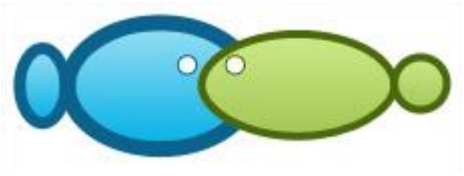

Impact of contemporary management practices in pond fish farming on the socio-economic condition of fish farmers in north-central Bangladesh

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Abstract. Aquaculture in Bangladesh has greatly improved diet structure, ensured food safety, and facilitated the transformation of fisheries growth mode. The study aimed to investigate the existing management techniques of fish farming in ponds and assess its impact on the socioeconomic status of fish farmers in the Trishal upazila (sub-district), Mymensingh, a region in north-central Bangladesh, from January to June 2023. Data were collected using a well-structured questionnaire. The majority of farmers (62.50%) had ponds that were 0.5-1.0 ha in size. Over half of the farmers (52.50%) practiced monoculture, with catfish comprising 37.13%. The average stocking density was 50,000-65,000 fry ha^{-1} With conventional post-stocking management, the majority of farmers (90%) utilized probiotics, and 87.50% used vitamins and minerals. Around 90% had formal education, and most individuals resided in standard housing. All participants had access to electricity and potable water, 96% had adequate sanitary facilities, and 95% of the farmers had proper healthcare facilities. Half of the farmers (50%) were involved in fish farming as their primary occupation. Most farmers (75%) earned an annual income ranging from 700 to 1,300 USD, and a significant 90% invested their own funds into fish farming. More than half of the farmers (55%) received technical assistance from their neighbors. Fish farming in the region has intensified, and the existing management practices have led to enhanced production, thus benefiting the livelihoods of the fish farmers. However, achieving long-term sustainability necessitates a supply of high-quality fry, cost-effective and high-quality feed, comprehensive training, and effective marketing strategies.

Key Words: pond aquaculture, intensive culture, monoculture, stocking management, livelihood.

Introduction. Bangladesh has diverse and abundant fisheries resources such as rivers, beels, haors, baors, lakes, ponds, marshland, inundated crop fields, estuaries, and a part of the Bay of Bengal. It is one of the world's leading fish-producing countries, with a total production of 4.759 million metric tons (MT), of which inland culture contributes 57.39%. The fisheries sector contributed 2.43% to the national GDP, 22.14% to the agricultural GDP, and 1.05% to foreign exchange earnings in 2021-22 (DoF 2022). Fish is a major dietary staple in many regions globally, and in Bangladesh, it serves as the primary source of protein for most people, constituting 67.80% of their animal protein intake. Additionally, fish is a significant provider of micronutrients such as vitamin A, calcium, and iron (Mondal et al 2018). Bangladesh ranked 5th in aquaculture production with 2.731 million MT worldwide (FAO 2022). Aquaculture greatly contributes to rural communities' socio-economic development by providing income, employment, services, and trade opportunities, improving livelihoods, food security, and alleviating poverty. It generates several job opportunities for individuals, especially those living below the poverty line, in various roles, including farmers, operators, employees, traders, intermediaries, day laborers, and transporters (Ahmed & Rahman 2005). Many rural pond fish farmers adopted fish farming as a source of income, enhancing their

socioeconomic status (Ara 2005). A significant number of farmers are transforming their rice fields into aquaculture ponds due to the higher profitability associated with this practice (Islam et al 2002). It contributes to improved pond fish production in Bangladesh, which could help meet the growing demand for fish. For good aquaculture and increased fish production, understanding the fish culture system and associated challenges is crucial. Besides, profitable fish farming relies on utilizing essential resources, effective management, and technological advancements. Production and profit directly impact the socio-economic conditions of fish farmers and fishermen. This topic concerns researchers aiming to study existing management practices and recommend ways of improvement, if needed, to ensure better production (Galib et al 2016).

Mymensingh district is a major hub for aquaculture in north-central Bangladesh. The district encompasses around 29,180 ha of ponds, which yield a fish production of 313,213 MT. According to the Department of Fisheries, Trishal, a subdistrict of Mymensingh, has a fish production of 85,122 MT, which exceeds its internal demand by approximately tenfold (DoF 2022). Hence, it is crucial to acquire knowledge of the cultural practices that led to higher productivity in Trishal and comprehend their impact on the lifestyle and economic aspects of farmers. Nevertheless, to date, only a few studies have been carried out in this area regarding management practices (Sheheli et al 2014) and the livelihood of fish farmers (Al-Mahadi et al 2020; Hasan et al 2016; Mithun et al 2020). Additionally, none of the studies established a connection between management and the status of farmers, nor did it demonstrate the impact of current fish farming practices on the socioeconomic status of pond fish farmers in this region. Therefore, this study was undertaken to explore the latest management practices of pond culture and assess their impact on the socio-economic condition of fish farmers in Trishal upazila (sub-district), Mymensingh, located in north-central Bangladesh.

Material and Method

Study area. The current study was conducted in Trishal upazila, Mymensingh district, Bangladesh, which is renowned for fish culture and production. After fulfilling its internal demands of 8,220 MT of fish, it produced an additional 76,902 MT of fish. The area consists of 2,795 ha of inland open water and 3,442 ha of closed water. This area had around 24,503 fish ponds and 3,309 listed fish farmers (DoF 2022). The study area is located between 25°46’ N and 88°53’ E (Figure 1).

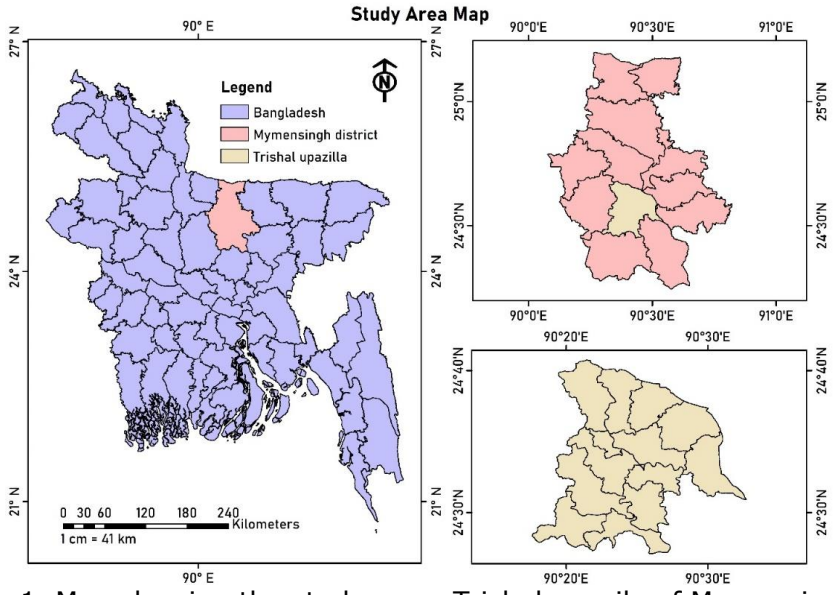

Figure 1. Map showing the study area, Trishal upazila of Mymensingh District, Bangladesh.

Data collection. The data were gathered using participatory rural appraisal (PRA) tools such as personal interviews, focus group discussions, and key informant interviews. A total of 48 fishermen were interviewed individually, while 2 focus group discussions were held with 10 participants in each group. Additionally, cross-interviews were conducted with 12 key informants to supplement the survey. In this study, a total of eighty (N = 80) individuals participated in different PRA tools. Data on the demographic and social condition of the fisherman was collected using different survey indicators such as age distribution, family status and size, educational qualifications, sanitation, drinking water facilities, electricity, annual income and so on. Additional sources of knowledge included scholarly journals, newspapers, and textbooks. The government officials from the relevant sectors were requested to appraise and authenticate the data. Data on existing management practices of fish culture were collected under three categories: pre-stocking, stocking and post-stocking management. In addition to conducting interviews, important information such as the characteristics of the culture ponds, the species being cultivated, biosecurity considerations, farming practices, and the process of fish harvesting and selling were obtained through direct observation.

Data processing and analysis. Data from multiple sources was imported into the computer using Microsoft Office, specifically MS Word and MS Excel 2019. The data were analyzed using the R and RStudio software. The data was presented in various formats including textual, tabular, graphical, and hierarchical. The cartographic representation of the research area was generated utilizing the Arc GIS software (Version 10.8).

Results

Existing management practices of fish culture

Pre-stocking management

Pond size and depth. The average pond size in the research area was 0.5-1.0 ha. Only 10% had ponds that were larger than 1 ha, while a quarter owned ponds that were smaller than 0.5 ha (Table 1). The range of the average depth of the ponds varied from 1.5 to 2.5 m.

Type of fish pond. Table 1 shows that 66.67% of ponds in Trishal were perennial and 33.33% seasonal. The water level in perennial ponds decreases during the dry season, but they are still suitable for fish farming. However, seasonal ponds are unsuitable for fish farming during the dry season.

Table 1

Pre-stocking management observed in Trishal upazila, north-central Bangladesh

Parameters	*Variables*	*Percentage (%)*
Pond size	>1 ha	10
	0.5-1.0 ha	62.5
	<0.5 ha	27.5
Pond type	Seasonal	33.33
	Perennial	66.67
Pond preparation	Drying	65
	Rotenone/ netting	35
	Bottom mud removal	77.5
	Embankment repairing	87.5
Fertilizer	Chemical	90
	Organic	7.5
	No fertilizer	2.5
Lime	Lime	95
	No lime	5

Pond preparation. In the study area, as a part of pond preparation, 65% of farmers engaged in pond drying, 77.5% participated in the removal of excessive bottom mud, and 87.5% undertook embankment repair. Pond bottoms with muddy substrates are removed to reduce toxic gases. During that time, lime was applied at 2-4 kg per decimal. 35% of the farmers used netting or rotenone. It was recorded that 90% of the farmers used fertilizers compared to 7.5% using manure, while 2.5% of fishermen used no fertilizer (Table 1). The average dose of organic fertilizer in the study area was 2,900 kg ha^{-1} yr^{-1}, and inorganic fertilizers such as urea and TSP were 275 kg ha^{-1} yr^{-1} and 185 kg ha^{-1} yr^{-1}, respectively. 85% of the farmers were observed to practice liming as a crucial pre-stocking management technique. Lime balances the pH of pond water. Lime was applied to ponds after drying out or in water at a concentration of 1–1.5 kg dL^{-1}.

Stocking management

Culture system. Inland closed-water culture practices in the study area can be classified into two broad categories: monoculture (catfish, monosex tilapia) and polyculture (carp species - rui, catla, mrigal, sharpunti - and tilapia, pangus, koi). Management practices can vary based on the cultural system employed, including factors such as stocking density, fish species, feeding rate and frequency, and disease control. Most farmers (52.5%) followed monoculture, while 47.5% followed the polyculture system (Table 2). Tilapia and catfishes were predominantly preferred for monoculture. Various carp, along with tilapia, pangus, and koi, were chosen for polyculture. In polyculture, farmers used a combination of 2-8 species.

Table 2

Culture system practiced in Trishal upazila, north-central Bangladesh

Culture system	*Fish species*	*Percentage (%)*
Monoculture		52.50
	Catfishes	37.13
	Tilapia	15.37
Polyculture		47.50

Stocking of fish seed. In the study area, farmers stocked different species of carp, barb, perch, and catfish; however, the culture was dominated by Cypriniformes (carps) and Siluriformes (catfishes) (Table 3). Three types of seeds were stocked: fry, fingerlings, and juveniles. Regarding the price per kg, fry had a higher price than fingerlings and juveniles due to the variations in numbers. The seeds of catfish received comparatively higher values, followed by carp, barb and perch. The fries of *Clarias batrachus* were sold at the highest price (54.54-72.72 USD kg^{-1}), whereas *Anabas testudineus* fries were purchased at the lowest price (22.72-27.27 USD kg^{-1}) (Table 3). In terms of species and types of seeds, stocking density varied. However, the average stocking density in the region was 50,000-65,000 fry ha^{-1}. Fish fries were acclimatized to reduce mortality.

Post stocking management. Post-stocking management, which incorporates activities such as feeding, disease prevention, utilization of probiotics and vitamins, as well as the processes of harvesting and marketing, plays a crucial role in fish culture. The duration of the culture period varied among different species depending on the types of seed stocked. The growth period for catfish ranged from 6 to 24 months, while for carp it spanned from 3 to 36 months. A prolonged duration is required in this context due to the fact that specific fish are cultivated for the purpose of breeding.

Feeding. This study found that farmers commonly use three kinds of feed: loose, floating pellets, or a combination of both. In our study, 60% of farmers prefer using floating pelleted feed, while 30% and 10% choose loose feed and pelleted feed, respectively (Figure 2). This study revealed that 75% of farmers provided their fish with feed twice daily, 20% fed them three times daily, and a mere 5% fed them once daily.

Table 3

Commonly cultured fish Species in different ponds at Trishal upazila, north-central Bangladesh

Order	*Group name*	*Common name*	*Local name*	*Scientific name*	*Stocking*			*Harvesting*	
					Type of seed	*Number of seeds kg^{-1}*	*Price of seed ($ kg^{-1})*	*Price of fish ($ kg^{-1})*	*Weight of fish in kg*
Cypriniformes	Carp	Indian carp	Rui	*Labeo rohita*	Fry	4,000-5,000	32.72-40.91	1.36-1.81	0.03-0.06
					Fing.	400-500	5.45-6.82	1.63-2.27	Up to 1
					Juv.	30-40	3.18	2.18-2.63	2-2.5
			Catla	*Gibelion catla*	Fry	4,000-5,000	36.36-45.45	2-2.72	0.03-0.06
					Fing.	400-500	7.27-9.09	2.45-2.72	Up to 1
					Juv.	30-40	4.54-5	2.54-3.18	2-2.5
			Bata	*Labeo bata*	Fry	4,000-5,000	32.72-40.90	1.36-1.81	0.03-0.06
					Fing.	400-500	5.45-6.81	1.63-2.27	Up to 1
					Juv.	30-40	3.18	2.18-2.63	1.5-2
			Mrigal	*Cirrhinus mrigala*	Fry	4,000-5,000	32.72-40.90	1.36-1.81	0.02-0.05
					Fing.	400-500	5.45-6.81	1.63-2.27	Up to 1
					Juv.	30-40	3.18	2.18-2.63	1.5-2.0
		Asian carp	Silver carp	*Hypopthalmichthys molitrix*	Fry	4,000-5,000	29.09	0.91-1.27	0.03-0.06
					Fing.	500-600	3.18-3.63	1.36-2	1-1.2
					Juv.	16-20	1.81-2.09	1.63-2.18	2-3
		Eurasian/ European carp	Common Carp	*Cyprinus carpio*	Fry	3,000-4,000	18.18-29.09	1.36-1.81	0.03-0.05
					Fing.	300-400	3.18-3.63	1.36-2	0.30-0.40
					Juv.	10-15	2.72-3.18	1.63- 2.18	1-1.2
		Olive barb	Sharpunti	*Puntius sarana*	Fry	4,000-5,000	29.09-31.81	1.36-1.54	0.04-0.06
					Fing.	300-400	3.18-4.09	1.36-1.63	0.1-0.12
					Juv.	10-12	1.81-2.27	1.45-1.81	0.40-0.70
Siluriformes	Catfish	Pabda catfish	Pabda	*Ompok pabo*	Fry	4,000-5,000	43.63-50	2.72-4.54	0.015-0.02
					Fing.	1,000-1,200	18.18-21.81	2.90-3.45	0.02-0.03
					Juv.	40-60	3.63-4.54	3.45-3.82	0.04-0.06
		Striped catfish	Pangas	*Pangasius hypophthalmus*	Fry	4,000-4,500	31.81-36.36	1-1.18	Up to 1
					Fing.	1,000-2,000	24.54-29.09	0.90-1.36	1-3
					Juv.	20-25	2.27-2.54	1.27-2	4-5
		Stinging catfish	Shing	*Heteropneustes fossilis*	Fry	5,000-6,000	36.36-38.18	2.36-2.72	0.2-04
					Fing.	1,000-1,500	22.72-27.27	2.54-2.91	0.04-0.06
					Juv.	40-60	3.18-3.63	2.73-3.18	0.10-0.12
		Walking catfish	Magur	*Clarias batrachus*	Fry	3,000-4,000	54.54-72.72	2.54-2.91	0.03-0.04
					Fing.	1,000-1,200	22.72-27.27	2.72-3.09	0.1-0.12
					Juv.	30-40	2.72-3.18	2.91-3.45	0.2-0.5

Order	*Group name*	*Common name*	*Local name*	*Scientific name*	*Stocking*			*Harvesting*	
					Type of seed	*Number of seeds kg^{-1}*	*Price of seed ($ kg^{-1})*	*Price of fish ($ kg^{-1})*	*Weight of fish in kg*
Cichliformes	Perch	Gangatic mystus	Gulsha	*Mystus cavasius*	Fry	4,000-5,000	43..63-50	2.72-3.18	0.08-0.15
					Fing.	1,000-1,200	18.18-21.81	2.91-3.45	0.02-0.03
					Juv.	40-60	3.63-4.54	3.45-3.81	0.03-0.05
		Nile perch	Tilapia	*Oreochromis niloticus*	Fry	4,000-5,000	25.45-29.09	0.72-1	0.20-0.30
					Fing.	500-600	6.30-7.27	0.72-1.27	0.30-0.50
					Juv.	50-60	2.54-2.90	1.09-1.63	0.80-1.0
Anabantiformes		Climbing perch	Koi	*Anabas testudineus*	Fry	2,500-3,000	22.72-27.27	1.36-1.63	0.20-0.25
					Fing.	1,000-1,200	13.63-21.81	1.45-1.63	0.30-0.40
					Juv.	60-70	2.27-2.72	1.63-1.72	0.50-0.60

1 USD-110BDT; Fing.-Fingerlings; Juv.-Juveniles.

Disease control measures. In this study area, 60% of farmers used aqua drugs for disease control measures. Additionally, 10% used salt and lime, 15% used water exchange, and 15% applied other measures. Farmers who practiced monoculture, especially high-density catfish farming, used more aqua drugs and medicines than polyculture farmers.

Use of probiotics. According to Figure 2, 90% of the farmers utilized probiotics. The methods of administration can be divided into three categories: applied through feed (40%), applied in water (17.5%), and a combination of both (32.5%). However, 10% of the farmers stated that they didn't use probiotics due to the high cost.

Vitamins and minerals. A study discovered that 90% of farmers utilized vitamins and minerals by incorporating them into their diet, water, or a combination of both. The majority of farmers (35%) administered them orally through feed, while only a small percentage (7.5%) used water as a method of administration (Figure 2).

Harvesting and marketing of fish. Fish harvesting was generally done year-round but peaked in November and December. Farmers finish their harvesting within a year; however, some also conduct a partial harvest from May to July. It was recorded that 62.5% of farmers were involved in the total harvest, while 37.5% participated in the partial harvest. No fixed channels for fish marketing were observed in the study region. Research showed that 65% of the collected fish is distributed to local agents (Paiker/Faria), while the remaining 35% is sold to retailers in nearby markets. The price of harvested fish ranged from 1 to 3.82 USD kg^{-1}. It was observed that juvenile fish reached market size faster and were sold at higher prices due to their larger size. Additionally, catfish were sold at a higher price than other fish (Table 3). Many poor rural people, including women and children, worked as brokers, day labourers, and transporters in the fish trading chain. The marketing from farmer to consumer encompasses three intermediaries, namely Paiker/Faria, wholesaler, and retailer.

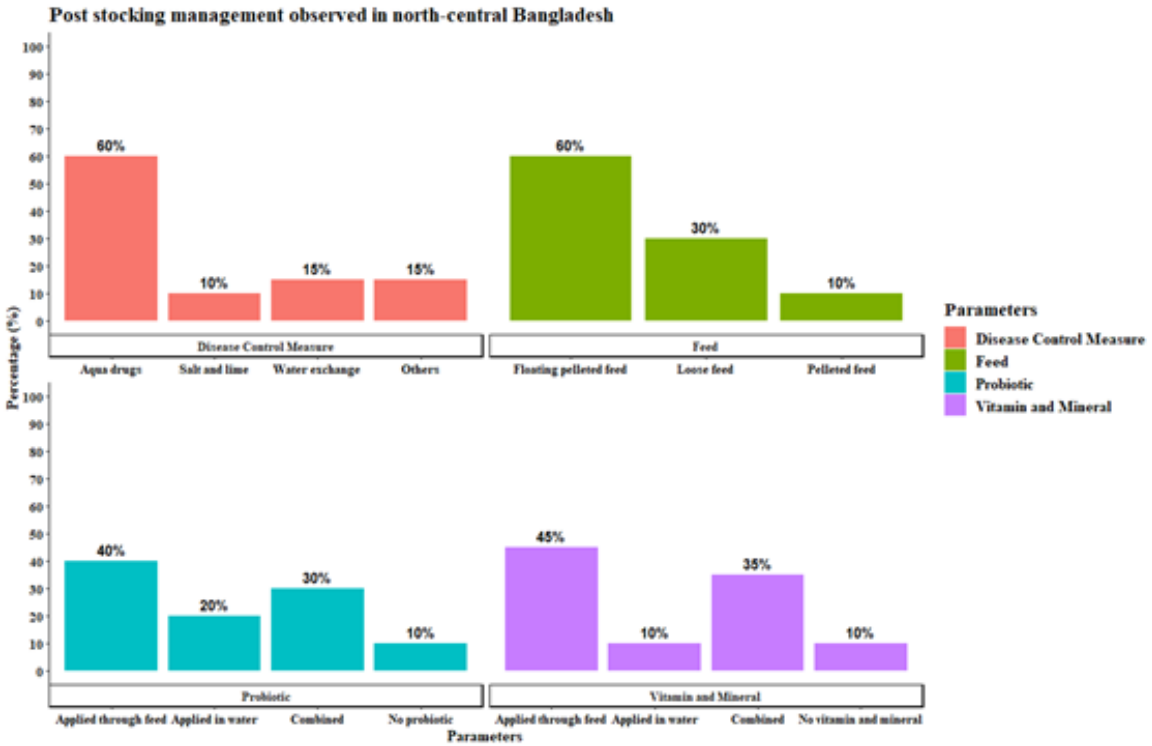

Figure 2. Post stocking management observed in north-central Bangladesh.

Demographics of fish farmers

Age distribution. The ages of the participants varied from 20 to over 60 and were divided into five categories. The pond fish farmers were categorized based on age groups: 20-30, 31-40, 41-50, 51-60, and over 60 (Figure 3). The graph in Figure 3 indicates that the highest percentage of farmers (40%) belonged to the age group of 31-40, followed by the age group of 41-50 (35%).

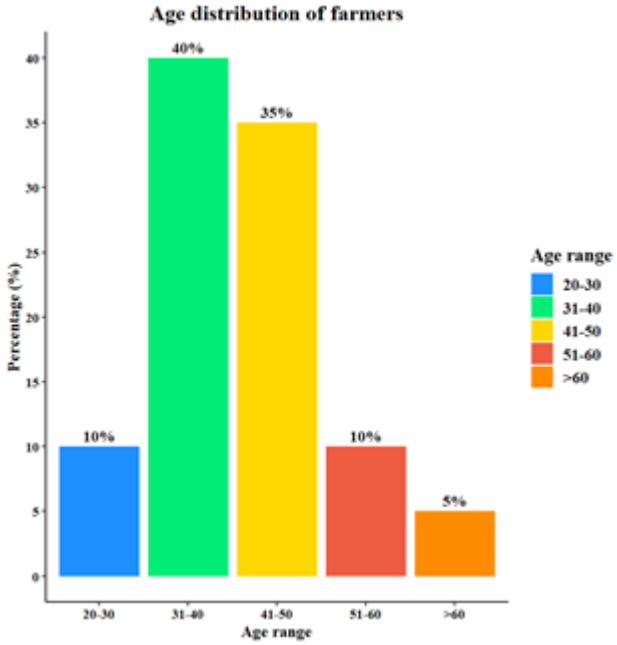

Figure 3. Age distribution of farmers.

Family status and size. Contrary to extended families, which made up 37.5% of the families of fish farmers, 62.5% were nuclear in the study area. Fish farmers' families can be divided into four groups based on the number of members. The family size category with 2 to 3 members had the lowest percentage, whereas the category with 4 to 5 members had the highest proportion (45%) (Figure 4).

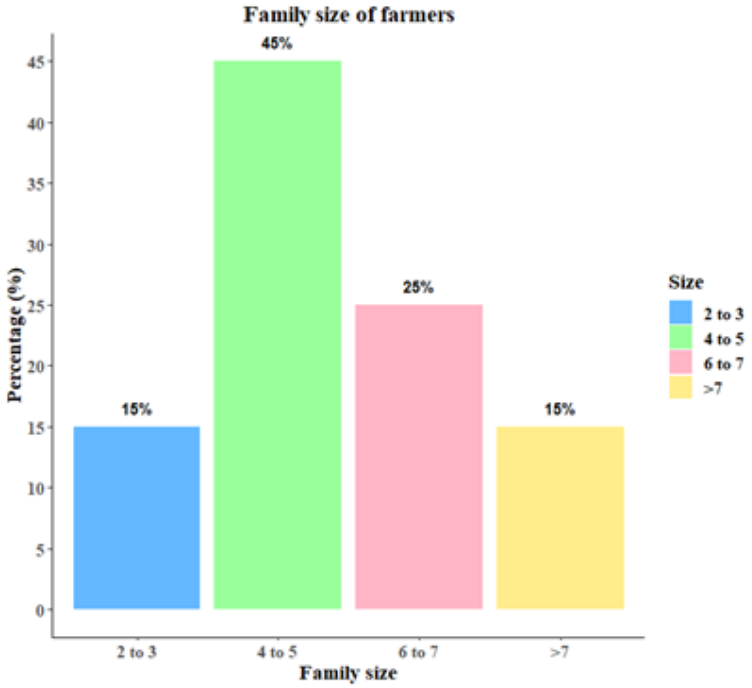

Figure 4. Family size of the farmers in the study area.

Educational status. According to our study, 10% of farmers had no formal education, 37.5% had completed their primary education, 17.5% had finished their SSC, 25% had completed their HSC, and 7.5% had obtained a bachelor's degree (Figure 5). It demonstrates the propensity of educated individuals to participate in fish farming.

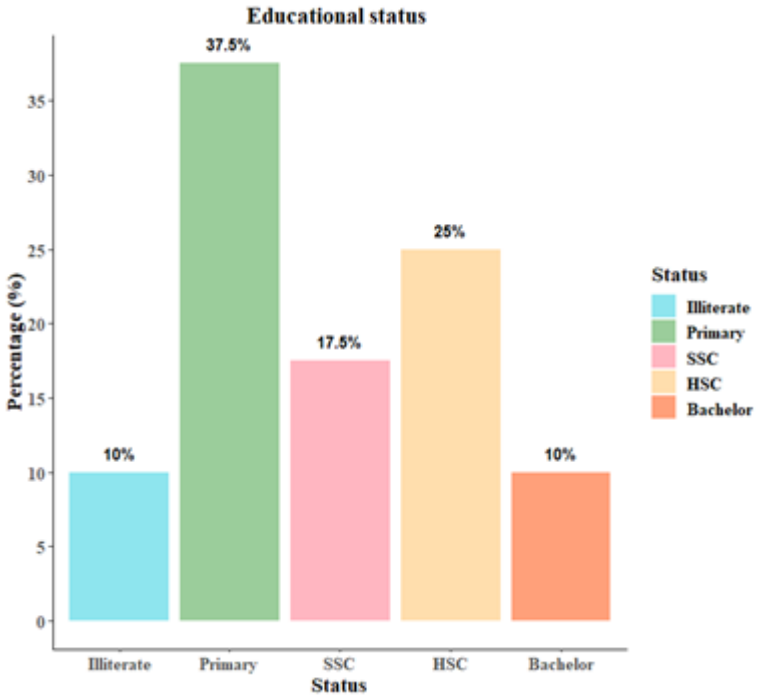

Figure 5. Educational level of the farmers in the research area.

Socio-economic status of farmers

Pond ownership. The survey found that 60% of the ponds were owned by farmers, whereas 40% were leased ponds. Regarding maintenance, 70% of the culture was conducted by a single entity, and the remaining 30% was conducted by a joint venture.

Housing conditions and sanitary facilities. This survey found that 53% of fish farmers' residences were semi-pucca (partially concrete structure) with tin shed roofs, 26 % were pucca (fully concrete structure), 15% were kaccha (without concrete structure), and 6 % were tin shed houses. Considering sanitary facilities, most farmers in the study had a well-developed sanitation system, with 38% having a pucca system, 58% having a semi-pucca system, and only 4% having a kaccha system.

Drinking water, health facilities and electricity facilities. Based on the survey, it was found that every household involved in fish farming obtained their water from tube wells. Specifically, 90% of the farmers utilized their own tube wells, while the remaining 10% relied on their neighbor's tube wells for their water supply. The current study found that despite 100% of families having access to the upazila health complex, 5% of households relied on village doctors, 60% at the upazila health complex, and 20% of households engaged in fish farming consulted MBBS (Bachelor of Medicine and Bachelor of Surgery) doctors at the district hospital. The remaining (20%) families relied on private consultants. Figure 6 shows the health facilities of the farmers of the studied area. Research findings also revealed that all fish farmers (100%) examined had access to electricity.

Figure 6. Types of health services received by fish farmers.

Main occupation of the fish farmers. The principal source of income for fish farmers was included in the current study. According to our research, 50% of fish farmers reported that fish farming was their primary vocation, while 15% were employed in the service industry and 25% worked in the business sector. The remaining individuals were engaged in other occupations.

Annual income. The participant fish farmers were classified into four categories based on their yearly income. In addition to fish farming, the farmers in the study area also raise crops, run companies, provide services and businesses, and keep animals. Figure 7 states the different income groups.

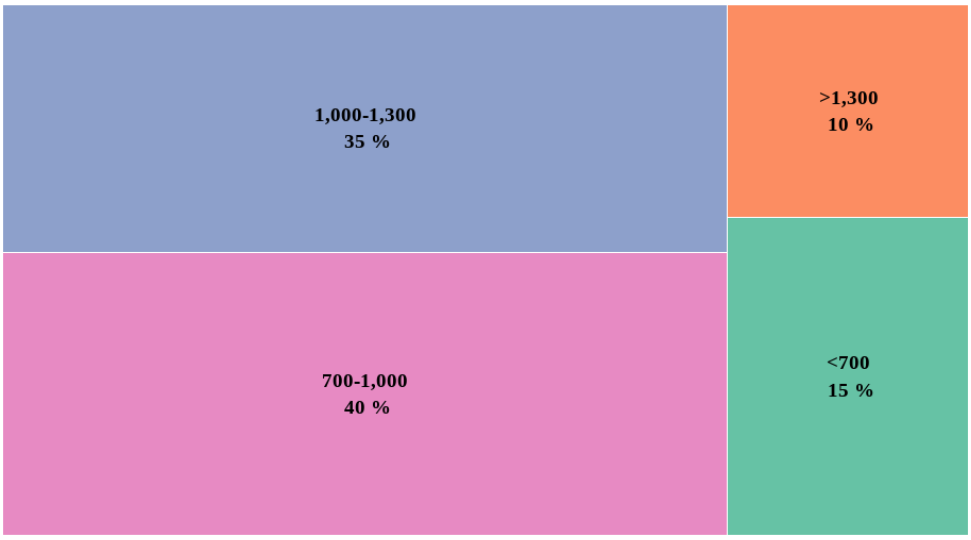

Figure 7. Annual income of farmers in USD.

Credit facilities. 90% of fish farmers used their self-funds for fish farming, while the remaining 10% obtained loans from friends, banks, and non-profit organizations. Most fish producers did not accept any loans because they were wealthy and prominent locals.

Training received. The study disclosed that 55% of fish producers sought technical assistance or advice regarding fish farming from local experienced farmers, while 35% obtained it from Government Organizations (GOs), and the remaining 10% received it from Non-Governmental Organizations (NGOs).

Discussion

Existing management practices of fish culture. The size and depth of ponds exhibited variability in different regions of Bangladesh (Monir et al 2011). In our study,

most fish ponds were medium in size, and farmers stated that it ensured easy management and higher productivity which is consistent with the findings of Sarker et al (2014). Nadia et al (2021) found that the average pond size in Rajbari ranged from 0.08 to 0.60 ha and the depth was between 1 and 2 m. In the selected farms in Cumilla, pond size ranged from 1.7 to 8.5 ha and the depth ranged from 1.82 to 2.35 m (Hassan et al 2019). Sheheli et al (2014) observed a comparable percentage of seasonal and permanent ponds in the study region. Nevertheless, Saha (2004) found that 63% of the ponds in Tangail, central Bangladesh, were perennial, while 37% were transient, which matches to the findings of this study. Rahman et al (2022) mentioned that farmers prepared their ponds by drying them (66.67%), removing pond mud (75%), and restoring pond embankments (83.33%). This survey and Nadia et al (2021) described a similar approach for pond preparation. Faruk et al (2017) also documented that 89% of farmers restored embankments. According to Hasan et al (2016), a pond dike was constructed at intervals of 3 to 5 years. Rahman et al (2022) found that just 16.67% of farmers fertilized their pods, whereas Sarker et al (2014) identified that 45% used fertilizer or manure. Nadia et al (2021) discovered that 70% of the farmers used fertilizer. Sheheli et al (2014) reported that 86% of farmers used cow dung at 150 kg ha^{-1} to fertilize their ponds along with chemical fertilizers. The fertilizer use rate was slightly higher in the present study than in Sylhet, northeastern Bangladesh (Rana et al 2016). Therefore, it can be stated that in recent times, there has been a growing trend among farmers to utilize fertilizers, particularly chemical ones.

In the study conducted by Sarker et al (2014), it was discovered that 84% of farmers utilized lime in their ponds. The dose of lime varied from 0.25 kg dec^{-1} to 1.50 kg dec^{-1}. However, in the present study, a higher percentage of farmers, specifically 95%, employed lime for pre-stocking management. Similarly, in the Mymensingh region, Sheheli et al (2014) and Rahman et al (2022) discovered that all fish farmers utilized lime. Among them, 54% used lime at a rate of 1 kg dec^{-1} and the remaining 46% used it at a rate of 1.5 kg dec^{-1}. Common types of lime used by farmers are as follows, viz.- burnt lime (CaO), slacked lime ($Ca(OH)_2$), gypsum ($CaSO_4.2H_2O$), dolomite ($CaMg(CO_3)_2$) and limestone ($CaCO_3$). When the pH of the water was less than 7, the farmers used limestone and dolomite; when the pH was more than 7, sometimes they used gypsum.

According to Rahman et al (2022), half (50%) of the farmers in the Mymensingh area adopted monoculture, synchronizing with our findings. Farmers in other regions of Bangladesh also prioritized polyculture over monoculture (Ali et al 2014; Nadia et al 2021; Sarker et al 2014). However, monoculture is becoming more common in north-central Bangladesh due to the widespread practice of intensive aquaculture. The preference for intensive monoculture of high-valued fish species at high density is primarily driven by its potential for increased profitability. To our knowledge, there has been not enough information regarding the pricing of fish seed in Bangladesh. This study could potentially serve as the basis for future studies. Recently, farmers in the study area have been making greater profits by stocking larger juvenile fish that can rapidly grow to a marketable size, as opposed to fry, and selling them at higher prices. Because, undoubtedly, consumers have a greater preference for larger and heavier fish. The study area exhibited a higher stocking density of fry compared to other areas in Bangladesh, suggesting culture intensification in this region. Rahman (2003) documented an average stocking density of 25,250 fish ha^{-1}, Islam et al (2002) observed 17,370 fry ha^{-1}, and Halim et al (2017) recorded 14,500 fry ha^{-1}, which is significantly lower than the findings of this study. According to Nadia et al (2021) and Faruk et al (2017), Rajbari had a fry density ranging from 20,000 to 40,000 ha^{-1}, while Mymensingh had a fry density ranging from 40,000 to 60,000 ha^{-1}. Stocking density varies depending on the culture systems and the kind of fish species and seeds being used. Increased stocking density necessitates a more intensified culture system. In post-socking management, feeding is crucial. Over the years, the use of floating pelleted feed has increased. Feed expenses are frequently the primary operational expenditure in various fish farming systems in Bangladesh (Ahmed 2007; Hossain and Islam 2014; Meah & Akther 2021). Therefore, farmers use those types of feed that are cost-effective and ensure proper growth. In

Mymensingh. In their study, Sheheli et al (2014) found that 60% of farmers employed floating pelleted feed, 23% opted for loose feed, and 17% utilized pelleted feed. These findings align with the results of the present research. The results were also comparable to Nadia et al (2021), who reported that 76% of farmers utilized commercial feed and 10% used formulated feed. Many farmers hesitate to use pelleted feed because of its high cost, with some opting for natural food instead (Ali et al 2014; Hossen et al 2020; Mondal et al 2018). Fingerlings are typically fed three to four times per day, while fish during the grow-out stage are fed one to three times per day (Davis & Hardy 2022). This feeding regime is predominantly adhered to in the study area. In Rajbari, Bangladesh, Nadia et al (2021) found that 54% of fish farmers fed their fish twice daily, and 46% fed them thrice daily. In the northern middle part of Bangladesh, 53.85% of farmers fed twice daily, while just 10.26% fed thrice daily (Sarker et al 2014).

This study found that most farmers are concerned about health management and disease control measures and use probiotics and vitamins to ensure better growth. It was found that 97.50% of farmers took disease control measures, much higher than the observations recorded by Hasan et al (2013) in northern Bangladesh and Aftabuddin et al (2016) in southern Bangladesh. Moreover, the present study reported that most farmers followed the modern approach of disease control rather than the traditional one. Probiotics are used for various functions throughout the culture period (Hossain et al 2013). Biswas et al (2019) stated that about 13%, 59%, and 28% of semi-intensive, extensive (traditional), and enhanced traditional farms, respectively, in Satkhira, southwestern Bangladesh, used probiotics, which was much lower than the present findings. Several vitamins and minerals are available in the market (Kawsar et al 2022; Shamsuzzaman & Biswas 2012). But there is limited data regarding the use of vitamins and minerals in ponds. However, evidently, farmers in north-central Bangladesh have recently been using more vitamins and minerals (Hasan et al 2013).

The time and type of fish harvesting vary across the country due to the geographical variations, local demand, cultured species, and the culture system practiced. Monoculture farms harvest totally, while polyculture farms exhibit partial harvests. Our findings in the monoculture-dominated research area corroborate this information. The cultured fish were harvested in Rangpur between September and October (Halim et al 2017). Sarker et al (2014) recorded a partial harvesting rate of 67.75%, while Sheheli et al (2014) found that 36% of individuals participated in partial harvest. Additionally, it was reported that farmers harvest all the fish stock during major illness outbreaks. Hossen et al (2020) discovered that pond farmers in Barishal Sadar harvest continuously throughout the year, with the highest activity occurring during the post-monsoon peak season. Ahmed (2003) indicated that the peak harvesting season occurred between December and March. The marketing channels of fish are varied in Bangladesh. The observed marketing channel was somewhat similar to the description of Halim et al (2017) and Sheheli et al (2014) regarding the number of intermediaries.

Demographics of fish farmers. Proficiency in fish farming requires both practical experience and significant physical capabilities, as the occupation demands strenuous manual labor and a comprehensive understanding of the technical aspects of fish farming. Roy & Basu (2020) found a positive relation between experience and age in individuals, which impacts production. Within the research domain, 75% of farmers fall within the age interval of 31-50 years, indicating that they possess both physical vigor and expertise. Hasan et al (2016) discovered that 54% of fish farmers in the Trishal upazila are between 36 and 50 years old. Ali et al (2009) and Ali et al (2010) discovered that 82.50% and 76% of fishermen belong to the 31-50 years category. These studies, in the context of the family status of fish farmers, also showed that 57.5% and 60% of the observed fish farmers lived in nuclear households, similar to our study's findings. However, Hossen et al (2020) found that most farmers (55%) lived in extended families in Barisal District, Southern Bangladesh. This might result from the geographical variations that impacts the choice of living. Hasan et al (2016) reported that 62.0% of fish farmers came from families with less than five members, which conforms to the present study's findings. Ali et al (2008) and Rahman et al (2021) found comparable

results in their respective research. Education enables individuals to remain informed about emerging techniques and technological advancements in fish farming, which is integral to the modernization of farm business operations. The literacy rate of fish farmers in Trishal, Mymenshing, is higher than the national literacy rate of 74% (BBS 2023). Hossen et al (2020) found that the majority of farmers (49%) were secondary school educated, whereas a few fish farmers (7%) were illiterate. A similar result was found by Ali et al (2009), Ali et al (2010) and Hossain & Islam (2014). However, Sohel et al (2008) and Zaman et al (2006) discovered an elevated rate of illiteracy, with rates of 13% and 23.3%, respectively.

Socio-economic status of farmers. In the domain of fish farming, owning a pond is paramount for farmers. When a pond is owned by a single individual, they solely bear the burden of any losses incurred; however, single ownership provides farmers with a greater sense of ownership and control over decision-making and pond management. Therefore, it is a crucial issue for the fish farming community. Results obtained from this study, with the majority (70%) of single ownership, are more or less similar to the findings of Ahmed et al (2023), Ali et al (2008) and Shajahan & Radović-Marković (2023). Besides, some fishermen run their operations on lease. The housing condition of the farmers provides insights into the occupants' social status. Throughout the survey, an effort was made to learn about the state of the people's dwellings. A study conducted by Hossain & Islam (2014) discovered similar patterns to our data on fish farmers in Trishal upazila. The majority of the farmers had semi-pucca houses, while 24% had kacha houses and 12% had pucca houses. According to Haque et al (2023), 65% of fishermen used tin sheds made with bamboo, followed by tin sheds made of tin (25%) and Straw (10%). A more or less similar result was also found in the findings of Latifa et al (2022). Good hygiene and sanitary practices ensure good living conditions. It was observed that farmers in this region had better hygiene standards than other regions in Bangladesh, and their sanitation has improved compared to decades ago. Hossain et al (2014) found only 64% of fish farmers had semi-pucca toilets, while only 20% of the fish farmers had pucca toilets, and the rest had kacha toilets in this region. Compared with other regions in the north (Natore) and Northwestern Bangladesh (Rajshahi and Rangpur), better sanitation was practiced in our study area. Only 12.5% (Ali et al 2008) and 6% (Halim et al 2017) of farmers had access to pucca sanitation in Rajshahi and Rangpur, respectively, cities of northwestern Bangladesh. In northern Bangladesh, 4% of the respondents even had no sanitary facilities (Latifa et al 2022). All the fish farmers in this research area had access to safe drinking water either from their own tube wells (90%) or tube wells from neighbors (10%). In Rajshahi, a study by Ali et al (2008) found that 88% of fish farmers utilized their own tube wells, while in Natore, Latifa et al (2022) reported that 46% of the fishermen used their tube wells. In Chuadanga, Southwestern Bangladesh, Haque et al (2023) discovered that 48% of the fishermen used their own tube well as a source of drinking water. Similar results were reported by Hossen et al (2020) in Barishal.

A study conducted by Hasan et al (2016) found that the health facilities utilized by the fish farmers were inadequate. They found that 38% of fish farmers relied on village doctors, whereas 22% received health services from the upazila hospital. However, the present investigation indicates a growing reliance on upazila health complexes and district medical hospitals for health services owing to better income and advancements in transportation. According to Haque et al (2023), a significant portion of fishermen (62%) sought medical assistance from village doctors lacking medical knowledge, 20% from ayurvedic practitioners (locally known as kabiraj), and 15% from upazila health complex in Chuadanga. Only 3% of fishermen receive medical care from MBBS doctors in an outdoor chamber. According to Latifa et al (2022), a study conducted in Natore, northern Bangladesh, revealed that 58% of fishermen sought healthcare from village doctors, while only 4% received medical services from private chambers of doctors with a MBBS degree. Electricity facilities for all are crucial in measuring the community’s development. All farmers in this study area have electricity access, similar to the findings of Rahman (2021) in Pabna, northern Bangladesh. In general, 99.34% of households in Bangladesh have access to electricity (BBS 2023). Ahmed et al (2023) found that 98% had electricity

facilities in Rajshahi district. While 78% of fishermen had electricity, and 22% of fishers did not use electricity in Dangapara fisheries village, Natore (Latifa et al 2022). Some farmers engage in fish farming as their primary occupation, while others consider it a secondary activity. Our findings regarding the main occupations of farmers in the study area correspond to the research conducted by Ali et al (2008), Haque et al (2023) and Hasan et al (2016). Ahmed et al (2023) found that about 48% of the respondents were involved in carp fish culture, 32% in agriculture, while 15% and 5% were involved in business and service, respectively, as primary occupations. Income is a key determinant of an individual's social class. The present study reported income range varied from 700-1,300 USD. Most of the fish farmers in the region earn more than the national average of 830 USD (BBS 2023). The annual income of fish farmers varied from 300-1,250 USD in Barishal, the southern region of Bangladesh. It showed the majority of fish farmers (31%) earned BDT 680 to 910 USD annually (Hossen et al 2020). Our data was also supported by the findings of Haque et al (2023) and Mithun et al (2020). Credit is essential not only for investing in fish ponds, fish handling, processing, and marketing facilities and services, but also for the efficient daily capture, cultivation, handling, processing, and distribution of fish. Hasan et al (2016) reported similar results to this investigation, where most fish farmers (58.0%) used their own money for their business, and the remaining took loans from banks and local NGOs. Ahmed et al (2023) stated that among the fish farmers, 85% took loans from different sources like banks, NGOs, local people, etc., whereas 15% did not because of their financial solvency, at Puthia, Rajshahi.

Fish farmers across the country seek advice from experienced neighbors regarding fish farming and necessary support, while others receive training from government officials. Pravakar et al (2013) reported identical findings to ours, indicating only 34% of the fish farmers in Chandpur, the east-central part of Bangladesh, received the necessary training from government officials. Sarker et al (2014) stated that 30.77% of fish farmers got training in fish farming from GOs and NGOs whereas 48.72% of owners gained their knowledge through personal contact and the rest had no training at all. Similarly, in northwestern Bangladesh, 45% of the carp fish farmers took technical help from friends and neighbors, while 25%, 15%, and 15% got technical assistance from GOs, NGOs, and others sequentially (Ahmed et al 2023).

Conclusions. This study illustrated that fish farmers followed modern cultural practices in north-central Bangladesh. Intensive culture systems accompanied by proper management techniques facilitate a comparatively better production in this part of Bangladesh. Most farmers made profits by cultivating fish. From an economic standpoint, the annual revenue generated from fish farming is relatively stable. The majority of farmers have enhanced their socioeconomic conditions by engaging in fish production, which plays a vital role in increasing income, food production, and employment opportunities. Their socio-economic status was comparatively better than other areas of Bangladesh due to their improved method of fish culture and management techniques. Nevertheless, there are certain factors that still need intervention to improve production and ensure long-term sustainability. These factors include high-quality fry, financing options, affordable and quality feed, training, and a downstream supply chain. Analysis of how fish farming affects fish farmers' livelihoods demonstrates that more than half of the fish farmers have seen a boost in their overall income as a result of engaging in fish farming. The accessibility of microloans, the provision of quality inputs such as fry, feed, vaccines, and other essential supplies, the adoption of advanced technology, the development of market infrastructure, and comprehensive training programs may contribute to a rise in fish production.

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References

Aftabuddin S. M. N., Islam M. A. B., Bhuyain M. A., Mannan, Alam M. M., 2016 Fish diseases and strategies taken by the farmers in freshwater at southwestern Bangladesh. Bangladesh Journal of Zoology 44(1):111–22.
Ahmed F., 2003 Comparative study on carp polyculture practices of three different in Mymensingh district. MSc Thesis, Department of Fisheries Management, Bangladesh Agricultural University, Mymensingh, Bangladesh, 65 p.
Ahmed M. B., Hannan M. A., Alam M. S., 2023 Assessment of the livelihood status of the carp fish farmers in two unions of Puthia upazila under Rajshahi district, Bangladesh. Journal of Agroforestry and Environment 16(2):48–53.
Ahmed N., 2007 Economics of aquaculture feeding practices: Bangladesh in economics of aquaculture feeding practices in selected Asian countries. FAO (Food and Agriculture Organization of United Nations), pp. 33–64.
Ahmed N., Rahman M. M., 2005 A study on fish marketing systems in Gazipur, Bangladesh. Pakistan Journal of Biological Sciences 8(2):287–292.
Ali H., Azad M. A. K., Anisuzzaman M., Chowdhury M. M. R., Hoque M., Sharful M. I., 2009 Livelihood status of the fish farmers in some selected areas of Tarakanda upazila of Mymensingh district. Journal of Agroforestry and Environment 3(2):85-89.
Ali M. H., Chowdhury M. A. H., Kabir M. A., Nur N. N., 2010 Assessment of the Livelihood Status of the Fish Farmers in Some Selected Areas of Rajshahi District. Journal of Agroforestry and Environment 3(2):25-29.
Ali M. H., Hossain M. D., Angm Hasan, Bashar M. A., 2008 Assessment of the livelihood status of the fish farmers in some areas of Bagmara Upazilla under Rajshahi District. Journal of the Bangladesh Agricultural University 6(2):367-374.
Ali M. M., Hossain M. B., Rahman M., Rahman S., 2014 Post stocking management practices by the pond fish farmers in Barisal District, Bangladesh. Global Veterinaria 13(2):196–201.
Al-Mahadi M. S., Rahman M. S., Islam M. S., Rahman K. M. M., Khanum R., 2020 Impact of pond fish culture on household livelihood capitals: An empirical analysis in Mymensingh District of Bangladesh. Journal of Bangladesh Agricultural University 18(4):1021–1028.
Ara Y., 2005 Assessment of small scale fresh water fish farming for sustainable of the rural poor farmers. MSc Thesis, Bangladesh Agricultural University, Mymensingh, 49 p.
Biswas P. C., Sultana S., Kabiraj M., Hossain S. S., 2019 Role of probiotics in aquaculture practice of Satkhira Region. International Journal of Fisheries and Aquatic Studies 7(5):174–181.
Davis D. A., Ronald W. H., 2022 Feeding and fish husbandry. Fish Nutrition, pp. 857–882.
Faruk M. A. R., Rahman N., Patwary Z. P., 2017 Risk factors associated with tilapia and pangasius diseases. Journal of Bangladesh Agricultural University 15(2):325–331.
Galib S. M., Hoque M. N., Akter S., Chaki N., Mohsin A. B. M., 2016 Livelihood, climate change and fisheries: a case study of three communities of northwestern Bangladesh. International Research Journal of Social Sciences 5(8):18–25.
Halim M. A., Rayhan A., Sharmin, Mondal D. K., 2017 Status of pond fish farmers in some selected areas of Mithapukur under Rangpur District, Bangladesh. International Journal of Agriculture & Environmental Science 4(3):12–16.
Haque F., Noori S. M., Hasan J., Shaha D. C., 2023 Declination of fish biodiversity and socio-economic status of the fishing community of Mathabhanga River in Chuadanga district of Bangladesh. Ecology Journal 5(1):27-36.
Hasan M. M., Faruk M. A. R., Anka I. Z., Azad M. A. K., 2013 Investigation on fish health and diseases in rural pond in three districts of Bangladesh. Journal of the Bangladesh Agricultural University 11(2):377–384.
Hasan M., Afrad M. S. I., Haque M. E., Barau M. H. A., 2016 Socioeconomic status of fish farmers and fishermen: A comparative in Trishal Upazila under Mymensingh District, Bangladesh. Bangladesh Journal of Extension Education 28(1&2):55-67.
Hassan R., Al Mahamud M. A., Evan D. M., Rahman T., Ahmed G. U., 2019 Fish health management practices of aquafarms in Cumilla District. Bangladesh Journal of Fisheries 31(1):111–118.

Hossain M. A., Pal R. K., Islam M. R., Haque M. R., 2014 A comparative study on livelihood status of fish farmer, stockist and fish retailer in Trishal Upazila of Mymensingh District. Journal of Science and Technology 12:41-47.
Hossain M. I., Kamal M. M., Mannan M. A., Bhuyain M. A. B., 2013 Effects of probiotics on growth and survival of shrimp (Penaeus) in coastal pond at Khulna. Journal of Scientific Research 5(2):363–370.
Hossain M. T., Islam M. N., 2014 Profitability analysis of small and large farms of fisheries-sectors: A case study at Trishal Upazila in Mymensingh. Journal of Economics and Sustainable Development 5(22):90–95.
Hossen S., Ali M. M., Sharker M. R., Jahan N., Hossain M. B., Sukhan Z. P., Mahmud A., Roy P., 2020 Present status of fish farming and livelihood of fish farmers in Barisal Sadar Upazila of Barisal District, Southern Bangladesh. World Applied Sciences Journal 38(2):143–152.
Islam M. S., Murshed S. M., Moniruzzaman M., Baree M. A., 2002 Rice-cum-fish farming in selected areas of Mymensingh District. Journal of Biological Sciences 2(10):715–718.
Kawsar M. A., Alam M. T., Pandit D., Rahman M. M., Mia M., Talukdar A., Sumon T. A., 2022 Status of disease prevalence, drugs and antibiotics usage in pond-based aquaculture at Narsingdi District, Bangladesh: A public health concern and strategic appraisal for mitigation. Heliyon 8(3):e09060.
Latifa G. A., Parvin M. M., Sardar M. A., 2022 Fish diversity and socio-economic condition of fishermen at the Halti Beel in Natore District, Bangladesh. Bangladesh Journal of Zoology 50(1):37–49.
Meah M. M., Akther K. R., 2021 Cost benefit analysis of fish farming at Northern Chattogram, Bangladesh. Social Change 10(1):163–271.
Mithun M. N. A. S., Kowsari M. S., Sheheli S., 2020 Socioeconomic characteristics and constraints of participatory fish farmers in Mymensingh District, Bangladesh. International Journal of Agricultural Research, Innovation and Technology (IJARIT) 10(2):170–176.
Mondal M. A. H., Begum K., Islam M. R., Mitul Z. F., Hossen S., Ali M. M., 2018 Pond fish culture in southwestern Bangladesh: An overview of the post stocking management practices. International Journal of Fisheries and Aquatic Studies 6(1):170–173.
Monir M. S., Haque M. R., Rahman S., 2011 Study on technical aspects of Pangasius (*Pangasianodon hypophthalmus*) farming in Mymensingh Region. International Journal of Sustainable Crop Production 6(1):36–42.
Nadia Z. M., Roy P., Rahman T., 2021 Culture practices and health management issues in selected of Rajbari, Bangladesh: A preliminary study. Journal of Agriculture, Food and Environment 2(1):109–116.
Pravakar P., Sarker B. S., Rahman M., Hossain M. B., 2013 Present status of fish farming and livelihood of fish farmers in Shahrasti Upazila of Chandpur District, Bangladesh. American-Eurasian Journal of Agricultural and Environmental Science 13(3):391–97.
Rahman M. H., Alam M. A., Flura, Azad M. R., Moniruzzaman M., Arifuzzaman M., Al-Amin, Mukti S. S., Jaman A., Talukdar A., Rahman, M. M., 2022 Culture and management practice in Mymensingh District: Perspective of fish production, disease occurrence and preventive measures. Journals of Entomology and Zoology Studies 10(5):44–49.
Rahman M. M., 2003 Socio-economic aspects of carp culture development in Gazipur, Bangladesh. MSc Thesis, Bangladesh Agricultural University, Mymensingh, 52 p.
Rahman M. M., Motin M. A., Islam M. S., Haque S. A., Islam M. F., Rahman M., 2021 Assessing livelihood and socioeconomic status of fishermen community adjacent to chalan beel area in Faridpur Upazila, Pabna, Bangladesh. Journal of Bioscience and Agriculture Research 28(1):2324–2334.
Rahman T., 2021 Culture practices and health management issues in selected aquafarms of Rajbari, Bangladesh: A preliminary study. Journal of Agriculture, Food and Environment (JAFE) 2(1):109–116.

Rana M. S., Uddin M. M., Uddin M. S., Alam M T., 2016 Status of aquaculture and livelihood of fish farmers in Golapgonj under Sylhet District, Bangladesh. Bangladesh. International Journal of Natural Sciences 6(2):66-74.
Roy A., Basu S., 2020 Determinants of livelihood diversification under environmental in coastal community of Bangladesh. Asia-Pacific Journal of Rural Development 30(1–2):7–26.
Saha S. K., 2004 Socio-economic aspects of aquaculture in Tangail Sadar Upazila. MSc Thesis, Bangladesh Agricultural University, Mymensingh, 47 p.
Sarker S. K., Hasan M. T., Das S. K., Mazumder S. K., 2014 Fish culture practice and socio economic status in northern part of Bangladesh. Malaysian Journal of Medical and Biological Research 1(1):42–51.
Shajahan K., Radović-Marković M., 2023 Building resilience of fishery and changing livelihood status of the fishermen in Bangladesh. Journal of Entrepreneurship and Business Resilience 6(1):33–44.
Shamsuzzaman M. M., Biswas T. K., 2012 Aqua chemicals in shrimp farm: A study from South-West Coast. The Egyptian Journal of Aquatic Research 38(4):275–285.
Sheheli S., Fatema K., Haque S. M., 2014 Existing status and practices of fish farming in Trishal upazila of Mymensingh District. Progressive Agriculture 24(1–2):191–201.
Sohel M. A., Akter N., Haq M. S., Nasrin S., Islam A. K. M. R., 2008 Assessment of the livelihood status of the fish farmers in some areas of Kahaloo Upazila, Bogra. Journal of Agroforestry and Environment 2(2):177–182.
Zaman, Tanjeena, Jewel M. A. S., Bhuiyan A. S., 2006 Present status of pond fishery resources and livelihood of the fish farmers at Mohanpur Upazila in Rajshahi District. University Journal of Zoology, Rajshahi University 25:31–35.
*** BBS, Bangladesh Bureau of Statistics, 2023 Household income and expenditure survey (HIES) 2022. Statistics and Informatics Division (SID), Ministry of Planning.
*** DoF, Department of Fisheries, 2022 Yearbook of fisheries statistics of Bangladesh 2021-22. Fisheries Resources Survey System (FRSS), Department of Fisheries, Bangladesh, Ministry of Fisheries.
*** FAO, 2022 The state of world fisheries and aquaculture 2022. FAO.

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