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DOES FARMERS' EDUCATION AFFECT THE PROFITABILITY OF SHRIMP FARMING? EVIDENCE FROM THE COASTAL REGION OF BANGLADESH

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Abstract

This study explores the impact of farmers' level of education on the profitability of shrimp farming. The authors have collected data from a sample of 200 shrimp farmers in three districts in the southwest region of Bangladesh, namely Khulna, Bagerhat, and Satkhira, using a proportionate random sampling technique. The shrimp farmers' education and productivity status are investigated through descriptive statistics. The authors estimated a Cobb-Douglas Production Function (CDPF) to examine the effect of farmers' level of education on the profitability of shrimp farming. Using a Tobit regression model, this study tried to investigate the association between the educational attainment of farmers and their degree of knowledge in farm management. The study finds that the average level of shrimp production in southwestern Bangladesh is 425 kg per hectare, resulting from the absence of modern farming methods and a deficiency in adequate farming knowledge. The activity budget equation illustrates that farmers with higher education levels exhibit greater profitability compared to their less educated counterparts. The analysis of efficiency factors of production (EFP) indicates that farmers with higher education levels exhibit greater efficiency than their counterparts with lower education levels. The break-even point (BEP) analysis reveals that the average production volume, price, and the gher size in the study area outstrip the BEP threshold, suggesting that shrimp farming in this region is economically feasible. The analysis of field-level data reveals a strong association between farmers' level of education and their profitability, suggesting that higher levels of education among farmers have a substantial positive impact on their financial gains. It is evident from the study findings that knowledge of farm management plays a significant role in shrimp productivity. Therefore, the degree of farm management knowledge is affected by the education of the farmers. Consequently, this research suggests augmenting the accessibility of contemporary technology-driven farming methods and effectively utilizing information via a training initiative targeting shrimp farmers. Additionally, this study recommends offering incentives or credit opportunities to newly participating educated farmers.

Keywords: Farmers' education, Shrimp, Profitability, Farm management knowledge, Farming method.

Introduction

The shrimp farming practice has made remarkable strides worldwide, more intensively in Asian countries than in non-Asian countries due to favorable climatic conditions (Garlock et al., 2020). The aquaculture sector is experiencing rapid growth, accompanied by several transformations and stumbling blocks triggered by climate change and the expansion of international trade (Hossain et al., 2022). Shrimp farming plays an indispensable part in driving the economic growth of the coastal region of Bangladesh (Azad et al., 2009). The time frame from 2000 to 2020 experienced a substantial upsurge in the cultivation and export of shrimp in Bangladesh (Washim et al., 2020).

Approximately 203,071 hectares of coastal shrimp farms produced an annual average of 75,167 metric tons of shrimp, or 235 kilograms per hectare (DOF, 2021). As Alam et al. (2005) indicated, shrimp production holds the second position in Bangladesh's economic sectors regarding its capacity to generate significant foreign currency, following the garment sector. The shrimp industry in Bangladesh is an important source of employment for rural people and plays an essential part in sustaining households across the country (Mondal et al., 2013; Ahmed et al., 2021; Tikadar et al., 2022). The shrimp industry has undergone significant transformations in terms of geographical

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coverage, output, and improvements in quality and marketing strategies (Hossain et al., 2013; Dhar et al., 2020). According to Hossain et al. (2013), it is evident that more extensive operations have the capacity to offer relatively high-paying employment possibilities.

Aquaculture is a rapidly expanding industry that offers an opportunity to improve livelihoods, ensure food security, and generate export earnings in several Asian nations (Washim et al., 2020; Hein, 2002). In the opinion of Feder et al. (1985), the education process promotes the development of a receptive mindset towards innovative methodologies. Numerous scholarly investigations, such as those conducted by Panda (2002), Alene and Manyong (2007), Adhiguru (2004), Ali and Kumar (2011), and Begum et al. (2013), have consistently demonstrated a worthwhile and preferable association between farmers' level of education and their propensity to accept new farming methods. According to Borthakur et al. (2015), the adoption behavior of a significant portion of farmers with lower education and skills is negatively affected by the degree of technical complexity.

According to Ali and Kumar (2011), the coastal region of Bangladesh exhibits a substantial proportion of educated individuals within the working-age population who are now experiencing unemployment. In the context of a developing nation, there is a persistent endeavor to generate job prospects for the substantial percentage of the educated working-age population that remains unemployed (Begum et al., 2013; Chowdhury et al., 2006). The proliferation of sustainable shrimp farming is a necessary prerequisite for the goal of sustainable socioeconomic development. The implementation of various technological advancements, the establishment of appropriate institutional frameworks to facilitate knowledge acquisition, and the systematic monitoring of environmental and social specifications are essential for addressing the identified challenges (Dierberg & Kiattisimkul, 1996; Primavera, 1997; Stonich & Bailey, 2000; Hein, 2002; Alam et al., 2005; Macusi et al., 2022).

The prevailing body of research on the beneficial impacts of education has mainly centered around agricultural yield, while the investigation of informal educational approaches remains relatively limited. There is an inchoate of comprehensive studies about the precise impact of farmers' education and farm management knowledge. The researchers have synthesized the knowledge acquisition process components by reviewing relevant literature (Paltasingh & Goyari, 2018; Marenya et al., 2003). The level of participation among educated farmers in shrimp farming in Bangladesh is comparatively lower than in other countries engaged in shrimp farming. This can be attributed to the limited productive efficiency and the absence of modern technology, resulting in lower profitability (Hein, 2002; Paez-Osuna et al., 2003; Chowdhury et al., 2006; Azad et al., 2009). Furthermore, it is essential to consider that farm productivity is significantly influenced by the level of farm management knowledge (Hossain et al., 2013; Nazu et al., 2021).

Recognizing the said gap, this study aims to analyze the effect of farmers' education on the profitability of shrimp farming. All kinds of visible and invisible education have been covered in the study concerning shrimp productivity. It is necessary to mention in this context that education has two components: (a) education for shrimp cultivators, which improves their skills and replaces their traditional attitudes with modern ones, which improves their innovative and allocative capabilities, and (b) research and training, contact with educated farmers and regular communication with local fisheries extension officer about shrimp production improves their new techniques of cultivation and new input as well (Begum et al., 2013; Ali & Kumar, 2011; Appleton & Balihuta, 1996; Devi & Ponnarasi, 2009). The broad aim was divided into two specific research questions, which are as follows:

i) What is the association between farmers' education and the profitability of shrimp farming?
ii) Does farmers' education enhance the level of farm management knowledge of the shrimp farmers?

Materials and Method

Sampling Technique and Data Description

The practice of shrimp farming in Bangladesh brings about a substantial influence on the socioeconomic status of coastal people. The majority of shrimp farms, accounting for 70 percent, are situated in the southwestern region of Bangladesh, specifically in the districts of Bagerhat, Khulna, and Satkhira. These farms contribute 77 percent of the nation's total shrimp production (DOF, 2021; Joffre, 2018). Farmers who are directly linked with shrimp cultivation are included in the sampling frame in the present study. The authors collected a list of all farmers from the fisheries extension office. The authors used the proportionate random sampling technique for collecting data from shrimp farmers that indicates each farmer has an equal chance to be a respondent concerning their numbers (Dhar et al., 2020). A total of 200 sample farmers have been chosen from a population of 1,298 by following the proportionate random sampling equation (i).

$$n = \frac{NZ^2P(1-P)}{ND^2+Z^2P(1-P)} \ldots\ldots\ldots\ldots\ldots\ldots\ldots (i)$$

In this context, the variables are defined as follows: n represents the sample size, N denotes the total number of farmers in the population, Z represents the confidence level, with a value of 1.96 for a 95% confidence level, P represents the estimated population proportion, set at 0.5 to maximize the sample size, and D represents the error limit, which is 10% or 0.1. The authors employed proportionate random sampling to select the necessary number of samples from the population, as indicated by Equation (i). The apportion of the sample size is presented in Table 1.

Table 1. Sample distribution

Districts	Upazila	Union	Population	Sample size
Khulna	Batiaghata	Batiaghata	52	35
Bagerhat	Rampal	Rampal Sadar	922	90
Satkhira	Assasuni	Shriula	324	75
Total	03	03	1,298	200

Source: Fisheries Extension Office, 2022

Analytical Techniques

This paper incorporates descriptive and econometric analysis to achieve its purpose. Descriptive statistics are employed as an initial approach to delineate and characterize socioeconomic status and production. The investigation of the factors that influence shrimp profitability is conducted through the utilization of the Cobb-Douglas production function (CDPF). Furthermore, the study applied a Tobit regression model to analyze the factors affecting farm management knowledge.

Cobb-Douglas Production Function

The authors used the Cobb-Douglas production function (CDPF) to examine the influence of production factors and farmers' education on shrimp productivity. The literature recommends utilizing a linear production function to assess the linear correlation between inputs and outputs (Asadullah & Rahman, 2009; Begum et al., 2013). The coefficients of a linear function exhibit a presumption of constant marginal productivity, indicating a limited degree of interaction between the inputs. Therefore, in order to address the limitations of the linear production function, the Cobb-Douglas production function emerges as a more favorable alternative (Reimers & Klasen, 2013; Pinckney, 1997). Equation (ii) depicts the production function of shrimp cultivators.

$$Q = f(X_{i,}\beta_i) + \varepsilon_i \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (ii)$$

Where, Q = Farm Output, X_i = explanatory variables for i^{th} observation, β_i = estimated coefficient of the explanatory variables for i^{th} observation, ε_i = stochastic error terms

The empirical model of the Cobb-Douglas production function is represented in Equation (iii).

$$Q_i = \alpha_0 X_{1i}^{\alpha 1} X_{2i}^{\alpha 2} X_{3i}^{\alpha 3} X_{4i}^{\alpha 4} X_{5i}^{\alpha 5} X_{6i}^{\alpha 6} X_{7i}^{\alpha 7} X_{8i}^{\alpha 8} X_{9i}^{\alpha 9} e^{\varepsilon i} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (iii)$$

The considered variables for the CDPF model are presented in Table 2.

Table 2. Variables for Cobb-Douglas production function

Variables	Symbol	Unit of Measurement
Explained Variable		
Farm Output	Q_i	BDT (Last year)
Explanatory Variables		
Gher size	X_1	Hectare
Pumping	X_2	BDT (Last year)
Fingerling's cost	X_3	BDT (Last year)
Insecticide cost	X_4	BDT (Last year)
Labor cost	X_5	BDT (Last year)
Lime cost	X_6	BDT (Last year)
Feed cost	X_7	BDT (Last year)
Transportation cost	X_8	BDT (Last year)
Farmer's Education	X_9	Year of Schooling

Source: Authors' Compilation based on literature survey, 2022

Activity Budget Equation

The measurement and comparison of profitability among various farm households and technologies is commonly conducted through an activity budget, as demonstrated by Rahman et al. (2013). Profit can be defined as the numerical outcome obtained by subtracting the total cost from the total revenue. To ascertain the profitability per hectare for each of the specified shrimp farming methods, as perceived by individual farmers, an algebraic equation might be formulated, which is as follows (equation iv):

$$\pi = TR - TC \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(iv)}$$

$$\pi = \sum (Q_Y . P_Y) + \sum (Q_b . P_b) - \sum_{i=1}^{n} (X_i . P_{xi}) - TFC \ldots\ldots\ldots\ldots \text{(v)}$$

Where, TR = Total Revenue; TC = Total Cost, π = Net returns from shrimp (BDT/ha); Q_y = Total quantity of (shrimp) outputs (kg/ha); Py = Per unit prices of the shrimp (Tk/kg); Q_b = Total quantity of the concerned byproduct (kg/ha); P_b = Per unit prices of the relevant byproduct (Tk/kg); X_i = Quantity of the concerned i^{th} inputs; P_{xi} = Per unit price of the concerned input; TFC = Total Fixed Cost.

Efficiency Factors of Production

The authors used the allocation of efficiency factors of production (Ki) to examine the allocative efficiency of production factor utilization in the context of shrimp production. This analysis was conducted using the formula proposed by Marsudi and Zikri (2020):

$$K_i = \frac{\beta_i . Y . P_Y}{X_i . PX_i} = \frac{\text{Marginal Production Value (MPV)}}{\text{Marginal Production Cost (MPC)}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (vi)$$

Where, β_i= coefficient of production inputs generated from Cobb-Douglas production function; Y = average shrimp production; Py= average shrimp price; X_i = average quantity of production inputs, and PX_i = average cost of production inputs. K_i = 1 demonstrates that the utilization of production factors is efficient; K_i <1 refers to the inefficient utilization of inputs; and K_i > 1 means that the applied inputs are not efficient yet. In order to measure the surface area of a pond under break-even point (BEP) conditions, the authors relied on a break-even methodology as suggested by Marsudi and Zikri (2020).:

$$\text{BEP of production volume} = \frac{\text{Total Production Costs}}{\text{Selling Price of Shrimp}} \ldots\ldots\ldots\ldots\ldots (vii)$$

$$\text{BEP of production price} = \frac{\text{Total Production Cost}}{\text{Total Production}} \ldots\ldots\ldots\ldots\ldots\ldots (viii)$$

$$\text{BEP of land pond scale} = \frac{\text{BEP of production volume}}{\text{Total production/Bigha}} \ldots\ldots\ldots\ldots\ldots (ix)$$

Tobit Regression Model

In an effort to explore the second research question, several studies have suggested that obtaining knowledge of farm management has a beneficial effect on productivity (Huq et al., 2007; Kumar et al., 2012; Samal et al., 2011). The accumulation of knowledge related to farm management encompasses various aspects such as gher preparation, monitoring water quality, disease surveillance, disease control, post-larvae collection, and stocking density (Paltasingh & Goyari, 2018; Marenya et al., 2003; Alene & Manyong, 2006). The measurement of farm management knowledge is usually carried out using a three-point Likert scale, where a rating of 3 indicates high knowledge, 2 indicates medium knowledge, and 1 indicates low knowledge. To assess the farmers' degree of farm management knowledge, the study determined their rank by calculating the obtained score and maximum score for the individual households. The estimated Equation is measured as follows:

$$\text{Level of Farm Management Knowledge} = \frac{\sum \text{Obtained Score}}{\text{Maximum Score}} \times 100 \qquad \text{(x)}$$

Oladele (2005) used the Tobit model to find the determinants of farmers' discontinued technology adoption behavior. In this study, the Tobit regression model was constructed to examine factors that influence farm management knowledge in shrimp farming. Here, the dependent variable is farm management knowledge, and it is censoring data. Equation (xi) expresses the Tobit regression model.

$$y^* = \beta_i X_i + \mu_i \ldots\ldots\ldots\ldots\ldots\ldots \text{(xi)}$$

Where, $y = y^* if\ y^* \geq 0, y = 0\ if\ y^* < 0,$

Here, X_i = Explanatory variables, β_i = Coefficient of the explanatory variables, and μ_i = stochastic error term. The functional form of the Tobit model for estimating the determinants of farm management practice is illustrated in Equation (xii).

$$Y_i = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \beta_3 X_{3i} + \beta_4 X_{4i} + \beta_5 X_{5i} + \beta_6 X_{6i} + \mu_i \ldots\ldots\ldots\ldots\ldots \text{(xii)}$$

The considered variables for the Tobit regression model are presented in Table 3.

Table 3. Variables for Tobit Model

Variables	Symbol	Unit of Measurement
Explained Variable		
Farm Management Practice	Y_i	Index value (Percentage)
Explanatory Variables		
Farming Method	X_1	Traditional = 1; Extensive = 2; Semi-Intensive = 3; Intensive = 4
Educational Status	X_2	Year of Schooling
Farming Experience	X_3	In years
Contact with Educated Farmers	X_4	Yes = 1, 0 = Otherwise
Training	X_5	Yes = 1, 0 = Otherwise
Access in FEO	X_6	Yes = 1, 0 = Otherwise

Source: Authors' Compilation based on literature survey, 2022

Marginal Effect

The marginal effect helps to understand the exact degree of relationship among variables. Using the marginal coefficient, the precise probability of the success variables was determined. The marginal effect was estimated by using Equation (xiii).

$$\frac{dp_i}{dX_i} = \frac{e^{\beta x_i}}{(1 + e^{\beta x_i})^2} \beta_i \ldots\ldots\ldots\ldots\ldots\ldots\ldots (xiii)$$

Results

Socioeconomic Characteristics of the Shrimp Farmers

Table 4 illustrates the socioeconomic status of the 200 shrimp farmers within the specified study area. The analysis of the age distribution shows that a majority (54.00 percent) of the farmers scrutinized are between the ages of 21 to 40, but a significant proportion (44.50 percent) are within the age range of 41 to 60 years. The mean age of the individuals engaged in shrimp farming is 42 years. The primary focus of this study is to deal with education. Extensive study indicates that education exerts a tangible as well as noticeable effect on productivity (Dhar et al., 2020).

The distribution of 200 individuals engaged in shrimp farming is portrayed in Table 4, categorized based on the level of education they have obtained. Out of 200 respondents, 55 percent of farmers were literate, and the remaining 45 percent were illiterate. The farmers, who were literate, only completed the primary level (1-5 classes) of formal education. Narrowly, we found that a large number of shrimp farmers are deprived of education due to the lower standard of living and poverty.

Table 4. Socioeconomic characteristics of the shrimp farmers

Variables	Frequency	Percentage	Mean	Standard Deviation
Age (in Years)				
21 – 40	108	54.00		
31 – 60	89	44.50	42.12	8.50
60 and above	3	1.50		
Educational Status (Year of Schooling)				
0	90	45.00		
1 – 5	32	16.00		
6 – 10	46	23.00		
11 – 12	19	9.50	4.58	5.06
13 – 16	10	5.00		
17 and above	3	1.50		
Family Size (in Numbers)				
1 – 3	61	30.50		
4 – 6	124	62.00	4.28	1.40
7 – 9	15	7.50		
Household Income (in BDT/Month)				
5,000 – 25,000	171	85.50		
25,001 – 45,000	28	14.00	19,345	7,809
45,001 and above	1	0.50		
Household Expenditure (in BDT/Month)				
5,001 – 20,000	169	84.50		
20,001 – 35,000	28	14.00	15,125	6,525
35,001 – 50,000	3	1.50		
Primary Earning Source of the Household (Dichotomous Choice)				
Shrimp Farming	176	88.00		
Otherwise	24	12.00		
Agricultural Land (in Hectares)				
0.00 – 0.75	138	69.00		
0.76 – 1.50	58	29.00	0.59	0.40
1.51 – 2.25	4	2.00		
Livestock Ownership (in Numbers)				
Yes	94	47.00		
No	106	53.00		
Engagement in Non-farming Activities (Dichotomous Choice)				
Yes	121	60.50		
No	79	39.50		
Observations (n)				**200**

The size of a household has a contingent impact on productivity. Table 4 shows that more than half (62.50 percent) of the shrimp farmer's family size varies between 4 to 6 members. The average shrimp farmer's household size consists of 4 and above members. Income is an essential factor determining shrimp farmers' socioeconomic status and Purchasing Power (PP). This proposition is supported by Rahman et al. (2013) and Dhar et al. (2020). The study findings indicate that the livelihood of shrimp farmers is far lower due to their sole dependency on shrimp farming which yields lower profitability resulting from lower production.

The research findings indicate that a significant majority (85.50 percent) of the shrimp farmer's earnings fall within the BDT 5,001 to BDT 25,000 monthly range. This can be attributed to factors such as reduced productivity and a high percentage of unemployment. This research conducted an analysis to determine the mean income of households involved in shrimp farming, which was found to be BDT 19,345, accompanied by a standard deviation of BDT 7,808.

It was noticed that approximately 50% of families do not possess any animals. The remaining 50% of households possess between 1 and 5 cattle. The average land ownership of shrimp farming households is 0.59 hectares, with a significant proportion of farmers possessing less than one hectare of agricultural land. Prior research has asserted that the size of a farm has a noteworthy influence on its output. The combination of constrained savings and limited access to credit facilities is likely to diminish the ability to make substantial investments, which in turn is often associated with lower levels of productivity. The presence of non-agricultural land contributes positively to the enhancement of household living conditions. On average, the shrimp farmers in the research area possessed 28 decimals of land.

As a consequence of curtailed shrimp production, a significant proportion of shrimp farmers derive their primary income from non-farming sources. It is found that 39.50 percent of the shrimp farmers rely only on shrimp production as their primary means of family income, without any additional non-farming income. On the other hand, it is noteworthy that the remaining 60.50 percent of shrimp farmers within the research region evolved their income from non-farming sources. It was noted that seasonal farmers were generally interested in a variety of non-farming professions due to the elevated levels of subsistence that they were required to maintain. (Paul et al., 2018).

Moreover, it is worth noting that a significant number of individuals involved in shrimp farming also partake in diverse agricultural practices, as evidenced by studies conducted by Goswami et al. (2002), Rahman et al. (2016), Hossain and Hasan (2017), and Islam et al. (2017). According to the study of Ali et al. (2014), the level of individuals' standard of living is decisively affected by factors such as the adequate sufficiency of their savings, their level of schooling, their non-agricultural occupations that generate income, and their possessions in the form of livestock.

Farming Methods and Productivity

The farming method constitutes an essential component of the differences in production perceived among the shrimp producers. In the study area, four distinct farming systems are observed. Semi-intensive and intensive farming practices represent contemporary technological advancements compared to conventional and extensive farming systems. The productivity level exhibits considerable variation due to variations in farming methods. Table 5 shows that 59 percent of the shrimp farmers cultivate shrimp based on traditional farming methods, while 10 percent have extensive farming methods. About 17.50 percent of farmers follow semi-intensive farming methods in their cultivation process, while 13.50 farmers have experienced intensive farming methods.

Table 5. Farming method and productivity

Farm Type	Frequency	Percent	Production (in KG/Hectare)	Profit (BDT/Hectare)
Traditional	118	59.00	261	61,927
Extensive	20	10.00	270	1,18,642
Semi-intensive	35	17.50	900	1,52,488
Intensive	27	13.50	642	1,54,114
Total	**200**	**100.00**	**425**	**95828**

Table 5 shows substantial productivity and profit differences among farming methods. Traditional farming methods exhibit comparatively lower output levels, with an average yield of 261 kilograms and a corresponding monetary value of BDT 61,927 per hectare. The farmers, who were engaged in extensive farming methods, achieved a per-hectare production of 270 kilograms and generated an annual profit of BDT 1,18,642. Farmers who implemented intensive farming methods achieved a per-hectare output of 642 kg and an annual profit of BDT 1,54,114. In this regard, farmers who adopted Semi-intensive farming methods maintained superior productivity compared to their counterparts, predominantly by using advanced technology, resulting in a per-hectare production of 900 Kg and an annual profit of BDT 1,52,488. The association between farming methods and productivity is bidirectional, and modern technology-based farming methods are more profitable than traditional farming methods (Asadullah & Rahman, 2009; Begum et al., 2013).

Differences in Net Returns between Educated and Less educated Farmers

An activity budget is widely used to portray the differences in profit or return between various entities. The authors provided evidence of the disparities in net returns between farmers with higher levels of education, defined as educated farmers, and those with lower education levels as less educated farmers. Table 6 demonstrates that farmers with higher education levels benefit more than those with lower education levels.

Table 6. Activity budget equation result

Variables	Less educated Farmers	Educated Farmers	Differences
Shrimp Production (Kg)	129	353	224##
Concerned Byproduct	0	0	0
Price of per Kg shrimp (BDT)	751	743	8#
Total Revenue (BDT)	97,231	2,67,463	1,70,232##
Total Variable Cost (BDT)	28,849	1,49,140	1,20,290#
Total Fixed Cost (BDT)	0	0	0
Net Returns (BDT)	**68,381**	**1,18,322**	**49,941##**

[Note: # = Less educated farmers gain; ## = Educated farmers gain]

Table 6 shows, there is a substantial difference in production between educated and less educated shrimp farmers. For less educated farmers, per hectare production is 128 kg, while educated farmers have 353 kilograms. The difference in productivity is 224.25 kg which is educated farmers gain. Shrimp farmers produce no byproduct. The price difference is BDT 8, which is less educated farmers gain. From the total revenue earning side, less educated farmers earn BDT 97,231 while educated farmers earn BDT 2,67,463 yearly. The difference between total revenue earned is BDT 1,70,232 which is gained by educated farmers. On the other hand, less educated farmers have a lower cost than educated farmers which is BDT 1,20,290. Less educated farmers gain the cost difference because most of them are traditional farming method adopters. The traditional farming method has low cost and low production, accompanied by no fixed cost.

In a nutshell, farmers with higher levels of education obtain net returns of BDT 1,18,322, while farmers with lower levels of schooling attain BDT 68,381. Educated farmers have achieved a net gain of BDT 49,941, signifying a disparity in returns. The data indicates that farmers with higher levels of education have a net return of BDT 49,941 greater than that of farmers with lower levels of education. The study's findings indicate that farmers with higher levels of education tend to achieve more profitability than their less educated counterparts. This assertion is substantiated by the research conducted by Pinckney (1997), Akber et al. (2017), Duy et al. (2022), Folorunso et al. (2021), and Huq et al. (2007).

Farmers' Education and Adopted Farming Methods

Farmers' education has various roles in shrimp production. Education helps farmers to understand diagnostic and implementation information of discovered technology in aquaculture. An educated farmer has more understanding of farm management knowledge in terms of gher preparation, disease monitoring, and water quality monitoring through decoding information about farm management practices. There exist four types of farming methods in the study.

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Table 7 reveals that 59 percent of the respondents followed the traditional farming method last year. Regarding traditional farming, 66.1 percent are less educated among 118 farmers. In contrast, 33.9 percent of farmers are educated. For the extensive farming method, 10 percent (20 farmers) of farmers practiced extensive farming methods. In this study, 55 percent of the farmers were educated, while 45 percent were less educated. Furthermore, semi-intensive farming methods were practiced commercially in the Khulna district by 17.5 percent of the total respondents. They reported that 97.14 percent of farmers are educated, while only 2.86 percent are less educated. For intensive farming, 13.50 percent of farmers practiced intensive farming among the respondents, especially in the Satkhira districts, 100 percent of whom are educated.

Eventually, less educated farmers have faced myriad problems to cope with the modern technology-based farming method. Education is the staple requirement to understand written documents and farm management practices. However, illiterate farmers may be productive through the knowledge-sharing process of farm management knowledge. Training or cooperation with the fisheries extension office may meliorate illiterate farmers' perception to follow profitable farming methods.

Table 7. Education and adopted farming methods

	Less educated Farmers		**Educated Farmers**	
Farming Methods	**Frequency**	**Percentage**	**Frequency**	**Percentage**
Traditional	78	66.10	40	33.90
Extensive	11	55.00	9	45.00
Semi-intensive	1	2.86	34	97.14
Intensive	0	0.00	27	100.00
Total	**90**	**45.00**	**110**	**55.00**

Determinants of Shrimp Profitability

According to Table 8, there exists a significant relationship between the size of the gher and the productivity of farms. Assuming all other variables remain identical, a one-hectare increase in the size of the gher is associated with 0.64 percent increase in farm output per hectare, with a significance level of 1 percent. The subsequent studies support the conclusions. The studies conducted by Paltasingh and Goyari (2018), Marsudi and Zikri (2020), and Abdulai and Huffman (2014) are relevant to the topic under consideration. The variable of pumping cost exerts a favorable influence on shrimp productivity. Assuming all other factors remain the same, a 1,000 Bangladeshi Taka (BDT) rise in pumping costs is associated with a 0.12% increase in farm output per hectare. The statistical significance of the finding is observed at a significance level of 1 percent. Duy et al. (2022), Paltasingh (2016), Pinckney (1997), Paltasingh & Goyari (2018), Marsudi & Zikri (2020), and Abdulai & Huffman (2014) have all reported comparable findings. Pumping costs are typically associated with semi-intensive and intensive farming practices.

Table 8. Estimated parameters of Cobb-Douglas production function

Explanatory Variables	**Coefficient**	**Standard Error**
Ln (Gher size)	0.640***	0.084
Ln (Pumping)	0.124***	0.037
Ln (Fingerlings)	0.086*	0.045
Ln (Insecticide)	-0.037	0.027
Ln (Labor)	0.106**	0.043
Ln (Lime)	0.127**	0.049
Ln (Feed)	0.172***	0.035
Ln (Transportation)	0.017	0.045
Ln (Education)	0.121***	0.039
Constant	**7.381*** **	**0.478**
Observations		**200**
R-squared		**0.73**

*[N.B.: *** p<0.01, ** p<0.05, * p<0.1, Ln = Logarithm]*

The variable corresponding to the cost of fingerlings exhibits a statistically significant positive impact on overall shrimp productivity. Under the assumption that all other variables remain unchanged, a one percent increase in the cost of fingerlings leads to a statistically significant 0.09 percent increase in output per hectare, with a significance level of 10 percent. Marsudi and Zikri (2020), Nyagaka et al. (2009), Begum et al. (2013), and Kumar et al. (2012) have reported equivalent results. The variable representing the cost of lime is commonly utilized in the production process. The Cobb-Douglas production function (CDPF) estimates demonstrate that, under the assumption of other factors remaining constant, a one percent rise in lime cost leads to a 0.13 percent increase in farm output per hectare. The statistical significance of the result is observed at a significance level of 5 percent. The variable cost associated with feed is a factor in the production process from the initial to the final output stage. According to the Cobb-Douglas production function (CDPF), with other factors held constant, a 1,000 BDT rise in feed costs leads to a 0.17% increase in farm output per hectare. The observed results exhibit statistical significance at a level of 1 percent. The validity of this research's findings is supported by the works of Pinckney (1997), Akber et al. (2017), Duy et al. (2022), Folorunso et al. (2021), and Huq et al. (2007).

The primary independent variable in this model is the level of education among farmers, which has a statistically significant positive effect on agricultural output. In the context of the CDPF, with other variables held constant, a one percent increase in farmers' education is associated with a 0.121 percent increase in farm output per hectare. The statistical significance of the finding is established at a significant level of 1 percent. Previous empirical research has extensively investigated the notion of the influence of education on production, yielding consistent results. These findings are substantiated by the works of Duy et al. (2022), Folorunso et al. (2021), Nyagaka et al. (2009), Serin et al. (2009), Paltasingh (2016), Asadullah & Rahman (2009), Alene & Manyong (2007), Paltasingh & Goyari (2018), and Abdulai & Huffman (2014). The CDPF model has produced results free from multicollinearity, as confirmed by the VIF test. Additionally, any heteroscedasticity error has been addressed by the utilization of robust standard error estimates.

Efficiency Factors of Production

Farm productivity narrowly depends on its efficiency. When a farm needs lower inputs to produce a higher outcome, it is called efficiency. In this study, the degree of efficiency was measured by efficiency factors of production. Table 9 shows the degree of efficiency factors of production for both educated and less educated farmers. Furthermore, the Break-even Point (BEP) analysis is also presented in Table 9.

Table 9. Result of efficiency factors of production

Factors of Production	**Coefficient (β)**	**Educated Farmers (EFP)**	**Less educated Farmers (EFP)**
Pumping cost	0.11***	6.01	109.63
Fingerlings cost	0.09**	0.87	1.29
Insecticide cost	-0.043*	-1.98	-2.62
Labor cost	0.057	1.90	4.18
Lime cost	0.089*	8.30	13.39
Feed cost	0.178***	1.36	2.89
Transportation cost	-0.003	-0.16	-0.17
Mean EFP		**2.33**	**18.37**
BEP of Production Volume (Kg)			**214.83**
BEP of Production Price (BDT)			**377.23**
BEP of Gher Size (Hectare)			**0.51**

[N.B.: EFP>1 = Not efficient; EFP<1 = Not efficient yet; EFP=1 = Efficient; EFP = Efficiency Factor of Production; BEP = Break-even point]

According to the data in Table 9, it is evident that the marginal production and efficiency levels associated with the variables of pumping, fingerlings labor, lime, and feed exhibit positive values. This finding implies that the shrimp production within the designated study region has a positive association with adding each unit of production input. Conversely, insecticide and transportation costs exhibit a negative association denoting inefficiency.

Pumping cost is essential when a farmer follows a semi-intensive farming method. It is observed that most of the traditional farmers are less educated. This finding indicates that pumping cost is not significant for traditional farming. Previously, CDPF analysis shows that pumping cost is statistically significant at a 1 percent level. Still, it has an impact on educated farmers who have followed semi-intensive or intensive farming methods. Overall, the pumping variable is not efficient in the study area.

The relationship between farm output and the cost of fingerlings is statistically significant at the 5% level, as shown in Table 9. However, the cost of fingerlings is inefficient for farmers with less education and is not yet efficient for farmers with more education. When insecticide cost has an unfavorable association with farm output, it is inefficient for producers of all levels of education. The variable labor is inefficient for educated and less educated farmers, but educated farmers tend to be more efficient than less educated farmers. The major factor is that variable feed is inefficient for educated and less educated farmers. However, educated farmers are more efficient than less educated farmers. The efficiency Factors of Production value of educated farmers is about nine times lower than less educated farmers' efficiency value. That indicates educated farmers are more efficient than less educated farmers.

The break-even Point (BEP) indicates that the study area's production volume is 214.83 kg per hectare. This production level does not benefit farmers economically, as the revenue generated is sufficient to support production costs. This condition is referred to as the break-even point. If a farm's produce falls below 214.83 kilograms, it will incur losses. In contrast, if a farm's output exceeds 214.83 kilograms, it will be profitable. In the region under study, the average farm output outweighs the break-even point. The BEP of production price also indicates that if a farmer sells their shrimp BDT 377 per kg, then they will not earn profit. This price-induced revenue is only able to cover the production cost. If a farmer sells below the breakpoint, then the farmer will suffer losses. If a farmer sells above the break-even point, then the farmer will earn a profit. The study inferred that the average market price for shrimp is above BDT 700 per kg. These findings indicate that the farmers sell their products twice the break-even point product price.

The break-even point of gher size of the study area is 0.51 hectares. Suppose a farmer cultivates in a gher size greater than 0.51 hectares. In that case, the farmer is economically benefitted compared to the farmers whose gher size is below 0.51 hectares, which asserts that it is an existing condition with traditional technology. Technology has upgraded rapidly. The semi-intensive and intensive farmers are more profitable in the study area.

Determinants of the Farm Management Knowledge

In this study, the authors try to find out the determinants that affect farm management knowledge in the study area. In this aspect, the authors introduced a Tobit regression analysis and considered the farm management practices as the explained variable. The result is illustrated in Table 10.

Table 10. Estimated parameters of the Tobit Regression Model

Explanatory Variables	**Marginal Effect**
Farmers' Education	0.677**
Farming Experience	-0.292
Contact with Educated Farmers	0.527
Access in FEO	14.750***
Participation in Fisheries Training	8.629***
Observations	**200**

*[N.B.: ***p<.01, **p<.05, *p<.1]*

Table 10 illustrates the positive relationship between the level of education among farmers and their knowledge of farm management. Assuming all other variables remain constant, a one-year increase in education level is associated with a 0.667 percent rise in the score of farm management knowledge. This study suggests a noteworthy positive association between the level of education among farmers and their knowledge of farm management. A farmer with a higher level of education is more likely to comprehend and assimilate production-related information than a farmer with a lower level of education. The degree of significance for the farmers' education is statistically significant at a 5 percent level. Within the designated research area, it has been observed that farmers who had access to the fisheries extension office exhibit a farm management knowledge score that is 14.75 percent higher in comparison to those farmers who had no access to that office. The observed result reveals statistical significance at a level of 1 percent. Plausibly, the fisheries extension office may exert necessary information regarding gher management, water quality monitoring, Stocking density, and other farm-related information which are beneficial to shrimp farming.

In a similar vein, farmers who have access to fisheries extension offices exhibit greater agricultural productivity compared to farmers who do not have such access. Ultimately, the farmers who underwent training exhibited a significant increase of 8.629 percent in their farm management knowledge scores, in contrast to their counterparts who did not receive any training. The observed results exhibit statistical significance at a significance level of 1 percent. This model has considered the factors of farmers' education and farming experience. The omission of additional variables was attributed to the issue of multicollinearity. In the field of aquaculture, the practice of farming is closely associated with the acquisition of farm management knowledge. The findings are corroborated by prior pertinent research conducted by Marsudi and Zikri (2020), Duy et al. (2021), Nyagaka et al. (2009), Begum et al. (2013), and Kumar et al. (2012).

Conclusion

Shrimp farming has emerged as the primary source of income for rural communities residing in the coastal region of Bangladesh. Shrimp aquaculture plays a substantial role in the sustenance of local communities and the advancement of regional economies. During the period known as the demographic dividend, a significant proportion of the working-age population with educational qualifications experienced unemployment. The government is endeavoring to establish work possibilities for its citizens. In contemporary times, farmers have increasingly engaged in cultivating shrimp on a greater scale, facilitated by comprehensive training and the acquisition of knowledge about environmental management strategies. According to the proposed hypothesis, a substantial positive association exists between levels of education and shrimp productivity. The authors endeavored to assess whether there was an association between the level of education among farmers and the productivity of shrimp. This study revealed that the level of education among farmers positively impacts both farm output and farm management knowledge. Following this, farmers who have received an education demonstrate a strong inclination to embrace farming techniques that yield significant profits.

Based on the research findings, the authors have proposed strategies to enhance shrimp productivity and farm management skills to foster socioeconomic growth and generate employment opportunities in the study area. To improve profitability, it is imperative to augment productivity and enhance farming techniques in the domain of shrimp farming. The government has the potential to offer incentives and establish training facilities for newly involved shrimp farmers with a higher education level, aiming to optimize their financial gains. The employment prospects of educated individuals will be enhanced by heightened awareness. Shrimp farming has a significant opportunity for generating employment possibilities on a broader scale. It is recommended that non-governmental organizations and investors prioritize their efforts toward developing shrimp farming by offering state-of-the-art technological infrastructure to enhance the capabilities of shrimp farmers.

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Conflict of Interest

The authors declare no conflicts of interest.

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