultural Economics, Bangladesh Agricultural University, Mymensingh), 63 p.

DoF. (2018). Yearbook of fisheries statistics of Bangladesh, 2017–18. Fisheries Resources Survey System (FRSS), Department of Fisheries (DoF). Ministry of Fisheries and Livestock, Bangladesh, *35*, 129 p.

DoF. (2019). Yearbook of Fisheries Statistics of Bangladesh, 2018–19. Fisheries Resources Survey System (FRSS), Department of Fisheries (DoF), Ministry of Fisheries and Livestock, Bangladesh, *36*, 135 p.

FAO. (2019). FAO Yearbook. Fishery and Aquaculture Statistics 2017/FAO annuaire, 109 p.

Hasanuzzaman, A. M., Rahman, M. A., & Islam, S. S. (2011). Practice and economics of freshwater prawn farming in seasonally saline rice field in Bangladesh. *Mesopotamian Journal of Marine Sciences*, *26*(1), 69-78.

Kamp, K., & Brand, E. (1994). Greater options for local development through Aquaculture. *CARE GOLDA Project, Dhaka, Bangladesh*, 56 p.

Mazid, M. A. (1994). Evaluation of prawn farming on socio–economic aspects. *Fisheries Research Institute, Mymensingh, Bangladesh*, 39 p.

McGinty, A. S., & Alston, D. E. (1993). Multiple stocking and multiple harvesting of Macrobrachium rosenbergii and tilapia. *From discovery to commercialization. Oost.-Bel. Euro. Aquaculture Soc*, *19*, 148.

Muir, J. F. (2003). The future for fisheries: economic performance. *Fisheries sector review and future development study. Commissioned with the association of the World Bank, DANIDA, USAID, FAO, DFID with the cooperation of the Bangladesh Ministry of Fisheries and Livestock and the Department of Fisheries, Dhaka*, 172.

Mitro, S. H. E. A. T. U., Khatun, R., & Baten, M. A. (2014). Socio-economic and environmental impacts of shrimp culture in some selected areas of Bagerhat District. *Journal of Environmental Science and Natural Resources*, *7*(1), 265-269.

Mahmud, H. (1998). *A comparative analysis of rice–cum–prawn and fish–cum–prawn culture in some selected areas under sadar of Gopalgang district. An M. Sc.* (Doctoral dissertation, thesis

submitted to the Department of Agricultural Economics, Bangladesh Agricultural University, Mymensingh), 67 p.

Rosenberry, B. (1992). The post–larvae fishermen of Bangladesh. *World Shrimp Farming*, *17*(3), 7-9.

Rutherford, S. (1994). An investigation of how freshwater prawn cultivation is financed. *Bangladesh Aquaculture and Fisheries Resource Unit (BAFRU), Dhaka*, 1212.

Shah, M. S., Sayeed, M. A. B., Ahmed, M. L., Hossain, M. A., Talukder, B. A., & Ghosh, A. K. (2008). Integrated prawn–agriculture gher farming system in Bagerhat, Bangladesh. *Khulna University Studies*, *9*(1), 71-78. https://doi.org/10.53808/KUS.2008.9.1.0809-L

Thangadurai, A. J. (1991). Experimental culture of freshwater prawn, *Macrobrachium rosenbergii* in ponds. In *Proceedings of National Symposium on New Horizons in Freshwater Aquaculture. Central Institute of Freshwater Aquaculture, Bhubaneswar, Orissa, India* (pp. 7-8).

Williams, D. & Khan, N. (2001). Freshwater prawn gher farming Systems: indigenous technology developed in southwest Bangladesh. *CARE GOLDA Project, CARE Bangladesh, Dhaka*.