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Article

Economics of fish production in paddy fields in Bangladesh

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Abstract: This study was conducted to assess profitability of fish production in paddy fields in the village of Kunia and Chandora, under Gacha union in Gazipur sadar upazila in Gazipur district. Primary data were collected from 15 fish farmers for the study during the period from June to November, 2016. Production performance of three stocking package were compared. CFP-1 package contained Thai sarpunti (24700/ha) + Tilapia (6175/ha); CFP-2 comprised of Thai sarpunti (24700/ha) + Common carp (6175/ha); while CFP-3 was represented by Thai sarpunti (24700/ha) + (Tilapia (6175/ha) + Common carp (6175/ha). Both tabular and functional analyses were used to achieve the objectives of the study. Fish productions in paddy fields are profitable business. The total cost of fish production under three selected stocking plans such as CFP-1, CFP-2 and CFP-3 were estimated to be Tk. 73085, Tk. 83459 and Tk. 86928 per ha, respectively. The corresponding total gross return (Tk./ha) were Tk. 209777, Tk. 274170 and Tk. 262721, respectively. The benefit cost ratio (BCR) was estimated to be 2.87, 3.28 and 3.02 for package-1, package-2 and package-3, respectively. Returns over per taka investment (NR/Tk.) were found to be 1.32, 1.69 and 1.42 for the above fish culture packages. Cobb-Douglas production function analysis indicated the positive contribution of fish fingerlings, fertilizer, fish feed and lime on the total income and farm productivity, while human labor and bank interest rate decreased the farm income. The values of R2 were 0.775, 0.739 and 0.812 for CFP-1, CFP-2 and CFP-3, respectively. About 77.5 percent, 73.9 percent and 81.2 percent of variation in yield and gross return of fish production in paddy fields could be explained by the multiple regression equations. Fish production in paddy fields are economically profitable, viable and environment friendly. The farmers may undertake fish culture in paddy fields if suitable paddy fields are available.

Keywords: economics; fish production; paddy fields; integrated aquaculture

1. Introduction

Fisheries sub-sector in Bangladesh is playing a vital role in employment generation, animal protein supply and foreign currency earning and poverty alleviation. Bangladesh has achieved remarkable progress in the fisheries sector since its independence in 1971. Fisheries sector have been playing a very significant role and deserve potential for future development in the agrarian economy of Bangladesh. This sector contributes 3.65% to the national gross domestic product (GDP) and almost one- fourth (23.81%) to the agricultural GDP (Bangladesh Economic Review 2016). Fisheries sector provides about 60% of the animal protein intake (DoF, 2016). About 11% of the population directly and indirectly depends on fisheries sector for their livelihood (DoF, 2016). Bangladesh is one of the world's leading fish producing countries with a total production of 3.684 m MT in the last financial year 2014-15 (DoF, 2016) and achieving 5th rank among the major aquaculture producing countries in the world (FAO, 2016). Out of total fish production, aquaculture contributes 55.93% and remaining 27.79% and 16.28% were from inland capture fisheries and marine fisheries, respectively (DoF, 2016) indicating aquaculture is the fastest growing food producing sector in Bangladesh. Huge employment opportunities have been developed based on fisheries in Bangladesh. It has been estimated that about 12 million rural people are involved in subsistence fishing. As an economic activity, fisheries ranks second to agriculture in terms of providing livelihood to an estimated 1.3 million of Bangladeshi population in full time and substantial livelihood support to 12 million part time fishermen (Akhter, 2009). In Bangladesh there are lot of marshy land, rice fields and ditches where we can easily cultivate fish not only to meet our domestic need of proteins but can export fish to earn foreign exchange to strengthen our economy. In Bangladesh, a large proportion of paddy fields remain under water during monsoon where Aman rice could not be grown due to accumulation of excessive water as a result of water submergence. But these paddy fields could be utilized for other productive purposes. Aquaculture involving fast growing fishes for short term culture period with Thai sarpunti, Tilapia and Common carp could easily be grown in that rice field. Therefore, any efforts to find out an economically viable and profitable production practice of aquaculture for temporary fallow paddy fields will be an excellent task.The main objectives of this study are to determine the socio-economic profile of the farmers practicing fish culture in paddy field; to investigate the costs and returns and the relative profitability of fish production in paddy fields.

2. Materials and Methods

2.1. Study area and periods

The present study was conducted in village Kunia and Chandhora under Gacha union in Gazipur sadar upzila in Gazipur district (Figure 1). The researchers collected data during the period from June through November, 2016.

Figure 1. Map showing Gacha union in Gazipur sadar upzila in Gazipur district.

2.2. Sampling techniques

The farmers herein after designated as "Contact farmer" were motivated to undertake fish culture in paddy field under three selected packages. The fish culture packages were (1) Thai sarpunti + Tilapia (2) Thai sarpunti + Common carp and (3) Thai sarpunti + Tilapia + Common carp. A total of 15 contacted farmers were selected to practice the above packages. Five plots were assigned for each package. Besides these, some other farmers undertook fish culture in paddy field with their own initiatives. Data were collected from those farmers for Cobb- Douglass Production Function Analysis only.

2.3. Research design

Fifteen rice plots (5 plots per package) were purposively selected to culture fish. There were three treatments each with three replications. The treatment 1 was combination of Thai sarpunti (24700/ha) and Tilapia (6175/ha); treatment 2 was combination of Thai sarpunti (24700/ha) and Common carp (6175/ha) lastly treatment 3 was combination of Thai sarpunti (24700/ha) and Tilapia (6175/ha) along with Common carp (6175/ha).

2.3.1. Plot preparation

Plot sizes were variable ranging from 15-20 decimal. Most of the plots were surrounded by home stead from two sides and one side was bounded by kacha road and the other open side was blocked by creating dike up to three feet from plot bed. The aquatic weed from each plot was removed manually. Lime was applied to the plot at the rate of 247 kg/ha. Cow dung or poultry excreta was applied at the rate of 1235kg/ha. Upon accumulation of rain water up to a depth of about 1-2 feet, urea and triple super phosphate were added to the experimental plot at the rate of 24.7 kg and 12.35 kg per hectare, respectively. TSP was soaked in water before applying to the plots. After development of blue green color of water phostoxin tablets (25 tablet/ha) were applied to each plot to destroy the undesirable animals. One week after administration of phostoxin each plot was stocked with specific fish fingerlings. The fingerlings were acclimatized before releasing them in the concerned plots. Fingerling sized was 2-3 inches.

2.3.2. Farm management

After stocked fish in each plot, rice bran was supplied to the fishes at 1% of the body weight. Feeding rate was adjusted based on monthly sampling. Outlet pipe was installed in suitable place in one of the dike to allow the excess water to flow out. Predatory animals such as snake and frog were killed as soon as they were seen.

2.3.3. Monthly sampling

The growth rate and health condition of the stocked fishes were monitored by monthly sampling. For this purpose cast net was used. Length (mm) and weight (g) of at least 10 fishes belonging to each species were recorded which served as a basis for adjustment of feeding rate.

2.3.4. Fish harvest

The fishes were harvested during the middle of November. At the time of harvest proper record was maintained regarding final body weight, size and number as well as amount of total harvested fishes. Species wise sale record was also maintained to carry out the financial analysis.

2.4. Processing, tabulation and analysis of data

After collection of primary data from the study areas, the collected data were summarized and scrutinized. Finally, tabulated data were analyzed and condensed by using range, average, and percentage through MS Excel and SPSS to interpret the result.

2.4.1 Analytical techniques

2.4.1.1. Tabular analysis

Tabular technique is the technique that is commonly followed to find out the crude association or differences between variables and output. Data were presented mostly in the tabular form. This form is simple in calculation, widely used and easy to understand. Some statistical measures, like average, percentage and ratios were calculated.

2.4.1.2. Functional analysis

Functional analysis was employed to show the individual effect of input use and other related factors of fish production in paddy fields with the help of Cobb-Douglas Production Function Model. For this purpose multiple regression function was specified as follows:

$Y= aX_1^{b1}X_2^{b2}X_3^{b3}X_4^{b4}X_5^{b5}X_6^{b6}e^u$

The equation may be alternatively expressed as log-linear form:

$In\ Y = In\ a + b_1\ InX_1 + b_2\ InX_2 + b_3\ InX_3 + b_4InX_4 + b_5InX_5 + b_6InX_6 + \mu_i$

Where

Y = Gross return (Tk./ha)

X_1= Fingerling cost (Tk./ha)

X_2= Feed cost (Tk./ha)

X_3= Fertilizer cost (Tk./ha)

X_4= Lime cost (TK./ha)

X_5= Human labor cost (Tk./ha)

X_6= Bank interest (Tk./ha)

In = Natural logarithm

a = Intercept

(b_1..... b_6) = Coefficients of respective variables and

μ_i= Error term

2.5. Methods of estimating cost items of fish production in paddy fields

For calculating profit or loss, it was essential to compute all the cost incurred for purchased and home supplied inputs. In the research periods the variable cost were human labor, fingerlings, feed, fertilizer, manure, lime and chemical. On the other hand, the fixed costs were land use cost, container and bank interest.

3. Results

3.1. Age distribution of contact farmers

Out of the total contact farmers the highest portion was about 53% which belonged to the age group of 30-40 years and the lowest was about 10% which was above 50 years (Figure 2).

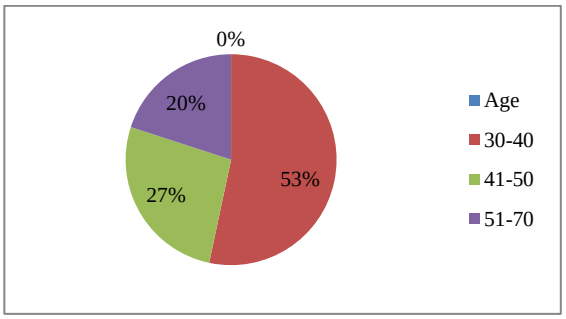

Figure 2. Age distribution of contact farmers.

3.2. Educational level of contact farmers

In this present study it was found that 33% of the contact farmers had up to secondary level of education (S.S.C) and only 7% of the contact farmers had masters' degree level of education (Figure 3).

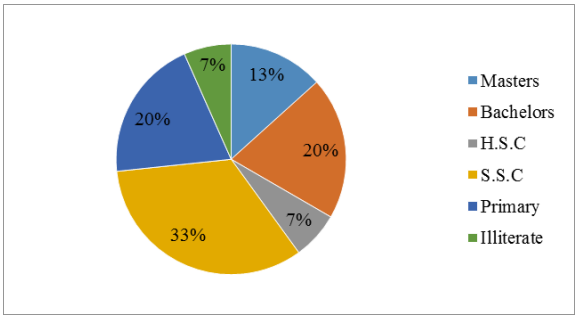

Figure 3. Educational level of contact farmers.

3.3. Family sizes

Data on family size which shows that 20% farmer has 1- 2 members, 66% farmer has 3-4 members and 13% farmer has 5-8 members (Figure 4).

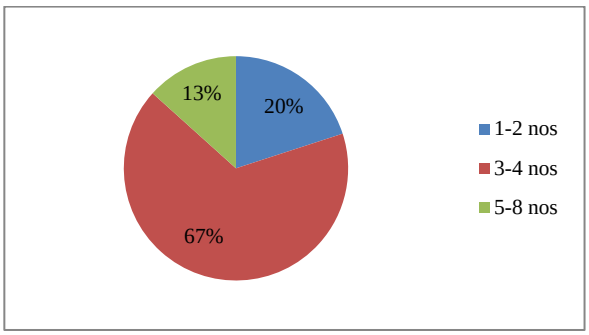

Figure 4. Family size of contact farmers.

3.4. Occupational structures of contact farmers

It is evident from the Table 1-4 that out of 15 contact farmers, 40% percent farmers main occupation was business, 26.66 percent house renting, 13.33 percent in service holder, 6.66% farmer were engaged in teaching, crop production and fish culture (Figure 5). The findings clearly indicated that majority of the contact farmers were engaged in business.

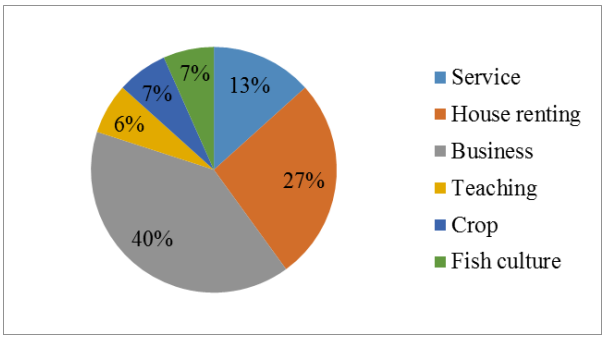

Figure 5. Occupational structure of contact farmers.

3.5. Land holding

It is evident that 40% contact farmers had 25-50 decimal land holding, another 40% had 51-100 decimal land holding, 13% had land holding of 101-200 decimal. Only 7% contact farmers had the opportunity of having 201-300 decimal land (Figure 6). This group of people is very rich in their locality.

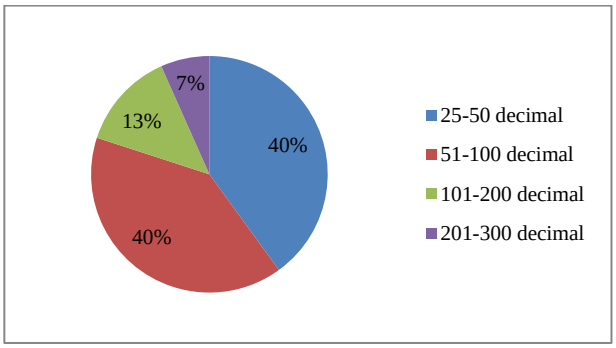

Figure 6. Land holding of contact farmers.

3.6. Annual incomes

It is evident that 33% of the contact farmer had annual income of Tk. 2-3 lac, 27% had 10.1-20 lac, 20% had annual income of Tk. 5.1-10 lac, 13% contact farmer enjoyed 20.1-30 lac Tk. Income. A small portion (7%) had

much less income of Tk. 3.1-5 lac only (Figure 7).

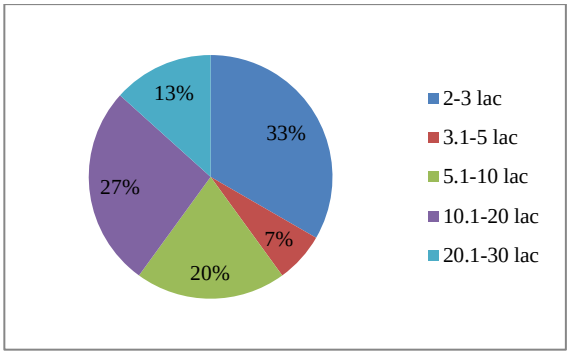

Figure 7. Annual income of contact farmers.

3.7. Costs, return and profitability of fish culture

3.7.1. Variables cost

The farmer input their plot different types of variables cost like labor cost, cost of release of fingerling, cost of fertilizer, costs of feed, cost of manure and cost of liming (Table 1-3).

3.7.2. Fixed cost

The fixed cost of the farmer was containers, pond lease value and bank interest value etc. (Table 1-3).

Table 1. Breakdown of the average cost of fish production under three stocking plans (Taka/ha).

Cost items	Treatment-1 (Tk./ha)	Treatment-2 (Tk./ha)	Treatment-3 (Tk./ha)
A : Variable cost			
1. Dike repair and weed control	6000	6000	6000
2. Predator control/ Phostoxin	750	750	750
3. Liming	2470	2470	2470
4.Urea (247 kg x Tk. 20/kg)	4940	4940	4940
5.TSP (124 kg x 30/kg)	3720	3720	3720
6. Cow dung (1235 kg x Tk. 1/kg	1235	1235	1235
7. Tilapia fingerlings (25 x 247 x Tk. 0.50/piece)	3087.5	0	3087.5
8. Thai sarpunti fingerlings (100 x 247 x Tk. 0.40/piece)	9880	9880	9880
9. Common carp fingerlings (25 x 247 x Tk. 2/piece)	0	12350	12350
10. Rice bran (5kg./deci x 247 x Tk. 2/kg)	2470	2470	2470
11. Hired labor for harvesting	5000	5000	5000
12. Tree branches for prevention of theft	500	500	500
Sub-total of variable cost :	**40054.5**	**49317**	**52404.5**
B: Fixed cost			
13. Containers	500	500	500
14. Pond lease value (Tk.100/deci x 247 decimal)	24700	24700	24700
15. Bank interest (12%)	7830.54	8942.04	9323.54
Sub-total of fixed cost :	**33030.54**	**34142.04**	**34523.54**
Total cost :	**73085.04**	**83459.04**	**86928.04**

Table 2. Materials inputs cost for three types of culture practices.

Material inputs	Amount (kg or Nos)	Treatment-1 Tk./ha)	Treatment-2 (Tk./ha)	Treatment-3 (Tk./ha)
Fish fingerlings				
Tilapia (Tk.0.5/pc)	6175 Nos	3087.5	0	3087.5
Thai sarpunti (Tk.0.4/pc)	24700 Nos	9880	9880	9880
Common carp (Tk.2/pc)	6175 Nos	0	12350	12350
Rice bran(Tk. 2/kg)	1235 kg	2470	2470	2470
Lime(Tk. 10/kg)	247 kg	2470	2470	2470
Urea(Tk. 20/kg)	247 kg	4940	4940	4940
TSP(Tk. 30/kg)	124 kg	3720	3720	3720
Cow dung (Tk.1/kg)	1235 kg	1235	1235	1235
Containers/pot	3	500	500	500
Total material cost (Tk.)		**28302.5**	**37565**	**40652.5**
Percentage of material cost to total cost (%)		**38.73**	**45.01**	**46.77**

3.8. Fish production

In the surveyed area per hectare seasonal fish production in the paddy fields ranged from 1887 kg to 2605 kg with an average of 2354.33 kg. It may be noted here that combined production of Thai sarpunti and Tilapia stood at 1887 kg under package-1, while Thai sarpunti and common carp yielded 2605 kg under package-2. Package-3 containing Thai sarpunti, Tilapia and Common carp gave yield of 2571 kg per hectare (Table 3).

3.9. Gross margins, net return per taka investment and BCR

Thai sarpunti was sold at the rate of Taka 110 – 130 with an average rate of Tk. 120 per kg, Tilapia at 95 Tk. per kg and Common carp at 95 Tk. per kg. The gross return from package-1, package-2 and package-3 were found to be Tk. 209777, 274170 and 262721, respectively, while the net return for corresponding fish culture packages stood at Tk 96637, 141393 and 123389, respectively. Net Return per Taka Investment for fish culture package-1, package-2 and package-3 was estimated to be 1.32, 1,69 and 1.41, respectively with corresponding benefit cost ratio(BCR) for those packages were found to be 2.87, 3.28 and 3.02 respectively. To estimate the net return from fish culture in paddy fields, total costs were deducted from gross return. The net return, according to different stocking plans is shown in Table 4. Per hectare per season average net return from culture of fish in paddy field stood at Tk. 96637, 141393 and Tk. 123389 for CFP-1, CFP-2 and CFP-3, respectively. Gross margin is the differences between the gross return and total variable cost. Net return per taka invested is the ratio between net return and total cost, while benefit cost ratio (BCR) is the ratio between gross return and total cost (Table 3).

Table 3. Comparative per hectare cost and economic return from fish culture under three stocking plan.

Particulars	Treatment-1	Treatment-2	Treatment-3
Fish yield (kg)			
Tilapia	666.90	0	629.85
Thai sarpunti	1220.18	1321.45	938.60
Common carp	0	1284.40	1002.82
Total yield	**1887.08**	**2605.85**	**2571.27**
Gross return (GR) Tk.			
Tilapia (Tk. 95/kg)	63355.50	0	59835.75
Thai sarpunti (Tk.120/kg)	146421.60	158574.00	112632.00
Common carp (Tk. 90/kg)	0	115596.00	90253.80
Total gross return (GR)	**209777.1**	**274170**	**262721.55**
Total variable cost (TVC) Tk.	40054.50	49317.00	52404.50
Total Fixed cost (TFC) Tk.	33030.54	34142.04	34523.54
Total cost (TC) (TC= TVC+TFC) Tk.	**73085.04**	**83459.04**	**86928.04**
Gross margin (GM=GR-TVC) Tk.	169722.60	224853.00	210317.05
Net return (NR= GR-TC) Tk.	**96637.56**	**141393.00**	**123389.01**
Return over per taka investment (NR/TC)	1.322	1.694	1.419
BCR (GR/TC)	**2.87**	**3.28**	**3.02**

3.10. Functional analysis

3.10.1. Fingerlings cost (X_1)

The regression co-efficient of fingerlings cost for fish production in paddy were positive. In case of fish culture the regression co-efficient of fingerlings cost was 0.573-0.601 which was statistically significant at l percent level of confidence. In case of fish culture package-1, package-2 and package-3, regression co-efficient of fingerlings cost were 0.573, 0.597 and 0.601, respectively which was statistically significant at 1 percent level of confidence. The regression coefficients implied that keeping other factors constant, 1.0 percent increase in additional expenditure on fingerlings, and the fish farmers would be able to increase 57.3, 59.7 and 60.10 percent of gross return, respectively. This is logical in a sense that increase number of fingerlings stocked would result in higher farm income.

3.10.2. Feed cost (X_2)

The regression co-efficient of feed cost were positive for three types of fish farming and they were 0.448, 0.527 and 0.511 which indicate that there is enough scope to increase the gross return per hectare by spending additional amount of feed. An increase of 1.0 percent spending on feed, keeping other factors constant would result in an increase of gross return by 44.80, 52.70 and 51.10 percent for package-1, package-2 and package-3, respectively.

3.10.3. Fertilizer cost (X_3)

The regression coefficients of fertilizer cost were 0.416 under package-2 which were significant at 5 percent level of significance. It means that 1 percent increase in fertilizer cost, keeping other factors constant would increase the gross return under package-2 (Thai sarpunti and Common carp) by 41.6 percent.

3.10.4. Lime cost (X_4)

The estimated regression coefficients of lime cost were 0.195, 0.221 and 0.162 for package-1, package-2 and package-3, respectively (Table 4). It had significant effect on fish production in each production packages. The above three coefficient was significant at 5 percent levels of confidence. This means that keeping other factors constant, 1 percent increase in additional expenditures would increase the gross return under package-1, package-2 and package-3 to the extent of 19.5%, 22.1% and 16.2%, respectively.

3.10.5. Human labor cost (X_5)

The regression co-efficient of human labor were negative for all categories of fish farming. Co-efficient of human labor for fish culture was found to range from - 0.084 to - 0.174 and that for fish production under package-3 (Thai sarpunti + Common carp) was 0.174 which were statistically significant at 5 percent level. It indicates that keeping other factors constant, 1 percent increase in additional expenditure on human labor would decrease the return of fish culture in paddy fields by 17.4 percent.

3.10.6. Coefficient of determination (R^2)

As it is evident from the Table 4 that value of the co-efficient of multiple determinations **(**R^2) were 0.775, 0.739 and 0.812 for package-1, package-2 and package-3, respectively. These imply that about 73 to 81 percent of the total variation in the per hectare gross return (Tk.) of fish production are explained by the included explanatory variables of the model. Some other variables might have been involved in the production processes which were not included in the present study to explain 100% variations.

3.10.7. Value of F

The measure of the overall fit of the estimated regression, F- value of the three individual equations obviously were highly significant at 1 percent level implying that inclusion of the variables were important for explaining the variation of fish production in paddy fields. In other word, the specification of the model was fairly accurate.

Table 4. Estimated values of coefficients and related statistics of Cobb-Douglas Production Function for fish production in paddy fields.

Explanatory variables	Estimated coefficients		
	Treatment-1	Treatment-2	Treatment-3
Intercept	3.712	4.218	3.736
Fish fingerlings (X_1)	0.573	0.597	0.601
Fish feed (X_2)	0.448	0.527	0.511
Fertilizer (X_3)	0.331	0.416	0.308
Lime (X_4)	0.195	0.221	0.162
Human labour (X_5)	-0.093	-0.174	-0.084
Bank credit (X_6)	-0.117	-0.121	-0.129
R^2	0.775	0.739	0.812
F- value	26.18	28.16	24.56
Return to scale (Σbi)	1.337	1.466	1.369

3.10.8. Return to scale

The rate at which output increase when all inputs are increased proportionately. For example if all the inputs could be doubled and output would also exactly be doubled, that process is said to exhibit constant returns to scale. If all included inputs are doubled, output grows by less than 1 percent the process shows decreasing returns to scale. If output grows by more than doubled, the process demonstrates increasing returns to scale. It can be seen from the results presented in Table 4 that the summation of the estimated coefficients i.e., the returns to scale (Σb_i) are more than 1.0 for fish production in paddy fields, it indicates that both the estimated individual production functions exhibited increasing return to scale and the production is occurred in stage I. It implies that all the explanatory variables specified in the production function were increased simultaneously by 1 percent, and the gross return would increase by more than one percent, respectively.

4. Discussion

Out of the total contact farmers the highest portion was about 53% which belonged to the age group of 30-40 years and the lowest was about 10% which was above 50 years. The age group study is relevant with the study of Asif *et al*. (2015); Hossain *et al*. (2015); Islam *et al*. (2014); Hossain *et al.* (2016) and Islam *et al*. (2015).In this present study it was found that 33% of the contact farmers had up to secondary level of education (S.S.C) and only 7% of the contact farmers had masters' degree level of education. The education status of farmer is relevant with the study of Asif *et al*. (2015); Hossain *et al*. (2015); Islam *et al*. (2014); Hossain *et al.* (2016) and Islam *et al*. (2015). Data on family size which shows that 20% farmer has 1- 2 members, 66% farmer has 3-4 members and 13% farmer has 5-8 members. The family size status of farmer is relevant with the study of Asif *et al*. (2015); Hossain *et al*. (2015); Islam *et al*. (2014); Hossain *et al.* (2016) and Islam *et al*. (2015). Farmers main occupation was business, 26.66 percent house renting, 13.33 percent in service holder, 6.66% farmer were engaged in teaching, crop production and fish culture. Which is not similar with the study of Asif *et al*. (2015); Hossain *et al*. (2015); Islam *et al*. (2014); Hossain *et al.* (2016) and Islam *et al*. (2015).It is evident that 40% contact farmers had 25-50 decimal land holding, another 40% had 51-100 decimal land holding, 13% had land holding of 101-200 decimal. Only 7% contact farmers had the opportunity of having 201-300 decimal land. There is no available publish data on that topics.It is evident that 33% of the contact farmer had annual income of Tk. 2-3 lac, 27% had 10.1-20 lac, 20% had annual income of Tk. 5.1-10 lac, 13% contact farmer enjoyed 20.1-30 lac Tk. income which is more or less similar with the study of Asif *et al*. (2015); Hossain *et al*. (2015); Islam *et al*. (2014); Hossain *et al.* (2016) and Islam *et al*. (2015).

Ali *et al.* (2016) stated that fertilizers include cow dung, urea and triple super phosphate (TSP). At the time of pond preparation, the mean application rates of these fertilizers were- cowdung, 240.52±124.03 kg/ha (79.04 to 565.63 kg/ha); urea, 160.55±81.49 kg/ha (49.40 to 365.56 kg/ha); and TSP, 158.20±80.25 kg/ha (49.40 to 365.56 kg/ha) fish production varies with the level of input used; culture and production practices and overall environment management. Fish production ranging from 2000 kg to 5000kg /ha/yr has been reported from different locations in Bangladesh (Biswas, 1990; Khaleque *et al*., 1998). Paddy yields were 1.5-3.7 tone/ha in rice fish and 1.5-1.8 tone/ha in rice alone culture with insignificant differences between the years. Alam (2006) demonstrated that farmer can get 3-5 tons of rice and 234 kg of fish from one hectare of land. The net benefit obtained from fish component was Tk. 1350 while the same from the rice component was Tk. 35,500. The author showed that rice fish integration is quite attractive. Indian farmer obtained rice yield ranging from 2.0 to 4.2 ton/ha, while the average per hectare of fish yield stood at 1100 kg. The net income from rice-cum fish

culture ranged from Tk. 22000 to 43000/ha in different plots (Ghosh, 1998). On the other hand Sevilleja (1999) reported production of rice was 5,150 kg/ha while for fish, the production was 208 kg/ha. The net returns from rice and fish stood at US $/ha 230.65 and 294.15 per hectare. In south-western region of Bangladesh 2.8 ton/ha of fish and 7.33 tone/ha of rice were produced with 5 species combinations (Ahmed, 2009). On the other hand, Ali (2009) recorded 3-5 tons of rice and 234 kg of fish from one hectare of rice field. The net benefits obtained from fish and rice were Tk. 1350 and Tk. 500, respectively. Mazid and Hossain (2010) recommended for inclusion of rajpunti (*Puntious gonionotus*), mirror carp (*Cyprinus carpio)* or nile tilapia (*Oreochromis niloticus*) in the rice cum fish culture system. They recorded net profit of Tk 10,000/ha/season from fishes against of Tk. 4,000 coming from the rice. Billah (2012) concluded that rice-fish productions are profitable business. They found total per hectare costs of rice-fish production to be Tk. 88,120. Per hectare variable cost of rice-fish production was Tk. 71,537. Total gross return, gross margin and net returns per hectare of rice-fish farming were estimated at Tk. 1,72,400, Tk.1,00863 and Tk.84,280.

Biswas (1990) reported to have achieved fish yield as high as 4534 kg/ha/yr from carp polyculture with gross and net return of Tk. 47680 and Tk. 37914 per hectare, respectively. A similar level of yield was also reported by Khaleque *et al.* (1998) from Kishoregonj and Mymensingh district. Average fish production cost, gross return and net return reported by Khaleque *et al.* (1998) were Tk. 86916, Tk. 166350 and 79437/ha respectively. A very much similar level of economic return was noted by Khan (1996) who estimated the production cost to be Tk. 81587, gross return Tk. 156362 and net return Tk. 74774/ha/yr with a BCR of 1.91. Among the production inputs, fertilizers feed and fish seed had significant positive effects on farm income, while the use of human labor, pond lease value exerted negative effects on the total farm income. Summation of all the production coefficients i.e., return to scale (Σ bi) was 1.337, 1.446 and 1.369 which exhibited increasing return to fish culture in paddy fields under different stocking plans. The results of the present study are in conformity with findings of the above reports. However, the present study contradicts the report of Rana (1996), who found negative effects of stocking densities of fingerlings on the fish production. Perhaps, the fish farmers in his study might have stocked under-sized fingerlings in the large quantity without taking proper care of the stocked fishes.

Benefit cost ratio (BCR) is an important indicator about the profitability of fish culture operation. The bigger is the ratio, the more is the economic return. The benefit cost ratio in the present study was found to 2.87, 3.28 and 3.03 in case of CFP-1, CFP-2 and CFP-3 package, respectively. A much similar level of BCR was noted by RMC (1995) for the fish culture program of MAEP. Shohel (1998) estimated the value of BCR to be 2.02 which revealed that the investment of 1.00 taka, the economic return is 2.0 taka.

Studies conducted by many authors (Amin, 1998; Shohel, 1998; Rahman, 1998) indicate that fish production under mono- and polyculture systems were highly profitable. For polyculture (per hectare per year) gross cost, gross return and net return stood at Tk. 82, 499' Tk. 197230 and Tk. 114730 as against of Tk. 71059, 170000 and 97940 for monoculture of Thai sarpunti. The total cost (TC), gross return (GR), net return(NR) for fish culture in rice fields under three selected packages in the present study were much higher than those reported by other researchers. The high values of these economic parameters as observed in the present investigation appeared to be due to gradual rise in the price of production inputs in Bangladesh. However, the economic return from Thai sarpunti, Tilapia and Common carp culture operations were also much higher indicating that higher investment brought more economic benefit to the fish farmers. Lucrative economic return from culture of different fishes in rice fields in the surveyed areas was possible due to use of scientific method, close supervision and efficient management of materials inputs.

The findings of the present study indicated that fish production under the specified three options (Thai sarpunti + Tilapia, Thai sarpunti + Common carp, and Thai sarpunti + tilapia+ common carp) were highly profitable business. Cobb-Douglas production function analysis indicated that inputs such as, fingerlings, fertilizers, feed, lime had positive impact on gross return and were highly significant. Return to scale (Σbi) derived from summation of the production coefficients of explanatory variables was 1.337, 1.466 and 1.369 for package 1, 2 and 3. The coefficients of determination (R2) were 0.778, 0.739 and 0.812 for the above stocking plans which are indicative goodness of the equations and reliability of the collected data or information. A very much closer value of ∑bi as well as R_2 was noted by various authors (Biswas *et al*., 2000; Rahman, 1999; Haque *et al*, 2002; Khaleque *et al.*, 1998, Shohag, 1996, Rana, 1996) for polyculture of carps. All these observations lead to the conclusion that fish culture in rice fields system is highly profitable venture.

5. Conclusions

Fish production in paddy fields are economically profitable, viable and environment friendly. The farmers may undertake fish culture in paddy fields if suitable paddy fields are available. Fallow lands which remain under

water during rainy season may be brought under fish culture programs. Further research should be conducted to find out as suitable and cost effective fish culture package for paddy fields.

Conflict of Interest

None to declare.

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