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Profitability and factors affecting production of pond fish culture under NATP project in Tangail district of Bangladesh

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Abstract. Profitability and input use efficiency of pond fish culture was studied at farming systems Research and Development (FSRD) site, Atia, Tangailfrom July 2019 to June 2020. The average pond fish production was recorded at 2808 kg/ha/year with the highest yield from the medium farms (2940 kg/ha/year) and lowest yield from marginal farms (2624 kg/ha/year). The highest gross return (Tk352,800/ha) was found with medium farmersfollowed by small farmers (Tk343,200/ha). The benefit cost ratio was also recorded higher (2.08) inmarginal and small farms.Considering the aggregate production function for all groups of farmers, it was found that inorganic fertilizer, organic fertilizer, feed and human labour were statistically significant in explaining the variation in pond fish output but the results varied with different farm categories. Since there was positive correlation between input use and production of fish, it is probable that an increase in application of inputs could increase production further.
Keywords: Profitability, Fish culture, NATP, On-farm, Aquaculture.

Introduction

Bangladesh is one of the world's fish producing countries with a total production of 4.621 million MTin FY 2020-21(DoF 2022). As an agro-based country, the contribution of fisheries to the national economy has always been essential and as the primary source of animal protein, employment opportunities, food security, foreign earnings and socioeconomic development. Bangladesh has ranked 3rd in the world in inland fish production 5th in aquaculture production (fifth position for six years) 8th and 11th in production of marine and coastal fish production in 2022 (FAO 2022).

Fish is the primary protein source in Bangladeshi diet contributing about 60% of total animal protein while per capita fish consumption in the country reaches 62.58 g, which is higher than their daily protein demand (60 gm) as per the report of the (BBS 2021). The demand of fish is increasing day by day due to increasing population and high price of meat. About 85% of total production of fish come from inland sources and 53% of them contributes from 2.49million ponds of the country. Almost 50% of these ponds is to some extent used for fish culture and the rest are either cultivable or in direct condition. At present, some of the fish farmers in our country understood the positive effect of scientific aquaculture and they started to cultivate their pond fish with the application of supplementary feed.

Bangladesh has great potentiality to increase her inland fish production and in this respect fish pond can play an important role if all ponds prevailing in country could be brought under scientific fish culture. Therefore, the yield of fish pond can be increased at least 5 to 6 times by using fertilizers and supplementary feed and it can be further increased through intensive cultivation employing other necessary inputs and

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management. Some adaptive and quick researches are essentialto improve the ponds for aquaculture.The National Agricultural Technology Project (NATP) Phase-2 is to promoting the sustainability of existing and newly selected farmers groups and producer organizations by facilitating their stronger participation in commodity value chain, market-linkages and improving their knowledge and skill base. Thus, the NATP-2 will be achieved through fish production models, locally adapted technologies, involving improved fish varieties at the small farm level and providing relevant production, value addition, food safety and marketing support.The present study was, therefore, undertaken to gather farm level information on fishes and management practices done by the farmers. The specific objectives of the study are-(i) to identify agro-economic characteristics of pond fish culture, (ii) to estimate the profitability of pond fish culture under different farm category and (iii) to estimate the factors responsible for yield variation of pond fish culture, so that policy interventions can be made accordingly.

Materials and Methods

The study was carried outto a cluster of five villages at Farming Systems Research and Development (FSR&D) site Atia under On-Farm Research Division, Bangladesh Agricultural Research Institute (BARI), Tangail assisted by NATP-2 research and development project. The study covered the period from July 2019 to June 2020 and formal survey was conducted during June-August 2019. Data were collected from all 60 ponds available at those villages in the FSRD site through a pre-designed and pre-tested schedule. Direct interviewing the owners of single ownership, and major shareholders of multiple ownership collected other information regarding fish culture. The collected information was edited and local units and measurements were converted into metric systems.

Cobb-Douglas form of production function was chosen on the basis of the best fit and significant result of output. Six inputs or explanatory variables were hypothesized to explain the pond fish production in the study area. The analysis was done according to the data collected from 21 marginal (0.21-0.50 ha), 27 small (0.51-1.0 ha) and 12 medium (1.0-2.0 ha) farm size. In case of multiple ownership average farm size of the shareholders was considered. The effect of input on pond fish output was estimated and quantified with the help of regression analysis of the following form-

$Y= ax_1^{b1}\ x_2^{b2}\ x_3^{b3}\ x_4^{b4}\ x_5^{b5}\ x_6^{b6}$

or $\text{Log } Y = \text{Log } a + b_1 \text{ Log } x_1 + b_2\text{Log } x_2 + b_3 \text{ Log } x_3 + b_4 \text{ Log } x_4 + b_5 \text{ Log } x_5 + b_6\text{Log } x_6$

Where,

$x_{1=}$ Fingerlings stocked (no)

$x_{2=}$Inorganic fertilizer (kg)

$x_{3=}$Organic fertilizer (kg)

$x_{4=}$Feed (kg)

$x_{5=}$Human labour (man-days)

$x_{6=}$Pond size (ha)

$b_{1=}$Regression co-efficient to be estimated

The inherent characteristics or factors in pond fish production that manly affect its environment such as age of pond, depth of pond water and ownership of ponds were not included in the study to explain the variation of pond fish output. Generally, ownership pattern influenced the production of pond fish, but in the study area 84 percent ponds were found to be in single ownership. As a result, this variable was not included in the production function. Besides the use of Cobb-Douglas production function some tabular presentation also prepared to explain the characteristics of pond, inputs used, costs incurred and return obtained from pond fish culture.

Results and discussion

Characteristics of the ponds

The largest pond size (0.14 ha) was found with medium farmers followed by small (0.09 ha) and marginal (0.07). Pond size increases with the increased farm size (Table 1). Net pond areasi.e.,water area of the ponds also varied with the variation of pond size. The water depth of the ponds in the peak and lean period showed that it varies with the farm size but did not follow the trend. In the lean period water depth was found highest (0.90 m) with the small farms followed by medium (0.87 m).

The physical condition of a pond is very important because fish farming copiously depends on it. The soil type of surveyed ponds varied from sandy loam to clay. A big portion of the pond soils was found to be Loamy (44%), sandy loam (30%) and clay (26%). However, the soil type also varied among the farm category. Most of the ponds (71 %) had light green water which is suitable for fish culture followed by muddy (23 %) and clear (06 %). Flooding condition of the ponds influenced its fish culture and productivity. Most of the ponds (66 %) at the surveyed area were flooded occasionally once in every 5-10 years and 24 % of the ponds was flooded every year during the monsoon. However, the percentage of flooding varied among the farm categories but did not follow any trend. The pond which was flooded seasonally or occasionally are likely to receive natural stocking.

The ownership pattern was classified as single, double and multiple. Among the surveyed ponds 76 % belonged the single ownership. It indicates that a large number of ponds were under single ownership and adverse effect of multiple ownership may not reflect in the productivity of the ponds.

Status of fish culture in the ponds

The study revealed that all surveyed ponds were used for fish culture. These ponds were newly excavated and preparing for fish culture within a couple of years. Polyculture with Indian major carps included rui (*Labeorohita*), catla (*Catlacatla*), mrigel (*Cirrhinusmrigala*), as well as some exotic species such as silver carp (*Hypophthalmichthysmolitrix*), common carp (*Cyprinuscarpio*), tilapia (*Oreochromisniloticus*) along with other local species like shingi(*Heteropneustesfossilis*), magur (*Clariusbatrachus*) and koi (*Anabustestudinews*) were found to culture in the ponds. However, these ponds were found to be cultured intermittently or in improved traditional systems. The culture period ranged from 6 to 8 months.

Table I. Characteristics of ponds at the FSRD site Atia, Tangail

Characteristics	Farm category			
	Marginal	Small	Medium	All
Average pond size (ha)	0.07	0.09	0.14	0.10
Net pond area (ha)	0.05	0.06	0.10	0.07
Water depth in September (m)	2.19	2.24	2.32	2.25
Water depth in April (m)	0.85	0.90	0.87	0.87
Soil type (%)				
Clay	23	28	27	26
Loamy	48	41	43	44
Sandy loam	29	31	30	30
Water colour (%)				
Light green	64	75	74	71
Clear	03	07	08	06
Muddy	33	18	18	23
Flooding (%)				
Never	10	08	12	10
Occasional	65	67	66	66
Seasonal	25	25	22	24
Ownership (%)				
Single	80	75	73	76
Double	20	18	19	19
Multiple	-	07	08	05

The mean stocking density was found highest (18,872 fingerlings/ha) with medium farms followed by small (18,799 fingerlings/ha) and marginal (16,060 fingerlings/ha). The mean density of fingerlings in all farm categories seems to be higher than recommendation (Table 2). Stocking density did not seem clearly related to farm size. Considering all categories of farm, the stocking density was 17,910 fingerlings per hectare, with a cost of Tk.28,656 corresponding to 17% of the total variable cost. A similar result was also supported by Khan *et al*. (2021) who found that fingerlings cost per hectare corresponding to 10 % of the gross cost. A few operators were found to treat their ponds with limewhich helps neutralize the acidity in the soil and prevents diseases. The rate of application ranged from 23 to 30 kg per hectare with an average of 26 kg/ha.

Farmers also use fertilizer in their ponds to facilitate the growth of algae, which is the natural feed for aquaculture, and to supplement feed pellets. Fish farmers apply various types of fertilizer, including urea, manure (cow-dung), and triple superphosphate (TSP). Use of urea was found comparatively higher than those of TSP anaMoP. The amount ofinorganic fertilizers application ranged from 122 to 160 kg/ha in different farm categories with an average of 138 kg/ha for production at an estimated cost of Tk. 3036 per hectare or 1.87 % of the total variable cost.These results were also supported by Khan *et al*. (2021) who found that fertilizer cost per hectare corresponding to 1 % of the gross cost. The farmers also used organic fertilizers like cowdung and poultry manure that they purchased or that is from their own livestock.at the rate of 790 kg/ha at an estimated cost of Tk. 9480 per hectare or 5.85 % of the total variable cost. The amount organic fertilizers used by the pond operators varied among the farm categories and did not follow any trend. The amount of feed applied to the ponds was consonantly related to the farm size. This may be due to taking more care of pond fishes by the larger group of farmers. Rice bran and oil cake were the main supplementary feed supplied by the farmers and the average rate was 1553 kg/ha. The human labour used by the farmers to pond fish culture was also similarly related to farm size. The lower farm size group used less labour than that of the larger farm group. This may be due to taking more care of pond fishes by the larger group of farmers.

Table II. Supplementary inputs use and yield obtained in pond fish culture at the FSRD site

Items	Farm category			
	Marginal	Small	Medium	All
Fingerlings stocked (no./ha)	16060	18799	18872	17910
Lime (kg/ha)	23	25	30	26
Inorganic fertilizer (kg/ha)	122	132	160	138
Organic fertilizer (kg/ha)	659	830	881	790
Feed (kg/ha)	1481	1558	1620	1553
Human labour (man-days)	177	188	196	187
Yield kg/ha)	2624	2860	2940	2808

The average yield of pond fishes was found to be 2808 kg/ha/year, which is comparable with the yields recorded by Hasan*et al*., (2002). The yield of pond fishes varied among the farm categories from 2660 to 2940 kg/ha/year. The highest yield was recorded with medium farmers (2940 kg/ha/year) followed by small (2860 kg/ha/year) and marginal (2624 kg/ha/year). Marginal farmers obtained lower level of yield because of taking less care and supply less supplementary feed (Table II).

Cost and returns

The major two cost items of pond fish culture were cost for fingerlings and cost for human labour which caused about 64 % of total variable cost (Table 3). This is consistent with findings in Mukta*et al*. (2019), where feed cost accounted for 70% of total production cost.The other input costs like feed and inorganic fertilizers also shared a handsome amount to the TVC. The highest TVC (Tk.171091/ha) was recorded with medium farms mainly due to use of more fingerlings and feeds (Table III). The lowest amount of TVC (Tk. 150758/ha) was found with marginal farmers due to use of fewer amounts of inputs.

The study revealed that gross return, gross margin and return cost ratio were mainly influenced by fish yield. The highest gross return (Tk.352800/ha) as well as gross margin (Tk. 171091/ha) was found with medium farmers followed by small and marginal farm categories. The highest return cost ratio (2.08) was found with marginal and small farmers. The lower return cost ratio was found with medium farmers due to higher TVC.

Table III. Cost and return analysis of pond fish culture at the FSRD site Atia, Tangail

Items	Farm category			
	Marginal	Small	Medium	All
Variable cost				
Fingerlings	25696	30078	30195	28656
Lime	345	375	450	390
Inorganic fertilizer	2684	2904	3520	3036
Organic fertilizer	7908	9960	10572	9480
Feed	29620	31160	32400	31060
Human labour	70800	75200	78400	74800
Interest on OC*	13705	14968	15554	14476
Total variable cost	150758	164645	171091	162165
Gross return	314880	343200	352800	336960
Gross margin	164122	178555	171091	171256
Benefit cost ratio (BCR)	2.08	2.08	2.06	2.07

*Interest on operating capital has been calculated *a* 10 percent per annum

Input price: Fish fry @ Tk.1.60/piece, Lime @ Tk 15/kg, Inorganic fertilizer @ Tk.22/kg, Organic fertilizer @ Tk. 12/kg, Feed @ Tk. 20/kg and Human labour @ Tk 400/man-day

Output price: Fresh fish @ Tk. 120/kg

Interpretation of functional analysis

The estimated coefficients of the variables and related statistics of Cobb-Douglas production function for individual and all farm categories are presented in table 4. The R^2 value ranged between 0.73 to 0.77 for individual farm category but for farm category it was 0.69 implying that the explanatory variables included in the model explained 0.69% of the variation of output for all farm group and it was 0.73 to 0.77% for individual farm category.

It is evident from the study that among the variables in aggregate production only one coefficient shows negative sign implying that one percent increase in pond size may cause 0.08 percent decrease in fish yield. This may be due to improper management of the big sized ponds. On the other hand, inorganic and organic fertilizers, feed and human labour for aggregate production function had significant impact on the yield of the pond fish. It was observed that out of 18 coefficients of individual farm category, 8 are significant at less or equal 5 percent level of significance, 13 had positive impact on pond fish yield and the remaining 5 had negative impact on fish yield. The negative impact occurred might be due to excessive use of those inputs in respective farm categories. The summation of all production coefficients was 0.91 for all farm category implying that production function exhibits decreasing return to scale and lies on the second stage of production function. On the other hand, increasing return to scale was observed in small and medium category except marginal farm. This farm category also produced decreasing return to scale. An increase in the area used for production reduces a farmer's ability to monitor all aspects of production, and farmers may fail to discover unfavorable conditions early enough to prevent production yield losses. Therefore, increasing production area is associated with increasing variability and risk in aquaculture production. A similar result was also supported by Losinger(2006), suggesting that risk increases with farm size.It is further noted that, the impact of explanatory variables on pond fish production varied among the farm categories. Considering the aggregate production for all farm category all the explanatory variables, except stocking of fingerlings and pond size showed statistically significant impact in explaining the variation of pond fish output.

Table IV. Cobb-Douglas production function model estimate the coefficients of determinants of pond fish culture

Explanatory variable	Farm category			
	Marginal	Small	Medium	All
Intercept	4.29	2.70	4.64	7.19
Fish fry stocked	-1.08	-0.97	0.30	0.17
(x_1)	(1.07)	(0.38)	(0.16)	(1.06)
Inorganic fertilizer	1.10	0.40*	0.59**	0.19*
(x_2)	(0.56)	(0.26)	(0.24)	(0.15)
Organic fertilizer	0.02*	0.48	0.04	0.11*
(x_3)	(0.65)	(0.17)	(0.12)	(0.23)
Feed	0.25*	0.62**	0.33*	0.24*
(x_4)	(0.62)	(0.22)	(0.14)	(0.32)
Human labour	-0.27	1.20*	0.11	0.28*
(x_5)	(0.32)	(1.08)	(0.12)	(0.82)
Pond size	0.57	-0.56*	-0.15	-0.08
(x_6)	(3.90)	(0.55)	(0.14)	(0.39)
R^2	0.76	0.73	0.77	0.69
F	5.18	9. 27	9.24	5.63
Return to scale $\sum bi$	0.98	2.11	2.12	0.11

**Significant at 1% level of probability and *Significant at 5% level of probability

Conclusions

The foregoing results and discussions reveal that improving the production technology in existing ponds can increase pond fish production. It was found that a good number of ponds at the FSRD site Atia, Tangail are not properly cultivated for fish production. Very few pond operators followed pond preparation practices like liming and fertilization before stocking fingerlings. The pond operators stocked more fingerlings than recommended rate which increased total increased total variable cost. Use of recommended rate of fingerlings may cause less TVC and more gross return. Based on aggregate production function, it was found that increasing human labour by one percent would induce an increase in fish yield by 0.28%, which is 1.47 and 2.55 times higher in comparison to application of inorganic and organic fertilizers, respectively. On the other hand, increasing feed supply to the ponds by one percent would also induce an increase in fish yield by 0.24 percent which is 1.26 and 2.18 times higher in comparison to application of inorganic and organic fertilizers respectively. There is also scope to increase the amount of organic and inorganic fertilizers for further increase in fish yield. Since there was positive correlation between input use and production of fish, it is probable that increased application of inputs could increase production further.

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