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Profitability, input demand and output supply of tilapia production at Trishal upazila of Mymensingh district in Bangladesh

S Islam*, JR Sarker

Depatment of Agricultural Economics, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur 1706, Bangladesh

Abstract

Fisheries sector has high potential for the economic development of Bangladesh. Bangladesh earns a considerable amount of foreign currencies by exporting fish, shrimps and other fisheries products. This study addresses profitability of tilapia production using benefit cost ratio. The study also examines input demand and output supply of tilapia farming in Bangladesh by applying a profit function approach. Results revealed that benefit cost ratio is greater than 1, means that tilapia production is profitable in the study area. Tilapia farmers are also responsive to changes in market prices of inputs and outputs. Tilapia price is the most dominant determinant of output supply and input demand. A 1% increase in tilapia price will increase output supply by 3.836% and increase demand for lime, fingerlings, feed and labour by 0.941%, 0.987%, 0.523% and 1.00%, respectively. Problem facing index analysis shows major problems faced by the farmers were low market price of tilapia, high prices of fish feed with adulteration and inadequate supply of good quality fry.

Key words: Tilapia, profitability, input demand, output supply, translog profit function

***Corresponding Author:** shamima0613@gmail.com

Introduction

Bangladesh is considered one of the most suitable countries in the world for freshwater aquaculture, because of its favorable resources and agro-climatic conditions. Aquaculture is expanding faster than any other area of agriculture in Bangladesh (Ali and Haque, 2011). According to FAO statistics 2016, Bangladesh is ranked 5th in world aquaculture production. The total annual fish production in Bangladesh was estimated at 41.34 lakh MT in 2016-17, of which 23.33 lakh MT (56.44 %) were obtained from inland aquaculture, 11.63 lakh MT (28.14%) from inland capture fisheries and 6.37 lakh MT (15.42 %) from marine fisheries (DoF, 2017). The target of fish production was 40.50 lakh MT in 2016-17, but it crossed the target by producing 41.34 lakh MT fish in Bangladesh. Through this remarkable achievement Bangladesh, first time in the history became a self-sufficient country in the fish production providing 62.8 g of fish per person in the daily dietary consumption. Bangladesh is now one of the world leading fish producing country and fisheries sector contributes 3.61% to GDP and 24.41% to agricultural GDP (BER, 2017). Bangladesh has hundreds and thousands of seasonal water bodies in the form of ponds, ditches, shallow road side canals, barrow pits and undoubtedly these water bodies have tremendous potential for aquaculture. These are especially suitable for the culture of fish species with short life cycle, fast growth rate and require low input support. In such cases, tilapia can be a promising fish for aquaculture in suitable seasonal water bodies. Tilapia culture has become widespread in Bangladesh in recent years and ranked 2nd in terms of annual fish production of ponds. Only tilapia shares about 16.72% of the annual fish production of ponds while major carps (Rui, Catla and Mrigal) share about 29.56% (DoF, 2017). Recently, the low market price had severely damaged the farming of the exotic riverine cat fish in the country. Therefore, a large number of commercial cat fish producers have found tilapia as an alternative species to culture in their farms to maximize profit. Tilapia (GIFT) was introduced to Bangladesh by ICLARM (International Center for Living Aquatic Resources Management, now known as the World Fish Center) and BFRI in 1994 (Hussain et al. 2004; Ponzoni et al. 2010). Desiree, 2013 identified that Tilapia and Pangasius have great opportunities in the export market as well as in the domestic market.

There were many economic studies on fish farming but a limited number of studied were done on tilapia farming in Bangladesh. The study of Alam *et al.* (2011) estimated the levels and determinants of farm-level technical efficiency of tilapia farmers of Bangladesh. Ahmed *et al*. (2011) made an investigation on the production and consumption status of tilapia in Bangladesh. Rahaman *et al*. (2015) examined the present status of tilapia (*Oreochromis mossambicus*) marketing system in greater Jessore region of Bangladesh. The study of Toma *et al.* (2015) found that the tilapia fish production is profitable business. Studies on profitability of tilapia production at the farm level in Bangladesh are not widely available although results from experimental stations are available. For example, Khan *et al.* (2008) conducted an experimental research in nine seasonal small ponds at Bangladesh Agricultural University campus located on tilapia production and reported productivity ranging from 972.50 kg/ha to 3941.50 kg/ha and Benefit Cost ratio (BCR) of 1.00 to 1.45. Similarly, Reza *et al*. (2015) conducted an experiment to study the effect of stocking density on the growth and production of monosex male tilapia. But such results are not comparable to farm level conditions as these estimates are obtained under controlled experimental conditions.

Most importantly, the nature of responsiveness of the tilapia farmers to changes in input and output prices are not known at all. This information is important because Bangladesh farmers not only need to be more efficient in their production activities, but also to be responsive to market indicators, so that the scarce resources are utilized efficiently to increase productivity as well as profitability in order ensure supply to the urban market (Rahman, 2003) and increase farmers' welfare.

Given this backdrop, the present study specifically addresses this critical research gap in knowledge on the farm-level profitability and nature of responsiveness of tilapia farmers to input and output price changes by systematically examining profitability and responsiveness of the tilapia producers to market forces. Specifically, the study aims to: (i) assess financial profitability of producing tilapia and (ii) estimate input demand and output supply elasticity's of tilapia production in the study area.

Materials and Methods

The study was primarily conducted in the Trishal upazila under Mymensingh district of north-central Bangladesh. Mymensingh is called the 'Mecca' of fresh water aquaculture in Bangladesh because of the 'blue revolution' (Ahmed 2009). In Mymensingh region many farmers have devoted to tilapia culture in their fish pond because of its high income gain with low cost of production (Toma *et al.,* 2015). Geographically, Trishal has been identified as the most important and promising area for tilapia culture, because of the availability of hatchery-produced fry, favorable resources, and climatic conditions, such as the availability of pond, warm climate, fertile soil etc. Some of the farmers in this area also received training in tilapia farming with the help of Department of Fisheries (DOF). Tilapia cultivation is much easier because of its some unique characteristics like high resistance to low quality water and tolerance to different types of diseases. Moreover, many pangas farmers have recently switched to tilapia farming due to lower market prices of pangas and hence has resulted in a moderate increase in tilapia production over the last few years (Ahmed *et al.*, 2011). Most of the farmers of Trishal cultivate tilapia fish as they can harvest it twice in a year and also the cultivation is easy. Three villages namely Dewanibari, Kazir Shimla and Kanhar under Bailar union of Trishal was selected purposively for the study. A total of 58 farmers were in which 25 farmers from Dewanibari, 19 from Kazir Shimla and 14 farmers from Kanhar village were selected randomly based on data availability. Survey method is followed to collect information from the Tilapia farmers. The survey was conducted during June 2018 through pre-designed interview schedules. The collected data were summarized and analyzed to fulfill the objectives set for the study. Both tabular and statistical techniques were used to achieve the major objectives of the study. We apply two main analytical tools to address these two objectives. (a) Cost-Benefit Analysis (CBA) to determine financial profitability of tilapia production at the farm level and (b) translog profit function to estimate input demand, output supply and fixed factor elasticities of tilapia production in the study area. The details are as follows:

Profitability analysis of tilapia fish

Profitability or Cost-Benefit Analysis (CBA) includes calculation of detailed financial costs of production and returns from tilapia on a per hectare basis. The total cost (TC) is composed of total variable costs (TVC) and total fixed costs (TFC). TVC includes costs of human labor (both family supplied and hired labor, wherein the cost of family supplied labor was estimated by imputing market wage rate), feed, fingerlings, fertilizers; irrigation, harvesting and other miscellaneous costs. TFC includes land rent (if owned land was used, then the imputed value of market rate of land rent was applied) and interest on operating capital and pond construction cost (Yuan *et al.* 2017). The gross return (GR) was computed as total tilapia output multiplied by the market price of tilapia. Profits or gross margin (GM) was computed as GR–TVC, whereas the net return (NR) was computed as GR–TC. Finally, the benefit cost ratio (BCR) was computed as GR/TC.

The profit function approach

A profit function approach was used to examine impacts of prices and fixed factors on farmers' resource allocation decisions. This is because profit function has a duality relationship with the underlying production function. An advantage of a profit function model is that it is specified as a function of prices and fixed factors, which are exogenous in nature and, therefore, are free from possible endogeneity problem associated with a production function model (Rahman *et al.*, 2012). The basic assumption is that farm management decisions can be described as static profit maximization problem. Specifically, the farm household is assumed to maximize 'restricted' profits from growing specific fishes, defined as the gross value of output less variable costs, subject to a given technology and given fixed factor endowments. We used a flexible functional form, the translog function that approximates most of the underlying true technology. The general form of the translog profit function, dropping the subscript for the farm, is defined as:

$$\ln(\pi)=\alpha_0+\sum_{i=1}^{4}\alpha_i\ln(p_i)+\frac{1}{2}\sum_{i=1}^{4}\sum_{j=1}^{4}\gamma_{ij}\ln(p_i)\ln(p_j)+\sum_{j=1}^{4}\sum_{k=1}^{4}\delta_{ik}\ln(p_i)\ln(Z_k)+\sum_{k=1}^{4}\beta_k(\ln Z_k)$$
$$+\frac{1}{2}\sum_{k=1}^{4}\sum_{h=1}^{4}\theta_{kh}\ln(Z_k)\ln(Z_h)+\varepsilon_i \qquad \ldots\ldots(1)$$

Where,

π = Restricted profit (Tk/Year) (total revenue less total cost of variable inputs)

p_i = Price of ith input

$i = j$ = 1, lime price; = 2, fingerlings price; = 3, feed price; = 4, Labor wage; Z_k = quantity of fixed input, k

$k = h$ = 1, age; =2, education; = 3, family; = 4, working person; ε_i = random error

ln = natural logarithm, and

α_0, α_i, γ_{ij}, β_k, δ_{ik}, and θ_{kh} are the parameters to be estimated.

The corresponding share equations are expressed as (Farooq *et al.*, 2001):

$$S_i = \frac{P_i x_i}{\pi} = -\frac{\partial \ln \pi}{\partial \ln p_i} = -\alpha_i - \sum_{j=1}^{4}\gamma_{ij}\ln p_j - \sum_{k=1}^{4}\delta_{ik}\ln Z_k \cdots\cdots\cdots (2)$$

$$S_q = \frac{p_q X_q}{\pi} = 1 + \frac{\partial \ln}{\partial \ln p_q} = 1 - \sum_{i=1}^{4}\alpha_j - \sum_{i=1}^{4}\sum_{j=1}^{4}\gamma_{ij}\ln p_i - \sum_{i=1}^{4}\sum_{j=1}^{4}\theta_{ih}\ln K_k \ldots\ldots (3)$$

Where, S_i = share of the input and S_q = share of output (q), X_i denotes the quantity of input *i* and Q is the level of output. Since the output and input share come from singular system of equations by definition (S_q - $\sum S_i = 1$) , one of the share equations, the output share is dropped and the profit function and variable input share equations are estimated jointly using Seemingly Unrelated Regression Estimation SURE procedure. The joint estimation of the profit function together with factor demand equations ensure consistent parameter estimates (Sidhu and Baanante, 1981).

Estimation of elasticities

The own price elasticity of demand for variable input *i* (η_{ii}) was computed as:

$$\eta_{ii} = -S_i - \frac{\gamma_{ii}}{S_i} - 1 \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots (4)$$

Where, S_i is the *i*th share equation, at the sample mean. For the cross price elasticity of demand for *i*th variable input with respect to the price of *j*th variable input (η_{ij}) was computed as:

$$\eta_{jk} = -S_j - \frac{\gamma_{ij}}{S_i} \quad \text{for } i \neq j \ \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots..(5)$$

The elasticity of demand for variable input (η_{iq}) with respect to output price P_q was computed as:

$$\eta_{iq} = S_q + \sum_{i=1}^{4}\frac{\gamma_{ij}}{S_i} \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots..(6)$$

Where, S_q is the output share at the sample mean. The elasticity of demand for variable input with respect to *k*th fixed factor, (η_{ik}) was computed as:

$$\eta_{ik} = \beta_k + \delta_{ik}\ln P_i + \sum_{k=1}^{4}\theta_{ik}\ln Z_k - \frac{\delta_{ik}}{S_i} \ \ldots\ldots\ldots\ldots\ldots..(7)$$

The elasticity of output supply with respect to price of *i*th variable input (ε_{qi}) was computed as:

$$\varepsilon_{qi} = -S_i - \frac{\sum_{i=1}^{4}\gamma_{ij}}{S_q} \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots (8)$$

The elasticity of output supply with respect to its own price (ε_{qq}) was computed as:

$$\varepsilon_{qq} = \sum_{i=1}^{4}S_i + \frac{\sum_{i=1}^{4}\gamma_{ij}}{S_q} \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots (9)$$

Finally the output supply with respect to *k*th fixed factor (ε_{qk}) was computed as:

$$\varepsilon_{qk} = (\beta_k + \sum_{i=1}^{4}\delta_{ij}\ln P_i + \sum_{k=1}^{4}\theta_{kh}\ln Z_k) + \frac{\sum_{i=1}^{4}\delta_{ik}}{S_q} \cdots\cdots\cdots(10)$$

Problem facing index

The interviewed fish farmers faced a variety of multi-dimensional difficulties and constraints (economic, social and technical) that affected the fish farming activities as well as their livelihood. The researcher identified the major problems faced by the farmers. The farmers were asked to give their opinion on 7 selected problems which were identified during data collection. Each respondent was asked to indicate the extent of his/her problem on a four-point scale (Abdullah and Chowdhury, 2016) where 3 assigned for 'severe', 2 for 'moderate', 1 for 'little' and 0 for 'not at all'. The problem faced score of a respondent was determined by summing up his/her scores for all the problems. Thus, possible score can vary from zero (0) to 21, where zero indicated no problem and 21 indicated the highest level of problem. Severity of problems perceived by the farmers was determined by using Problem Facing Index (PFI) and it was computed by the following formula:

Problem Facing Index (PFI) = (P_s × 3) + (P_m × 2) + (P_l × 1) + (P_n × 0)……………………………………..(11)

Where,
P_s= Number of respondents faced severe problem,
P_m= Number of respondents faced moderate problem,
P_l = Number of respondents faced little problem,
P_n= Number of respondents faced no problem.
Thus, the Problem facing index (PFI) of the farmers could range from 0 to 174, where '0' indicating no problem and '174' indicating highest problem.

Sample characteristics

Table 1 presents the summary statistics of the relevant variables for the tilapia farmers and tilapia fish production.

Table 1. Summary statistics of the variables

Name of the variables	Mean	Max	Min	SD
Area of tilapia culture (Decimal)	201.17	532	11.41	150.30
Fingerlings size (inch)	1.60	4.5	0.50	1.06
Annual income (Tk)	1567043	6744850	146300	1580697
Age	41	58	27	8.38
Education	9.83	13	1	3.13
Family size	6.82	14	2	2.45
Male	1.64	4	1	0.87
Female	0.72	2	0	0.42
Training (Days)	3.58	15	0	3.39
Farm Size (Decimal)	480.68	2404	68.4	464.86
Yield (Kg/Ha)	36128.33	141613.33	5763.33	27023.41
Labor (Man-day/Ha)	53	216	5	45.30
Fingerlings (no./Ha)	119643.7	370500	15808	78808.99
Feed (Kg/Ha)	48314.64	197600	6374.194	35716.97

The study found that that majority of the farmers in the study area (58.62%) were middle aged, whereas the figure for young and old are 29.31% and 12.07% respectively. The table also reveals that considerable variation exists among the farmers in terms of production practices and the socioeconomic attainments of the farmers. The lowest annual income of tilapia farmer was Tk 146300 and the highest income was Tk. 6744850 per year with the mean Tk 1567043. Education in general was well, in the sense that tilapia producers of the study area have proper education. The mean yield of tilapia was 36128.33 kg per hectare per annum ranging from a minimum of 5763.33 kg to as high as 141613.33 kg. The average size of fingerling is 1.58 inch (1.71 inch at Alam *et al*., 2011). The lowest annual income of tilapia farmer was Tk 146300 and the highest income was Tk. 6744850 per year with the mean Tk 1567043. Furthermore, 66% farmer received formal training from different organizations and 38% farmers were expecting training in the study area. The duration of training received by the framers was maximum 15 days. The average amount of credit received by a farmer was estimated at Tk 50680 per year from all sources.

Results and Discussion

Financial profitability of tilapia fish

Table 2 presents profitability information of tilapia production. It is clear from Table 2 that tilapia production is profitable based on the net return and BCR in the central region of Bangladesh.

Table 2. Financial profitability of tilapia fish production

Yield (Kg/ha)	36128.33
Sale price (Tk/Kg)	92.76
Gross return (Tk/Ha)	3332496
Variable cost (Tk/ha)	1748979
Total cost (Tk/Ha)	1929180
Gross margin (Tk/Ha)	1583517
Net return (Tk/Ha)	1403315
Undiscounted BCR	1.71

The average yield is estimated at was 36128.33 kg/ha and the net return is estimated at Tk 1403315 with BCR of 1.71. The estimated tilapia yield of 36128.33

kg/ha is substantially higher than the yield of 23553 kg/ha in Mymensingh District (Toma *et al*., 2015). The average market price of tilapia was Tk 92.76 per kg**.** The average total cost of tilapia production per hectare was estimated at about Tk 1929180. The computed BCR of 1.71 is higher than tilapia production in Mymensingh estimated at 1.29 (Toma *et al*., 2015). The implication is that the profitability of tilapia production is increasing. Tilapia production is high in the study area because of soil fertility, environment, proper management by the farmer, farmers' own interest on fish farming and most of the farmers practice monoculture resulting in 2-3 production cycle per year which ends up with high level of productivity.

Output supply, input demand and fixed factor elasticity's of tilapia production

Table 3 presents estimates of the profit function model estimated jointly with four variable input share equations. It is evident from the table that the coefficient of multiple determination of R^2 was 0.261 for the tilapia farming which implies that 26.1% of the variation of profit of tilapia production has been explained by the explanatory variables included in the model. Further, a large number of coefficients on the variables are significantly different from zero at the 10% level at least in the model. Significance of the coefficients in some of the interaction terms indicates non-linearity in the production structure, which justifies use of a translog function instead of a more restrictive Cobb-Douglas function.

Among the four variable inputs lime price and feed price has significant relationship with profit. The regression coefficient of the lime price was significant at 1% level. The results of the analysis indicated that keeping other factors remain constant, one percent decrease in the price of lime would increase the profit of tilapia farming by 0.190% which indicates that production of tilapia is very slightly responsive to changes in the price of lime because significant change in lime use doesn't take place whether the price of lime moves up or down. On the other hand, feed price was significant at 10% level and the analysis result indicated that keeping other factors remain constant, one percent increase in the price feed would increase the profit of tilapia farming by 5.873%. This indicates that production of tilapia is extremely dependent upon feed price as it is the core input variable in case of tilapia farming. The regression coefficient of the education and male working person were significant at 10% level. The results of the analysis indicated that keeping other factors remain constant, one percent increase in the education level would increase the profit of tilapia farming. On the contrary, one percent increase in male working person would decrease the profit of tilapia farming.

The parameter estimates of the profit function model were used to estimate the elasticities with respect to variable input demand, output supply and fixed factors using (Table 4). All own price elasticities have shown negative signs which are consistent with theory, but all of them are in the inelastic range except fingerlings, which is in the elastic range. Results of the cross-price elasticities of demand are mixed with some being complements and some being substitutes.

On the whole, changes in market price of inputs and output significantly influence farmers' resource use and productivity (tilapia supply) as expected. The output supply response to output price change is positive consistent with theory. The elasticity value 3.836 indicates that a 1% increase in output price will increase output supply by 3.836%.

On the other hand, demand for lime, fingerlings, feed and labor will increase in response to an increase in output price consistent with expectation. The demand for lime, fingerlings, feed and labour will increase by 0.941%, 0.987%, 0.523% and 1.00% respectively for a one percent increase in output price. The responsiveness of fingerlings increase is in the elastic range. This is expected because fingerlings are one of the main variable inputs in tilapia production. Therefore, the farmers' response to a rise in fingerling was quite high estimated at –1.166 implying that a one percent increase in the price of fingerlings will reduced fingerlings demand by 1.166%. Among the fixed factor endowments, supply response to an increase in age is high. A 1% increase in age will decrease output supply by 2.308%. This is expected because young farmers were more productive than the aged farmers.

Table 3. Restricted parameter estimates of the translog profit functions along with input share equations

Variables	Obs	Parms	RMSE	R-sq	F-Stat	P
Profit	58	17	0.903	0.261	3.490	0.000
Sli	58	8	0.030	0.403	6.680	0.000
Sfi	58	8	0.134	0.546	10.200	0.000
Sfe	58	8	0.766	0.570	9.520	0.000
Sla	58	8	0.034	0.270	3.960	0.000

Variables	Coef.	Std. Err.	t	P>t	[95% Conf.Interval]	
Profit Function						
ln_lime_p	-0.190***	0.050	-3.820	0.000	-0.289	-0.092
ln_finger_p	-1.740	2.037	-0.850	0.394	-5.754	2.273
ln_feed_p	5.873*	3.312	1.770	0.077	-0.652	12.397
ln_labor_p	0.043	0.060	0.720	0.472	-0.074	0.160
ln_limeXln_lime_p	0.017	0.012	1.480	0.140	-0.006	0.040
ln_finger_pXln_fi_p	-0.813*	0.489	-1.660	0.098	-1.777	0.151
ln_feed_pXln_fee_p	-2.390	1.815	-1.320	0.189	-5.966	1.186
ln_lab_pXln_lab_p	-0.051***	0.014	-3.600	0.000	-0.079	-0.023
Age	0.011	0.014	0.810	0.418	-0.016	0.038
Education	0.066*	0.035	1.890	0.060	-0.003	0.135
Family_size	0.073	0.053	1.370	0.173	-0.032	0.178
Working_person_male	-0.260*	0.142	-1.830	0.069	-0.540	0.020
ln_limeXln_finger	-0.271	0.332	-0.820	0.415	-0.925	0.383
ln_limeXln_feed	0.970	1.137	0.850	0.394	-1.269	3.209
ln_limeXln_lab	0.264	0.209	1.260	0.208	-0.147	0.675
ln_fingerXln_feed	1.722***	0.587	2.940	0.004	0.567	2.878
ln_fingerXln_lab	0.010	0.007	1.540	0.126	-0.003	0.024
_cons	8.529*	4.379	1.950	0.053	-0.099	17.158
Lime share equation						
ln_lime_p	0.017	0.012	1.480	0.140	-0.006	0.040
ln_finger_p	-0.011*	0.006	-1.880	0.061	-0.023	0.001
ln_feed_p	-0.047***	0.013	-3.520	0.001	-0.073	-0.021
ln_lab_p	0.041***	0.013	3.040	0.003	0.014	0.067
Age	0.001	0.000	1.610	0.109	0.000	0.002
Education	0.003**	0.001	2.320	0.021	0.000	0.005
Family_size	0.002	0.002	0.980	0.330	-0.002	0.005
Working_person_male	-0.014***	0.005	-2.820	0.005	-0.025	-0.004
_cons	-0.190***	0.050	-3.820	0.000	-0.289	-0.092
Fingerlings share equation						
ln_lime_p	-0.182**	0.071	-2.560	0.011	-0.323	-0.042
ln_finger_p	-0.184***	0.029	-6.340	0.000	-0.242	-0.127

ln_feed_p	-0.051	0.058	-0.870	0.387	-0.166	0.065
ln_lab_p	0.010	0.007	1.540	0.126	-0.003	0.024
Age	0.001	0.002	0.450	0.655	-0.003	0.005
Education	0.002	0.006	0.410	0.682	-0.009	0.013
Family_size	0.017**	0.008	1.990	0.048	0.000	0.033
Working_person_male	-0.067***	0.023	-2.960	0.003	-0.112	-0.022
_cons	-1.401***	0.199	-7.030	0.000	-1.793	-1.008
Feed share equation						
ln_lime_p	-0.047***	0.013	-3.520	0.001	-0.073	-0.021
ln_finger_p	0.134	0.157	0.850	0.396	-0.176	0.444
ln_feed_p	-1.809***	0.301	-6.010	0.000	-2.402	-1.216
ln_lab_p	0.000***	0.000	-2.680	0.008	0.000	0.000
Age	0.040***	0.012	3.210	0.002	0.015	0.064
Education	0.049	0.032	1.530	0.127	-0.014	0.111
Family_size	0.117**	0.047	2.480	0.014	0.024	0.210
Working_person_male	-0.532***	0.130	-4.100	0.000	-0.788	-0.277
_cons	-4.865***	0.790	-6.160	0.000	-6.421	-3.310
Labor share equation						
ln_lime_p	-0.023	0.016	-1.440	0.153	-0.055	0.009
ln_finger_p	0.010	0.007	1.540	0.126	-0.003	0.024
ln_feed_p	0.000**	0.000	-2.480	0.014	0.000	0.000
ln_lab_p	-0.051***	0.014	-3.600	0.000	-0.079	-0.023
Age	0.001	0.001	1.520	0.130	0.000	0.002
Education	-0.001	0.001	-0.540	0.592	-0.004	0.002
Family_size	-0.001	0.002	-0.690	0.493	-0.005	0.003
Working_person_male	-0.009	0.006	-1.510	0.133	-0.020	0.003
_cons	0.043	0.060	0.720	0.472	-0.074	0.160

*** Significant at 1% level ($p < 0.01$); ** Significant at 5% level ($p < 0.05$); * Significant at 10% level ($p < 0.10$)

Table 4. Estimated elasticities of the translog profit function of tilapia

Parameters	**Output price**	**Lime price**	**Fingerling price**	**Feed price**	**Labor price**	**Age**	**Education**	**Family size**	**Working person Male**
Output supply	3.836 (3.752)	-0.209 (2.966)	0.231 (-0.080)	-4.213 (0.902)	0.354 (-4.214)	-2.308 (3.771)	-1.001 (3.847)	-1.122 (2.544)	-0.569 (1.507)
Lime demand	0.941 (37.744)	-0.597 (1.221)	0.435 (-1.978)	0.336 (-0.709)	0.583 (-1.078)	-1.844 (10.037)	-1.234 (10.639)	-0.759 (4.028)	1.856 (-10.538)
Fingerling demand	0.987 (0.969)	-0.098 (0.474)	-1.166 (5.543)	0.274 (-1.563)	0.447 (-21.050)	-1.833 (34.271)	-1.210 (47.793)	-0.832 (24.823)	1.913 (-62.672)
Feed demand	0.523 (0.316)	-0.062 (11.216)	0.447 (-6.214)	-0.073 (0.143)	0.099 (54.053)	-2.987 (21.515)	-1.789 (26.081)	-1.640 (14.386)	3.746 (-42.220)
Labor demand	1.000 (33.561)	0.397 (-1.507)	0.492 (-4.017)	0.463 (66.561)	-0.318 (1.045)	-1.836 (14.830)	-1.228 (15.313)	-0.763 (5.727)	1.778 (-15.060

Figures in parentheses are t-ratios.

Problem faced index

The observed problem faced index of the selected seven problems in tilapia fish farming ranged from 55 to 158 against the possible range of 0 to 174. The intensity of the problems were arranged in rank order according to the descending order of problem faced index (PFI) as shown in Table 5.

The most common problem faced by the farmers is 'high prices of fish feed with adulteration' (PFI = 158). Costs of fish farming were reported to have increased significantly in recent years as a result of increased feed cost (Sheheli *et al.*, 2013) and farmers often bought low quality feed because of adulteration. The second most important constraint was 'low market price of tilapia'. Fish farmers indicated that the demand for tilapia fish is decreasing day by day by the consumers but supply is increasing which results in law market price of tilapia. 'Inadequate supply of good quality fry' was the 3rd most commonly encountered problem for the fish farmers. According to the report of fish farmers, the increase in fish hatchery and demand for fry decreased the quality of fry over time. Some farmers indicated that they have less formal training in technical matters regarding fish farming, which keeps them away from using technology and up-to-date information.

Table 5. Rank order of the problems faced by the farmers in tilapia farming with Problem Faced Index (PFI)

Sl No.	Problems	Extent of problem faced (N=58)				PFI	Rank order
		Severe (3)	Moderate (2)	Little (1)	Not at all (0)		
1	High prices of fish feed with adulteration	46	9	2	1	158	1
2	Low market price of tilapia	38	16	4	0	150	2
3	Lack of technical knowledge.	22	13	7	18	99	4
4	Inadequate supply of good quality fry	31	19	6	2	137	3
5	Natural calamities	2	13	23	20	55	7
6	Lack of credit facilities	15	11	10	22	77	6
7	Lack of proper marketing facilities	9	13	31	5	84	5

Furthermore, poor infrastructure facilities such as earthen roads and lack of bridges created a marketing problem, and there was a lack of marketing channels. During monsoon, they faced difficulties to travel on the muddy roads. Often, they could not reach market sites easily and in a timely manner. In addition, they reported that social insecurity and natural calamities hindered their fish farming. Therefore, supply of adequate finance though credit program, establishing good quality hatcheries to supply adequate fry on time, taking appropriate preventive and controlling measures and extension of different facilities in the study area are essential.

Suggestions to overcome the problems of tilapia farming

Participants were asked to give their opinion on possible solutions to overcome barriers that hindered the fish cultivation. In response to financial, social and technical barriers, they suggested a number of initiatives that might be taken by development organizations (such as GOs, NGOs, and private organizations) to remove barriers and to improve fish cultivation. After a lively discussion with each other, they put forward the following suggestions which have been arranged in Table 6. Here, lower rank indicates

Table 6. Possible solutions to overcome the problems of tilapia farming as perceived by farmer (n = 100)

Solutions	Number of citations	Rank order
Adequate supply of quality inputs (fry, feed, hormone, vaccine) in time	45	1
Providing sufficient credit at low interest rate in time	38	2
Taking necessary steps by the government	35	3
Providing sufficient need-based training facilities on fish farming from GOs and NGOs	30	4
Developing a cooperative society to resolve the marketing problems	25	5

the need first priority and higher rank indicate least priority to overcome the constraints.

Conclusion

The principal aim of this study was to assess financial profitability of tilapia farming and responsiveness of the tilapia farmers to input and output price. Results revealed that tilapia farming is profitable (BCR = 1.71). The average yield of tilapia was 36128.33 kg/ha and the net return of TK 1403315 per ha. Farmers are responsive to changes in market prices of tilapia and inputs. The overall performance of translog profit model reveals that the key variables included in the model were individually or jointly responsible for variation in the profit of tilapia production. In this regression analysis four explanatory variables and four fixed factors were used and all of the input variables has positive impact on tilapia production. The main influencing factors were lime price, feed price, education, male working person in tilapia farming. The major problems faced by the farmers were low market price of tilapia, high prices of fish feed with adulteration and inadequate supply of good quality fry etc. It is noteworthy that adequate supply of quality fry on time was most important to the fish farmers for improving their livelihood. In addition, they gave priority to credit facilities, low-cost of quality feed, training, and marketing channel to improve their existing livelihood status.

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