Research in
ISSN : P-2409-0603, E-2409-9325
AGRICULTURE, LIVESTOCK and FISHERIES
An Open Access Peer-Reviewed International Journal

Article Code: 514/2025/RALF
Article Type: Research Article

Res. Agric. Livest. Fish.
Vol. 12, No. 3, December 2025: 529-546.

Fish Farming Practices in Rice Environments of Bagerhat District in Bangladesh

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ARTICLE INFO

Received
25 November 2025

Revised
15 December 2025

Accepted
18 December 2025

Key words:

Rice-cum-fish culture
Economic analysis
Fish-shrimp production
Farming constraints

ABSTRACT

This study was conducted to examine fish farming practices within rice-based ecosystems, assess the current status and economic performance of rice-cum-fish culture, and identify key constraints faced by farmers practicing fish culture in rice environments. Primary data on rice-cum-fish farming were collected from fourteen villages across three upazilas of Bagerhat district, Bangladesh, through interviews with 60 randomly selected farmers. Data was analyzed using tabular methods and Microsoft Excel functions. The findings revealed that the per-hectare cost of material inputs for rice-cum-fish culture was Tk 115,590, while the per-hectare cost of human labor was Tk 16,240, resulting in a total production cost of Tk 131,830 per hectare. Average rice yields were 8,648 kg/ha for Boro and 9,882 kg/ha for Aman rice, indicating higher productivity of Aman rice in the study area. In addition, average fish and shrimp production under rice-cum-fish systems were 494.18 ± 40.97 kg/ha and 439.79 ± 30.26 kg/ha, respectively. Major constraints identified by farmers included limited scientific knowledge, unavailability of quality fingerlings, inadequate investment capital, and disease incidence in fish and shrimp. Although training programs provided by government and non-government organizations have contributed to addressing some of these challenges, further efforts are required. The study recommends wider dissemination of improved rice-cum-fish culture techniques and removal of existing constraints to enhance rice and fish productivity as well as farm income.

To cite this article: Devnath S., K. Munni, M. A. Razzak and S. M. T. I. Shourav, 2025. Fish farming practices in rice environments of Bagerhat district in Bangladesh. Res. Agric. Livest. Fish. 12(3): 529-546.

DOI: https://doi.org/10.3329/ralf.v12i3.86385

Introduction

Bangladesh is among the world's leading producers in the fisheries industry. This industry contributes significantly to food security by offering safe, high-quality animal protein. The fishing industry is crucial to Bangladesh's rural life, economy, and nutrition. More than 50.18 lakh metric tons of fish from both marine and inland sources were produced in the fiscal year 2023–2024, contributing 22.26% to the agricultural sector and 2.53% to the national GDP (DoF, 2024; BSS, 2024). Approximately 20 million people, including 1.4 million women, rely on fish for their livelihoods, making it the primary source of animal protein and accounting for roughly 60% of the country's protein intake (DoF, 2024; BSS, 2024). In Bangladesh, aquaculture production is the fifth highest globally and the second most in inland capture fisheries (FAO, 2024). The export of fish and fishery products from Bangladesh in the fiscal year 2023-24 totaled approximately 77,000 MT, or 4,531.86 crore (Taka).

A rice-fish farming technique where the raising of fish is done within rice paddy fields. This system offers advantages such as enhanced nutrient recycling, natural pest management, improved soil health, and increased overall productivity of the agricultural system (Halwart & Gupta, 2004). Rice-fish farming has been addressed in this broader context as an environmentally friendly and viable means of production. According to some studies, these rice-cum-fish systems have the potential to increase rice yields by 10-15% while also generating additional fish harvests, hence improving food security and rural incomes (FAO, 2021). Bangladesh has vast potential for rice-fish integration, as evidenced by its 2.68 million hectares of intermittently viable inundated rice fields (DoF, 2022). Empirical studies show that integrated systems yield 6.7-7.5 tons/ha of rice along with 0.75-2.25 tons/ha of fish, significantly enhancing land productivity (FAO, 2015). It has been discovered that introducing fish to rice fields can increase the rice yield as they consume harmful insects, pests, and weeds (Coche, 1967).

Bagerhat, located on the southwest coast of the nation, is well-known for its rice-fish farming systems, notably those based on gher technology. Farmers who use rice-fish integrated farming can increase yields and profitability when compared to traditional rice cultivation. However, these methods remain underused due to a lack of technical expertise, high input costs, limited access to high-quality seeds, and environmental restrictions such as annual floods and salt intrusion (Kabir, 2016). Cultivation of rice fish is feasible, even though Bangladeshi research is mostly focused on national or regional perspectives. Little attention has been paid to the tactics, financial successes, and difficulties faced by farmers in the Bagerhat region; even less is known about how climatic unpredictability impacts the growth of integrated systems. In order to enhance rice and fish farming in Bangladesh, the goal is to assess how well resources are allocated in integrated agricultural systems, identify significant implementation obstacles, and develop appropriate policies and strategies.

Materials and Methods

Selection of the study area

One of the most crucial first steps in the research process is selecting the subject area. In the Bagerhat district, where rice-fish integrated farming is prevalent, the study was conducted in three upazilas: Bagerhat Sadar, Morrelganj, and Kachua. Several villages were specifically chosen because of the high frequency of rice-fish culture and farmer collaboration, including Boidhopur, Dobharia, Charkathi, Narendropur, Vandarkhola, Srirampur, Solarkola, Raripara, Kakarbil, Moshni, Bolovadropur, Gorpalpur, Protappur, and Kalibunia. Approximately, the district's coordinates are 89°47′–89°53′ E longitude and 22°27′–22°40′ N latitude.

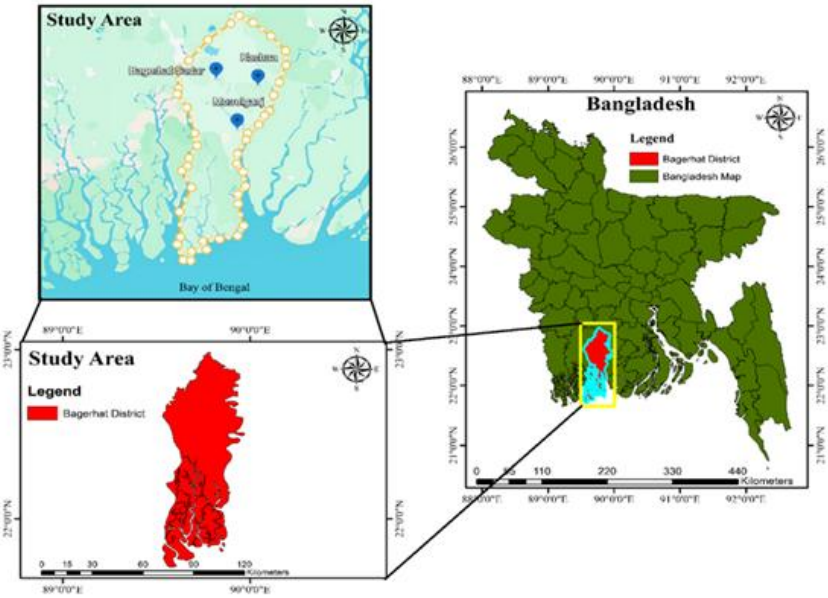

Figure 1. Geographical Location of Selected Study Areas (Bagerhat Sadar, Morrelganj, Kachua Upazilla) of Bagerhat district

Period of the study

The period of data collection mainly depends on the rice and fish cultivation and harvest seasons. In this study, data were collected from July 2016 to April 2017.

Sampling Technique

For this study, we used random sampling methods. We randomly selected 60 rice–fish farmers from the list of farmers who were actively practicing the trade. There were three types of farmers based on the size of their farms: small (1 hectare or less), medium (1.01 to 2 hectares), and large (more than 2 hectares). We were guaranteed a representative sample of the various farm categories in the research area thanks to this method.

Method of Data Collection

Through surveys, farmer interviews, and on-site observations, we collected primary data straight from the field. These covered the farmers' socioeconomic situation, farming methods, input use, production levels, and challenges they face. Secondary data were also examined from journals, official reports (especially from the Department of Fisheries), and other published sources to enhance the study.

Survey Schedule Preparation

Before starting the main survey, we designed a draft questionnaire and tested it with a few farmers. Based on their feedback and advice from subject experts, the questionnaire was refined to ensure the questions were relevant, accurate, and arranged in a logical order. The final version was kept simple and easy to understand so that farmers could respond comfortably.

Editing and Tabulation of Data

The interview schedule was designed to collect information in local units. However, local units were converted later on into standard units. The collected data were carefully edited in order to remove ambiguities and internal inconsistencies. The data were transferred to the master sheet from the interview schedules.

Data Processing and Analysis

Descriptive, tabular, and statistical method was mainly used to analyze the data to arrive at meaningful conclusions. All data were entered in the computer's MS Excel worksheet by the researchers. The data were arranged in a tabular form and were analyzed as per the objectives of the study. Tabular techniques were applied with the help of averages and percentages to show the results comprehensively. Interpretation and discussion of the findings were presented in simple terms.

RESULTS

Socio-Economic Characteristics of the Sample Farmers

Personal and familial traits frequently influence how people behave. The socioeconomic variables affecting farmers' behavior, means of livelihood, and methods of cultivation include age, education, occupation, family size, and land ownership. Data was obtained from respondents, arranged, and examined in order to comprehend these influences. The major socio-economic characteristics of the sample households are presented in the following sections.

Distribution of Sample Farmers

Based on their land ownership, about 60 farmers were separated into three groups. Small farmers were characterized as those with 0.1–1.00 hectares, medium farmers as those having 1.01–2.00 hectares, and large farmers as those with more than 2.01 hectares (Table 01).

Table 1. Distribution of Sample Farmers According to Farm Size

Farm size (ha)	Sample farmers	
	No. of farmers	Percentage
Small (up to 1.00)	34	56.66
Medium (1.01-2.0)	15	25
Large (2.01-above)	11	18.33
Total farms	**60**	**100**

Sample Farmers' Level of Education and Literacy

Each evaluated area has a primary school and a madrasa, alongside high schools available in town. Bagerhat Sadar Upazila has two government colleges; there were two-degree colleges in Kachua, and Morrelganj has one. Education is an integral indicator of societal success and a prerequisite for agricultural and aquaculture progress. It enables farmers to adopt new technology, boost productivity, raise income and savings, and establish a more responsible and progressive approach to managing their households and farms. Table 02 shows the rate of education of the sample farmers.

Table 2. Level of Education of The Sample Farmers

Education level	Farm size					
	Small		Medium		Large	
	No	**%**	**No**	**%**	**No**	**%**
Illiterate	8	23.52	2	8	1	9.09
Primary	12	35.28	6	24	3	27.27
Below S.S.C	6	17.64	9	36	2	18.18
S.S.C	5	14.7	5	20	3	27.27
H.S.C. and above	3	8.82	3	12	2	18.18
Total	**34**	**100**	**25**	**100**	**11**	**100**

Patterns of Sample Farmers' Livelihoods

The study area mainly focuses on agriculture and aquaculture, with support from the local seafood processing sector. Most villagers work in aquaculture and farming; many practices integrated rice-cum-fish and pond fish farming. To increase their income, some households work for the government or in non-farm jobs. Fish farming remains the primary occupation, and farmers seek education and other opportunities to improve their quality of life.

Sample Farmers' Social Behavior and Religion

The majority of people living in the study region are Muslims, while the minority are Hindus. In both village gatherings and farm-related activities, the community is well-known for its warmth and cooperative character.

Agriculture and Rice-Cum-Fish Culture

Low-lying regions are influenced by the Bhairav River, which nourishes the soil with silts rich in nutrients and produces seasonal floods. Clay loam to sandy loam soil types are particularly well-suited for rice-cum-fish integrated farming. Farmers raise aman and boro rice as their primary crops, but fish is their main cash crop and a major source of earnings. During the Rabi season, households produce seasonal crops like garlic, chili, beans, and others for their personal use and sale at markets. Domestic and draft purposes are the main justifications for keeping animals and fowl. Agriculture and aquaculture are often the primary sources of revenue, and farmers are increasingly employing innovative and improved techniques to boost productivity, earnings, and overall economic stability. In this system, fish are cultured in both the Boro and the Aman seasons. This depends on soil quality and the availability of fish fry. Fish cultivation is less in the Boro season compared to the Aman season.

Steps of rice-fish culture followed by farmers in the Boro season which is given below:

Land selection (November)

↓

Soil to be prepared suitably for rice-fish culture/ soil preparation (Dec-Jan)

↓

Production of seeding in the seedbed (4^{th} week Nov-2^{nd} week Dec).

↓

Land preparation for transplantation of seeding (4th week Jan-Mid-Feb)

↓

Seedling transplantation (4th week Jan-Mid-Feb)

↓

Liming 15-20 days after seedling plantation.

↓

Fish stocking 25-30 days after seedling plantation (Last week of Feb to Mid-March)

↓

Application of the Supply feed regularly, 10-15 days after fish stocking

↓

Weeding and Fertilizer Application (20-25 days after seedlings are sown)

↓

Irrigation and Management (regularly after seedlings are sown)

↓

Fish Harvesting (April-May) 1-7 days after paddy harvest

↓

Paddy Harvest (April-May).

Figure 2. Steps of Rice-Fish Culture in The Boro Season

Steps of rice-fish culture followed by farmers in the Aman season, which is given below:

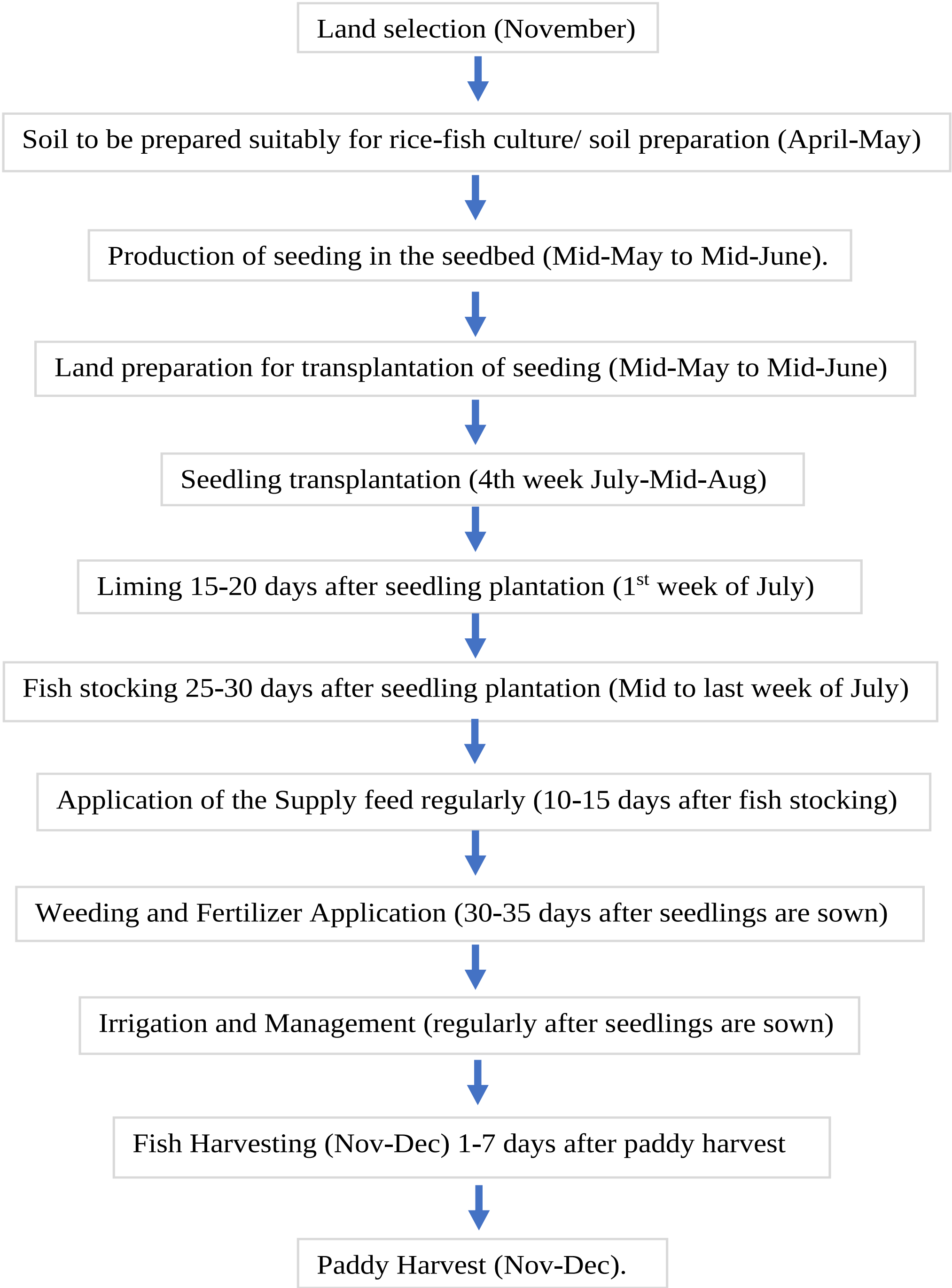

Figure 3. Steps of Rice-Fish Culture in The Aman Season

Rice-Cum-Fish Culture Inputs

Depending on farm size, there were considerable differences in the inputs used in rice-cum-fish farming (Table 03). Small farms used the least rice seed (63 kg/ha), while larger farms used the most (67 kg/ha). The average amount of rice seed planted was between 63 and 67 kg/ha. Most commonly, farmers used chicken droppings, mustard oil cake, and rice bran as fish feed. Large farms used the most rice bran (348 kg/ha), mustard oil cake (128 kg/ha), and chicken droppings (280 kg/ha), while small farms used the least amount. The usage of chemical fertilizers showed similar patterns. Large farms used more urea, MP, TSP, and gypsum than small farms, despite medium farms using the most lime (37 kg/ha) and small farmers applying the least (25 kg/ha). Organic manure, primarily cow dung, was utilized by all agricultural groups. Small farms applied a small amount (3548 kg/ha), while medium farms applied the most (4546 kg/ha), followed by large farms (4172 kg/ha).

Table 3. Level of Input Used Per Hectare in Rice-Cum-Fish Culture

Inputs (kg/ha)		**Farm category**			**All farm (Average)**
		Small	**Medium**	**Large**	
Rice Seed	Rice Seed	63	67	65	64
Fish Feed	Rice Bran	300	348	408	360
	Mustard Oil Cake	95	88	128	90
	Poultry Dropping	110	150	280	180
Fertilizer	Urea	163	167	175	165
	TSP	55	70	89	70
	MP	32	36	59	35
	Gypsum	32	37	48	40
	Lime	25	28	27	26
	Insecticide	380	450	500	443
Cow-dung	Cow-dung	3548	4172	4546	4088

Fish Stocking in Rice-Cum-Fish Culture

In rice-cum-fish farming, seven species are often raised, such as raj puti, mirror carp, silver carp, rui, catla, pangus, tilapia, and shrimp fry (Table 04). The quantity of fish delivered per hectare was influenced by farm size. Compared to medium and large farms, tiny farms maintained fewer fish overall. For example, compared to other species, shrimp fry and Raj puti were sown in far greater quantities. The average number of fish per hectare on all farms was around 1,850 for Raj Puti, 550 for Mirror Carp, 600 for Silver Carp, 270 for Rui, 440 for Catla, 420 for Pangus, 750 for Tilapia, and 20,000 for shrimp fry.

Table 4. Stocking Density of Fish in Rice Environment

Inputs (No./ha)		Farm category			All farm (average)
		Small	Medium	large	
Fingerlings	Raj puti	1528	2224	2124	1850
	Mirror carp	480	632	346	550
	Silver carp	216	412	742	600
	Rui	262	262	394	270
	Catla	232	440	494	440
	Pangus	320	410	480	420
	Tilapia	650	740	800	750
	Shrimp fry	17753±2469	21268±3705	25527±4547	20000±3410

Cost of Material Inputs in Rice-Cum-Fish Culture

The expenditure of cultivating rice-cum-fish (Table 05) was influenced by the farm's size. Small farms paid an average of Tk 115,590 per hectare, medium farms Tk 116,400, and large farms Tk 121,100. Although rice seed was very inexpensive, costing between Tk 1,430 and Tk 1,470 per hectare, the majority of the input expenses were for fish feed and fingerlings. Fingerlings cost between Tk 17,000 and Tk 17,600 per hectare, while fish feed varies from Tk 80,000 to Tk 90,000 per hectare, depending on the size of the farm. The price of the fertilizers, which varied from Tk 190 for gypsum to Tk 3,550 for TSP per acre, was only a small portion of the total cost. At Tk 2,480 to Tk 2,490 per hectare, cow dung, a necessary organic element, is about the same price on all farms. Because most farmers did not have serious pest problems and applied pesticides sparingly, the cost of insecticides was cheap, at around Tk 500–600 per acre.

Table 5. Per-hectare cost (Tk/ha) of material inputs of rice-cum-fish culture

Inputs	Farm category			All farm (average)
	Small	Medium	Large	
Rice seed	1430	1470	1430	1400
Fish seed	17530	17600	17550	17000
Fish feed	80000	85000	90000	85000
Fertilizer	9190	9290	9040	9160
Urea	2600	2550	2400	2510
Tsp	3400	3500	3550	3480
Mp	2000	2050	1900	1980
Gypsum	190	190	190	190
Lime	1000	1000	1000	1000
Insecticide	500	550	600	550
Cow-dung	2483	2490	2490	240
Total Cost	**111133**	**116400**	**121110**	**111550**

Human Labour

Human labor is necessary for almost every step of the production process in rice-cum-fish cultivation, including land preparation, irrigation, weeding, drying, storing, guarding, marketing, and replanting. On average, each acre requires 320 man-days of work, of which around 28% are supplied by family members and the remaining 72% are hired (Table 06). Approximately 32% of family work is contributed by small farmers, who must reduce the cost of hired labor due to their limited resources. Large farmers, on the other hand, are wealthier and depend on hired labor for around 73% of their work, contributing less family labor themselves. All things considered; medium-sized farms use the greatest work when compared to small farms. For the support of advanced technology, human labour utilization is decreasing day by day.

Table 6. Operation-wise Human Labour Utilization in Rice-Cum-Fish Culture (Man-day/ha)

Operations	**Labour type**	**Farm category**			**All farm (average)**
		Small	**Medium**	**Large**	
Land Preparation	Family	12	10	08	10
	Hired	48	54	58	53
	Total	60	64	66	63
	Family	16	12	10	13
Transplanting	Hired	40	52	48	46
	Total	56	64	58	59
	Family	12	12	08	10
Weeding	Hired	26	38	32	32
	Total	38	50	40	42
Insecticide and Fertilizing	Family	10	10	14	11
	Hired	22	30	26	26
	Total	32	40	40	37
Harvesting and Threshing	Family	20	18	18	18
	Hired	36	44	36	38
	Total	56	62	54	56
Drying and Storing	Family	14	14	14	12
	Hired	24	20	22	22
	Total	38	34	36	34
	Family	08	08	08	08
Catching Fish	Hired	14	16		
	Total	22	24		
	Family	06	06	06	06
Marketing	Hired	-	-	-	-
	Total	06	06	06	06
	Family	98 (31.32)	90 (26.79)	86 (26.54)	90 (28.13)
Grand Total	Hired	210 (68.18)	246 (73.21)	238 (73.46)	230 (71.87)
	Total	308 (100)	336 (100)	324 (100)	320 (100)

Cost of Human Labour

It is visualized from (Table 07) that in rice-cum fish culture per-hectare cost of human labour was 15440 Tk for small farms, TK 17575 for medium farms, TK 16210 for large farms, and 16240 Tk for all farms. On average, the highest labour cost (3300 Tk/ha) was needed for land preparation, as the labour needed for border making, trench making, canal digging, drain making, and ditch making were included under land preparation. The lowest labour cost (350 Tk/ha) was needed for the marketing activity. In marketing, no hired labour cost was needed.

Table 7. Per-Hectare Cost of Human Labour (Tk/Ha) in Rice-Cum-Fish Culture

Operations	Labour type	Farm category			All farm (average)
		Small	Medium	Large	
	Family	720	525	450	550
Land Preparation	Hired	2640	2750	2870	2750
	Total	3360	3275	3320	3300
	Family	820	640	520	650
Transplanting	Hired	2200	2860	2640	2540
	Total	3020	3500	3160	3190
	Family	660	660	440	570
Weeding	Hired	1430	2090	1630	1650
	Total	2090	2750	2070	2220
Insecticide and Fertilizing	Family	520	520	750	550
	Hired	1200	1600	1400	1400
	Total	1720	2120	2150	1950
Harvesting and Threshing	Family	980	850	850	850
	Hired	1520	2200	1640	1550
	Total	2500	3050	2490	2400
Drying and Storing	Family	650	650	650	650
	Hired	1200	1000	1100	1000
	Total	1850	1650	1750	1650
	Family	440	440	440	440
Catching Fish	Hired	770	440	480	560
	Total	1210	880	920	1000
	Family	350	350	350	350
Marketing	Hired	-	-	-	-
	Total	350	350	350	350
	Family	4480	4635	4450	4790
Grand Total	Hired	10960	12940	11760	11450
	Total	15440	17575	16210	16240

Cultured Rice Species and Production of Rice

Farmers cultivated Boro and Aman, both rice species, in the Rice cum fish environment of these areas. They mainly cultured these species of Boro (BR11, BR14, BR-3, BR-16, BR-20, BR-20, BR-26, BR-27, BR-28). The culture period of the Boro was January to April. Farmers harvest Boro in April or May. The production of Boro is 8648 Kg/ha. The culture period of Aman was from July to November. They harvest Aman in November or December. The production of Aman is 9882 kg/ha.

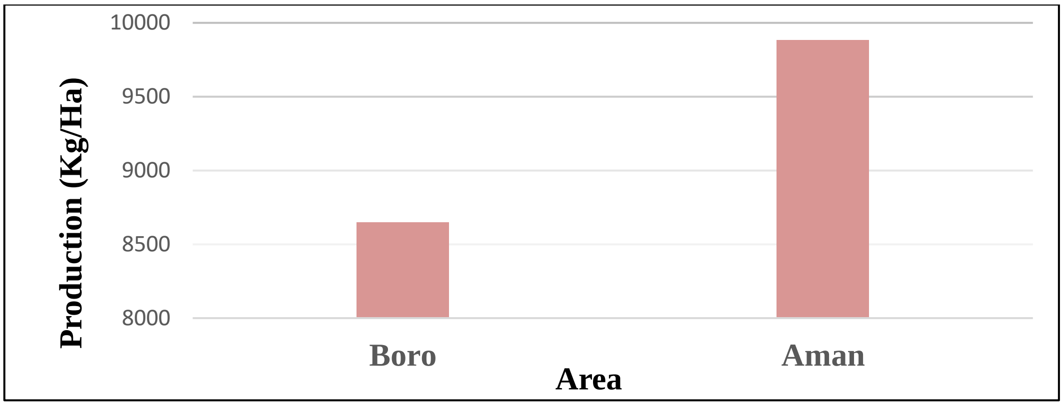

Figure 4. Production of Rice

Production and Market Price of Fish

Fish and crustaceans are both cultured in the rice cum fish culture environment in the Bagerhat district. The water quality of this area is saline water. So, Shrimp culture is also profitable for the Bagerhat district. Average production was found to be 494.18 ± 40.97 kg/ha for fish and 439.79 ± 30.26 kg/ha for crustaceans. Harvesting time depends on rice variety: April for Boro and December for Aman. Market prices range from Tk 110–350/kg for fish and Tk 1200–1500/kg for shrimp (Table 08). Integrated farming has increased overall production.

Table 8. Production of Fish and Market Price

Species	Harvest time	Market price/kg	Production/ha
Raj Puti	April and December	110-130	
Mirror carp	April and December	140-150	
Silver carp	April and December	150-160	494.176 ± 40.97
Rui	April and December	250-300	
Catla	April and December	250-350	
Pangus	April and December	120-140	
Tilapia	April and December	140-150	
Shrimp	April and December	1200-1500	439.79 ± 30.26

Disease of Paddy

In rice fields, several pests and diseases were observed (Table 09). Stem borer (Majra poka) and stem rot, mainly attacking Aman rice in August, are caused by *Leptocorisa acuta*. Farmers attempted control with insecticides like ETL and Malathion dust (5%, 8 kg/acre). Brown planthopper (Badami poka), caused by *Nilaparvata lugens,* affected both rice varieties in February and August; farmers applied Zn powder (1 kg/bigha) for control. Green horned caterpillar disease has attacked both types of rice. This disease also appeared in February and September. Locally, it is known as Leda poka disease. The responsible insect's name is *Melanitis leda.* Farmers mainly controlled this disease biologically.

Table 9. Diseases of Paddy

Disease Name	Scientific Name	Month	Used Chemical	Dose
Majra Poka disease or Stem rot disease	*Leptocorisa acuta*	August	ETL, Malathion	1nymph /adult per hill, 5% 8kg/acre.
Badami poka disease or Brown Planthopper Disease	*Nilaparvata lugens*	February and August	Zn	1 kg/bigha
Leda poka disease (Green horned caterpillar Disease)	*Melanitis leda*	February and September	Biological control	

Disease of Fish

According to the majority of farmers, they have a significant problem with fish diseases (Table 10). *Columnari*s, a frequent illness in carp that causes yellow coloring, was treated with oxytetracycline and salt baths. There were Aeromonas bacteria. The major causes of septicemia were poor water quality and overcrowding. NaCl and trichloroform were used to treat common anchor worm infections. Shrimp producers faced a danger from viral infections, which often came from sudden changes in water quality and caused rapid epidemics and high death rates. Chlorine treatment was typically used to suppress these outbreaks.

Table 10. Diseases of Fish

Disease Name	Scientific Name	Used chemical	Dose
Columnary Disease (Yellow pigment disease)	*Flavobacterium columnare*	Oxytetracycline, Salt treatment	65-75mg/19water for 1-2hrs, Bath-1-2% salt solution.
Motile Aeromonas Septecemia (MAS) (Red spot Disease)	*Aeromonas hydrophila*	Improve water quality. Reduce overcrowding.	
Anchor worm	*Lernaea cyprinacea*	Trichloroform, NaCl	250-300ml/bigha, 500g/ decimal.
White Spot Syndrome disease of Shrimp	White Spot Syndrome Virus	Chlorine	The affected pond was treated with 30 ppm chlorine to kill infected shrimp. Rapid changes in temperature, hardness, salinity, reduced DO, and pH should be stopped.

Training

Government and non-governmental groups provided a number of training programs to farmers in the study region (Table 11). World Vision offered a seven-day fish culture course in Kachua Thana in 2013. A further three-day training session on rice-cum-fish culture was later organized by BFRI and DoF in Bagerhat Sadar and Badhal Thana in 2016. Under the USDA initiative, a seven-day rice culture training was held in 2017. In 2012, BRRI and DAE collaborated to host a three-day course on the culture of rice, cum, and fish. These programs enhanced farmers' skills in aquaculture and integrated farming practices.

Table 11. Training from Government and Non-Government Organizations

Name of the Organization	Types of Training	Where from	Duration (Days)	Year
World Vision	Fish Farming	Kachua	7	2016
BFRI, Bagerhat	Fish Farming, Rice Cum Fish Farming	Bagerhat Sadar	3	2013
DoF	Fish Farming	Badhal	3	2010
USDA Project	Fish Farming	Badhal	6	2017
BRRI	Rice Farming	Morrelganj	3	2012
DAE, Bagerhat.	Rice Cum Fish Farming.	Bagerhat Sadar	3	2012

Problems Faced by the Rice-Cum-Fish Culture Farmers

The primary technical and financial obstacles faced by rice-cum-fish producers were several (Table 12). The absence of fingerlings and scientific expertise, feed shortages, boundary collapse, and disease outbreaks were among the main technical issues. Low capital, high input costs, low fish prices, and inadequate transportation caused farmers to suffer economically. There were fewer social issues, including fish stealing.

Table 12: Problems Faced by the Rice-Cum-Fish Culture Farmers

	Problems	Number of farmers	Percentage (%)
Technical Problems	Unavailable of Fingerlings	24	80
	Unavailable of fish feed	17	57
	Lack of scientific knowledge	24	80
	Problems of insecticide and pesticide use	09	30
	Attack of fish parasites and diseases	12	40
	In sufficient water in the dry season	08	27
	Fish migration through the outlet channel	10	33
	Breakdown of boundaries	18	60
	Overflooding in the rainy season	09	30
Economic Problems	Lack of investment capital	22	73
	Low price of fish	18	60
	High price of artificial fish feed	16	53
	Lack of a transportation system	11	37
	High price of fertilizer	21	70
Social Problems	Theft of fish	06	20
	Discouragement of local people.	-	-

Suggested solutions for problems in the rice-cum-fish culture

Rice-cum-fish farmers are in real danger due to improper use and management. And rapid environmental change, both man-made and natural. The rice-cum-fish Farmers expressed different opinions at the time of the interview. They were asked to give Some suggestions for improving rice-cum-fish culture in the light of their problems. The suggestions reported by the sample farmers are discussed below:

- For rice-cum-fish culture to be profitable, technology must be improved.
- It is necessary to get a timely supply of high-quality fingerlings from Thana fisheries officials and government hatcheries.
- Farmers lack scientific expertise; technical issues can be resolved with extension work and brief training.
- Farmers should receive instruction on how to apply insecticides safely and sparingly.
- By creating high field boundaries, overflooding and fish migration can be avoided.
- To address the lack of capital, easy bank loans or credit should be made available.
- The government ought to upgrade the infrastructure for communication and transportation.
- Legal action should be taken by the local government to stop fish stealing.

Discussions

Socioeconomic variables such as farm size, education, and occupation influence the adoption and efficiency of rice-cum-fish farming. The distribution of land ownership in this study shows that 18.33% of the property is huge (>2.01 ha), 25% is medium (1.01-2.0 ha), and 56.66% is small (0.1-1.0 ha). According to a study by the International Food Policy Research Institute (IFPRI), 2024, large and medium farmers own 47% of the land and account for 17% of the agricultural population, while small and marginal farmers account for 83% of the farm population and cultivate 53% of the arable land. Similarly, Dipu et al. (2019) observed that 81% of farmers in the Barind region were marginal, with just 18% classified as small and 1% as medium. This indicates a higher proportion of marginal farmers than in our data, which might reflect regional disparities in land distribution.

Education has a significant influence on the number of individuals who begin growing rice and fish. In this study, illiteracy was highest among small farmers (23.5%), while large farmers showed better attainment (27.3% SSC, 18.2% HSC+), indicating stronger capacity for innovation. Similar patterns were reported by Islam et al. (2015) and Ahmed et al. (2011) found that the adoption of integrated rice-fish systems in Bangladesh is significantly influenced by farm size and education.

The main sources of income were aquaculture and rice-cum-fish farming; other households depended on jobs in non-farm sectors like seafood processing. This supports other studies showing that integrated systems encourage well-being and income diversification (Ahmed, 2011). The majority-Muslim, minority-Hindu population exhibited cooperative behavior in social settings, encouraging the widespread application of integrated agricultural practices.

The fertile soils of the low-lying Bhairav River regions, which are periodically restored by floods, make them perfect for raising fish, rice, and arum. The primary source of income in these areas is fish, although farmers frequently grow Aman and Boro rice. In order to meet home and commercial demands, families also cultivate seasonal crops throughout the Rabi season. Because of better soil conditions and more fry available, fish farming becomes increasingly popular during the Aman season. Thus, raising fish and rice together enhances output and the sustainability of the environment (Islam, 2015). According to Ahmed et al. (2011), despite the clear benefits of rice-fish systems, socioeconomic and technological barriers usually prohibit their

widespread adoption. Roy (2016) provides more evidence of its economic benefits by demonstrating that mixed rice–fish farming may provide higher revenues than traditional rice monoculture.
The amount of inputs used in Bangladeshi rice-cum-fish farming depends on the farm's size and location. Small farms used the least amount of feed and rice seed (63 kg/ha) in the Sherpur district study, whereas large farms used the most rice bran (408 kg/ha), mustard oil cake (128 kg/ha), and chicken droppings (280 kg). Larger farms applied more chemical fertilizer, while medium-sized farms most frequently employed cow dung (4172 kg/ha). Large farmers used the most pesticides (500 kg per acre). These trends are consistent with research by Roy (2016), who found that mixed rice-fish farming outperformed monoculture systems in terms of profitability and production efficiency in the southwest part of Bangladesh, and larger farms often use more inputs to produce higher yields. To improve the sustainability and productivity of rice-cum-fish, use fewer pesticides, concentrate on organic fertilizers, and use inputs more effectively.

Larger farms tend to stock more fingerlings in rice-cum-fish production; the most common variety is shrimp fry, which are cultivated at 20,000/ha (N. Ahmed & Diana, 2015). The Raj Puti (≈1,850/ha) was the most prevalent finfish due to its necessity and adaptability (Roy, 2016). To increase variety, larger farms planted more huge carps, such as Rui (≈270/ha) and Catla (≈440/ha) (Samanta, 2024). Furthermore, due to their rapid development and durability, tilapia (≈750/ha) were crucial (Rahman, 2020). In integrated aquaculture, stocking patterns frequently illustrate how farm size and profitability impact species selection.

Small farms had the lowest material input costs (Tk 111,133/ha) for rice-cum-fish production, whereas large farms had the highest costs (Tk 121,110/ha). Fish seed and feed accounted for between 70 and 75 percent of the overall costs, while rice seed, fertilizer, and cow dung accounted for the least amount. Due to the low level of pest pressure, pesticide costs were low, at about Tk 500–600 per hectare. The findings indicate that the primary determinants of production costs are feed and seed, with fertilizers and pesticides having the least impact. This is consistent with Roy (2016) and Ahmed et al. (2011).

Fish and rice cultivation required an average of 320 man-days per acre, of which 28% came from family members and 72% from paid labor. Small farms with mixed rice-fish systems relied on family labor (≈32%), while large farms used hired labor (≈73%) to reduce costs, according to Roy (2016). Because midsize farms are more active, they need the greatest amount of work. The average labor cost per hectare was Tk 16,240, with land preparation paying the highest (Tk 3,300/ha) and marketing the lowest (Tk 350/ha). The results validate the hypothesis of Ahmed and Diana (2015) that mechanization and the adoption of new technologies gradually reduce total labor demands, with the most labor-intensive procedures being harvesting, transplanting, and land preparation.

Farmers grew both Boro and Aman rice in rice-cum-fish systems, yielding 8,648 kg/ha and 9,882 kg/ha, respectively. These findings align with those of Kabir et al. (2015), who found that enhanced soil fertility under integrated farming results in rice yields remaining constant or even increasing. Crustaceans, primarily shrimp, produced 439.79 ± 30.26 kg/ha, while fish produced an average of 494.18 ± 40.97 kg/ha. In saline regions such as Bagerhat, shrimp production was especially lucrative, with prices reaching Tk 1,200–1,500/kg, while finfish prices ranged from Tk 110–350/kg. Ahmed and Diana (2015) made similar observations, emphasizing shrimp's economic primacy in coastal integrated systems. The integration of rice, fish, and shrimp enhanced both production and profitability, supporting Rahman et al. (2020), who reported that integrated rice–fish culture increases overall bio-economic efficiency compared to monoculture.

Several diseases have an impact on aquaculture and agriculture, including rice-cumfish yield. Insecticides, zinc, and biological methods were used to suppress the stem borer (*Leptocorisa acuta*) and stem rot, which primarily damaged Aman rice in August, the brown planthopper (*Nilaparvata lugens*) in both seasons, and the green horned caterpillar (*Melanitis leda)* in February and September, respectively. While shrimp were vulnerable to the White Spot Syndrome Virus, often caused by sudden water changes and chlorine treatment, fish were commonly infected with anchor worms (*Lernaea cyprinacea*), columnaris *(Flavobacterium columnare*), and Aeromonas septicemia. These findings support previous studies by Kabir et al. (2021) and

Ahmed & Diana (2015), which highlight the need for integrated pest and disease management that combines chemical, biological, and environmental strategies.

Various organizations, including World Vision, USDA, BFRI, DoF, BRRI, and DAE, provide farmers with training to improve their skills in fish and rice cultivation. They encountered social difficulties (fish theft), economic limits (lack of finance, high material costs, poor fish prices), and significant technical challenges (few fingerlings, insufficient feed, illnesses, border collapse). Farmers proposed a variety of remedies, including a consistent supply of healthy fingerlings, quick technical training, better pesticide use, enlarged field borders, loan availability, improved transportation, and legal assistance. According to Roy (2016) and Ahmed and Diana (2015), using these strategies can improve productivity, profitability, and sustainability.

Conclusion

Rice-cum-fish culture in Bagerhat has shown strong potential to increase rice and fish yields, diversify income, and ensure better use of land and water. Aman rice and shrimp farming were particularly profitable in the study area. Still, farmers face challenges such as a lack of fingerlings, feed shortages, high input costs, and disease problems. This technique can become more sustainable and profitable with improved training, timely input delivery, and loan availability. Rice-fish culture has the potential to play a significant role in Bangladesh's economy, food security, and rural development with the right institutional and governmental support.

Conflicts of Interest

The authors declare that they have no conflict of interest.

Acknowledgements

Financial support from the Research and Training Centre (RTC), Patuakhali Science and Technology University, is gratefully acknowledged. We also acknowledge the farmers of Bagerhat District for their valuable participation in this study.

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