Profitability assessment and efficiency analysis of tilapia farming in Bangladesh: An application on data envelopment analysis

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A B S T R A C T

This study was carried out to find out the financial profitability and technical efficiency of tilapia fish farmers in the selected area of Bangladesh. A total of 70 tilapia fish farmers (large 36 farmers and small 34 farmers) were selected from major tilapia producing area at Trishal upazila of Mymensingh district in Bangladesh. To fulfill the objectives of this study, profitability, socioeconomic analysis, Cobb-Douglas production function and Data Envelopment Analysis (DEA) were employed. Study revealed that gross profit margin of the large farmers was 24.42% and small scale farmers was 23.8% indicating that farmers did not enough well in managing their farm and farmers has less capacity to cover for operating, financing and other cost. Break-even price for the large tilapia farmers worked out Tk. 77.33 per kg and small farmers was Tk. 81.56 per kg while break-even production for large farmers was found 1159.64 kg per hectare. Benefit cost ratio, net profit margin were found more than one and positive respectively, indicated that tilapia farming was commercially profitable. Considering all selected farmers, tilapia farming found a profitable business where undiscounted BCR for large farmers was 1.213 and a small farmer was 1.230. The mean technical efficiency level of tilapia fish farmers was 81.8 (where allocative efficiency was 93.1 and scale efficiency was 88.2) percent, implies that by operating at full technical efficiency levels, tilapia yield could be increased and efficient farmers found more productive than inefficient farmers. The results of technical efficiency showed that the farmers were efficient nevertheless, the sample farmers operated well below the production frontier and hence that they still had a chance to achieve targeted yields. Farmer's financial benefit can be increased by reducing the feed price or increasing the output price.

Keywords: Benefit-cost ratio, Data Envelopment Analysis (DEA), Profitability, Technical efficiency

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Introduction

The shortage of fish in the country increased day by day due to increase in population density. At the same time, due to land requirement of increased people for housing, marketing extension, road, offices etc. the water resources are declining every year. Fish farmers are now heavily dependent on input oriented aquaculture practices. Many researchers also recommended that tilapia farming is effective in poorer countries and it can give socio-economic development and overall development of Bangladesh. In recent years, tilapia farming is facing some problems. The marginal farmers have been replaced to the other farming instead of tilapia farming. Some farmers have practiced mixed culture with a small scale of tilapia in their pond. Fish farmers are shifting from fish cultivation to other agriculture and non-agriculture activities. This leaves the production sector vulnerable, which requires more attention. Now a day the production cost became high

enough compared to the market price of the tilapia and the farmers are being discouraged to tilapia farming. It is being envisaged that if rising demand is not met by equally fast supply growth, shortages of fish will cause lower fish consumption, especially among the poor and threaten food security (World Fish Center, 2007). Therefore, tilapia production needs to be increased which can be achieved by increasing the efficiency of tilapia farmers using existing technology and encouraging them through profiting. New technology and scientific management practices that promise higher returns or lower costs are constantly being introduced. Improvements in these technology and production systems are all interlinked where research can complement traditional knowledge to improve the efficiency and productivity of aquaculture. Moreover, the available evidence suggests that farmers in the developing countries fail to exploit the full potential of a technology and/or make allocative errors (Thomas and

Sundaresan, 2000). Thus, the measurement of financial profitability and the technical efficiency of tilapia is an important issue from the standpoint of aquaculture development exercises in developing countries like Bangladesh. It will give pertinent use and useful information for making sound management decisions on resource allocations and for formulating aquaculture policies.

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 second in terms of annual fish production of ponds. Only tilapia shares about 16.25% of the annual fish production of ponds while major carps (Rui, Catla and Mrigal) share about 30.06% (DoF, 2020). Recently, the low market price had severely damaged the farming of the exotic riverine catfish in the country. Therefore, a large number of commercial catfish producers have found tilapia as an alternative species to culture in their farms to maximize profit. Tilapia 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 has 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 revealed that the profitability and farm-level technical efficiency of tilapia farmers of Bangladesh. The study it is was 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. 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. Few studies on profitability and technical efficiency in different aquaculture farms had been conducted but research work related to financial profitability and technical efficiency of tilapia farming in Bangladesh is very few.

Therefore, this study is a modest attempt to find out whether the tilapia culture is profitable and the farmers efficiency on production in the selected area through the following objectives:

i. To estimate the financial profitability of tilapia farming;
ii. To find out the factors of tilapia farming in that selected area;
iii. To assess the efficiency of tilapia farming in that selected area.

Data and methodology

Data or Information was collected for fulfillment of the objectives of the study. A total 70 farmers were selected from a field survey, which was conducted at Trishal Upazila in Mymensingh District. Five villages from three unions of the Trishal Upazila were taken under the consideration. Random sampling technique was used to estimate the sample size. This area was selected considering the large number of pond farms in this area. There is an easy communication facility, which raises the possibility of fish production trend in this area. The study area was not far away and thus it was less expensive as well as easier for data collection for the researcher.

The economic profitability analyses involved the use of farm budget to calculate revenues (R), total cost (TC), fixed cost (FC), total variable cost (TVC), average variable cost (AVC), total profit (TP), profit margin (PM), benefit-cost ratio (BCR), break-even price (BEP), and break-even production (BEPr), using the following formulas:

$$TC = \sum_i{}^{N}{}_{=1} Q_i.P_i + \sum_i{}^{N}{}_{=1} TFC \quad \text{.................................. (1)}$$

Where, Q is quantity (kg/year) of the ith variable of ith input and P is the per unit price (Tk/kg) of the ith variable input.

Gross return (GR) was calculated by the quantity produced with multiplying the prevailing price of product. The formula was used for calculating GR as follows:

$$GR = \sum_i{}^{N}{}_{=1} Q_{ai}P_{ai} + \sum_i{}^{N}{}_{=1} Q_{bi}P_{bi} \quad \text{.......................... (2)}$$

Where, Q_{ai} is the quantity of the tilapia (kg/hectare), P_{ai} indicates per unit price (Tk/kg) of tilapia, Q_{bi} is quantity of other fish (kg/hectare), and P_{bi} is per unit price (Tk/kg) of other fish.

Gross margin (GM) is the difference between gross return and total variable cost. The formula was given as:

$$GM = \sum_i{}^{N}{}_{=1} Q_{ai}P_{ai} + \sum_i{}^{N}{}_{=1} Q_{bi}P_{bi} - \sum_i{}^{N}{}_{=1} Q_iP_i \quad \text{........... (3)}$$

Net return (NR) or profit means the total monetary sales value minus total cost of production. It estimated as:

$$\pi = \sum_i{}^{n}{}_{=1} Q_iP_i - \sum_i{}^{n}{}_{=1} (P_iQ_i) - \sum_i{}^{N}{}_{=1} TFC \text{..........................(4)}$$

Other equations are as follows:

AVC=TVC/Q
TP = Q × (P-AVC)-FC
PM=TP/TC
 BCR=R/TC
BEP=AVC+(FC/Q)
BEPr=FC/(P-TVC/Q)

Benefit-cost ratio (BCR) is one of the most common indicators normally used in capital budgeting to determine the financial desirability of an investment. Calculating a BCR helps investors in assessing the certainty of how promising or successful an aquaculture enterprise might be. An investment is therefore profitable if the BCR is greater than one. Other important profitability indices are break-even price and break-even production.

A combination of descriptive statistics and economic analysis will be used to analyze the data.

In the study area, production costs and net return of Tilapia will be estimated as well as Benefit Cost Ratio (BCR).

The following type of Cobb-Douglas production function model was used for estimating the factors of production in tilapia farming.

$$Ln\ Y_i = \beta_0 + \beta_1 lnX_{1i} + \beta_2 lnX_{2i} + \ldots\ldots\ldots\ldots\ldots + \beta_n lnX_{ni} + V_i$$

Where, Ln represents the natural logarithms, the subscript i represents the ith farmer in the sample, Y represents the yield of tilapia, X_i represents the variable factors of production, β_i unknown parameter to be estimated, V_i assumed to be independently and identically distributed random errors, having N $(0, \sigma^2)$ distribution.

The empirical Cobb-Douglas production function with double log forms can be expressed as:

$$Ln\ Y_i = \beta_0 + \beta_1 LnX_{1i} + \beta_2 LnX_{2i} + \beta_3 LnX_{3i} + \beta_4 LnX_{4i} + \beta_5 LnX_{5i} + \beta_6 LnX_{6i} + \beta_7 LnX_{7i} + \beta_8 LnX_{8i} + \eta_1 D_{1i} + \eta_2 D_{2i} + V_i$$

Where, Ln= Natural logarithm

Y= Yield of tilapia of ith farm (kg/ha)
X_1= Cost of pond preparation (Tk./ha)
X_2= Cost of lime used for tilapia production (kg/ha)
X_3= Cost of fingerlings (no./ha)
X_4= Cost of feed used by the ith farm (Kg/ha)
X_5= Carrying cost used by ith farm (Tk./ha)
X_6= Cost of labor (no./ha)
X_7= Electricity cost (Tk./ha)
X_8= Education level of tilapia farmer (year of schooling)
D_{1i}= Dummy for received training (1= yes, 0= no)
D_{2i}= Dummy for conduction of station (1= yes, 0= no)

β's and η's are unknown parameters to be estimated, V_i assumed to be independently and identically distributed random errors, having N $(0, \sigma^2)$ distribution.

To estimate the efficiency level of the fish farmers, the mean production function with normal distribution of data envelopment analysis (DEA) was employed which was found suitable for the data set. The DEA model used to assess technical efficiency under the Variable Returns to Scale (VRS) assumption was developed by Banker and Natarajan (2008) and was called the BCC (Banker, Charnes and Cooper) model. The use of the VRS specification permits the calculation of technical efficiency (TE) without the scale efficiency (SE) effects (Coelli and Battese, 1996). As the scale efficiency can be obtained by the ratio TE (CRS)/(TE)VRS thus the values of efficiency under CRS and VRS are required to calculate the scale efficiency.

The aim of this study is to analyses the nonparametric technique used in many studies of the agriculture sector. The econometric frontier approach – DEA (Data Envelopment Analysis) – allows the use of multiple inputs/outputs without imposing any functional form on data or making assumptions of inefficiency. Technical Efficiency refers to the ability of a fish farmer to get the maximum output for a given set of inputs, with reference to a production function. Conversely, Allocative Efficiency concerns the ability of a tilapia farmer to use the inputs and produce outputs in optimal proportions given their prices. These two measures are combined to provide the measurement of total Economic Efficiency. The DEA model permits the measurement of both when we have information about prices and we want to consider a behavioral objective, such as minimizing costs and maximizing revenues. In the production-oriented models, DEA proposes the identifying of inefficiency as a proportional increase in production use. An input-oriented model for technical inefficiency with a proportional decrease in the use of the inputs can be used.

Results and Discussion

For making comparison among farmers, large and small farm size categories are identified. Farmers having pond size less than 200 decimals are considered as small and having pond size more than 200 decimals are considered as large farmers. For estimating profitability, cost items were classified into variable cost and fixed cost. Pond preparation, application of lime and salts, fingerlings, feed, carrying, labor, harvesting, electricity cost, marketing cost, medicine and miscellaneous costs were considered as variable cost. Variable cost varies the overall farm income. Lease value of land and construction of water supply and housing of the farm are fall into the category of fixed cost.

Profitability analysis of the large tilapia farmers

Farm profit was increased with the decreasing of variable costs. The cost of pond preparation was varied due to the size of a pond. It is necessary for a farm to prepare the pond for fish culture. The study revealed that the average cost of pond preparation of the large farmer was Tk. 19784.06 per hectare, which was 3.85% of total variable cost. For a better management of a farm, appropriate preparation of a pond must be needed before application of fingerlings to the pond.

Table 1. Profitability analysis of the large tilapia farmers (per hectare).

Item	Values (Tk.)	% of total variable costs
Pond preparation	19784.06	3.85
Lime	5426.78	1.06
Salt	3559.72	0.69
Fingerlings	92468.11	17.99
Feed	307945.06	59.90
Carrying cost	13573.22	2.64
Labor	72755.56	14.15
Electricity cost	11023.94	2.14
Marketing cost	2818.29	0.55
Medicine and miscellaneous cost	2567.28	0.50
Total variable cost	514122.014	89.90
Lease value of land	16840.00	58.99
Construction of water supply and housing cost	11706.58	41.01
Total fixed cost	28546.58	10.10
Total cost	571893.81	100.00
Return	Values	
Return from tilapia	426771.06	
Return from other fish	266701.11	
Total Return (TR) or Gross Return (GR)	693472.17	
Gross Margin (GM)	169350.16	
Net Return (NR)	121578.36	
Benefit Cost Ratio (BCR)	1.213	
Gross Profit Margin (GPM)	24.42%	
Net Profit Margin (NPM)	17.53%	
Break-even Price (BEP)	BDT 77.33 kg^{-1}	
Break-even Production (BEPr)	1159.64 kg	

Lime varies the yield of tilapia culture. The estimated values of lime calculated Tk. 5426.78 per hectare, which was 1.06% of total variable costs. The study revealed that cost of lime directly affect the tilapia production. Salt is also an important input variable for fish culture specially tilapia production. The estimated average cost of salt was Tk. 3559.72, which is 0.69% of the total variable costs. Therefore, this variable affects the ultimate production of tilapia. Farmers used purchased fingerlings except some large fish farmers from the fingerlings collectors and hatchery. There was a variation in the per unit price of fingerlings from location to location and time to time. Therefore, fingerling cost was calculated based on actual price paid by farmers in different times. The average price of fingerling was Tk. 1 per piece and average stocking density per hectare was about 55700. Per hectare fingerling cost found Tk. 92468.11 which was 17.99% of average total variable cost. Supplementary feed was applied for better growth and survival of tilapia fingerlings. Feed cost was varied by the seed agents or small shopkeepers or location and volume. In the study area, it was observed that the tilapia farm owners used different kinds of supplementary feeds.

Total cost of feed per hectare was Tk. 307945.06, which was about 59.90% of average variable cost. In the selected area, some large farmers were applied feed from their home made feed for tilapia culture instead of buying from the market for maximizing profit. Carrying costs were varied from location to location and time to time. The calculated average cost for carrying of feeds was Tk. 13573.22, which was about 2.64% of the average variable cost of per hectare tilapia production. Both family and hired labor were used for the tilapia production. Most of the fish farmers were small in size and they were used only family labor. The prevailing wage rate in the market for hired labor was considered as the opportunity cost of family supplied labor. In the study area, a man-day was considered to be 8 hours of work. For avoiding complexity, average rate has been taken into account, thus the average calculated wage rate was Tk. 400.00 per man-day for tilapia farming. The average labor cost of per hectare was found about Tk. 72755.56 and that was 14.15% of average variable cost for tilapia production. In the harvesting period, farmers need more extra labor for catching fish and grading according to their size. There was also a costs involved for harvesting of hired net

cost. This cost was adjusted to the labor account. In this study, electricity cost was varied due to the depth of a pond. The calculated average values of electricity cost in per hectare production of tilapia was Tk. 11023.94 and it was 2.14% of total average variable cost. Marketing cost was involved in the selling of tilapia in the market. The farmers who were sold their fish in the farm gate, for whom was not included the market cost. The average marketing cost for one hectare was Tk. 2818.29, which was 0.55% of total average variable cost. There was involved some miscellaneous cost like medicine, matrix etc. in the tilapia farming and combine tilapia culture. The estimated per hectare miscellaneous cost was Tk. 2567.28 which was about 0.5% of total average variable cost. The lease value of pond was varied due to the ownership of land, which was actually fallow land for some farmers. For calculating the cost of tilapia production, land leasing cost was calculated Tk. 16840 per hectare which was 58.99% of total fixed cost on average. Water supplying canal was used in the tilapia farm in order to facilitate the intake and drain out of water when necessary. The estimated average cost for water supply and housing construction was about Tk. 11706.58 and it was 41.01% of total fixed cost on an average. The study revealed that the average total variable cost was Tk. 514122.014, which was about 89.9% of the total cost. Therefore, the profit of tilapia production was depended exactly on total variable cost. In this study, total fixed cost was Tk. 28546.58 per hectare for tilapia production, which was 10.1% of total cost for per hectare production of tilapia.

Seventy (70) tilapia farmers were selected in which 36 farmers were lies in large category and data were collected through direct interview method. Financial profitability was analyzed from different point of view. Benefit cost ratio and net profit margin were found more than one and positive respectively, indicated that the tilapia farming was commercially profitable. From the Table 1, the estimated total variable cost was Tk. 514122.014, total fixed cost Tk. 28546.58, and total cost Tk. 571893.81 per hectare within the production period. The study shows that the estimated return from tilapia was Tk. 426771.17 per hectare within the production period. The return from other fish which was cultured with the combination of tilapia production was calculated Tk. 266701.11 per hectare. Gross margin from per hectare tilapia farming was found Tk. 169350.16 and benefit-cost ratio was1.213 mentioned in Table 1. It implies that by investing Tk. 1, farm earned Tk. 1.213 indicates that the tilapia farming was profitable. Study revealed that gross profit margin was 24.42%, which indicates managing cost of sales and other expenses is 75.58%. In other words, about 24.42% of the revenue is available that earned from total sale in the farm after covering costs. Study also revealed that the net profit margin was 17.53%. It means, it managed to convert 17.53% of its sale into net income of tilapia farming. Study also found the break-even price was Tk. 77.33 per kg. At this break-even price level, farm can cover the cost of production by selling tilapia. The study revealed that the average weighted price (Tk. 100.21) exceeds the break-even price (Tk. 77.33) per kg of fish. Since per hectare of production, gross return and per kg of price higher than the break-even point. That's why, the tilapia farming was financially profitable venture in the study area. Study also found the break-even production was 1159.64 kg per hectare. This break-even production was higher and farm was profitable.

Profitability analysis of the small tilapia farmers

The study revealed that the average cost of pond preparation of the small farmer was Tk. 27791.82 per hectare, which was 4.51% of total variable cost. The estimated values of lime calculated Tk. 5815.06 per hectare, which is 0.94% of total variable costs. The estimated average cost of salt was Tk. 3992.12, which was 0.65% of the total variable costs. Per hectare fingerling cost of small farmer found Tk. 112855.65, which was 18.3% of average total variable cost. Total cost of feed per hectare was Tk. 331710, which was about 53.79% of average variable cost. The calculated average cost for carrying of feeds was Tk. 18458.53, which was about 2.99% of the average variable cost of per hectare tilapia production. The average labor cost of per hectare was found about Tk. 96223.53 and that was 15.6% of average variable cost for tilapia production. The calculated average values of electricity cost in per hectare production of tilapia was Tk. 13369.24 and it was 2.17% of total average variable cost. The average marketing cost for one hectare was Tk. 2646.24, which was 0.43% of total average variable cost.

Table 2. Profitability analyses of the small tilapia farmers (per hectare).

Item	Values (Tk.)	% of total variable costs
Pond preparation	27791.82	4.51
Lime	5815.06	0.94
Salt	3992.12	0.65
Fingerlings	112855.65	18.30
Feed	331710.00	53.79
Carrying cost	18458.53	2.99
Labor	96223.53	15.60
Electricity cost	13369.24	2.17
Marketing cost	2646.24	0.43
Medicine and miscellaneous cost	3842.41	0.62
Total variable cost	616704.60	93.74
Lease value of land	16840.00	40.91
Construction of water supply and housing cost	24328.56	59.09
Total fixed cost	41168.56	6.26
Total cost	657873.16	100.00
Return	Values	
Return from tilapia	495692.00	
Return from other fish	313626.47	
Total Return (TR) or Gross Return (GR)	809318.47	
Gross Margin (GM)	192613.87	
Net Return (NR)	151445.31	
Benefit Cost Ratio (BCR)	1.23	
Gross Profit Margin (GPM)	23.8%	
Net Profit Margin (NPM)	18.71%	
Break-even Price (BEP)	BDT 81.56 kg^{-1}	
Break-even Production (BEPr)	1584.63 kg	

In this study, it was mentioned that the cost of pond preparation of a large farmers is higher than the small-scale tilapia farmers. Due to the fluctuation of labor wage rate and family labor, the cost of pond preparation was diversified. The study revealed that the estimated per hectare miscellaneous cost was Tk. 3842.41 which was about 0.62% of total average variable cost. For calculating the cost of small-scale tilapia production, land leasing cost was calculated Tk. 16840 per hectare which was 40.91% of total fixed cost on average. The study revealed that the estimated average cost for water supply and housing construction was about Tk. 24328.56 and it was 59.09% of total fixed cost on an average. The study found that the average total variable cost was Tk. 616704.60, which was about 93.74% of the total cost. In this study, total fixed cost of small-scale tilapia farmer was Tk. 41168.56 per hectare for tilapia production, which was 6.26% of total cost for per hectare production of tilapia. Seventy tilapia farmers were selected in which 34 farmers were lies in small category and data were collected through direct interview method. From the above table, the estimated total variable cost was Tk. 616704.6, total fixed cost Tk. 41168.56, and total cost Tk. 657873.16 per hectare within the production period. The study revealed that the estimated return from tilapia was Tk. 495692 per hectare. The return from other fish which was cultured with the combination of tilapia production was calculated Tk. 313626.47 per hectare. Gross margin from per hectare tilapia farming was found Tk. 192613.87 and benefit-cost ratio was 1.23 mentioned in table 2. It implies that by investing Tk. 1, farm earned Tk. 1.23 indicates that the tilapia farming was profitable. Study revealed that gross profit margin was 23.80% which indicates that about 23.80% of the revenue was available that earned from total sale in the farm after covering costs. The net profit margin was 18.71%. It means, it managed to convert 18.71% of its sale into net income of tilapia farming. Study also found the break-even price was Tk. 81.56 per kg. At this break-even price level, farm can cover the cost of production by selling tilapia. The study revealed that the average weighted price Tk. 102.44 exceeds the break-even price Tk. 81.56 per kg of fish. Since per hectare of production, gross return and per kg of price higher than the break-even point. That's why, the tilapia farming was financially profitable venture in the study area. Study also found the break-even production was 1584.63 kg per hectare. This break-even production was higher and farm was profitable.

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Factors influencing tilapia production

The independent variables have a great influence on the yield of tilapia production. There were selected 8 most important variables in the Cobb-Douglas production function for determining the effects of the input variables. A correlation test was also conducted and multi co-linearity effects of the variables were excluded from the analysis. In table 3, the estimated values of coefficient and related statistics was presented.

The regression coefficient of feeds positively related to the tilapia culture. The result of coefficient found that 0.28 at 1% level of significant. It implied that an increase in feed use by one percent with other factors remaining same would increase by 0.28 percent of tilapia production. The production of tilapia would increase with the increased by feed used. Similarly, the regression coefficient of labor was significant at 1% level. The coefficient was 0.18 (p value 0.02) indicates that an increase in labor employment by one percent, remaining other factors constant, would increase the tilapia production by 0.18 percent. Electricity cost was positively related to the tilapia production. At 1% level of significant, the coefficient of electricity was 0.25 having p value 0.00. These results implied that the one percent increase in irrigation, would occur 0.25 percent positive changed in production of tilapia.

Lime was negatively related to the tilapia production. The regression coefficient of lime was significant at -0.12, indicated that an increase of lime cost, other factors remaining constant, would decrease the tilapia production by 0.12 percent. The cost of pond preparation was positive and insignificant. It implied that the production of tilapia would increase by 0.09 percent, keeping the other factors constant, if farmers increase one percent additional cost for tilapia production. Fingerling cost and training was negatively related to the tilapia production and insignificant. These results implied that the production of tilapia would decrease. The caring cost was positive and significant. It implied that the production of tilapia would increase by 0.09 percent, keeping the other factors constant, if farmers increase one percent additional carrying cost would increase the tilapia production by 0.9 percent. Station conduction and education of the tilapia farmer was positively related and insignificant. So, there was no effect of the conduction of the station for tilapia farming.

Table 3. Estimated values of coefficient, standard error and p-value of Cobb-Douglas production function of tilapia culture.

Particulars	Coefficients	Standard Error	P-Value
Intercept	5.30	0.99	0.00
Ln cost of pond preparation	0.09	0.06	0.14
Ln cost of lime	-0.12*	0.06	0.06
Ln cost of fingerlings	-0.04	0.08	0.61
Ln cost of feed	0.28***	0.05	0.00
Ln carrying cost	0.09*	0.06	0.10
Ln labor cost	0.18***	0.07	0.02
Ln electricity cost	0.25***	0.08	0.00
Ln training	-0.05	0.12	0.69
Conduct of station	0.05	0.15	0.76
Education (year of schooling)	0.00	0.01	0.68

*Note: *** indicates at 1%, ** indicates at 5% and * indicates at 10% level of significance.*

Efficiency analysis of tilapia farmer

Economic efficiency gives us this idea whether the farm is operating on optimal condition or not. Technical efficiency differs from 0 to 1. That means if technical efficiency (TE) is 0 then the farm is fully inefficient and if 1 then the farm is fully efficient. When we consider the input quantities with the output, we can take the assumption of constant return to scale for calculating technical efficiency. However, if we take consideration about price too, we use variable returns to scale. The technical efficiency, allocative efficiency and cost efficiency for individual tilapia fish farmer is discussed here.

Many studies show that the TE scores obtained from a CRS DEA into two components. One is scale inefficiency and other is pure technical inefficiency. If there are two different TE scores for a particular DMU, there is scale efficiency. The scale efficiency can be calculated from the difference between the VRS TE score and CRS TE score. In that study area, most of the tilapia farmers were in a state of technologically inefficient in that is stated table 4. Among them, the number of tilapia farmers whose technical efficiency value was less than 0.7 account for 16.67% of the total number of fish farmers, the number of tilapia farmers whose technical efficiency value was greater than or equal to 0.7 and less than 0.8 account for 26.67% of the total number of tilapia farmers; the number of tilapia farmers whose technical efficiency was greater than or equal to 0.8 and less than 0.9 account for 21.67% of the total number of tilapia farmers; the number of tilapia farmers whose technical efficiency value was greater than or equal to 0.9 and less than or equal to 1.0 account for 35% of

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the total number of tilapia farmers. Allocative efficiency was 1 about 1.67% of the total farmers, efficiency is between 0.7 to 1.0 was about 80% farmers and below or equal to 0.7 is about 18.33% farmers. Among 70 farmers, farmer no 5 was fully costs efficient farmer which was about 1.67% of total farmers, efficiency is between 0.6 to 1.0 was about 53.33% farmers and below or equal to 0.6 is about 45% of total farmers.

Table 4. Calculating technical efficiency, allocative efficiency and cost efficiency for individual fish farmers.

Technical efficiency		
Interval	No. of fish farmer	percentage
TE<0.7	14	16.67%
0.7≤TE≤0.8	18	26.67%
0.8≤TE≤0.9	15	21.67%
0.9≤TE≤1.0	23	35.00%
Total	70	
Allocative efficiency		
Interval	No. of fish farmer	percentage
0.5-0.7	10	14.29%
0.7-0.8	38	54.29%
0.8-0.9	16	22.86%
0.9-1.0	6	8.57%
Total	70	
Cost efficiency		
Interval	No. of fish farmer	percentage
0.40-0.60	32	45.71%
0.61-0.70	24	34.29%
0.71-0.80	9	12.86%
0.81-1.00	15	21.43%
Total	70	
Mean value of technical, allocative and cost efficiency		
	Mean	Mean %
Technical efficiency	0.818	81.8
Allocative efficiency	0.775	77.5
Cost efficiency	0.632	63.2

Percentage of costs efficient farmer is calculated by % of farmers= $(No.\ of\ farmers \div 70) \times 100$

Table 5. Comparison of Technical efficiency in CRS and VRS using multistage method.

Scale	Fully Technically Efficient farmers	Percentage
Constant returns to scale (CRS)	12	17.14%
Variable returns to scale (VRS)	47	67.14%

From the above table we see, under constant returns to scale assumption technical efficiency is 1 for 17.14% and variable returns to scale assumption technical efficiency is 1 for 67.14% where scale efficiency is 1 for 17.14% of the total tilapia fish farmers. But when we use constant return to scale instead of variable returns to scale than 12 farmers become fully efficient where efficiency increases for 57 framers.

Table 6. Comparison of average for CRS, VRS and SE.

	Mean	Mean %
CRS(TE)	0.818	81.8
VRS(TE)	0.931	93.1
SE(TE)	0.882	88.2

In the above table; Mean of the Variable Returns to Scale is highest (93.1%). The lowest mean of the Cost Return to Scale (81.8%).

Conclusion

Tilapia fish farming among local fish farmers with limited financial resources remains a challenge. Most of the tilapia fish farmers face the challenge of unavailability of start-up capitals, high operating cost and poor management skill. Financial profitability and technical efficiency analysis is an important tool necessary for business planning, seeking financial assistance and successful management of the fish farm.

For getting higher production it is an important criterion, average return to each taka invest on

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production for measuring profitability of tilapia production. On an average, benefit cost ratio was found for the large-scale tilapia producer to be 1.213 and small-scale tilapia producer was found to be 1.230 based on total fixed cost and variable cost. The small-scale tilapia producers were more profitable along with production than large-scale tilapia producers. It indicates that overall performance of tilapia production in the study areas is encouraging in terms of profitability. This difference has resulted due to the variation in input use and poor management at farm level. To increase tilapia yield, the existing production practices of tilapia at farm level needs to be identified first. Adoption of new technology and production practices may be varied by the farmer's experiences on tilapia production, education, training and proper management skills. Variation in amounts in different factors of production and production pattern are responsible for yield difference among farmers and pond utilization.

Study also revealed that gross profit margin of the large farmers was 24.42% and small scale farmers was 23.80% indicating that farmers did not enough well in managing their farm and farmers has less to cover for operating, financing and other cost. Break-even price for the large tilapia farmers worked out Tk. 77.33 per kg and small farmers was Tk. 81.56 per kg while break-even production for large farmers was found 1159.64 kg per hectare. Benefit cost ratio and net profit margin were found more than one and positive respectively, indicated that tilapia farming was commercially profitable. Considering all selected farmers, tilapia farming found a profitable business where undiscounted BCR for large farmers was 1.213 and small farmer was 1.230. This study used the data envelopment analysis to estimate the efficiency. The mean technical efficiency level of tilapia fish farmers was 81.8 where allocative efficiency was 93.1 and scale efficiency was 88.2 percent, implies that by operating at full technical efficiency levels, tilapia yield could be increased and efficient farmers found more productive than inefficient farmers did. The results of technical efficiency showed that the farmers were efficient nevertheless the sample farmers operated well below the production frontier and hence that they still had a chance to achieve targeted yields. Farmers financial benefit can be increased by reducing the feed price or increasing the output price. Feed price reduction or enhance the quality of feed could be effective policy options for sustaining the tilapia farming. There is necessary to have a better farm management knowledge to maximize profit. Financial profitability of tilapia farmer was estimated by using their different type of input and output variable. To determine the effect of production inputs, 10 important variables were included in a Cobb Douglas production function.

A highly significant F and R square- value also indicated that the included variables collectively are important for explaining the variation in yield. Lime costs, feed costs, carrying costs, labor costs and electricity cost are significant variable of the study area. In times of operating a farm, to make an optimal use of inputs for getting best possible output is essential. Hence, economic efficiency given us this idea whether the farm is operating on optimal condition or not. Technical efficiency differs from 0 to 1. That means if technical efficiency is 0 then the farm is fully inefficient and if 1 then the farm is fully efficient. When we consider the input quantities with output we can take the assumption of constant returns to scale for calculating technical efficiency. The average technical, allocative and cost efficiency scores for tilapia was 81.8%, 93.1% and 88.2% respectively. Hence, among 70 farmers, 18.33% farmers are fully technical efficient, 18.33% farmers are fully allocative and 53.33% farmers are fully cost efficient.

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