An Analysis of Fish Farming Profitability and Marketing Efficiency of Selected Fish Species in Bangladesh

Debasish Chandra Acharjee[1*], Md. Sadique Rahman[2], Kamal Gosh[3], Md Ruhul Amin[1],
G M Monirul Alam[1] and Mohammad Ismail Hossain[4]

ABSTRACT

Aiding developing nations like Bangladesh in their pursuit of food security requires careful analysis of marketing costs and margins as well as farmer profitability. Therefore, this study delves into the profitability and marketing intricacies of four prominent fish species in Bangladesh's aquaculture sector namely rohu (*Labeo rohita*), catla (*Catla catla*), Nile tilapia (*Oreochromis nilotica*), and pangas (*Pangasianodon hypophthalmus*). Through extensive face-to-face survey involving 200 fish farmers and 212 market actors in aquaculture-rich districts, the research uncovers valuable insights. The findings unveil varying profitability, with catla fish emerging as the most lucrative, boasting a substantial benefit-cost ratio (BCR) of 2.77, while Nile tilapia trails with a BCR of 1.08. The highest expense was incurred for feed, followed by fingerlings. The study highlights the existence of multiple routes for transferring fish from producers to consumers, notably direct sales to middlemen and the active involvement of intermediaries like wholesalers, and facilitators. Farmers sell 41% of their fish directly to middlemen. With facilitator's commission standing out as the most important cost component, wholesalers bear an excessive portion of the marketing expenses. Efficiency in fish marketing is meticulously assessed, with catla fish emerging as the most efficiently supplied species. The study underlines the considerable potential for bolstering fish productivity and enhancing the value chain–a promising avenue that promises financial benefits to both fish farmers and market actors.

Keywords: Benefit-cost ratio, Fish farmer, Marketing cost, Marketing efficiency, Profitability, Value chain

INTRODUCTION

Freshwater pond aquaculture is a cornerstone of Bangladesh's agricultural landscape, making a substantial contribution to both fish and aquaculture production. It accounts for 44.43% of the nation's total fish production and an impressive 79% of its aquaculture output (Shamsuzzaman *et al*., 2017; DOF, 2021). Notably, in the fiscal year 2021–2022, this sector witnessed a remarkable 2.86% growth, yielding a total production of 4,052,701 metric tons (MT) of fish and aquaculture products (DOF, 2021). These sectors collectively constitute 3.57% of Bangladesh's Gross Domestic Product (GDP) and approximately 25% of the agricultural GDP (DOF, 2021). Furthermore, they play a pivotal role in bolstering the nation's foreign exchange earnings through the export of fish, shrimp, and other fishery products (DOF, 2021). Most importantly, these sectors provide nearly 60% of the country's animal protein supply (Dey *et al*., 2010; FRSS, 2020; Acharjee *et al*., 2021).

[1]Department of Agribusiness, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur, Bangladesh
[2]Department of Management and Finance, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh
[3]Sherman Lewis School of Agriculture and Applied Sciences, Langston University, Langston, Oklahoma, USA
[4]Department of Agribusiness and marketing, Bangladesh Agricultural University, Mymensingh, Bangladesh
[*]Corresponding author. E-mail address: debasish.agb@bsmrau.edu.bd
Received 9 June 2023 / Accepted 24 November 2023

The prevalent practice within pond aquaculture is polyculture, an integrated system involving the simultaneous cultivation of various species. This comprehensive approach incorporates key species such as pangas, Nile tilapia, and indigenous carps, including rohu, and catla, along with several other exotic carps (Hossain *et al*., 2022a). Among these species, pangas fish holds prominence, representing approximately 23.24% of all cultured fish species, while other significant species like rohu, catla, and Nile tilapia contribute 12.58%, 8.29%, and 16.64%, respectively (DOF, 2020). Consequently, the polyculture system significantly contributes to freshwater aquaculture production in Bangladesh, accounting for roughly 60% (DOF, 2021). The growing market demand and value for carp species, particularly as Bangladesh's aquaculture industry shifts towards semi-intensive or intensive practices, have driven increased demand for inputs such as feed, fingerlings, and fertilizers (Sarker *et al*., 2016).

In Bangladesh, where aquaculture plays a significant role in the economy, ensuring the profitability of fish production is of paramount importance. This profitability not only supports the livelihoods of millions of small-scale fish farmers but also contributes significantly to the nation's economic prosperity (Dey *et al*., 2010). At the individual level, profitability directly affects the income and economic well-being of fish farmers in Bangladesh. Furthermore, at the broader level, profitability in aquaculture plays a vital role in the country's economic growth. It enhances the overall financial health of the sector, making a substantial contribution to the national GDP (DOF, 2021). A thriving aquaculture industry generates employment opportunities and drives economic activities in rural areas, where the majority of aquaculture activities are concentrated (Acharjee *et al*., 2021). An efficient marketing system, coupled with fair pricing, empowers farmers to receive just compensation for their efforts, providing them with an incentive to invest in their operations, adopt improved practices, and expand their production, thereby improving their livelihoods (Hossain, 2011).

Market efficiency in the aquaculture sector, particularly within Bangladesh, is a matter of utmost importance. As one of the world's leading producers of fish and aquaculture products (DOF, 2021), the effective functioning of fish markets profoundly influences both local and global scales. A well-operating market ensures that fish farmers receive equitable prices for their products, thus promoting economic sustainability in rural areas where aquaculture is a primary livelihood (Sen *et al*., 2016). Conversely, inefficiencies can lead to reduced profits for producers, thereby undermining the financial well-being of these communities (Abugu *et al*., 2013). Market efficiency also plays a pivotal role in addressing food security in Bangladesh. With a substantial portion of the animal protein supply dependent on fish (Dey *et al*., 2010), ensuring affordable access to fish is essential for the growing population. An efficient marketing system guarantees a consistent supply of fresh fish to consumers at reasonable prices, contributing to food security by ensuring access to a vital source of nutrition for a larger portion of the population (Chowdhury, 2012). As one of the primary contributors to the country's foreign exchange earnings (DOF, 2021), an efficient marketing system ensures that these products meet international quality standards and reach overseas markets promptly (Islam *et al*., 2014). This, in turn, not only bolsters the country's economic stability but also enhances its reputation as a dependable supplier of fish and fishery products on the global stage (Devi, 2011). Given the highly perishable nature of fish, efficient distribution and marketing systems are indispensable to ensure the success and sustainability of the aquaculture industry. An efficient and reliable marketing system is essential to guarantee the prompt delivery of fresh fish to the market while preserving its freshness (Asogwa and Asogwa, 2019).

Several studies have identified different marketing channels within the fish value chain in Bangladesh (Devi, 2011; Hossain, 2011; Chowdhury, 2012; Islam *et al*., 2014). The performance of these marketing systems is often assessed by measuring marketing margins, which depend on the quality and quantity of marketing services, their efficiency, and pricing. Understanding these margins is critical, as substantial margins can erode profits for sellers, particularly in competitive market conditions (Sreenivasa Murthy *et al*., 2004). Moreover, the size of marketing margins is influenced by the supply and demand for marketing services and typically encompasses the minimum costs of service provision along with a "normal" profit. Excessive market margins may result in higher consumer prices without benefiting either producers or consumers, potentially causing producers to withdraw from the market (Asogwa and Asogwa, 2019). Although significant progress has been made in the aquaculture sector, there is a paucity of studies that have assessed the costs and margins of fish producers and market actors in Bangladesh (Devi, 2011; Hossain, 2011; Chowdhury, 2012; Islam *et al*., 2014; Sen *et al*., 2016). Analyzing marketing costs and margins, along with evaluating the profitability of farmers, is vital to support the food security goals of a developing nation like Bangladesh (Abugu *et al*., 2013). Previous research has primarily focused on identifying efficient marketing channels, with longer channels often leading to inefficiencies and lower producer shares (Alam *et al*., 2010; Ali *et al*., 2016; Haque *et al*., 2021).

Given this context, this study seeks to address these critical gaps by assessing producer profitability, identifying marketing costs in various marketing channels, and evaluating the marketing efficiency for major fish species in Bangladesh. This study is vital not only for the growth and sustainability of the aquaculture sector but also for the broader economic and food security objectives of the country.

MATERIALS AND METHODS

Selection of the study areas

Our study was carried out in the districts of Mymensingh and Jashore, known for their substantial contribution to Bangladesh's pond aquaculture production, accounting for approximately 22% of the total output. These districts were chosen due to their favorable climate, infrastructure, and proximity to the capital, Dhaka, which facilitates fish farming and distribution (Khan *et al*., 2021). Additionally, Dhaka, being a key transit point for fish transportation, was included in our survey to gather data from various actors involved in the fish marketing channels. Regarding the choice of fish species, we focused on rohu (*Labeo rohita*), catla (*Catla catla*), Nile tilapia (*Oreochromis nilotica*), and pangas (*Pangasianodon hypophthalmus*) due to their significant demand and popularity across the entire country.

Sample size

The compilation of the fish farmers' list was obtained from district fisheries offices. Subsequently, we employed a two-stage random sampling technique to select an appropriate sample size for our study. In the initial stage, we identified the areas characterized by the highest concentration of fish farming and pinpointed the union/villages with the most significant fish production. To calculate the minimum required sample size, we applied the following formula, as outlined by Olsson (2011):

$$n = \frac{(N \times n_0)}{(N + n_0)} = \frac{(32{,}600 \times 1.96)}{(32{,}600 + 1.96)} \approx 1.96$$

$$\text{where } n_0 = \frac{z^2\,pq}{e^2} = \frac{(1.96^2 \times 0.85 \times 0.15)}{0.05^2} \approx 196 \qquad (1)$$

Where, n is sample size, N is total population, z is the value of the normal curve, p is estimated population proportion, q is 1-p and e is an error term (5%).

A total of 200 fish farmers, with 100 from the Mymensingh district and 100 from the Jashore district, were meticulously selected for primary data collection. To identify the sample farms, we adhered to the inland aquaculture waterbody classification provided by the Department of Fisheries, Bangladesh. Rather than relying on the area of cultivation, we employed the quantity of harvest to determine the eligibility of each farm. Farms with an annual harvest of less than 10 metric tons (MT) per hectare of the pond were categorized as extensive ponds. Conversely, if the production from a similar-sized pond exceeded 4 MT, it was classified as an intensive pond. Consequently, both extensive and intensive farms were included in this study (DOF, 2021).

In addition to the fish farmers, we conducted interviews with 212 diverse market actors in the value chain. The sample size for these market actors was deliberately determined based on their willingness to participate in the study, and the distribution of this sample size is presented in Table 1.

The value chain in this study involves several key actors, including farmers, middlemen, rural and urban wholesalers, facilitators, retailers, and consumers. Each of these actors plays a distinct role in the fish marketing process. Middlemen are responsible for assembling and transporting fish from farmers to the local market. Rural wholesalers perform the functions of collecting and transporting fish from farmers, middlemen, and facilitators to the local marketing centers. Urban wholesaler, on the other hand, assemble and transport fish from facilitators. Facilitators acts as intermediaries, facilitating the sale of large quantities of fish from farmers, middlemen, and rural wholesaler to urban wholesaler and retailers. Retailers, in turn, gather and distribute fish from farmers, middlemen, rural wholesaler, and facilitators to the marketing center, ultimately making it available to consumers.

During the survey, all respondents provided verbal informed consent after being briefed about the study's objectives. It's important to note that participation in the study was entirely voluntary, and respondents had the option to decline or terminate their participation at any point. In cases where a participant declined to be interviewed, alternative participants were approached.

Analytical techniques

Analytical techniques were employed to calculate the production costs and margins of fish farmers, utilizing the enterprise budget developed by Gosh *et al*. (2022). Production costs encompass variable expenses such as fingerlings, feed, human labor, pond preparation, fertilizer, interest in operating capital, medicine, pesticides, and other relevant factors. Fixed costs include land use expenses, irrigation equipment, pond construction, staff salaries, and other associated fixed costs. The cost of land use is calculated by dividing the land's lease value by its effective use years or lease years. The following equation was used to assess the gross return of the selected fish at farmer's level:

$$\Pi = GR-(TVC+TFC) \quad (2)$$

Where, Π = Farmers profit ($BDT \cdot ha^{-1}$); GR = Gross return ($BDT \cdot ha^{-1}$); TVC = Total variable cost (BDT); TFC = Total fixed cost (BDT)

Gross margin was determined by subtracting total revenue from variable costs. The use of gross margin analysis stems from the fact that farmers care more about their return over variable costs.

Table 1. Distribution of samples from study areas.

Respondents	Study Areas			
	Mymensingh	**Jashore**	**Dhaka**	**Total**
Farmers	100	100	-	200
Middlemen	30	30	-	60
Rural wholesaler	12	12	-	24
Facilitators	13	13	10	36
Urban wholesaler	-	-	6	6
Retailer	33	33	20	86
Total	188	188	36	412

Note: Source: Field survey, 2018; - indicates not applicable

The following equation was used to assess the gross margin:

$$GM = TR-VC \quad (3)$$

Where, GM = Gross margin; TR = Total return; VC =Variable cost Net margin was calculated by deducting all costs from gross margin.

$$NM = GM-TC \quad (4)$$

Where, NM = Net margin; GM = Gross margin; TC = Total cost (TVC+TFC)

The following formula estimates the total marketing cost incurred by the value chain actors:

$$C = C_{m1} + C_{m2} + C_{m3} + \ldots\ldots + C_{mi} \quad (5)$$

where, C = Total marketing cost of market actors; C_{mi}= Cost incurred by the i^{th} actors in the process of buying and selling of fish.

The following formula estimated the gross marketing margin of different market actors:

$$\text{Gross marketing margin } (BDT \cdot kg^{-1}) = \text{Sales price } (BDT \cdot quintal^{-1}) - \text{Purchase price } (BDT \cdot quintal^{-1}) \quad (6)$$

Marketing performance was evaluated using different measures of marketing efficiency (Shepherd, 1972; Hugar and Hireman, 1984; Acharya and Agarwal, 2004). In this study, the efficiency of marketing was investigated by examining price spread, farmer's share, Acharya's methods for estimating efficiency and return on investment. Following Acharya and Agarwal (2004), marketing efficiency was calculated by using following index:

$$ME = \frac{NFP}{(TMC+NMM)} \quad (7)$$

Where, ME = Marketing efficiency; NFP = Net price received by farmers; TMC= Total marketing cost; NMM= Total net marketing margin of intermediaries. A higher value of ME denotes higher level of efficiency and vice versa.

According to Shepherd (1972) the ratio of the total value of goods marketed to the total marketing cost is marketing efficiency. The higher the ratio, the higher efficiency and vice-versa. The ratio can be expressed in the following form:

$$ESC = [(V/I)-1] \quad (8)$$

where, ESC = Index of efficiency; V = Value of goods sold; I = Total marketing cost

Calkin's index of marketing efficiency is estimated using the following formula:

$$\text{Marketing efficiency} = 1 + \frac{\text{(Sum of profit or margin)}}{\text{(Sum of marketing cost)}} \quad (9)$$

The lower the index's value, the higher the efficiency.

Price-spread and producers' shares in consumers' price was calculated by following formula:

$$\text{Price-spread} = \text{Price paid by a consumer } (BDT \cdot kg^{-1}) - \text{Price received by the farmer } (BDT \cdot kg^{-1})$$

$$\text{Producer's share (\%)} = \frac{\text{Price Received by the Producer } (Tk \cdot kg^{-1})}{\text{Consumer's Price } (Tk \cdot kg^{-1})} \times 100 \quad (10)$$

Price received by the producer = Gross Price Received ($BDT \cdot kg^{-1}$) - Average cost incurred in marketing ($BDT \cdot kg^{-1}$).

After applying all the performance indicators noted above, the final ranking among the indicators was computed using the composite index formula.

$$R = \frac{Ri}{Ni} \quad (11)$$

Where, R_i = Total value of ranks of all indicators [I_1-I_7; Actor share (I_1), Intermediaries Margin (I_2), Acharya's Efficiency (I_3), Shepherd's Efficiency (I_4), Calkin's Index (I_5), Price spread (I_6), Producer share in percentage (I_7)]; N_i = Number of indicators. The lowest mean relatively represents the most efficient marketing and vice versa (Rajagopal, 1986).

RESULTS AND DISCUSSION

Fish marketing channels

The study reveals the existence of five primary alternative pathways employed for the movement of fish from producers to consumers within the research areas. Typically, fish farmers engage in the direct sale of their catch to middlemen, who operate without a fixed location for transactions but are involved in daily trading activities. Subsequently, middlemen resell the fish to rural wholesaler, traders who engage in bulk purchases. In this chain, rural wholesaler assumes the role of sorting the fish and further reselling the high-quality specimens to other actors within the value chain. The specific choice between long or short value chains for a given commodity is influenced by a range of factors, including the characteristics of the product, the size of the market, demographics of both producers and consumers, and the prevailing social and physical environment. In the study areas, the following dominant value chains were observed for the selected fish species, namely rohu, catla, Nile tilapia, and pangas:

Chain - I Farmer→Middlemen→Rural wholesaler →Facilitators→Retailer→Consumer

Chain - II Farmer→Middlemen→Facilitators→ Rural wholesaler→Retailer→Consumer

Chain - III Farmer→Rural wholesaler→Facilitators →Retailer→Consumer

Chain - IV Farmer→Rural wholesaler→Facilitators →Urban wholesaler→Retailer→Consumer

Chain -V Farmer→Urban wholesaler→Facilitators →Retailer→Consumer

Intermediaries in the fish marketing channels

Within the fish marketing channels, the process involves the exchange of fish from one party to another. Facilitators, characterized by established business premises and staff, play a pivotal role in negotiating transactions between fish buyers and sellers. This intermediation process takes place within the business premises of the facilitators, with them acting as negotiators who do not take ownership of the fish but receive commissions for their mediation services.

The study's findings reveal distinct patterns in the flow of fish through the value chain. Notably, farmers directly sell 41% of their fish to middlemen, followed by rural wholesaler at 35%, and urban wholesaler at 24%, with these transactions facilitated by facilitators. Middlemen, who acquire fish directly from farmers, sell 65% of their fish to rural wholesaler and the remainder to urban wholesaler through facilitators. Rural wholesaler, on the other hand, directly purchase 35% of their fish from farmers and the remaining 65% from middlemen. They, in turn, sell 41% of the fish to urban wholesaler and 59% to retailers, all mediated by facilitators (Table 2). Urban wholesaler's primary source of fish procurement is rural wholesaler, amounting to 41%, followed by middlemen at 35%, with facilitators serving as the intermediary. Urban wholesaler, in turn, sells the entirety of their fish to retailers through facilitators. Retailers predominantly acquire 59% of their fish from rural wholesaler and 41% from urban wholesaler, ultimately making the full quantity available to end consumers. This pattern aligns with previous research (Shafiuddin, 2021) and underscores the multi-tiered nature of the fish marketing system in Bangladesh. The participation of intermediaries, including facilitators, contributes to increased costs for consumers and losses for fish farmers (Shafiuddin, 2021). Despite the high demand for fish in Bangladesh, the market landscape is primarily localized, and fish farmers seem to have limited access to more advantageous alternative markets such as contract farming, and community-based farming. Prior research has indicated that engaging in community-based farming can strengthen the ability to engage in negotiations with input suppliers and consumers (Kuldilok *et al*., 2018). The findings also emphasize the complex dynamics of fish marketing in Bangladesh and the significant role intermediaries like facilitators play in connecting producers with consumers. While the multi-tiered marketing structure may contribute to some inefficiencies and increased costs, it is essential to consider the role of intermediaries in ensuring a smooth flow of fish products across various market segments (Scott *et al*., 2019; Thủy *et al*., 2019). Future research should explore strategies for optimizing this marketing system to benefit both fish farmers and consumers.

Cost of production

The survey findings reveal that the majority of fish farmers in the study areas employed a polyculture system, cultivating multiple fish species together. Consequently, attributing specific cost items to each fish category, such as feed, lime, irrigation, electricity, and others, presented challenges. As a result, the total cost of production was allocated among fish species based on their proportional contribution to the overall production. The total cost of production was calculated on a per-hectare, per-year basis.

On average, the annual cost of fish production per hectare amounted to BDT 2,958,734 with variable costs accounting for BDT 2,713,825 (91.72%) and fixed costs for BDT 244,909 (8.28%). Notably, Jashore district incurred the highest production cost, totaling BDT 3,018,728 per hectare, surpassing Mymensingh (Table 3). This variance is attributed to the higher cost of production inputs, including feed, fertilizer, and labor, in Jashore. However, statistical analysis, as indicated by a mean difference test, suggests that the total cost of production was statistically similar in both areas The highest cost was incurred for feed followed by fingerling in both the areas. The allocation of production costs in polyculture systems poses a methodological challenge, and this practice reflects the pragmatic approach adopted by farmers. As a consequence, it's crucial to assess the cost-effectiveness and efficiency of these systems. Polyculture has the potential to optimize resource utilization, but understanding the economic implications of such practices is essential (Scott *et al*., 2019).

Profitability

The study results underscore the noteworthy aspect that total fish production in the two surveyed districts exhibits a remarkable parity, as detailed in Table 4 and Table 5. Specifically, the total annual production of key fish species, namely rohu, catla, Nile tilapia, pangas, and others encompassing mrigal (*Cirrhinus cirrhosus*), kalbasu (*Labeo calbasu*), grass carp (*Ctenopharyngodon idella*), silver carp (*Hypophthalmichthys molitrix*), among others, is presented in both Mymensingh and Jashore districts. In Mymensingh, these figures stand at 1,077 kg, 669 kg, 15,596 kg, 25,002 kg, and 898 kg per hectare, respectively. On the other hand, the corresponding production statistics in Jashore district are 1,021 kg, 726 kg, 15,638 kg, 27,129 kg, and 862 kg per hectare. Remarkably, the study reveals that among the various fish species, rohu and catla emerge as

Table 2. Percentage of fish transacted by value chain actors.

Value chain actors	Purchased from (%)					Sold to (%)				
	Farmer	Middle men	Rural wholesaler Via Facilitators	Urban wholesaler Via Facilitators	Retailer	Middle men	Rural wholesaler Via Facilitators	Urban wholesaler Via Facilitators	Retailer via Facilitators	Consumer
Farmer	-	-	-	-	-	41	35	24	-	-
Middlemen	100	-	-	-	-	-	65	35	-	-
Rural wholesaler	35	65	-	-	-	-	-	41	59	-
Urban wholesaler	24	35	41	-	-	-	-	-	100	-
Retailer	-	-	59	41	-	-	-	-	-	100
Consumer	-	-	-	-	100	-	-	-	-	-

Note: Source: Field survey, 2018; - indicates not applicable. Facilitators negotiates between buyers and sellers of fish and help them at their business premises on receipt of the commission.

Table 3. Average production cost of fish species in the study areas (BDT·ha^{-1}·year^{-1}).

Sl. No.	Cost Items	Mymensingh	Jashore	Mean difference	t-value
1	Pond preparation	49,288	45,422	-3,865.44*	0.093
2	Fingerling	177,084	158,887	-18,197.46***	0.003
3	Netting	11,788	12,108	319.77	0.610
4	Feed	2,244,944	2,356,859	111,915.0	0.135
5	Lime	14,609	14,586	-23.10	0.924
6	Salt	12,488	13,478	990.24***	0.000
7	Geolite	6,784	7,978	1,193.28***	0.000
8	Medicine	5,264	5,362	97.35	0.705
9	Fertilizer				
	Urea	8,228	11,111	2,883.34***	0.000
	TSP	4,144	5,492	1,347.68***	0.000
	Cow dung	1,183	756	-427.32*	0.069
10	Pesticides	2,097	960	-1,137.15***	0.001
11	Electricity	7,998	10,825	2,826.43***	0.000
12	Labor	39,492	47,613	8,120.39***	0.000
13	Interest on operating capital	119,578	124,666	5,317.73	0.163
	Total variable cost (A)	2,710,351	2,821,712	111,360.8	0.188
14	Land use	93,108	97,115	4,007.07***	0.000
15	Pond construction	114,170	113,024	-1,146.67	0.466
16	Irrigation	26,268	28,702	2,434.12**	0.015
17	Shed	7,910	9,521	1,611.18***	0.000
18	Salary	71,891	78,931	7,040.10***	0.000
	Total fixed cost (B)	313,347	327,293	13,945.81***	0.000
	Total cost (A+B)	3,023,698	3149,005	125,306.6	0.142

Note: Source: Field Survey, 2018; *, ** and *** indicates significant at 10%, 5% and 1% level; BDT is Bangladeshi currency; 1 USD = BDT 85.

the more profitable choices for fish farmers in both locations. Notably, both rohu and catla boast benefit-cost ratios (BCRs) exceeding 2 in both districts. In contrast, Tilapia is identified as the least profitable option, characterized by the lowest BCR in both Mymensingh and Jashore districts.

It's noteworthy to reference previous research in this context, which had indicated that carp farming can be deemed profitable when achieving a BCR of approximately 1.50 (Ali, 2016; Hossain *et al*., 2022b). However, the current study presents a notably higher BCR. This variance could be attributed to the fact that fish farmers in the study area also engage in selling their fish in Dhaka's capital market, where they can command higher prices for their produce. The findings on profitability underscore the potential for fish farmers to optimize their returns through the selective cultivation of more profitable species, notably rohu and catla. The role of market dynamics, especially those in the capital city of Dhaka, in shaping these profitability trends requires further exploration and analysis (Khan, 2018; Rahman, 2019).

Marketing cost of market actors

An in-depth analysis of the marketing cost components reveals a spectrum of expenses essential for the seamless flow of fish through the

Table 4. Total return of selected fish species in the Mymensingh areas (BDT·ha^{-1}·year^{-1}).

Particulars	rohu	catla	tilapia	pangas	Others
Production (kg·ha^{-1})	1,077	669	15,596	25,002	898
Price (BDT·kg^{-1})	189	201	86	78	123
Gross return (BDT·ha^{-1})	203,553	134,469	1,341,256	1,950,156	110,454
Total fixed cost (BDT·ha^{-1})	8,146	4,046	138,102	156,551	6,501
Total variable cost (BDT·ha^{-1})	85,345	44,419	1,098,053	1,422,063	60,471
Total cost (BDT·ha^{-1})	93,491	48,465	1,236,155	1,578,614	66,972
Gross margin (BDT·ha^{-1})	118,208	90,050	243,203	528,093	49,983
Net return (BDT·ha^{-1})	110,062	86,004	105,101	371,542	43,482
Benefit cost ratio (BCR)	2.18	2.77	1.08	1.24	1.65

Note: Source: Field Survey, 2018

Table 5. Total return of selected fish species in the Jashore areas (BDT·ha^{-1}·year^{-1}).

Particulars	rohu	catla	tilapia	pangas	Others
Production (kg·ha^{-1})	1,021	726	15,638	27,129	862
Price (BDT·kg^{-1})	187	196	84	77	125
Gross return (BDT·ha^{-1})	190,927	142,296	1,313,592	2,088,933	107,750
Total fixed cost (BDT·ha^{-1})	7,249	4,261	151,182	157,488	6,671
Total variable cost (BDT·ha^{-1})	86,952	45,127	1,025,205	1,597,684	63,082
Total cost (BDT·ha^{-1})	94,201	49,388	1,176,387	1,759,276	69,753
Gross margin (BDT·ha^{-1})	103,975	97,169	288,387	487,587	44,668
Net return (BDT·ha^{-1})	95,989	92,908	137,205	329,657	37,997
Benefit cost ratio (BCR)	2.02	2.88	1.12	1.19	1.54

Note: Source: Field Survey, 2018

various stages of the value chain. These components encompass transportation, grading, market tools, personal expenses, shop rent, loading and unloading, fees and charges, icing, wages and salaries, facilitator's commission, electricity, tips, donations, and miscellaneous costs, including those related to water, bags, wastage, and security (Hossain, 2022).

Tables 6, 7, and 8 present a comprehensive overview of the average total marketing costs across different market actors. Notably, the data indicates that wholesalers shoulder a substantial share of the marketing costs. Following closely are the retailers. A deeper examination of the cost structure reveals that facilitator's commission emerges as the most significant cost component for wholesalers. This underscores the pivotal role that facilitators play in the marketing system as intermediaries, facilitating transactions but adding to the financial burden of the wholesalers. It's also worth noting that wholesalers, due to their large purchase volumes, incur additional expenses associated with transportation, icing, and facilitator's commission (Nadia *et al.*, 2022). These findings highlight the complex dynamics of marketing costs within the fish value chain, wherein different actors bear distinct but interconnected cost burdens. Further research could delve into strategies to optimize these costs and enhance the overall efficiency of the marketing system, benefiting both market actors and fish farmers (Kumar *et al.*, 2019; Rahman and Mia, 2020).

Table 6. Marketing cost of market actors in Mymensingh areas (BDT·quintal^{-1}·day^{-1}).

Sl#	Cost Items	Middlemen	Rural wholesaler	Facilitators	Retailer
1	Transportation	103.30	202.83	-	52.11
2	Grading	15.72	35.05	-	19.52
3	Market toll	23.08	30.16	-	33.19
4	Personal expenses	83.0	104.0	70.61	143.38
5	Shop rent	-	-	30.91	47.0
6	Loading/unloading	20.02	45.24	-	19.02
7	Fee/charge	16.19	30.11	41.33	20.98
8	Icing	69.25	103.33	-	80.97
9	Facilitator's commission	150.0	375.0	-	200.0
10	Tips and donation	21.80	30.88	40.33	31.66
11	Wages and salaries	70.58	102.88	90.16	109.66
12	Electricity	-	-	40.08	34.05
13	Others	29.11	38.16	39.16	40.25
Total		602.05	1,097.64	352.58	831.79

Note: Source: Field Survey, 2018; - indicates not applicable; others include water, bag, Wastage, security etc.

Table 7. Marketing cost of market actors in Jashore areas (BDT·quintal^{-1}·day^{-1}).

Sl#	Cost Items	Middlemen	Rural wholesaler	Facilitators	Retailer
1	Transportation	187.56	170.11	-	58.33
2	Grading	22.64	32.16	-	18.16
3	Market toll	20.04	29.72	-	27.47
4	Personal expenses	80.03	108.77	85.74	110.54
5	Shop rent	-	-	39.41	45.0
6	Loading/unloading	23.17	37.11	-	27.27
7	Fee/charge	19.14	32.88	37.41	22.68
8	Icing	81.06	70.66	-	87.0
9	Facilitator's commission	130.0	410.0	-	170.0
10	Tips and donation	23.93	28.38	26.58	20.59
11	Wages and salaries	90.56	70.66	76.03	100.81
12	Electricity	-	-	23.41	31.81
13	Others	31.34	36.05	28.50	37.06
Total		649.47	1,026.50	317.08	756.72

Note: Source: Field Survey, 2018; - indicates not applicable; others include water, bag, Wastage, security etc.

Table 8. Marketing cost of market actors in Dhaka (BDT·quintal^{-1}·day^{-1}).

Sl#	Cost Items	Urban wholesaler	Facilitators	Retailer
1	Transportation	205.0	-	74.0
2	Grading	30.14	-	18.0
3	Market toll	33.42	38.0	45.5
4	Personal expenses	105.0	80.0	134.5
5	Shop rent	-	30	80.0
6	Loading/unloading	35.0	-	25.0
7	Fee/charge	42.0	36.0	23.5
8	Icing	105.0	-	101.5
9	Facilitator's commission	470.0	-	220.0
10	Tips and donation	25.0	34.0	27.25
11	Wages and salaries	85.0	92.0	101.5
12	Electricity	-	32.0	32.5
13	Others	35.0	35.0	34.0
Total		1,170.56	374.0	917.25

Note: Source: Field Survey, 2018; - indicates not applicable; others include water, bag, Wastage, security etc.

Marketing efficiency

A comprehensive assessment of marketing efficiency was conducted, employing multiple indicators to develop a composite index. The results, detailed in Table 9, provide a valuable insight into the efficiency of the fish marketing channels within the studied regions. It is noteworthy that the existing marketing channels for fish in these regions closely align with prior research findings (Heltberg and Tarp, 2002; Islam *et al*., 2014; Amin, 2019). This study, however, did not aim to establish the single most efficient channel but rather focused on identifying the fish species that were efficiently supplied.

In both Mymensingh and Jashore regions, catla fish emerged as a frontrunner, claiming the top position in terms of actor share (I_1), Acharya's efficiency ranking (I_3), and Shepherd's efficiency (I_4). Following closely was rohu. In the Dhaka region, the supply chain dynamics differed from the other two regions, with rohu taking the lead as the most efficient, while pangas ranked as the least efficient fish species (Table 9).

Table 9. Marketing efficiency of fish species.

Indicators	Mymensingh				Jashore				Dhaka			
	Rohu	Catla	Nile tilapia	Pangas	Rohu	Catla	Nile tilapia	Pangas	Rohu	Catla	Nile tilapia	Pangas
Actor share (I_1)	2	1	4	3	2	1	4	3	1	2	4	3
Intermediaries Margin (I_2)	4	3	2	1	4	3	1	2	3	4	1	2
Acharya's Efficiency (I_3)	2	1	4	3	2	1	4	3	2	1	3	4
Shepherd's Efficiency (I_4)	2	1	3	4	2	1	3	4	2	1	3	4
Calkin's Index (I_5)	4	3	2	1	4	3	1	2	3	4	1	2
Price spread (I_6)	4	3	1	2	4	3	1	2	4	3	1	2
Producer share (%) (I_7)	2	1	3	4	2	1	3	4	2	1	3	4
Composite Index (Ri/Ni)	2.8	1.8	2.7	2.5	2.8	1.8	2.4	2.8	2.4	2.2	2.2	3
Final Ranking	4	1	3	2	3	1	2	3	1	2	2	3

Analyzing the composite index across these regions, it becomes evident that Catla was supplied most efficiently in Mymensingh. In Jashore, the efficiency hierarchy started with catla, followed by Tilapia. In Dhaka, rohu stood out as the most efficient, while pangas ranked as the least efficient among the fish species.

Further exploration of price spreads revealed that pangas exhibited the lowest price spread, with the highest share of producers, followed by Nile tilapia, catla, and rohu. Notably, the findings suggest that pangas and Nile tilapia were the most efficient fish species based on intermediaries' margin and price spread. Conversely, carp species, including rohu and catla, displayed efficiency across the majority of indicators. This can be attributed to the higher marketing costs associated with high-priced fish, resulting in larger marketing margins and profits compared to low-priced fish (Rabbani *et al*., 2017).

It's important to consider that high-priced fish species also incur greater processing and transportation costs, rendering them less efficient according to most efficiency indicators. In contrast, carp species like rohu and catla have attained a significant level of consumer preference and demonstrate substantial growth potential, solidifying their status as essential and efficiently supplied farmed fish species in the studied regions. These findings shed light on the complex interplay of efficiency within the fish marketing chains and provide valuable insights for stakeholders to enhance the marketing system's overall performance and sustainability (Rahman and Mia, 2020; Sarker, 2021).

CONCLUSION

The study outcomes underscore the profitability and feasibility of fish production in the study areas. While certain fish species exhibit efficient supply chains, others necessitate more focused attention and development. This offers a clear indication that there exists untapped potential for boosting fish productivity and optimizing the marketing chain, ultimately benefiting both farmers and market actors engaged in fish production and marketing. Acknowledging that the marketing channel represents a significant cost driver, it is imperative to explore possible alternatives such as contract farming arrangements to improve fish quality and ensure market availability.

Moreover, to further bolster the efficiency of fish marketing, the development of institutional support mechanisms for fishing and marketing activities, coupled with investments in adequate infrastructure facilities for fish storage and processing, becomes essential. In addition, facilitating farmers' access to high-quality feed and fingerlings is crucial to elevating fish production standards and enhancing supply efficiency. The pursuit of these improvements, rooted in a comprehensive and coordinated approach, is poised to yield lasting benefits in terms of fish profitability and supply efficiency. The study underscores the significant potential for improving fish production and marketing in the study areas. Realizing this potential requires collaborative efforts between government agencies, farmers, and market actors. Such concerted actions can help to fortify the long-term sustainability and profitability of the fish production and marketing sectors in the region.

LITERATURE CITED

Abugu, R.O., J.M. Chah, C. Nwobodo, A.N. Asadu and E.M. Igbokwe. 2013. Agricultural extension needs of farmers in Telfairia production and marketing in Enugu State, Nigeria. **Journal of Agricultural Extension** 17(1): 49–60.

Acharjee, D.C., M.I. Hossain and G.M.M. Alam. 2021. Post-harvest fish loss in the fish value chain and the determinants: empirical evidence from Bangladesh. **Aquaculture International** 29: 1711–1720.

Acharya, S.S. and N.L. Agarwal. 2004. **Agricultural Marketing in India,** 4th ed. Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi, India. 506 pp.

Alam, M.J., R. Yasmin, A. Rahman, N. Nahar, N.I. Pinky and M. Hasan. 2010. A study on fish marketing system in Swarighat, Dhaka, Bangladesh. **Nature and science** 8(12): 96–103.

Ali, M.M., A.A. Asif, M.A.I. Shabuj, S. Vaumik, M.A. Zafar and B.N. Sharif. 2016. Status of polyculture *Pangasius hypophthalmus* with carps in Jhikargacha Upazila of Jessore District, Bangladesh. **International Journal of Fisheries and Aquatic Studies** 4(1): 423–430.

Ali, A. 2016. Profitability and economic efficiency of carp polyculture farming in Bangladesh. **Aquaculture Economics and Management** 20(2): 216–231.

Amin, A. 2019. Agriculture marketing system in Bangladesh: A review. **Advances in Social Sciences Research Journal** 6(8): 140–155.

Asogwa, V.C. and J. Asogwa. 2019. Marketing of fish products. **Journal of Aquaculture and Marine Biology** 8(2): 55–61.

Chowdhury, M.M., M.S. Ahmed, M.A. Matin and A.N. Faruq. 2012. Study on supply and value chain analysis for exporting yard long bean from Bangladesh. **International Journal of Sustainable Agricultural Technology** 8(10): 6–10.

Department of Fisheries (DOF). 2020. **Yearbook of Fisheries Statistics Bangladesh.** Ministry of Fisheries and Livestock, Government of the People's Republic of Bangladesh, Dhaka, Bangladesh. 139 pp.

Department of Fisheries (DOF). 2021. **Yearbook of Fisheries Statistics Bangladesh.** Ministry of Fisheries and Livestock, Government of the People's Republic of Bangladesh, Dhaka, Bangladesh. 149 pp.

Dey, M.M., M.F. Alam and M.L. Bose. 2010. Demand for aquaculture development: Perspectives from Bangladesh for improved planning. **Reviews in Aquaculture** 2: 1–17.

Devi, V.V. 2011. A Study on value chain management practices of fresh fish: An empirical study of coastal Andhra Pradesh marine fisheries. **IOSR Journal of Business and Management** 7: 80–90.

Fisheries Resources Survey System (FRSS). 2020. **Fisheries Statistical Report of Bangladesh.** Department of Fisheries, Government of the People's Republic of Bangladesh, Dhaka, Bangladesh. 139 pp.

Gosh, K., T.R. Hanson, D. Drescher, D. Robinson, W. Bugg, N. Chatakondi, G. Kumar, C. Jeffers and R.A. Dunham. 2022. Economic effect of hybrid catfish growth variability on traditional and intensive production systems. **North American Journal of Aquaculture** 84: 25–41.

Haque, S.A., M.F. Islam, M.C. Rahman, M.S. Islam and M.M. Rahman. 2021. Supply chain and logistics of fish: A case study of Jamalpur district markets in Bangladesh. **Asian Journal of Agricultural Extension, Economics and Sociology** 39(7): 8–27.

Heltberg, M.R. and F. Tarp. 2002. Agricultural supply response and poverty in Mozambique. **Food Policy** 27(2): 103−124.

Hossain, M.B., A.U. Nur, M.M. Ahmed, M.A. Ullah, M.F. Albeshr and T. Arai. 2022a. Growth, yield and profitability of major carps culture in coastal homestead ponds stocked with wild and hatchery fish seed. **Agriculture** 12(8): 1131. DOI: 10.3390/agriculture 12081131.

Hossain, M.E., M.A. Khan, S.M. Saha and M.M. Dey. 2022b. Economic assessment of freshwater carp polyculture in Bangladesh: Profit sensitivity, economies of scale and liquidity. **Aquaculture** 548: 737552. DOI: 10.1016/j.aquaculture.2021.737552.

Hossain, M.J. 2022. Comparative economic analysis of mono-sex tilapia and common carp culture in seasonal pond and rice-field in Bangladesh. **Aquaculture Economics and Management** 26(1): 1–16.

Hossain, M.M. 2011. **Marketing System of Prawn in Khulna District: Unlocking the Present Problems.** Master Thesis, Bangladesh Agricultural University, Mymensingh, Bangladesh. 77 pp.

Hugar, L.B. and K.C. Hireman. 1984. Efficiency of alternative channels in the marketing of vegetables in Belgium City. **Indian Journal of Agricultural Economics** 39(3): 192–200.

Islam, M.S., M.S. Rahman, M.M. Haque and S. Sharmin. 2014. Economic study on production and marketing of shrimp and prawn seed in Bangladesh. **Journal of the Bangladesh Agricultural University** 12(2): 359–368.

Khan, S.A. 2018. Factors influencing fish production in Bangladesh: An empirical analysis. **Journal of Agricultural Economics** 50(2): 123–140.

Khan, M.A., K.H. Roll and A. Guttormsen. 2021. Profit efficiency of Pangas (*Pangasius hypophthalmus*) pond fish farming in Bangladesh–The effect of farm size. **Aquaculture** 539: 736662. DOI: 10.1016/j.aquaculture.2021.736662.

Kuldilok, K., R. Tokrisna and K. Boonchowong. 2018. Economic and marketing capability improvement for small scale aquaculture farmers through community organizations. **Journal of Fisheries and Environment** 42(1): 33–52.

Kumar, U., A.M. Helen, J. Das, M.S. Parvez, S.K. Biswas and S. Ray. 2019. Unraveling the hidden truth in a poorly managed ecosystem: The case of discarded species of conservation interest in Bangladesh industrial marine fisheries. **Regional Studies in Marine Science** 32: 100813. DOI: 10.1016/j.rsma.2019.100813.

Nadia, Z.M., P. Roy, J. Hossain, M.F. Hossain, M. Rahman, M.A. Salam and R. Jahan. 2022. Fish availability and market channel in Rajbari, Bangladesh. **Heliyon** 8(9): e10526. DOI: 10.1016/j.heliyon.2022.e10526.

Olsson, U. 2011. **Statistics for Life Science 1.** Student litteratur AB, Lund, Sweden. 351 pp.

Thủy, P.T.T., O. Flaaten and A. Skonhoft. 2019. Middlemen: Good for resources and fishermen? **Environment and Development Economics** 24(5): 437–456.

Rabbani, M.G., M.S. Islam and R.Y. Lucky. 2017. Marine fish marketing and prices changes in different levels of market in Bangladesh: an empirical study using primary data. **The Agriculturists** 15(2): 79–87.

Rahman, M.A. 2019. Economic analysis of freshwater fish farming in Bangladesh. **Aquaculture Economics and Management** 23(4): 381–396.

Rahman, M.M. and M.S. Mia. 2020. Market channel choices and access of smallholder farmers in Bangladesh. **Journal of the Bangladesh Agricultural University** 18(1): 149–157.

Rajagopal. 1986. Economic efficiency of paddy marketing system in Madhya Pradesh. A case study. **Indian Journal of Agricultural Economics** 41(4): 583–589.

Sarker, M.A.A., F.M. Arshad, M.F. Alam, Z.A. Mohamed and M.A. Khan. 2016. Feed technology and production performance of Thai koi (*Anabas testudeneus*) in Bangladesh. **Journal of Applied Aquaculture** 28(2): 76–91.

Sarker, M.H. 2021. Analysis of supply chain management of shrimp in Bangladesh. **World Journal of Food Science and Technology** 5(2): 1–8.

Scott, J.K., L.P. Smith and R. Patel. 2019. Economic analysis of polyculture systems in aquaculture. **Journal of Agricultural Economics** 45(3): 321–335.

Sen, B.R., T. Islam, K. Alam and M. Fuad. 2016. Performance of exporting shrimps and dry fishes from Bangladesh. **Journal of the Bangladesh Agricultural University** 14(1): 69–74.

Shafiuddin, M. 2021. Assessment of value chain for commercially important fish marketing approach in Bangladesh. **Social Change** 10(1): 140–164.

Shepherd, W.G. 1972. The elements of market structure. **The Review of Economics and Statistics** 54(1): 25–37.

Shamsuzzaman, M.M., M.M. Islam, N.J. Tania, A.M.M. Abdullah, P.P. Barman and X. Xu. 2017. Fisheries resources of Bangladesh: Present status and future direction. **Aquaculture and Fisheries** 2(4): 145–156.

Sreenivasa Murthy, D., T.M. Gajanana and M. Sudha. 2004. Post-harvest loss estimation and its impact on marketing cost, margin and efficiency: A Study in grapes in Karnataka. **Indian Journal of Agricultural Economics** 59(4): 770−786.