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AN ECONOMIC ANALYSIS OF PANGAS (*PANGASIANODON HYPOPHTHALMUS*) FARMING CONSIDERING SOCIOECONOMIC AND ENVIRONMENTAL IMPACTS: A CASE STUDY IN TRISHAL UPAZILA, BANGLADESH

[a]Samiul Haider, [a]Sadika Haque, [a]Santa Islam*, [b]Nazmus Sayadat, [a]Md. Salman
[a] *Department of Agricultural Economics, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh.*
[b] *Department of Agricultural Extension, Ministry of Agriculture, Bangladesh.*

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ABSTRACT

Pangas is a relatively fast-growing fish species with great production and export growth potential in Bangladesh, but its socioeconomic and environmental effects remained less explored. Therefore, the study was conducted, to explore the profitability and factors influencing the gross return of Pangas fish farming and to analyse the socioeconomic and environmental effects. Data were collected using a simple random sampling technique from 60 Pangas fish producers living in two villages of Trishal Upazila under the Mymensingh district of Bangladesh, through face-to-face interviews using a semi-structured interview schedule. The Benefit Cost Ratio (BCR) analysis was calculated to measure the profitability; while the Cobb-Douglas type production function was used to analyze the factors affecting commercial Pangas fish production. The cost-benefit analysis showed that Pangas fish production was profitable, with an average per hectare net return of BDT 1,439,174 (13237.25 USD). The benefit-cost ratio (BCR) was found 1.27, indicating profitability. The regression analysis of the Cobb-Douglas type production function found that human labour, feed, fingerlings, and medicine/pesticide costs positively and significantly affected Pangas fish production. The study highlighted the positive socioeconomic impacts of Pangas fish production but also raised concerns about the environmental implications. Producers faced challenges related to technical, economic, and social aspects. The findings provide valuable insights for policymakers, extension workers, and Pangas fish producers in formulating strategies and policies to promote sustainable growth and address the challenges faced by Pangas fish producers.

Corresponding Author: Santa Islam
Email: santa.aers@bau.edu.bd

INTRODUCTION

Bangladesh is widely recognized as one of the most suitable regions for aquaculture worldwide. Fish farming, primarily conducted in tanks, fish ponds, and ocean enclosures, is the predominant form of aquaculture in the country. The sector contributes approximately 3.57% to Bangladesh's GDP, accounting for more than a quarter (26.5%) of the agricultural GDP (Yearbook of Fisheries Statistics 2020-21). Fish and fishery goods constitute around 1.39% of the country's total export revenue (BER, 2020). Currently, fish fulfils approximately 60% of the nation's demand for animal protein. Bangladesh produces a sufficient quantity of fish to meet its domestic needs, with per capita consumption

exceeding the targeted 60 grams per day, reaching 62.58 grams (BBS, 2016). Over the past 12 years, the fisheries sector has experienced an average GDP growth rate of 6.2% (DoF, 2022). The fishing industry's contribution to Bangladesh's GDP remains at 3.57%, constituting over a quarter (26.5%) of the agricultural GDP (Yearbook of Fisheries Statistics, 2020-21). The total fish production in Bangladesh increased from 27.1 lakh metric tons in the 2008-09 financial year to 46.21 lakh metric tons in the 2020-21 financial year (DoF 2022). More than 85% of the total fish production in Bangladesh is derived from inland fisheries, where inland open water (capture) contributes 28.16% (13.01 lakh MT), and inland closed water (culture) contributes 57.10% (26.39 lakh MT) to the total fish production (Statistical Yearbook, 2020-21). Fish currently satisfies around 60% of the country's population's animal protein requirements. Bangladesh's fish production is self-sufficient, surpassing the targeted per capita consumption of 60 grams per day and reaching 62.58 grams, as reported by the Bangladesh Bureau of Statistics (BBS) in 2016. Pangas (*Pangasianodon hypophthalmus*) cultivation has emerged as a significant economic activity in the South and South-East Asian aquaculture (FAO, 2010). The term "Thai Pangas" refers to cultured Pangas, which were first imported into Thailand and subsequently introduced to Bangladesh by the Ministry of Fisheries and Livestock in 1990. Successful breeding of this species was achieved in Bangladesh's hatcheries in 1993. The fish's popularity grew more than other species due to its rapid development, delicious flavour, and size, which was achieved through widespread artificial reproduction across the country. It has gained significant popularity as a commercially cultivable species in recent years due to its high productivity, ease of cultivation, strong market demand, adaptability to the climate, and availability of Pangas seeds to meet farmers' requirements (Sarkar, 2000). The scenario of different species-wise fish production in the fiscal year 2020-21 (Figure 1). Notably, the younger, educated generation has shown increased interest in Pangas farming industry, leading to improved production efficiencies (Akter *et al.,* 2018).

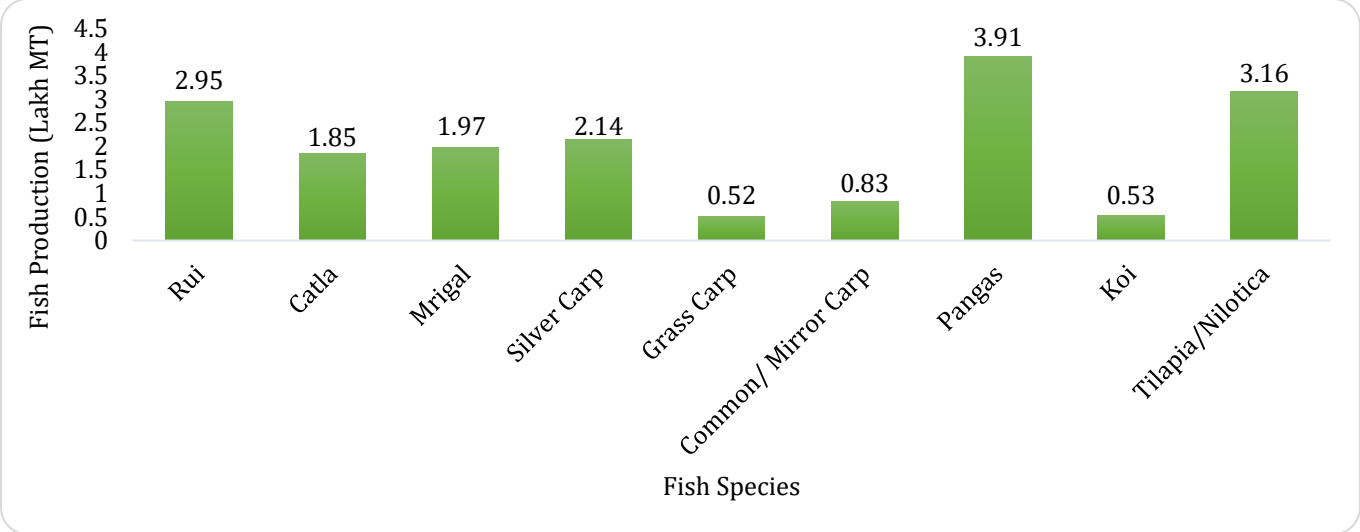

Figure 1. Species-wise fish production of pond aquaculture in 2020-21. Source: DoF, 2022

Pangas fish serves as a valuable source of animal protein. Each 100g of Pangas fish provides approximately 92 Kcal energy, 15g protein, 3.5g fat, and 80 mg cholesterol (Everyday-Fish, 2017). Given this nutritional profile, Pangas fish production can contribute to meeting the growing domestic demand for fish and addressing protein deficiencies. However, the species is more susceptible to diseases compared to other species (Rahman *et al.,* 2017). Consequently, research work focusing on pond-based Pangas fish culture is crucial for effective planning, strategy development, and future requirements in the country. This research will generate essential information to guide decision-making for existing and prospective producers. The findings will also support policymakers and extension workers in making informed decisions regarding Pangas fish culture. The specific objectives of this study encompass determining the per unit costs and returns of pond-

based Pangas production, investigating the factors influencing the productivity of Pangas fish farming, assessing the socioeconomic and environmental impacts of commercial Pangas farming, and identifying the key challenges faced by Pangas producers, along with potential solutions recommended by them.

METHODOLOGY

Selection of the Study Area, Sample Households and Sampling Techniques

Mymensingh is located in central Bangladesh, and it is known for its abundance of rivers, ponds, and water bodies, which create a suitable environment for fish farming. Moreover, the region's warm and tropical environment has made it more suitable and famous for Pangas fish farming and associated activities (Hossain et al., 2019). The targeted population of this study was the Pangas fish farmers in Trishal upazila. A multi-stage sampling technique was used to select the sample. Firstly, two villages (Bailor and Kanthal) of Trishal upazila (Figure 2) were selected purposively as a large number of the targeted population were there. Then using the simple random sampling technique, primary data were collected from a total of 60 (based on the targeted population) sample Pangas fish farmers from July to September 2022. The semi-structured interview schedule was used to collect the information as some portions were open-ended for the respondents like what problems they faced and what would be their suggestions.

Figure 2. Map of the study area.

Analytical Techniques of the Study

Profitability Analysis

The profitability of Pangas has been analyzed to compare the cost incurred and the return received by the cultivators (Khandoker *et al.,* 2017; Sujan *et al.,* 2017). The following algebraic equation has been used to assess the costs and returns:

Variable cost = $VC_{ij} = \sum_{t=1}^{n} XiPj$ or, $TVC_{ij} = VC_{ij} + IOC_{ij}$ or, $TC_{ij} = TVC_{ij} + TFC_{ij}$

Where, TC_{ij} = Total cost (Tk./ha), TVC_{ij}= Total variable cost (Tk./ha), TFC_{ij} = Total fixed cost (Tk./ha), VC_{ij}= Variable cost (Tk./ha), IOC_{ij}= Interest of operating capital (Tk./ha), X_{ij} = Quantity of inputs (kg), P_{ij} = Price of inputs (Tk./kg), i = Number of Pangas cultivators (1.2.3……..n)

Equations for profitability analysis

Dillon & Hardaker, 1993 stated that gross return can be calculated by multiplying the total volume of output by the average price of output.

Gross return, GR = ∑YP; Net return = GR – TC;

Barnard and Nix, 1978 found gross margin by subtracting the total variable costs from the output value of any enterprise.

Gross margin = GR – VC

Where, GR = Gross return (Tk./ha), P = Price (Tk./ha) of Pangas fish, Y = Quantity (kg/ha) produced

Benefit Cost Ratio (BCR) Analysis

The benefit-cost ratio (BCR) of an investment is the ratio of the undiscounted value of all cash inflows to the undiscounted value of all cash outflows during the life of the project.

It can be estimated using the following formula:

BCR= $\sum_{i=1}^{n} \frac{Bi}{Ci}$

Where, B_i = Total benefit (Tk./ha), C_i = Total cost (Tk./ha), i = Number of output (t =1, 2, 3, …….n)

Cobb-Douglas type Production Function

The cobb-Douglas production function model was employed as the functional analysis to show the individual effect of input use and other related factors on commercial Pangas fish farming. The multiple regression function was specified as follows:

$Y=aX_1^{b1}X_2^{b2}X_3^{b3}X_4^{b4}X_5^{b5}X_6^{b6}X_7^{b7}X_8^{b8}e^{\mu}$

The equation may be alternatively expressed in log-linear form.

$\ln Y = \ln a + b_1 \ln X_{1i} + b_2 \ln X_{2i} + b_3 \ln X_{3i} + b_4 \ln X_{4i} + b_5 \ln x_{5i} + b_6 \ln X_{6i} + b_7 \ln X_{7i} + b_8 \ln X_{8i} + \mu i$

Where,

Y = Gross return (Tk./ha)

X_1 =Human labour cost (Tk./ha)

X_2 = Fingerling cost (Tk./ha)

X_3 =Feed cost (Tk./ha).

X_4 = Salt cost (Tk./ha)

X_5 = Lime cost (Tk./ha)

X_6 = Medicine and pesticide cost (Tk./ha)

X_7= Electricity cost (Tk./ha)

X_8= Communication cost (Tk./ha)

ln = Natural logarithm

a = Intercept

(b_1…….b_8) = Coefficients of respective variables and

μ_i= Error term

RESULTS AND DISCUSSION

One of the important objectives of this study was to determine the profitability of Pangas farming. Calculating net return and gross margin is a quick and easy approach to analyzing the profitability of any enterprise (Sarker *et al.,* 2016).

Table 1 reflects the cost and return analysis of Pangas fish production.

Table 1. Cost and return of Pangas fish cultivation (Tk./ha).

Items	Units	Quantity per hectare/Year	Unit price(TK.)	Cost (TK.)	Percentage of the total cost (%)
Variable cost					
Human labour	Man-days	600	420	252000	4.74
Fingerlings	Piece	40000	7	280000	5.26
Feed	Kg	101619	42	4267998	80.21
Lime	Kg	429	20	8580	0.16
Salt	Kg	265	20	5300	0.10
Medicine and pesticide	-	-	-	14000	0.26
Electricity	Kilowatt-hour	23970	10	239700	4.50
Communication	Tk.	-	-	1500	0.03
Interest in operating capital	Tk.	-	-	40000	0.75
A. Total Variable cost	Tk./ha	-		5109078	96.02
Fixed Cost					
Land use Cost	Tk.	-	-	211748	3.98
B. Total Fixed Cost	Tk./ha	-		211748	3.98

C. Total Cost(A+B)	Tk./ha	-		5320826	100
D. Yield of Pangas	Kg	52000	-	-	-
E. Price	Tk./Kg	-	130	-	-
F. Gross Return	Tk./ha	-	-	6760000	-
G. Gross Margin	Tk./ha	-		1650922	-
H. Net Return	Tk./ha	-		1439174	-
I. BCR				1.27	-

Source: Author's calculation based on field survey (2022).

Estimation of cost, return and profitability

Table 1 shows the cost-benefit analysis involved in Pangas fish production that consists of the yield, price, as well as gross return, gross margin, net return, and benefit-cost ratio. Calculation of cost and return of any production process is important as it helps the producer to make the best decisions. The total expenses of any production are derived by adding total variable and fixed costs together (Kohinoor *et al.,* 2016). The entire cost of producing Pangas farming in this study was assessed at Tk. 5320826 (48939.95 USD) per hectare. Data mentioned in Table 1 shows that the total yield of Pangas was 52000 kg per hectare per year and the total gross return was 6760000 Tk. (62177.20 USD) per hectare. The per hectare gross margin of Pangas production was evaluated at Tk. 1650922 Tk. (15184.87 USD) which indicates the difference between gross return and total variable cost. Per hectare net return of Pangas was Tk.1439174 (13237.25 USD); while the Benefit Cost Ratio (BCR) was found 1.27, indicating that the benefits derived from Pangas fish production are 1.27 times greater than the costs incurred, which is coherent with the study of Shawon *et al.,* (2018), Aktar *et al.,* (2018), Kumar *et al.,* (2016) and Sarker *et al.*, (2014).

Empirical results of the factors influencing the Gross return of Pangas fish farming

In this study, the Cobb-Douglas type production function was selected as the most suitable model for assessing the impact of various factors on the gross return of Pangas fish production (Table 2). This analysis considered eight independent variables, namely the costs associated with human labour, fingerlings, feed, salt, lime, pesticides or medicine, electricity, and communication for the farmers.

Table 2. The Estimated value of coefficients and related statistics of cobb-Douglass production function model.

Explanatory Variable	Coefficient	Standard error	t-value
Intercept	4.595	0.875	5.251
Human labour cost (X_1)	0.218**	0.113	1.929
Fingerling cost (X_2)	0.170**	0.109	1.559
Feed cost (X_3)	0.370***	0.023	16.087
Salt cost (X_4)	0.213	0.145	1.469
Lime cost (X_5)	-0.075	0.136	-0.551
Medicine/pesticide cost (X_6)	0.297***	0.103	2.883
Electricity cost (X_7)	0.120	0.092	1.304
Communication cost (X_8)	-0.029	0.026	-1.115
R^2		0.761	
F-Value		11.165***	
Returns to scale (∑bi)		1.284	

Note: ***significant at 1% level, ** significant at 5% level, * significant at 10% level

The estimated coefficient and related statistics of the Cobb- Douglass production function for Pangas production are presented in Table 2.

The regression analysis results indicate that certain factors have a significant influence on the gross return of Pangas fish farming in the study area. Labour cost, fingerling cost, feed cost and medicine/pesticide costs exhibit positive and statistically significant effects on gross return. A 1% increase in labour cost leads to a 0.218% increase in gross return, while a 1% increase in fingerling cost, feed cost, and medicine/pesticide cost results in a 0.170%, 0.370% and 0.297% increase in gross return, respectively. The results clarify that human labour cost and fingerling cost were significant at 5% level whereas the feed cost and medicine/pesticide cost were significant at 1% level. These findings suggested that investing in labour, acquiring higher-cost fingerlings, and increasing feed and medicine/pesticide investment can enhance the profitability of Pangas fish farming.

The findings of the current study are consistent with the report of Aktar *et al.,* (2018) and Sarker *et al.,* (2014). The value of the coefficient of determination (R^2 = 0.761) stated that all the explanatory variables explained approximately 76.1% of the variation in the gross return of Pangas fish production. Additionally, the returns to scale, represented by the sum of the coefficients (1.284), suggests that the factors considered collectively contribute to increasing gross return beyond a proportional increase in input costs.

Effects of Pangas Fish Farming

There is great potential for Pangas culture in Bangladesh, which is very productive and brings increased income among the fish farmers (Rahman *et al.,* 2011). In addition, Pangas can be stocked at a much higher density in ponds compared to other cultivable species (Ali *et al.,* 2011). Silver Carp polyculture with Pangas is both environmentally and financially beneficial. (Sarkar *et al.,* 2005). This study sought to broadly understand the direct or indirect socioeconomic and environmental effects of Pangas fish farming in Bangladesh.

Table 3. Socioeconomic and Environmental Effects of Pangas Farming.

Effects of Pangas fish farming	Statements	Response of producers (%)
Socioeconomic effects	Purchasing capacity increased	56
	Household saving increased	64
	Investment capacity increased to the other business	58
	Employment opportunity increased	76
	Children education increased	53
	Using of collective goods and services increased	24
Environmental effects	Converting the agricultural land into Pangas fish pond	77
	Increasing water pollution in the pond	65
	Increasing the risk of disease outbreak	60
	Damaging adjacent rice fields	54
	Soil quality deterioration	30

Source: Field survey, 2022

The results indicate that Pangas fish farming in Bangladesh has positive socioeconomic effects. The majority of respondents reported an increase in purchasing capacity (56%), household savings (64%), investment capacity for other businesses (58%), employment opportunities (76%), and children's education (53%). However, the impact on the use of collective goods and services (24%) was perceived to be relatively lower.

On the environmental front, concerns were raised regarding the conversion of agricultural land into Pangas fish ponds (77%) and the associated risk of water pollution (65%). Respondents also expressed apprehension about the increased potential for disease outbreaks (60%) and damage to adjacent rice fields (54%). Soil quality deterioration was mentioned by a relatively smaller percentage of respondents (30%).

Overall, while Pangas fish farming has shown positive socioeconomic effects, there are concerns about the environmental implications. Efforts to mitigate the negative environmental effects, such as implementing sustainable practices and proper waste management,

are crucial to ensure the long-term viability of Pangas fish farming while minimizing its impact on the environment.

Problems Faced by the Pangas Fish Producers

Bangladesh's Pangas fish producers face various economic, technical, social, and marketing constraints (Figure 3).

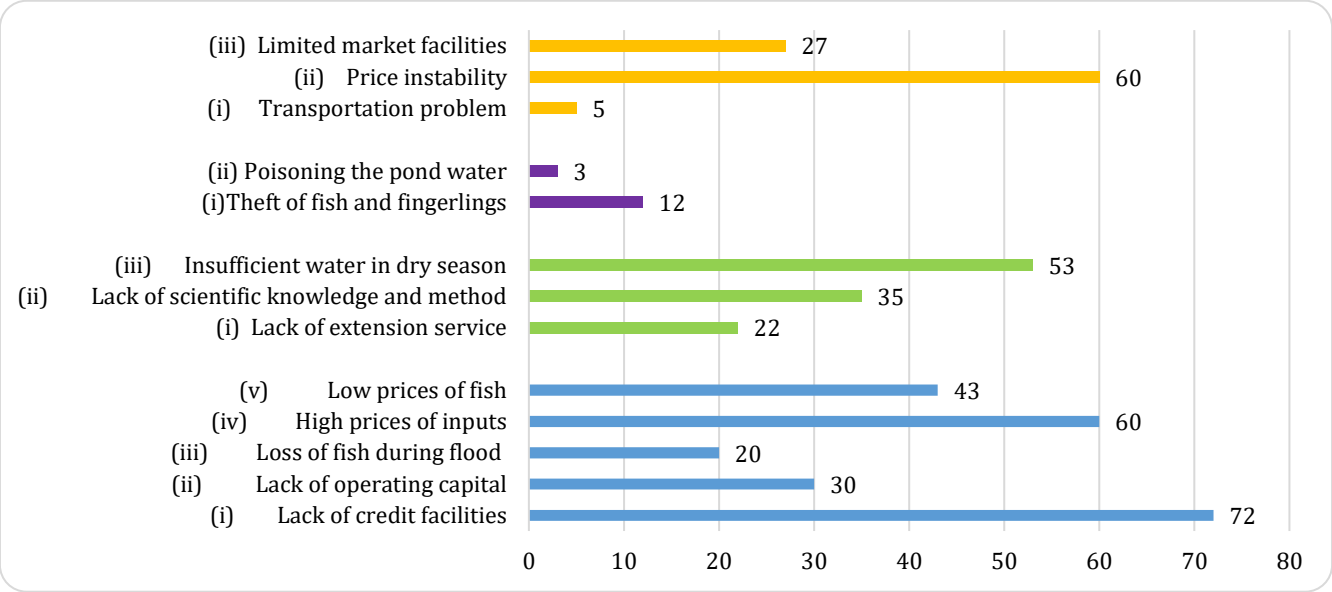

Figure 3. Problems faced by the Pangas producers in the study area. Source: Field Survey, 2022

Note: Yellow bars refer to Marketing problems. Blue bars refer to economic problems. Green Bars refers to technical problems. Purple refers to social problems

Economically, the most prevalent challenges reported by producers were the lack of credit facilities (72%) and operating capital (30%), which hinder their ability to access funds for investment and day-to-day operations. Additionally, significant proportions of producers reported the loss of fish during excessive rainfall (20%), high prices of inputs (60%), and low prices of fish (43%) as economic challenges they encounter.

On the technical front, a notable portion of producers highlighted the lack of extension services (22%) and insufficient water availability in the dry season (53%) as issues they face. These constraints impede their access to necessary knowledge, techniques, and resources for effective fish farming. Social problems, although less frequently reported, include theft of fish and fingerlings (12%) and pond water poisoning (3%), which can lead to financial losses and disruption in production. Regarding marketing, transportation problems (5%), price instability (60%), and limited market facilities (27%) pose challenges to Pangas fish producers in reaching consumers and obtaining fair prices for their products. Addressing these challenges requires targeted interventions and support systems. Providing improved access to credit and operating capital, strengthening extension services, implementing measures to mitigate losses during floods, ensuring fair input prices and stable fish prices, and addressing social and marketing issues can contribute to the sustainable growth and development of Bangladesh's Pangas fish farming sector.

Suggestions to solve the problems

Producers put forward some suggestions, the prominent of which were an easy procedure for obtaining a bank loan; low rate of interest; availability of fish seeds and inputs in proper time; social, moral, and scientific education and training; improved marketing facilities; fixed price of major inputs and implementation of government rules. According to Khan *et al.* (2021), improved profitability in Pangas fish production is linked to enhanced availability of credit, training, and extension services. These findings underscore the importance of implementing policies that enhance access to these services, which are crucial for ensuring the long-term viability of fish farming in Bangladesh.

Table 4. The solution to the problems

	Suggestions	Number of producers (%)
i.	Maintaining an easy procedure for obtaining the loan	36 (60)
ii.	Initiating the high-yielding variety of fingerlings	20 (33)
iii.	Ensuring the availability of fish seed at the proper time	17 (28)
iv.	Improving the marketing facility	23 (38)
v.	Providing credit at a low rate of interest	42 (70)
vi.	Making available inputs at the right time	18 (30)
vii.	Fixing prices of major inputs	07 (12)
viii.	Providing social, moral, and scientific education and training	12 (20)
ix.	Improving the training system	04 (07)
x.	Executing government rule	02 (03)
xi.	Ensuring the availability of water in the dry season	10 (17)

Source: Field survey, 2022

The data given in Table 4 presents the suggestions provided by pond fish producers in Bangladesh to address the challenges faced by Pangas farmers. Among all the producers surveyed, the most commonly suggested solutions include maintaining an easy procedure for obtaining loans (60%), initiating the use of high-yielding fingerlings (33%), and ensuring the timely availability of fish seed (28%). Other significant suggestions involve improving marketing facilities (38%) and providing credit at low-interest rates (70%). Additionally, the respondents highlighted the importance of timely availability of inputs (30%), fixing prices of major inputs (12%), and providing social, moral, and scientific education and training (20%). Improving the training system (7%), executing government rules (3%), and ensuring water availability in the dry season (17%) were also mentioned. Existing pieces of literature showed that access to credit facilities and getting loans for production purposes could significantly enhance profit (Khan *et al.,* 2021). On the other hand, if farmers got difficulties in access to credit and loans, then it becomes a barrier to production optimization (Khan *et al.*, 2018). The availability of fingerlings is still a problem in the production process which is linked with various socio-economic issues (Zaman *et al.,* 2017). Seed plays an important role in the overall production but it is also found that utilized inefficiently (Ahmed *et al.*, 2010; Mugaonkar *et al.,* 2019). Some logical relationships like the level of education and its effect on different aspects of characteristics associated with human behaviour i.e., the knowledge level, skill development, exposure to production technology, marketing and adoption of improved technology need to be addressed in achieving the optimum level of production (Agboola, 2011). Training should be promoted to enhanced production as well (Agboola, 2011; Ahmed *et al.,* 2010).

CONCLUSION

The study indicates that Pangas fish farming is a lucrative venture in Bangladesh in which labour, fingerling, and feed costs were found to have significant positive effects on the gross return. Though this farming in Bangladesh has shown positive socioeconomic effects, there are concerns about the environmental effects. Producers face various economic, technical, social, and marketing challenges. To address these issues and assure the long-term growth of Pangas fish farming, targeted interventions such as increased access to credit, extension services, and training, as well as measures to mitigate environmental consequences and stabilize fish prices, are required. Implementing an easy financing procedure, assuring the availability of quality fingerlings, and giving timely access to fish seed and inputs, according to producer ideas, are critical for the industry's success. Improving marketing infrastructure, setting input prices, and providing social and scientific education and training can all help the sector work better. Pangas fish farming has the potential to be a viable and useful venture for Bangladeshi farmers, providing to greater income and job opportunities. However, sustainable management practices and supportive regulations are required to address environmental issues and overcome producer hurdles.

By putting these safeguards in place, the Pangas fish farming sector can continue to develop and contribute positively to the country's economy and people's livelihoods.

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