



Efficient Management of Farm Resources and Food Consumption Level of Pond Fishers in North-Central Bangladesh

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Authors' contributions

This work was carried out in collaboration among all authors. Author MAQ has undertaken the fieldwork guidance and supervision, analyses of results, managed the literature searches and wrote the protocol and first and final draft of the manuscript. Author KMMR has designed the study, construct the interview schedule, performed the statistical analysis and revised the final draft. Authors SKS and MAS have undertaken the field works, data processing and analysis and wrote the partial draft of results. All the authors read and approved the final manuscript.

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ABSTRACT

Aims: The study was conducted to assess the efficient management of farm resources of pond fish farmers and level of their household food consumption in order to deal with sustainable development of pond culture system and food security issue.

Study Design: Three unions out of 9 in Melandah upazila of Jamalpur district were selected, as a large number of ponds are available. Sixty fish farmers were randomly selected from the population of 200. Data were collected using a structured questionnaire during January to March 2017.

Methods: Cobb-Douglas stochastic frontier production function and technical inefficiency effect model were used to assess efficient management of farm resources. Also, multiple regression models in double-log forms were employed to determine the factors influencing households' per capita food consumption, calorie intake and protein intake.

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Results: Gross return and net profit were \$8,081 and \$2,262 respectively and cost benefit ratio was 1.39. Technical inefficiency estimates show that farmers' education (0.0009) and training (0.0042) had insignificant but positive sign for fish production. Experience (-0.0083) and culture period (-0.0054) had significant and negative sign and age of farmers has insignificant negative sign indicated that technical efficiency increased with the increase in experience and fish culture period. The mean efficiency was 0.92 in fish farming indicates 8% of fish production could be increased with the existing resources and available technology. Per capita per day food consumption was 1288.36 g, calorie intake 2592.23 k. calorie and protein intake 84.27 gram.

Conclusion: A linkage between Upazila Fisheries Officer, Bangladesh Fisheries Research Institute, fisheries extension workers and pond fish farmers should be established. Calorie and protein intake of the farm households is higher due to increase of food sufficiency of the country and buying capacity of the farmers but the nutritional wellbeing of them is still low.

Keywords: Pond fisheries; cost-return; efficient management; frontier analysis; food consumption.

1. INTRODUCTION

Bangladesh is blessed with vast area in the form of ponds, canals, ditches, floodplains, haors (natural depression), baors (ox-bow lake), rivers, estuaries etc. those are rich ecosystems for fish. Annual fish production is about 34.1 million metric tones and per capita fish consumption is about 18 g/day [1]. Presently 1.4 million people are engaged full time and 12 million as part time in fisheries sector for livelihood and trade [2]. Between 660 and 820 million people like workers and their families depend totally or partly on fisheries, aquaculture and related industries as a source of income and support [3]. It performs a significant GDP growth rate over the last ten years, which is almost steady and encouraging varying from 4.76 to 7.32 percent with an average growth rate 5.61 percent [4]. Production in pond fishes with controlled water bodies through modern and intensive culture can play an important role in supplying ever-increasing fish needs of the people. Total pond area in Bangladesh estimated as 0.371 million hectare, which can contribute 4.1 million ton of fish production [5]. Pond fish culture can generate income and employment and could improve the quality of life of the rural poor in Bangladesh [6]. Pond fish farming has been proved to be a profitable business than rice cultivation and hence many farmers in rural areas are converting their rice field into aquaculture pond as their secondary occupation [7] as well as to improve their socioeconomic condition [8].

Melandah is an important upazila in the district of Jamalpur, north-Central part of Bangladesh. The upazila occupies an area of 258.32 square kilometer which, is located between 24°51' and 25°5' north latitudes and between 89°42' and 89°53' east longitudes and population 3,23,182

[9]. Here a vast opportunity is exists in pond fish farming and large number of rural households are involved in this activity as a main source of employment as well as household income. There are 2,796 ponds covering 280.2 ha of land, engaged 2600 fishermen and produced 1,303 metric ton fishes [10]. Thus, marginalized people take such opportunities and invest money for pond fish culture and cultivate them intensively on commercial basis. They cultivate these ponds either secondary or primary source of income by applying improved input management and technologies. Melandah is not only showing a significant development in fisheries but also have fisheries academic and research as well as communication facilities. Therefore, Melandah upazila has been chosen for this study. If fishers adopt improved pond fish culture technology and community based fisheries management through good aquaculture practices in this ideal fish production area then fish production will be increased.

Information on socioeconomic framework of the fish farmers forms a good base for planning and development of the economically backward sector [11]. Lack of adequate and authentic information on socioeconomic condition of the target population is one of the serious impediments in the successful implementation of development program [12]. Food constitutes a key component of a number of fundamental welfare dimensions, such as food security, nutrition, health, and poverty of fisher's households. Proper measurement of food consumption is, therefore, central to the assessment and monitoring of various dimensions of well being of any population [13]. Understanding the per capita food consumption, per capita calorie, protein intakes and consumption scores can help government to

enrich formulation and implementation of appropriate policy measures to improve living standard of the rural people. On the other hand, it is essential to increase productivity and efficiency of fish production, increase efficient manpower and explore the growth promoting factors for rapid increase of fish production [14]. There is considerable scope to expand pond fish output and also productivity by increasing production efficiency at the relatively inefficient farms and sustaining the efficiency of farm [15]. Due to the increasing scarcity of resources, enhancement of productivity through efficient utilizing of existing resources or inputs is very crucial [16]. Efficient producers are able to produce maximum output by using a given input [17]. Therefore, it is very important to measure efficiency of the production and identify the factors that have significant effects on efficiency. The result of this can be provided to policy makers for productivity improvement of aquaculture sector in order to deal with food security issue and for sustainable development of pond culture system. Thus, the present study was conducted to assess the socioeconomic profile of pond fish farmers, estimate the productivity and farm specific efficiency, and determine the factors influencing fishers' household food consumption.

2. MATERIALS AND METHODS

2.1 Study Area, Sample Size and Collection of Data

Melandah upazila in Jamalpur district was selected for the study. There are nine unions in this upazila out of which three unions (Ghosherpara, Mahmudpur and Nangla) were selected purposively as a large number of ponds are available there for fish culture. The selection was done on the basis of suggestions made by Upazila Fisheries Officer. An updated list of all the pond fish farmers in the selected unions were collected by the help of Upazila Fisheries Officer. There were 200 fish farmers as a population of the study. A total of 60 fish farmers (30% of the population) were selected as respondents using random sampling method. A structured questionnaire was prepared considering all the objectives of the study. Data were collected during January to March 2017 by the researchers. During the interview, every respondent was given a brief introduction about the nature and purpose of the study. The questions were asked systematically in a very simple manner with explanations wherever they

were felt necessary and the answers were recorded on the schedules.

2.2 Processing and Measurement of Data

The collected data were entered into Microsoft Excel and analyses were carried out using Statistical Package for Social Science (SPSS), version-16.

2.2.1 Calculation of cost and return

The cost incurred for fingerlings, manure cum fertilizers (lime, manure, urea and TS), feed, labor (hired), utility (maintenance, lime cost, transportation cost, etc.) were considered as variable cost. The expenses on primary preparation of pond, depreciation of farm tools, and machineries were included under fixed cost. The total cost of production was calculated by summing total variable cost and total fixed cost incurred in the production process. Gross return = Total price of fish produced (price of consumed fish and price of selling fish). Net return was calculated by deducting total cost from gross return. The benefit cost ratio (BCR) was calculated by dividing gross return with total cost.

2.2.2 Measurement of food consumption data

On the basis of the amount of food consumption by the respondents and their family members, per capita calorie and protein intakes were measured by the direct calorie intake (DCI) method estimates. In this method the food consumed during the last seven days in a household was first averaged. Afterwards, the amount of daily per capita food intake was converted into daily per capita calorie intake. Food conversion ratios were used to convert different food items into calorie and protein intakes. Total calorie intake was derived from total consumption of food for all food items and total protein intake derived from total consumption of food for all items.

2.3 Model Specification

2.3.1 Cobb-douglas stochastic frontier production function

In order to estimate the level of technical efficiency with the theory of production function, a Cobb-Douglas type of stochastic production function was specified having some well-known properties that justify its wide application in economic literature [18]. Stochastic frontiers

model for the technical inefficiency effect and simultaneously estimate all the parameters involved in the model [19-21]. The Cobb-Douglas stochastic frontier production function was used to analyze productivity and resource use efficiency of pond fishes to provide an adequate representation of production technology. The functional form of stochastic frontier is as follows:

$$\ln Y_i = \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5 + \beta_6 \ln X_6 + V_i - U_i$$

Where Y = Output (kg), X1= area under fish pond (decimal), X2 = fingerlings (kg), X3 = water depth (meter), X4 = cow manure (Kg), X 5 = utility cost (Tk.), X6 = inorganic fertilizer (Kg), V_i are assumed to be independently and identically distributed random errors and distributed as $V \sim N(0, \sigma_v^2)$ and U_i are non-negative one sided random variables called technical inefficiency effects and distributed as $U \sim N(0, \sigma_u^2)$.

2.3.2 Technical inefficiency effect model

The model for technical inefficiency effect in the stochastic frontier of equation is as follows:

$$U_i = \delta_0 + \delta_1 \text{Education} + \delta_2 \text{CulturePeriod} + \delta_3 \text{Age} + \delta_4 \text{Training} + \delta_5 \text{Experience} + \delta_6 \text{FarmSize} \quad [22-23].$$

The β and δ coefficients are unknown parameters to be estimated together with the variance parameters which, are expressed in terms of: $\sigma^2 = \sigma_u^2 + \sigma_v^2$ and $\gamma = \sigma_u^2 / \sigma^2$, where $0 < \gamma < 1$. The model for technical inefficiency effect can only be estimated if the inefficiency effects are stochastic and have a particular distribution specification and hence we need to test the null hypothesis i.e. $\delta_1 = \delta_2 = \delta_3 = \delta_4 = \delta_5 = \delta_6 = 0$. The technical efficiency of a farmer is between zero and one and is inversely related to the inefficiency effect. The parameters of the function were estimated together with farm-specific technical efficiencies and mean technical efficiency for the farms using frontier version 4.1.

2.3.3 Regression model for food consumption, calorie intake and protein intake

Multiple regression models in double-log forms were employed to determine the factors that influence households per capita food consumption, calorie intake and protein intake.

Model for per capita food consumption:

$$\ln Y_i = \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + u_i.$$

Where, Y_i = Daily per capita food consumption (g),

X_1 = Daily per capita calorie intake (k. cal.),
 X_2 = Daily per capita annual income from fisheries (Tk.),
 X_3 = Total area of land of the fish farmers (decimal).

Model for per capita calorie intake:

$$\ln Y_i = \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + u_i.$$

Where, Y_i = Daily per capita calorie intake (k. cal.),

X_1 = Total amount of annual fish production (kg),
 X_2 = Total area of land of the farmers (decimal),
 X_3 = Household's annual income from fisheries (Tk.).

Model for per capita protein intake:

$$\ln Y_i = \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + u_i.$$

Where, Y_i = Daily per capita protein intake (g),

X_1 = Daily per capita fish consumed (g),
 X_2 = Household's annual income from fisheries (Tk.),
 X_3 = Total area of land of the fish farmers (decimal).

3. RESULTS

3.1 Socio-Demographic and Cost-Benefit Profile of Fish Farmers

3.1.1 Socio-demographic and pond farming characteristics of farmers

The age of the fish farmers ranged from 26 years to 68 years with an average of 41.27 years. The data indicated that 38.3% of the respondents were of age below 35 years, 45% were of age group 35-49 years and the rest 16.7% were 50 years and above. The result show that 36.7% of the respondents were illiterate or had primary education, 30% had secondary education and 28.3% had higher secondary education. Family size of the respondents ranged from 4 to 9 with an average 5.92 of which, majority (58.3%) were medium sized i.e. 5-6 members. Experience in pond fish farming of the respondents ranged

from 3 to 20 years with an average of 8.37 years. It was observed that 28.3% of the respondents had low experience (up to 5 years), most of them (58.3%) had medium experience (6-10 years) and 13.3% had experience 10 years and above (Table 1). The result show that 83.33% of the respondents received training on scientific fish farming technique and management system. Area under fish farming ranged from 0.08 to 0.70 hectare and most of the farmers (60.3%) cultured 0.20 to 0.49 hectare of ponds. Forty five percent fish farmers spent own money, 30% were dependent on bank loan and remaining 25% were dependent on NGOs and others. Sources of pond water were rain (38.3%), rain and deep tube well (56.7%) and other sources like river, canal and marsh (5%). Major portion (50%) of the farmers inherited their ponds; some of them (16.7%) bought for fish culture and others (33.3%) used leased ponds. Depth of the ponds

ranged from 4 to 7 feet with an average 5.48 and average fish culture period was 8.5 months. Annual income from fish farming was \$2,262, which contributed 59.54% of the total household income.

3.1.2 Cost-benefit of pond fish farmers

The variable cost, fixed cost and total cost of fish production per hectare were \$4,823, \$997 and \$5,820 respectively i.e. variable cost was 82.9% of the total cost. The largest amount of money spent by fish farmer in the study area was mainly on purchase of fish feeds (56.9%), then fixed cost (17.1%) and labor cost (13%). Cost of fingerlings, fertilizers and utility were 4.9%, 4.2% and 3.9% respectively of the total cost. Gross return and net return (profit) were \$8,081 and \$2,262 per hectare respectively. The benefit-cost ratio (BCR) was 1.39 (Table 2).

Table 1. Socio-demographic and pond characteristics of farmers

	Numbers N = 60	Percentage
Age (Year)		
< 35	12	38.3
35-49	36	45.0
>49	12	16.7
Level of Education		
Up to Primary	25	36.7
Secondary	14	30.0
Higher Secondary	10	28.3
Graduation and above	06	5.0
Family size (Number)		
Small (up to 4)	08	13.3
Medium (5-6)	35	58.3
Large (>6)	17	28.3
Fish Farming Experience		
Low (up to 5 years)	17	28.3
Medium (6-10 years)	35	58.3
High (>10 years)	08	13.3
Training Experience		
Yes	35	58.3
No	25	41.7
Area under pond farm		
Small (up to 0.20 ha)	12	20.0
Medium (0.20 -0.49 ha)	38	60.3
Large (0.50 ha and above)	10	16.7
Sources of fund		
Own	27	45.0
Bank loan	18	30.0
NGO and others	15	25.0
Sources of water		
Rain	23	38.3
Rain and deep tube well	34	56.7
Other sources	3	5.0
Pond acquiring process		
Inherited	30	50.0
Bought	10	16.7
Leased	20	33.3

Table 2. Cost and return of pond fish production per hectare per year

Cost item	Tk./ha	% Total Cost
Variable Cost		
Fingerlings	22,714	4.9
Fertilizer/ manure	19,466	4.2
Fish feeds	2,64,740	56.9
Labor cost	60,650	13.0
Utility cost	18,275	3.9
Total variable cost	3,85,845	82.9
Fixed Cost	79,725	17.1
Total cost	4,65,570	
Gross Return	6,46,500	
Net Return (NR)	180930	
BCR (GR/TC)	1.39	

1 US Dollar = Tk. 80 at the time of data collection

Table 3. Maximum likelihood (ML) estimates for parameters of Cobb-Douglas(C-D) stochastic frontier production function and technical inefficiency model for fish production

Variables	Parameter	Coefficients	Asymptotic Std. error
Frontier Model			
Intercept	β_0	0.6122	0.8727
Ln(Area)	B_1	0.4542**	0.1014
Ln(Fingerlings)	B_2	0.1085**	0.0203
Ln(Water depth)	B_3	-0.1093	0.0835
Ln(Cow manure)	B_4	-0.5983*	0.2654
Ln(Utility cost)	B_5	-0.1225	0.1308
Ln(Fertilizer)	B_6	0.2429*	0.1207
Inefficiency Effect Model			
Intercept	δ_0	0.1951*	0.0963
Education	δ_1	0.0009	0.0091
Culture period	δ_2	-0.0054**	0.0012
Age	δ_3	-0.0045	0.0016
Training	δ_4	0.0042	0.0254
Experience	δ_5	-0.0083*	0.0042
Family size	δ_6	0.0200	0.0068
Variance	σ^2	0.0063**	0.0012
Log likelihood	γ	0.0074*	0.0037
Generalized likelihood ratio	GRL	14.19*	
Adjusted R ⁻²	R ⁻²	0.96	
F-statistic	F	211.59**	

3.2 Productivity and Farm Specific Efficiency

The farm-specific factors used in the model are pond area, fingerlings, water depth, cow manure, fertilizer and utility cost. The model is well fitted to the data as suggested by significant F values. The results show that the estimated coefficients of pond area, fingerlings and fertilizers (0.4542, 0.1085 and 0.2429 respectively) are positive and significant implies that these three factors have significantly positive impact on pond fish production whereas cow manure is significantly negative effect on fish production (Table 3). Water depth and utility cost are insignificantly negative effect on pond fish production. Results of technical inefficiency estimates show that the determinants farmers' education, family size and

training have insignificant but positive sign for fish production. Experience and culture period have significant and negative (expected) sign and age of farmers has insignificant negative sign. The variance (σ^2) is an indication of goodness of fit was statistically significant at 5% level (Table 3), showing the goodness of fit of the survey data with the model used and the correctness of the specified coefficients. Estimated γ parameter (0.0074), which measures the variability of the two sources of error was statistically significant at 5%, hence it was suggested that 95% of the total variation of total production were related to inefficient error term and 5% of the total variations attributed to stochastic random errors and implies that there were significant inefficiency in the production of pond fish.

Results of the frequency distribution of farm-specific technical efficiency estimates for fish from Cobb-Douglas stochastic frontier reveals that 55% of the respondents of fish farming obtained outputs were very close to the maximum output (above 90%) technically efficient. There were 1.67% of the respondents of fish farming whose technical efficiency levels ranged from 70% to 80% whereas 43.33% ranged from 81% to 90% (Table 4). The mean efficiency was 0.92 in fish farming i.e. 8% of fish production could be increased with the existing resources and available technology.

Table 4. Frequency distribution of fish specific technical inefficiency estimates from Cobb-Douglas stochastic frontier

Efficiency level (%)	Number of farmers
70-80	1 (1.7)
81-90	26 (43.3)
91-100	33 (55.0)
Total respondents	60 (100)
Mean efficiency	0.92
Minimum efficiency	0.79
Maximum efficiency	0.99

Figures in the parentheses indicate percentages

3.3 Household Food Intake Level and Its Determinants

3.3.1 Household food intake level

Average daily per capita intake of rice was 466.54 g. The second important food item was vegetables and the consumption rate of the vegetables was 137.87 g per capita per day. The third important food item was potato with a consumption rate of 118.81 g. The next important food item was milk followed by fish and pulse respectively. Total amount of food consumption was observed to be 1288.36 g per capita per day. The overall average daily per capita calorie intake was 2592.23 k. cal. About 60% of the total calorie intake was received from the rice consumption only. The second highest contribution to calorie intake came from the soybean oil and the third contribution from the pulse consumption. It was observed that on average, daily per capita protein intake was 84.01 g. Rice consumption contributed the most (23.33 g) to the intake of protein. Soybean oil consumption was the second largest contributor to the protein intake. The next important

contributors were pulse, fish and meat respectively.

3.3.2 Determinants of per capita food intake

Highly significant F-values for food consumption and protein intake interpret that regression functions were well fitted to the data of the models. The coefficient of daily per capita fish consumption (0.601) was positive and significant at (P = 0.01) with the dependent variable protein intake and the coefficient of daily per capita calorie intake (1.210) was positive and significant at (P = 0.01) with the food consumption (Table 6). It was observed that total area of land of the fish farmers and daily per capita calorie intake had positive and significant impact on daily per capita food consumption. Total annual fish production and annual income from fisheries had positive but insignificant impact on daily per capita calorie intake. Daily per capita fish consumption had positive and significant impact on daily per capita protein intake but households' annual income from fisheries and total area of land of the fish farmers had no impact on protein intake.

4. DISCUSSION

The majority of the sample farmers were of age group 35 to 49 years, which is more relevant to the finding of Khatun et al. [24], indicating that fish farmers of this group provided more physical efforts for fish farming. Education has a role in influencing yields through production activities. Education level was found better in this study i.e. secondary education 30% and higher secondary education 28.3% of the farmers but these two levels were only 8.9% and 6.7% of the fish farmers of Mohanpur upazila in Rajshahi district [25]. Low experienced (up to 5 years) 28.3%, medium experienced (6-10 years) 58.3% and above 10 years experienced 13.3% farmers were observed in this study. Similar results (23.3%, 46.7% and 30% respectively) obtained by Hossain and Islam [26]. It was found that 58.3% farmers received training on scientific fish farming technique and management system. Khatun et al. [24] and Hossain [27] stated that only 14% and 20% farmers respectively received training and these findings differ from Biswas [28] and Sultana [29]. Thus, the fish farmers in the study area had the opportunity to receive training on different aspects of fish culture and related fields.

Table 5. Average per capita daily intake of food items, calorie and protein by farm households

Food item	Food consumed (g)	Calorie intake (K. Calorie)	Protein intake (g)
Rice	466.54	1516.25	23.33
Potato	118.81	109.31	2.37
Vegetable	137.87	25.37	5.07
Pulse	46.94	154.43	9.50
Meat	44.53	60.57	8.91
Flour	28.03	91.10	3.39
Fish	104.03	99.13	10.41
Milk	111.38	73.51	2.23
Egg	8.06	14.11	0.96
Soybean oil	46.74	199.60	11.69
Mustard oil	16	5.29	3.52
Sugar	32.49	121.19	0
Fruits	39.01	31.98	0.35
Onion	44.39	20.63	0.53
Garlic	17.72	24.27	0.94
Chili	15.07	35.72	0.24
Ginger	10.75	9.77	0.57
Average	1288.36	2592.23	84.01

Table 6. Factors influencing household’s food consumption, calorie intake and protein intake

Variables	Coefficients		
	Food Consumption	Calorie Intake	Protein Intake
Log of household’s annual income from fisheries	0.026*(0.012)	0.030(0.048)	0.022(0.032)
Log of total area of land of the fish farmers	0.020*(0.009)	-0.103(0.131)	0.003(0.025)
Log of total annual fish production		0.149(0.145)	
Log of daily per capita fish consumption			0.601**(0.053)
Log of daily per capita calorie intake	1.210** (0.037)		
F-statistic	359.204**	0.695	44.053**

Figures in the parentheses indicate standard errors, ** and * indicate significance at 0.01 and 0.05 probability level respectively

The largest amount of money spent by fish farmer in the study area was mainly on purchase of fish feeds 56.9%; the result of highest feed cost is in agreement with the findings of Okpeke Akarue [30] who accounted 59.45% in Nigeria. Feed costs were significant for pond operation in China and Thailand, where they account for about 46% and 33% of the total costs, respectively [31]. Cost of fingerlings and fertilizers were 4.9% and 4.2% respectively of the total cost in this study, whereas higher cost of fingerlings (5.39%) and lower cost of fertilizer (1.25%) were used [26]. The utility cost such as pond management cost, liming cost and transportation cost was 3.9% of the total cost in this study, whereas lime (3.94%) and miscellaneous cost (2.38%) accounted by Sarker and Ali [32] and lime (8%), miscellaneous (4%) accounted by Provakar [33]. The costs and returns of fish production vary widely due to differences in production environments, input levels, culture practices and farming systems. Gross return was found \$8,081 and net return (profit) was \$2,262 per hectare. Approximate

similar result of profit in fish culture was found by previous study \$1,275 [34] and \$1,493 [33]. Return over per taka investment was calculated as the ratio between net return and total cost and this figure was 0.39 that indicates by spending Tk.100 net return of Tk. 39 was obtained. The benefit-cost ratio (BCR) was 1.39 whereas this figure was 1.51 in Tangail [35], 1.30 in Mymensingh [36], 1.78 in Jessore [36] and 1.17 in Rangpur [14] for pond fish farming. The finding justifies that benefit cost ratio was not similar or greater than all others studies but a potential for pond fish culture and profitable for the farmers of Melandah.

Results of the Cobb Douglas model indicate that with a positive sign in coefficients of pond area, fingerlings and fertilizer are the inputs those will result in an increase in fish yield. However, the results show that the elasticity of output with respect to pond area, fingerlings and fertilizer were statistically significant, hence for a 10% increase in pond area fish production is expected to increase by 4.5%, 10% increase in fingerlings

fish production is expected to increase by 1.1% and 10% increase in fertilizer fish production is expected to increase by 2.4% in the study area. An insignificant change was expected with a 10% increase in fingerlings, tilapia productions were 0.65% in Malawi and 0.15% in China [37]. On the other hand, cow manure had negative and significant impact on fish production. The negative coefficient of cow manure is unusual but not surprising; might be happen due to the use of over doses of cow manure in the pond.

In the technical inefficiency effect model, culture period, age and experience in fish farming had negative and significant on the inefficiency effects indicate that technical efficiency increased with the increase in the above factors. Age of farmers has insignificant negative sign in this study which is agrees with [38] but age of farmers was a significant determinant of technical inefficiency for Chinese farms [39]. However, it had significant positive influence on technical efficiency as was in Dey et al. [40]. Education can enhance production in that the higher a farmer goes with education, the better he becomes in assessment of the importance of new technologies and education improves the managerial capacity of a farmer as well as the efficient use of inputs, which consequently leads to significantly higher efficiency [37]. Higher level of education has negligible effect on efficiency in our study, which is in agreement with findings by Chiang et al. [41] and Khan and Alam [42]. The more experience a farmer has, the higher is his output and higher is the technical efficiency i.e. negative coefficient [43]. Finding of the present study is in line with this statement. The positive sign of coefficients asserts that this variable has negative effect on technical efficiency [44-46].

The result indicates that rice, pulses, fish, meat, milk and fruit consumption is comparatively higher in our study compared to previous national survey [47] but vegetables and egg consumption are lower. The average quantity of food items consumed was estimated at 1000.5 g at rural areas [48], indicates average food consumption of the studied people is 28.8% higher than 7 to 8 years before. Per person per day fish consumption was 60.33 g at household level while it was 44.65 g at national level i.e. they consumed 15.68 g more fish than that of national level [49]. On the other hand, 3.33% fishermen households had acceptable high food consumption and 20% household having poor food consumption, whose average calorie intake was 1692.32 k. calories [50]. The mean energy

intake and protein were 2455.4 kcal, 55.06 g, respectively, though energy intake was satisfactory [51]. Average daily per capita food intake was 1300.26 g, calorie 2449 kilo calorie and protein 86.78 g [52]. Calorie and protein intake of the studied people were higher than the above findings and also increased 17.27% and 31.66% compared than in household income and expenditure survey in Bangladesh, 2016. This improvement may be due to increase of food sufficiency of the country as well as the production and buying capacity of people of the study area. However, the increase of food intake could not ensure the desired level of balanced nutrition of the fish farmers due to inadequate consumption of all types of food items at a time.

Increase of total annual fish production increases daily per capita calorie intake and increase of fish consumption increases daily per capita protein intake significantly of the fish farms household. Daily per capita calorie intake and total area of land of the farmers had positive and significant impact on daily per capita food consumption. The estimated value of the coefficient of income from fisheries and land area were significantly positive with individual food intake. Also, coefficient of food intake was significantly positive with protein intake. These were happened because more land area gave more earning capacity to the fish farmers, so they were able to consume more nutritious foods like fish, meat, milk and fruits to get more opportunity of protein.

5. CONCLUSION

Pond fish culture in Bangladesh has become a stable economic activity of rural people. It helps increase of income, food consumption, and calorie and protein intakes. Efficient management of farm resources in the production process increases the fish production with the available inputs and existing technology. That is, at least 8 percent fish production can be increased by increasing the technical efficiency only without increasing the use of inputs with existing technology. Age and experience of fish farmers and culture period increase the technical efficiency. Farmers can further increase the fish production if they are well trained about pond fish culture. Upazila Fisheries Officer, Bangladesh Fisheries Research Institute and fisheries extension workers should provide proper guidelines and arrange training program to the pond fish farmers. Household's income and land size increase the food consumption and fish consumption increases the protein intake

significantly. Fish production and consumption increase the food security of people. However, the nutritional wellbeing of the fish farmers is still low because of insufficient access to sufficient, safe and nutritious food. Government intervention and nutrition education of people will ameliorate the food security scenarios of people.

CONSENT

Informed consent of the respondents was taken before conducting their personal interview.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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