Archives of Agriculture and Environmental Science 7(3): 415-424 (2022)
https://doi.org/10.26832/24566632.2022.0703016

e-ISSN: 2456-6632

This content is available online at AESA

Archives of Agriculture and Environmental Science

Journal homepage: journals.aesacademy.org/index.php/aaes

ORIGINAL RESEARCH ARTICLE

Shifting from paddy production for aquaculture: An economic study in a selected area of Bangladesh

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ARTICLE HISTORY

Received: 14 July 2022
Revised received: 31 August 2022
Accepted: 21 September 2022

Keywords

Aquaculture
Bangladesh
Economic study
Paddy production

ABSTRACT

Shifting rice cultivation to aquaculture is a burning issue of agricultural land use policy in Bangladesh. The study was conducted to identify the reasons for change the paddy farming to fish culture and relative profitability of both enterprises randomly selected 50 sample farmers from Mymensingh district in Bangladesh. Primary data were collected through field survey. Mostly tabular analysis was done to achieve the objectives. To determine the net return of fish and rice production, profitability analysis was applied. The findings revealed that 70% of the respondents belonged to the age group of 30-64 years and average annual income and expenditure were Tk. 2333234 (US$ 24874.56) and Tk. 2025860 (US$ 21597.65), respectively. About 96 % of the respondents said that the profit motive was one of the main reasons to shift rice farming to aquaculture. Per hectare per/season gross margin and net return were Tk. 545994 (US$ 5820.83) and Tk. 487494 (US$ 5197.16), respectively for fish culture and Tk. 16404.00 (US$ 174.88) and Tk. 7064.00 (US$ 75.31), respectively, for rice cultivation. The BCR of fish culture and rice cultivation was 1.86 and 1.07, respectively (Full cost basis). Lower profit and scarcity of labour in harvesting period were the main problems faced by the rice farmers. Diseases and high feed cost were the main problems faced by the fish farmers. The fair price of paddy and the supply of paddy harvesting machineries need to be ensured by the government and other agencies to make profitable agribusiness by the rice farmers.

Citation of this article: Rahman, M. A., Monim, M., Mukta, M. A., Khatun, M., & Roy, A. C. (2022). Shifting from paddy production for aquaculture: An economic study in a selected area of Bangladesh. *Archives of Agriculture and Environmental Science*, 7(3), 415-424, https://dx.doi.org/10.26832/24566632.2022.0703016

INTRODUCTION

The consumption and livelihood pattern of the people of Bangladesh largely depend upon rice farming and fish culture. Rice and fish are the most common staple foods in Bangladesh. The farming practices of rice and fish are very important issues of Bangladesh, not only for providing large employment, but also for fulfilling the dietary requirements of its increasing population (Rahman *et al*., 2012). The national economy of Bangladesh is greatly influenced by the rice and fish productions. Total rice and inland fish productions are 35.3 million metric tons and 3.7 million metric tons, respectively in 2018-19 (BBS,

2020). The fisheries sector contributes 3.69 % of the gross domestic product (GDP), 22.60% of agricultural GDP (BBS, 2019). At the age of modern economics rice and fish are not only being cultured for consumption purpose but also for commercial purpose. Freshwater aquaculture has expanded rapidly in Bangladesh. Over the past few decades, paddy-based farming systems in Bangladesh have been shifting toward aquaculture (Ahmed *et al*., 2011; Dey *et al*., 2013; Mondal, 2008). In many areas of Bangladesh, it is a very common tendency to transform from paddy farming to aquaculture due to the availability of knowledge about aquaculture adoption demonstrates that increased knowledge of aquaculture (Sattar, 2019). The shift towards aquaculture could also have been motivated by other changes in the economy which are not directly linked to the farmers themselves, but they experience the impact of those changes. For example, an increase in demand for fish as average incomes grows, and the development of other sections of the fish value chain, such as supply of fish feed, hatcheries, and transportation.

Rice farming in the country is labour intensive. Apart from land preparation, which is gradually being mechanized, the rest of rice tasks are done by female and male workers. Few studies predicted the shift from paddy production to aquaculture. Dehadrai (1992) stated that aquaculture in the paddy field might save the time men and women spent in fish culture, though this effect is somewhat counterbalanced by the additional work required to manage both rice and fish. Likewise, social and economic empowerment of women is more likely to upsurge when they accomplish small-scale enterprises such as pond aquaculture (Kusakabe, 2002). It is found from different studies that when women have access to income, they have a tendency to spend on education and food items, thus confirming nutrition and health security of the family members (Quisumbing *et al*., 2014). Poor women who are actively engaged in rice production tend to participate more in agriculture -related decisions (Pandey *et al*., 2010). Thus, there is a need to assess the profitability of the change from paddy-based agricultural systems for aquaculture.

In Bangladesh, transformation from rice farming to fish culture has been a very popular term over the last few decades. Transformation from rice farming to fish culture refers the shifting fish based agricultural practice from rice based agricultural practice. Fish farming in Bangladesh is playing an important role in the total national income of this country. Bangladesh is a South Asian country and there are hardly any areas in the country where rivers or any other water source is not available. A major part of the total population of this country is directly or indirectly involved with fish or fish related business. More than 12 percent of the 165 million population of Bangladesh depends on fisheries and aquaculture related activities on full time and part time basis for their livelihoods. The fisheries sector contributes 3.50% to the national GDP and 25.72% to the agricultural GDP in the financial year of 2018-2019 (DoF, 2020). In Bangladesh, the agriculture sector is subjugated by rice production. Rice is the staple food for the people of Bangladesh. Rice alone has a large contribution to our GDP. Although the total land area is the same in each year, but the total cultivated area is decreasing year to year due to industrialization. The experience of technological change led by varietal improvement in Bangladesh has significantly contributed to the growth of paddy production during the last three decades. There are three seasons of rice grown which are known as Aus, Aman and Boro. The advance of high yielding rice varieties which are very receptive to manure and pesticides, appropriate soil management and water control helped the country to meet the increasing demand of food grain. The total rice cultivated area has been estimated 28213000 acres of land. And total rice production has been estimated 36604000 metric tons (BBS, 2020).

The fish culture and rice farming are significantly important in the economy of Bangladesh. Fish is the main source of animal protein and it creates employment opportunity both for rural and urban people. Again rice is the staple food in Bangladesh and the main source of carbohydrate. Rice and fish culture, both are the old agricultural practices in Bangladesh. Farmers, in many areas of the country, are more interested in fish culture than rice farming. For a few years, it has become a significant trend to convert the rice field into fish plot. Definitely, it has increased the fish production of the country. At the same time, the rice plot has been reduced day by day and farmers are becoming reluctant to rice farming.

Chandra *et al*. (2019) found that appropriate agricultural practices have positive and sustainable impacts on rural farmers' livelihood possessions and strategies to overcome the climate vulnerabilities. Sattar (2019) explained that earning higher profit was a motive for the farmers' making the shift from rice to fish culture. Palas *et al*. (2018) found the commercial fish farming land area was converted mostly from cropland area and then a little portion came from Khas (Government owned fallow land) and fallow land area. Gurung *et al*. (2016) found commercial aquaculture increased both farm income and income inequality, brought in new sources of employment, changed gender roles and relations, altered women's access to and control of assets, changed family food consumption patterns, and augmented market dependence for essential food. Rasel (2016) Anisuzzaman *et al*. (2015) found that among all variables considered, some variables, precisely, the amount of land holdings, access to credit, contact with GOs/NGOs, intrusion of saline water, perception of profitability of shrimp, and water logging had a significant relation with shifting to shrimp culture. Similarly, the binary logistic regression had identified five significant determinants of shifting from rice cultivation to shrimp culture: occupation, land holding, access to credit, the intrusion of saline water, and water logging. Akteruzzaman (2005) found that when rice-fish farming became profitable, a large number of people started converting their rice fields in to rice-fish culture ponds.

This study was conducted to determine the main reasons for shifting from paddy farming to fish culture, estimate the relative profitability of paddy production and fish culture; and identify the nature of problems and constrains faced by the

paddy and fish farmers in the study area. The information about the transformation of rice farming to fish culture will be helpful to the policy makers formulating proper policy regarding two main agricultural practices rice farming and fish culture in Bangladesh.

MATERIALS AND METHODS

A sample of 50 both rice and fish culture farmers was selected randomly from North Rangchapra, South Rangchapra, Bairpathar and Medila villages in Bhaluka upazila of Mymensingh district in Bangladesh. The data were collected using semi-structured interview schedule. Focus group discussions (FGDs) and observation techniques also used for getting relevant information.

Functional analysis

Gross return: We can find out the gross return by multiplying the total output of an enterprise by the average farm gate price in the harvesting period (Dillon and Hardaker, 1993). To estimate the gross return, the following equation was used.

$$GR_i = \sum_{i=1}^{n} Q_i P_i \quad (1)$$

Where,

GR_i= Gross return from i^{th} product (Tk./ha);

Q_i =Quantity of i^{th} product (Kg/ha);

P_i=Average price of the i^{th} product (Tk./Kg);

i=1, 2, 3,.....,n.

Gross margin: The difference between total return and variable costs is the gross margin

That is,

$$GM=TR-VC \quad (2)$$

Where,

GM=Gross Margin

TR=Total Return

VC= Variable Costs

Net return: Net return was calculated by deducting variable cost and fixed cost from gross return. To determine the net return of rice and fish production the following equation was used in the present study:

$$\pi = P_y Y - \sum_{i=1}^{n} (P_{xi} X) - TFC \quad (3)$$

Where,

π = Net return (Tk. /ha);

P_y= Price of the product (Tk. /kg);

Y= Amount of the production per hectare (Kg);

P_{xi}= Price of i^{th} inputs (Tk.);

X_i =Amount of the i^{th} inputs per hectare (kg);

TFC= Total fixed cost (Tk.);

i=1,2,3.....,n (number of inputs).

RESULTS AND DISCUSSION

Age distribution

The study illustrates the age distribution of rice and fish farmers during the period of study. In this study, the age groups of the selected sample farmers are classified into three categories according to the working age classification of Bangladesh Bureau of Statistics (BBS, 2020). These categories: age between 15 to 29 years of old, age between 30-64 years old and age of 65 years old and above. In this study the respondents were classified into three age groups such as 15-29 years, 30-64 years above 65 years. It was found from the Table 1 that 22% of the respondents belonged to the age group of 15-29 years. About 70% of the respondents belonged to age group of 30-64 years and rest 8% of the respondents belonged to the age group of above 65 years. Mithun *et al*. (2020) found that the majority (90%) of the fish farmers in Muktagachha upazila of Mymensingh district were young to middle aged. This information implies that the majority of the sample farmers were in active age group of 30 - 64 years, indicating that they provided more physical efforts for rice and fish farming.

Level of education distribution of respondents according to literacy

Though education is not itself a necessary condition in advance of agriculture, it is surely a basic condition (Mellor, 1974). Educated farmers can have better access to the relevant technical information for improved production and can make rational economic decisions. Education helps a person to effectively understand the production requirements and implement the knowledge correctly. It makes a man more capable to manage the scarce resources and earn maximum profit. Education of farmers also helps them to manage their earnings efficiently on their family consumption, Children's education, housing and other expenditures. On the basis of Bangladesh Bureau of Statistics, education status of the respondents was classified into three levels (BBS, 2015). These levels are: Primary (from grade 1 to 8), Secondary (From grade 9 to 10) and higher secondary (Above grade 11). The Table 2 shows that, about 22% had no education; about 12% had primary level; about 52% had secondary level; about 10% had higher secondary and about 4% had above the higher secondary level of education in the study areas. Mithun *et al*. (2020) found that the maximum of the respondents (65%) in Muktagachha upazila of Mymensingh district had primary to secondary education. The average year of schooling of the fish farmers in Mymensingh district was 8.78 years (Rahman and Haque, 2011).

Income and expenditure distribution of the respondents

Expenditure of farmers depends on their income. In the study area, the farmers spent their income for food, clothes, children's education, medicine, purchasing, production inputs, leasing or mortgaging lands, and electricity by solar panel or fuel energy, etc. Their income sources were mainly from rice cultivation, poultry farming, fish cultivation, shrimp production,

Table 1. Age distribution of the respondents.

Age group (years)	Number of respondents	Percentage (%)
15-29	11	22
30-64	35	70
Above 65	4	8
Total	50	100

Source: Field Survey, 2021

Table 2. Educational status of the respondents.

Education level	No. of Respondents	Percentage (%)
Illiterate	11	22
Primary	6	12
Secondary	26	52
Higher secondary	5	10
Above higher secondary	2	4
Total	50	100

Source: Field Survey, 2021

Table 3. Annual income and expenditure of the respondents according to family size.

Family Size	No. of households	Percentage%	Average Income (Tk.)	Average Expenditure (Tk.)
Small family (up to 4)	21	42	2556700 (US$ 27256.93)	2289000 (US$ 24402.99)
Medium family (5 to 9)	19	38	2349000 (US$ 25042.64)	1976000 (US$ 21066.10)
Large family (10 and above)	10	20	1834000 (US$ 19552.24)	1568000 (US$ 16716.42)
Total	50	100	2333234 (US$ 24874.56)	2025860 (US$ 21597.65)

Source: Field Survey, 2021 (US$ 1= Tk.93.80).

Table 4. Respondents perceived socioeconomic factors for shifting from rice for fish culture.

Socioeconomic Factors	Number of the respondents	Percentage (%)
Fish farming is more profitable than rice production	48	96
Labour shortage for rice production	45	90
High cost of labour and other inputs for rice production	39	68
Unavailability of good quality seeds	17	34
Unavailability of agricultural extension services	20	40

Source: Field Survey, 2021

tree, vegetable production, remittance, services, business and lease out of lands etc. Table 3 shows that an average income and expenditure of the respondents were Tk. 2333234 (US$ 24874.56) and Tk. 2025860 (US$ 21597.65) respectively. For small family group the average annual income was Tk. 2556700 (US$ 27256.93) and expenditure was Tk. 2289000 (US$ 24402.99). At the same time the average annual income and expenditure was Tk. 2349000 (US$ 25042.64) and Tk. 1976000 (US$ 21066.10) for medium family and Tk. 1834000 (US$ 19552.24) and Tk. 1568000 (US$ 16716.42) large family, respectively.

Reasons for shifting from paddy cultivation to aquaculture

This chapter highlighted some reasons for shifting rice cultivation to aquaculture. Aside from the high demand for fish in the domestic as well as international market, improved market access, extension service and more information, the survey revealed the following reasons for the popularity of shifting rice cultivation to fish culture: (i) Fish farming is more profitable than rice production; (ii) Labour shortage for rice production; (iii) High cost of labour and other inputs for rice production; (iv) Unavailability of good quality seeds and (v) Unavailability of agricultural extension services (Table 4). Table 4 shows that about 96% of the respondents said that fish farming is more profitable than rice production that influenced them to shifting rice cultivation to fish culture. Sattar (2019) also found in his study that the profit motive of the farmers was one of the main reasons to shift rice farming to aquaculture. Table 4 also shows that about 90% respondent claimed that the labour shortage of rice production was another reason to shift rice production to fish culture. About 68% of the respondents said that the high cost of labour and other inputs for rice production was another reason to shift from rice production to fish production. The real wages of agricultural labourers in Bangladesh have more than doubled in the last decade (Zhang *et al.*, 2014) and the shortage of farm labour is increasing due to the increased rural out-migration of young men (Hossain and Bayes, 2009). The high

Table 5. Per hectare per season (6 months) total cost of fish culture.

Items	Units	Quantity	Price/ Unit	Total cost
A. Variable cost	Tk.	-	-	506606 (US$ 5400.92)
Human labour (Family and hired)	Man-day	190	500.00	95000 (US$ 1012.79)
Fingerlings	No.	6025	7.00	42175 (US$ 449.63)
Fertilizer				
Urea	Kg	300	18	5400 (US$ 57.57)
TSP	Kg	115	22	2530 (US$ 26.97)
MP	Kg	89	15	1335 (US$ 14.23)
Manure	Kg	963	1.00	963 (US$ 10.27)
Feed	Kg	3600	84	302400 (US$ 3223.88)
Oil cake	Kg	210	70	14700 (US$ 156.72)
Rice bran	Kg	637	17	10829 (US$ 115.45)
Lime	Kg	325	22	7150 (US$ 76.23)
Interest on operating capital	Tk.	-	10%	24124 (US$ 257.19)
B. Fixed cost	Tk.	-	-	58500 (US$ 623.67)
Land use cost	Tk.	-	-	58500 (US$ 623.67)
Total cost (A+B)	Tk.			565106 (US$ 6024.58)

Source: Author's estimation, 2021 (US$ 1= Tk.93.80)

Table 6. Per hectare/six months gross return from fish culture.

Production	Main product			Gross return (Tk.)
	Quantity (Kg)	Price (Tk./Kg)	Value (Tk.)	
Yield	11080	95	1052600	1052600 (US$ 11221.75)

Source: Author's estimation, 2021 (US$ 1= Tk.93.80)

Table 7. Per hectare/six months cost, return and benefit-cost ratio of fish culture.

Particulars		Fish polyculture
A. Gross return (Tk.)		1052600 (US$ 11221.75)
B. Variable cost (Tk.)		506606 (US$ 5400.92)
C. Total cost (Tk.)		565106 (US$ 6024.58)
D. Gross margin (A-B) (Tk.)		545994 (US$ 5820.83)
E. Net return (A-C) (Tk.)		487494 (US$ 5197.16)
BCR (A/B)	Cash cost	2.08
BCR (A/C)	Full cost	1.86

Source: Author's estimation, 2021 (US$ 1= Tk.93.80)

cost of labour coupled with its shortage is another reason that encouraged large farmers to shift from rice monoculture to fish culture. This is consistent with the study's finding that the shortage of labour is a major reason for shifting from rice farming to fish culture. Seed is a very important input for any crop production. Good quality seed is essential for good production. Table 4 indicates that 34% of the respondents said that good quality of Boro rice seed was not available which another reason to shift to fish culture was.

Table 4 shows that about 40% respondents expressed that unavailability of agricultural extension services was another reason for shifting rice cultivation to fish culture. Agriculture training targeted at poor farmers will enable them to take up profitable crop farming. This requires friendly policies and increased investment in a farmer's training as well as the staff of service delivery organizations. Innovative extension approaches, such as field demonstrations, farmer-to-farmer extension, provision of technological services through farmers' groups, field schools, use of video-mediated learning, and other information and communication technologies, such as mobile phones, to train poor farmers can empower them by increasing their decision-making power besides access to and control over resources, and farm incomes. Despite the economic benefits of shifting from rice cultivation to fish culture, it is accompanied by unintended negative social consequences for women, households, and the society as a whole. These consequences include increased income inequality, reduced overall employment and income opportunities for the poor, especially the women, decline in women's participation in rice production and fish culture related decisions, and fall in women's access to and control over home-grown rice and fish for consumption. The FGDs revealed that households whose land was surrounded by large neighbouring fish farms were often compelled to lease or mortgage their lands to these farms as waterlogging caused by the aquaculture farms solidified these lands frail for crop agriculture. Frequently, such farmers faced stress from powerful

persons to lease out their lands as their deficiency of access to the money kept them from involving aquaculture themselves.

Profitability fish farming

Fish farmers in the study area did not maintain any written records of costs and returns of fish culture. However, it is presumed that they possess a sharp memory and can calculate everything related to their farm business. The purpose of this section is to determine per hectare cost and return of fish culture which were determined for the whole production period, i.e., six months. There are two types of costs such as fixed cost and variable cost. In this study, variable cost items included were hired labour, fingerling, feed and interest on operating cost. The land use cost considered as a fixed cost. On the return side, per hectare yield, gross return, gross margin, net return and benefit-cost ratio also estimate and analyse.

Variable costs

Human labour was the most important and one of the largest inputs used for tilapia-carp fish production. There were broadly two different categories of human labour, i) family labour and ii) hired labour (Permanent hired labour, temporary hired labour, pond repairing labour, harvesting labour). The intensity of labour depends on how carefully and what operations have to be done by the farmers. In this study, human labour was measured in terms of man-days, which usually consisted 8 hours of work by an adult man. For women and children, the man equivalent day was estimated. This was performed as follows (Yang, 1965): 1 adult man = 1.5 adult women = 2 children. The average wage rate was Tk. 500 (US$ 5.33) per man-day in the study area. The costs of family labour had been calculated according to the wage rate at which the farmers could hire labour. Per hectare total cost of hiring labour was calculated from per hectare labour used in different operations multiplied by wage rate. Table 5 shows that, per hectare/6 months cost of human labour was Tk. 95000 (US$ 1012.79) for fish farming. The stocking rate of fingerlings varies with the fertility of the pond. The respondents in the study area used to buy fingerlings and the fingerling price depends on their size and the fish species. The respondents in the study area generally culture the fish species of Rui, Catla, Mrigal, Karfu, Silver carp, Grass carp, Mirror carp, Shrimp, Chetol, Tilapia, Pangus, Kalabous and Sharpunti in their ponds. Table 5 shows that, per hectare average cost of fingerlings were estimated at Tk. 42175 (US$ 449.63).

Fertilizer was generally used in the fish pond to create conditions, which facilitates an increase in production of good quality natural fish feed, thereby increasing fish production. Farmers used three kinds of chemical fertilizers namely, Urea, Triple Super Phosphate (TSP) and Murate of Potash (MP). The costs were Tk. 5400 (US$ 57.57), Tk.2530 (US$ 26.97) and Tk.1335 (US$ 14.23), respectively per hectare per season (six months). Manure was important for fish production. It is observed that, farmers used cow-dung in fish ponds as manure in the study area. Cow-dung was home supplied and purchased. The cost of cow-dung was calculated Tk.1/kg. It observed that farmers used 963 kg manure per hectare per season (six months). So, the manure cost was Tk. 963 (US$ 10.27)/hectare/season. It is important to supply of artificial supplementary feeds, which contribute to increase fish production. Fish farmers mostly used rice bran and oil cake as supplementary feed for fish. Fish culture per hectare/6 months cost of feed was Tk. 302400 (US$ 3223.88). Farmers also added oil cake and rice bran as feed which added the additional cost of Tk. 14700 (US$ 156.72) and Tk. 10829 (US$ 115.45), respectively. Lime was used mainly to neutralize acidity in the soil and water of the pond. Lime assists in the release of the nutrient from the soil and promotes the bacterial breakdown of water material including green manure. The average cost of lime was Tk.7150 (US$ 76.23)/ha/6 months. Interest on operating capital for fish culture was Tk. 24124 (US$ 257.19) per hectare/6 months.

Fixed cost

The cost of land use was different from one plot to another, depending upon location, distance and topography. The cost of land use was estimated on the basis of rental value. The land use cost was Tk. 58500 (US$ 623.67)/hectare/season (Table 5).

Gross return

The money value of total output is the gross return. The gross return was calculated by summing up all the returns earned from selling fishes. Per hectare/6 months gross return from fish production was Tk. 1052600 (US$ 11221.75) (Table 6).

Gross margin

Gross margin is defined as the difference between gross return and variable costs. Farmers are interested in gross margin because they like to know the total return over variable cost. Table 7 reveals that gross margin for fish farming was Tk. 545994 (US$ 5820.83).

Net return

In general net return is termed as an entrepreneur's income. The net return is the difference between gross return and total costs. Table 7 reveals that per hectare per year net return of production of fish was Tk. 487494 (US$ 5197.16) which indicates that fish culture is profitable business.

The benefit-cost ratio for fish culture was calculated as the total return divided by total cost. From Table 7 reveals that the benefit-cost ratio of fish farming for cash cost was 2.08 and benefit- cost ratio of fish farming for full cost was 1.86 (overall). These values are higher than the findings of Ferdoushi *et al.* (2019) which were 1.34 for polyculture and 1.51 for tilapia monoculture. On the basis of the above discussion, it could be concluded that fish culture is profitable.

Profitability *Boro* rice cultivation

This section attempts to calculate the costs, return and profitability of cultivating Boro rice. The items of costs include fertilizer, seed, labour cost, land cost and cost on operating capital @10 percent in 6 months. After calculating all the cost and

Table 8. Per hectare per season (6 months) total cost of *Boro* rice cultivation (considering home supplied labour were paid).

Items	Units	Quantity	Price/ Unit (Tk.)	Total Cost
A. Variable cost	Tk.	-	-	86946.00 (US$ 926.93)
Human labour	Man-day	110	500.00	55000.00 (US$ 586.35)
Power-tiller cost	Tk.			8120.00 (US$ 86.57)
Seedlings	Kg	54	40.00	2160.00 (US$ 22.60)
Fertilizer:				
Urea	Kg	200	16.00	3200.00 (US$ 34.12)
TSP	Kg	115	22.00	2530.00 (US$ 26.97)
MoP	Kg	90	15	1350 (US$ 14.39)
Insecticide	Tk.			1550.00 (US$ 16.52)
Cow dung	Kg	2696	1.00	2696.00 (US$ 28.74)
Irrigation	Tk	-	-	6200.00 (US$ 66.10)
Interest on operating capital	Tk.			4140.00 (US$ 44.14)
B. Fixed cost	Tk.			9340.00 (US$ 99.57)
Land use cost	Tk.			9340.00 (US$ 99.57)
Total cost(A+B)	Tk.			96286.00 (US$ 1026.50)

Source: Author's estimation, 2021 (US$ 1= Tk.93.80)

Table 9. Per hectare/season gross return from *Boro* rice cultivation.

Item	Main product			Return (Tk.)
	Units	Quantity	Price/unit	
Yield of paddy	Kg	4387.50	20.00	87750.00 (US$ 935.50)
By product (Straw)	Tk	-	-	15600.00(US$ 166.31)
Total				103350.00(US$ 1101.81)

Source: Author's estimation, 2021 (US$ 1= Tk.93.80)

return, the benefit cost ratio for individual category farmers and all farmers were calculated. All the calculations were performed by hectare.

The cost of inputs is an important factor that plays an important role in financial decision making for performing and income generating activity. Respondents in the study area used to purchased inputs as well as home supplied inputs. The cost of purchasing inputs and home supplied inputs were not calculated separately. The cost of rice cultivation can be broadly classified under the following two heads:

a) Variable cost
b) Fixed cost

a) Variable cost

This mainly includes the following heads:
i) Cost of seed
ii) Human labour cost
iii) Fertilizers cost
iv) Machinery cost
v) Irrigation cost
vi) Insecticide cost
vii) Interest on operating capital

b) Fixed cost
i) Land use cost

Per hectare per season (6 months) total cost of *Boro* rice cultivation (considering home supplied labour were paid)

Gross return: The monetary value of total output is called gross return. The gross return was calculated by summing up all the returns earned from selling paddy and straw. The gross return was calculated by multiplying the total amount of products and byproducts with average selling. Per hectare/6 months gross return from *Boro* rice cultivation was Tk. 103350 (US$ 1101.81) (Table 8).

Gross margin: Gross margin is defined as the difference between gross return and variable costs. The argument for using the gross margin analysis is that the farmers are interested to get returns over variable cost. Table 9 reveals that gross margin for farming was Tk. 16404 (US$ 174.88).

Net return: In general net return is termed as an entrepreneur's income. The net return is the difference between gross return and total costs. Table 10 reveals that per hectare per season net return of production of Boro rice was Tk. 7064 (US$ 75.31) which indicates that Boro rice cultivation is not so profitable business. Islam *et al.* (2002) found that the net return was Tk. 5011(US$ 53.42) per hector for boro rice in the same study area.

The benefit-cost ratio for tilapia-carp fish was determined as the ratio of total return to total cost. From Table 10 reveals that the benefit-cost ratio of Boro rice cultivation for cash cost was 1.19 and full cost was 1.07.

Problems and constraints of *Boro* rice cultivation and fish culture

The *Boro* rice cultivation and fish farmers in the study area were facing various problems during their farming activities. These problems broadly categorized as economic, natural, technical and societal. The farmers confronted the problems

Table 10. Per hectare/season cost, return and benefit-cost ratio of *Boro* rice cultivation.

Particulars		*Boro* rice cultivation
A. Gross return (Tk.)		103350.00 (US$ 1101.18)
B. Variable cost (Tk.)		86946.00 (US$ 926.93)
C. Total cost (Tk.)		96286.00 (US$ 1026.50)
D. Gross margin (A-B) (Tk.)		16404.00 (US$ 174.88)
E. Net return (A-C) (Tk.)		7064.00 (US$ 75.31)
BCR (A/B)	Cash cost	1.19
BCR (A/C)	Full cost	1.07

Source: Author's estimation, 2021 (US$ 1= Tk.93.80)

Table 11. Problems of *Boro* rice cultivation as ranked by farmers (Percentages are in parentheses).

Problems	Number of times problem was ranked				
	First	Second	Third	Fourth	Total (n = 50)
Low profit	38	2	5	3	48 (96%)
Labour intensive	12	14	00	5	31(62%)
Scarcity of labour in harvesting period	24	10	8	3	45 (90%)
Lack of agricultural extension services	15	7	3	1	26(52%)

Source: Field Survey, 2021

Table 12. Problems and Constraints of pond fish culture as ranked by farmers (Percentages are in parentheses).

Problem	Number of times problem was ranked				
	First	Second	Third	Fourth	Total (n = 50)
Insufficient water	4	2	5	3	14(28%)
Diseases	28	14	00	5	47(94%)
High feed cost	14	15	10	3	42(84%)
Predators	0	0	2	2	4(8%)
Theft	0	2	0	1	3(6%)
Unexplained mortalities	0	0	7	5	12(24%)

Source: Field Survey, 2021

during Boro rice cultivation was ranked in the Table 11 and the farmers confronted the problems and constraints in fish culture were ranked in the Table 12.

Problems of *Boro* rice cultivation

Low profit: Net income is an indicator of a sustainability of a farm. Table 11 shows that about 96% of the respondents claimed that unacceptable or very low profit was one of the main problems of Boro rice cultivation. The market price of the paddy during the harvesting period generally very low and most of the farmers sell their paddy at that time. For this reason their revenue from selling rice is the minimum which lead to very low profit. If government rice procurement policy can successfully implement and the production cost can be reduced, then this problem might be solved.

Labour intensive: Labour is an essential input for Boro rice production. Table 11 shows that about 62% of the respondents said that *Boro* rice production is a labour intensive farming, which is another problem for Boro rice cultivation. Now-a-days the agricultural labour wage rate is very high that leads to the high production cost. If the farmers can apply more machineries instant of human labour then this problem could be minimized.

Scarcity of labour in harvesting period: Harvesting period is very crucial for Boro rice farmers in Bangladesh. Table 11 shows that 90% of the respondents said that scarcity of labour in harvesting period is another problem for them for Boro rice production. If a farmer can use a combined harvester for their paddy harvesting this problem can be minimized.

No agricultural extension services: Most of the farmers are very experienced and informally educated in Boro rice production. But sometimes they are not able to able to identify some biological problems. At that time, they were looking for professional expertise like Agricultural Extension Officer. But, unfortunately the Table 11 shows that about 52% Boro rice farmers said that unavailability of agricultural extension services is another problem for rice production. If government can ensure this service to the *Boro* rice farmers, this problem can be solved. Islam *et al.* (2002) found that lack of institutional credit, higher priced of inputs, lack of marketing knowledge regarding rice cultivation are the major problems facing the farmers.

Problems and constraints of fish culture

Insufficient water: Water was essential for pond fish culture. Bangladesh belongs to the monsoon region, sufficient water

was in the monsoon season, but insufficient water was in the dry season. About 28% of the pond fish farmers complained that the insufficient water was the problem in the selected area. They ranked 8%, 4%, 10% and 6% reported as the first, second, third and fourth problems, respectively (Table 12).

Diseases: Table 12 reveals that 94% of the respondents were claiming that diseases of the fish were the major problem in pond fish culture. Of this, 94%; 56%, 28%, 0% and 10% reported as the first, second, third and fourth problems, respectively. Agricultural extension workers and Upazilla Fisheries Officer can help to the farmers in solving this problem.

High feed cost: High feed cost was one of the main problems in fish culture in the study area. As a result of high feed cost farmers, the cost of production was increased and profitability decreased. Table 12 shows that the highest 84% of the respondents claimed that high feed cost were there big problem. Out of 84%; 28%, 30%, 20% and 6% reported as the first, second, third and fourth problems, respectively. Government should take appropriate policies to overcome this problem.

Predators: Predators were other minor problem in the selected area. Only 8% of the respondents claimed predators as the fourth problem (Table 12). Some kind of birds and some animals, that's lived in the water was the predators of fish. This problem was not so big for the farmers.

Theft: Theft of fish was another problem in the selected area. Table 12 reveals that 6% of the respondents claimed that the theft was a problem for them. From this 4% and 2% complained as the second and fourth problems, respectively. This problem was raised where 'Night Guard' was not available.

Unexplained mortality: Table 12 shows that 24% of the respondents claimed that unexplained mortality of fish was their major problem due to lack of proper knowledge of the relevant technology. Out of that 24%; 14% and 10% complained as third and fourth problems, respectively. This problem arises when farmers are not able to find the causes of mortality of the fish. Fisheries expert could help to solve this problem. Islam *et al.* (2002) found that insufficient water in dry season, attack of diseases and theft of fish are the major problems facing the farmers.

Conclusion

The study demonstrates that the shift from rice farming to fish culture in a selected area of Mymensingh district in Bangladesh. Food security is the primary objective of rural households, which makes paddy farming unavoidable, although paddy lands are being converted to fish culture. In view of the agricultural labour shortage, rising wages, and high labour requirements in paddy farming, it is important to mechanize transplanting and harvesting to minimize the cost of paddy farming. This requires a concerted awareness drive through field demonstrations to make farmers aware of the advantages of mechanization. This should be followed by effective extension programmes. The main drivers leading to fish culture are less profit from rice farming, shortage of labour and its rising cost, and increase in the cost of other inputs for rice farming. Fish farming is significantly more profitable than rice farming, although high capital investment is a major constraint in its adoption. Per hectare per/season gross margin and net return were Tk. 545994 (US$ 5820.83) and Tk. 487494 (US$ 5197.16), respectively for fish culture and Tk. 16404.00 (US$ 174.88) and Tk. 7064.00 (US$ 75.31), respectively, for rice cultivation. The BCR of fish culture and rice cultivation was 1.86 and 1.07, respectively (Full cost basis). The fish market is well developed and integrated into Bangladesh. Hence, market access, output price, and access to inputs such as fingerlings are not major problems in fish farming. At the household level, fish farming is mainly adopted by higher income households because of the high initial investment and business operation. The findings have the following recommendations.

i). Mechanize rice transplanting and harvesting to over-come labour crisis and increase profits from rice farming.

ii) Diversify rice-based farming systems.

iii) Provide targeted training to farmers on new farming practices

Conflict of interest

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

ACKNOWLEDGEMENT

The first author gratefully acknowledges the Ministry of Science and Technology of the Government of People's Republic of Bangladesh for funding this research project.

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